PACIFIC COAST GROUNDFISH 5-YEAR REVIEW OF ESSENTIAL FISH HABITAT

REPORT TO THE PACIFIC FISHERY MANAGEMENT COUNCIL
PHASE 1: NEW INFORMATION

SEPTEMBER 2012
(INCLUDING ADDENDUM)

PACIFIC FISHERY MANAGEMENT COUNCIL
7700 NE AMBASSADOR PLACE, SUITE 101
PORTLAND, OR 97220
(503) 820-2280
(866) 806-7204
WWW.PCOUNCIL.ORG

Members of the Pacific Coast Groundfish Essential Fish Habitat Review Committee:
Brad Pettinger (Chair), Oregon Trawl Commission
Megan Mackey (Vice Chair), Ecotrust
Ed Bowlby, NOAA National Ocean Service, Olympic Coast National Marine Sanctuary
Robert Eder, F/V Timmy Boy
Chris Goldfinger, Oregon State University
H. Gary Greene, Moss Landing Marine Laboratories
Jennifer Hagen (Designee), Quileute Indian Nation
Dayna Matthews, NOAA Office of Law Enforcement
Karen Reyna (Designee), NOAA National Ocean Service, Gulf of the Farallones National Marine Sanctuary
Geoff Shester, Oceana
Joe Schumacker, Quinault Indian Nation
John Stadler, NOAA Fisheries Northwest Region
Waldo Wakefield, NOAA Fisheries Northwest Fisheries Science Center
Mary Yoklavich, NOAA Fisheries Southwest Fisheries Science Center

Other key contributors:
Joe Bizzarro, University of Washington and University of California Santa Cruz
Chris Romsos, Oregon State University, College of Earth, Ocean, and Atmospheric Sciences
Curt Whitmire, NOAA Fisheries Northwest Fisheries Science Center
Marlene Bellman, NOAA Fisheries Northwest Fisheries Science Center
Kerry Griffin, Pacific Fishery Management Council
Chuck Tracy, Pacific Fishery Management Council
Eric Chavez, NOAA Fisheries Southwest Region

NOAA = National Oceanic and Atmospheric Administration

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ADDENDUM TO PACIFIC COAST GROUNDFISH PHASE 1 REPORT

SEPTEMBER 2012

The Pacific Coast Groundfish Essential Fish Habitat Review Committee (EFHRC) proposed an addendum to the Phase 1 Report that was included in the briefing book materials for the September 2012 meeting of the Pacific Fishery Management Council (Council). The Council made minor changes to the addendum, and are included below:

1. Marine Protected Area (MPA) maps were omitted from the report issued on August 23 2012, and will be made available on the Consolidated GIS Data Catalog and Online Registry for the 5-Year Review of Pacific Coast Groundfish EFH:
   http://efh-catalog.coas.oregonstate.edu/overview/

2. Section 4.5.4 Marine Fisheries Managed by the Tribes **[This section subject to legal review, as per Council direction]**

3. Appendix C, page 145, Paragraph 3: It is essential to understand that the Acoustic Data Coverage comparison plates simply reveal the distribution of new acoustic data identified across the region. It should not be assumed that each new data source has been mapped for seabed substrate type. Although many nearshore and continental shelf sources have been interpreted, there are continental slope and deep-water sources that need substrate interpretation. Table C.1 may be used to determine which bathymetry or backscatter source has been used to create a seabed habitat map. Therefore, map users should not assume that the *Aggregate Seabed Habitat Map Distribution 2011* (bottom figure of each plate) map presents a spatially uniform understanding of seabed type. *The Aggregate Seabed Habitat Map Distribution 2011*map is a "mashup" of varying quality and certainty.

4. Appendix C-2: Substrate, Map Plate 7 of 12: Seabed Habitat Map Distribution 2005 to 2011: San Francisco & Monterey Bay and Aggregate Seabed Habitat Map Distribution 2011: San Francisco & Monterey Bay: Cochrane Bank, which is west of Fanny Shoal, is missing from the two map plates in the Council report issued on August 23, 2012, but is available online and has been added to the Consolidated GIS Data Catalog and Online Registry for the 5-Year Review of Pacific Coast Groundfish EFH and data portal plate maps at: http://efh-catalog.coas.oregonstate.edu/platesCD/

5. Information and Research Needs
   The EFHRC developed additional detail on the recommended information and research needs in Section 7 of the Phase 1 Report, in order to improve the designation, monitoring, and effectiveness of groundfish EFH. The following research and information needs replace Section 7 in the Phase 1 Report.

High, medium, and low priorities are indicated in parentheses.

I. Analyze the new information gathered in the EFHRC groundfish EFH Phase 1 Report, in order to inform decisions to modify the 2006 groundfish EFH designations.

a. (**high**) Evaluate the boundaries of the 2005 EFH closures, relevant to the distribution of seafloor habitats in the newly developed 2011 maps, to identify areas where habitat protection should be refined.
b. (**high**) Evaluate changes in the distribution of fishing effort, using the new 2005 and 2011 maps of effort for the bottom-contact fisheries, and determine if changes to current area management measures and gear restrictions from 2006 groundfish EFH regulations may be warranted.
c. (**high**) Update the table in Amendment 19 (*Summary of mean sensitivity levels and recovery times for all combinations of major gear types (including new gear types and midwater trawl) and bottom habitat types: Appendix 10 of Appendix A, Table 3*) that addresses relative ranking of gear types in terms of their habitat impacts.
d. (**high**) Evaluate new information on EFH relative to Level 1-4 (as defined in the EFH guidance, EFHRC Phase I Report page 13) and compare to information level available in establishing the 2006 groundfish EFH regulations.
e. (**medium**) Evaluate associations of vulnerable groundfish species and benthic habitats, relevant to the 2011 maps of distribution of seafloor habitats, to identify areas where habitat protection should be refined.
f. (**medium**) Evaluate new information on non-fishing-gear impacts to EFH (including environmental/oceanographic trends), especially relevant to 2006 groundfish EFH regulations.
g. (**high**) Evaluate corals and sponges as components of EFH for groundfishes.
h. (**high**) Evaluate the 2005 mobile-fishing-gear risk assessment model relevant to new data.
i. (**high**) Run the habitat suitability probability models for all west coast groundfish species, using the new maps of habitat distributions and other relevant data.
j. (**medium**) Conduct field experiments to determine the role of corals and sponges as components of EFH for groundfishes.

II. (**high**) Conduct visual, no-take surveys of fishes and habitats inside and outside current EFH closures in order to evaluate the effectiveness of these conservation areas.

III. Improve seafloor maps (bathymetry, backscatter, and associated interpreted substrata types):
a. (**high**) Develop maps of interpretative substrate from a backlog of sonar mapping data. The geographic location of all new acoustic mapping (i.e. where surveys have been conducted) is shown. However, all new acoustic mapping may not have been examined or used to create substrate interpretations (i.e. new substrate classifications in the substrate maps in Appendix C-2).
b. (**high**) Create an integrated data set from the "aggregate seabed habitat" data, 2011, in Appendix C-2. Specifically, this means to develop an integrated product from available interpretative substrate data. These integrated data should result in a seamless product that is suitable for a regional scale analysis.
c. (**high**) Conduct high-resolution seafloor mapping, particularly on the shelf and slope associated with groundfish EFH conservation areas.

IV. Improve the Habitat Use Database (HUD):
a. (**high**) Develop tools and protocols to aid in data entry and to address specific architectural problems

b. (**high**) Address potential biases associated with inclusion of species from the Oregon Nearshore Strategy
c. (**high**) Update associations and distribution of groundfish habitat (including prey), using new information reported in the EFHRC report. Add descriptions for other species groups similar to those provided for Flatfish group.
d. (**high**) Update HUD definitions, documentation, and standards (e.g. clarify 'preferred depth'; consider young of year (YOY); verify species range and habitat preference using fishery dependent and independent survey data; develop standards for recording database amendments and expert opinion).
e. (**low**) Develop crosswalk between HUD habitat types with other seafloor habitat classification schemes (i.e., Greene et al., 1999, FGDC CMECS, 2012)
f. (**low**) Implement a maintenance plan, including an oversight committee of HUD users (NOAA, EHFRC, OSU) and a schedule for regular HUD updates

V. (**medium**) Conduct surveys and experiments to evaluate adverse impacts to EFH, across the geographic range of groundfishes.

VI. (**low**) Advance the understanding of the affects of a changing climate on West Coast groundfishes.

VII. Improve groundfish prey information.
a. (**high**) Develop criteria for defining major prey species for groundfish species and lifestages.
b. (**high**) Compile lists of major prey species for the all stocks and lifestages in the groundfish FMP.
c. (**high**) Evaluate the habitat use and distribution of major prey species for groundfishes.
d. (**high**) Evaluate potential adverse effects from fishing and non-fishing activities on the major prey species in the diets of groundfishes.

In addition to the recommendations made regarding research and data needs, the EFHRC recognizes 1) a need to consider data and information on pelagic habitat components, as related to groundfish distribution, abundance, and productivity; and 2) a need for socio-economic impact studies in the wake of EFH changes. The EFHRC does not have the appropriate expertise to evaluate socio-economic impacts. However, the EFHRC assumes that this will be addressed in the fishery management plan (FMP) Amendment NEPA analysis, if the Council decides to move forward with Phase 3.

Agenda Item H.6.b
EFHRC Report 1
September 2012

Pacific Coast Groundfish 5-Year Review of Essential Fish Habitat
Report to the Pacific Fishery Management Council
Phase 1: New Information

Groundfish Essential Fish Habitat Review Committee

August 23, 2012

EXECUTIVE SUMMARY

The designations and detailed descriptions of essential fish habitat (EFH) in the fishery management plans (FMPs) are used during the EFH consultation process to determine where and for what species EFH has been designated in the project area. The analyses of the adverse effects from the proposed action, and potential conservation measures that avoid, minimize, or offset those effects, are informed by the information contained in the FMP.

The regulatory guidelines for implementing the EFH provisions of the Magnuson-Stevens Act (MSA) state that Regional Fishery Management Councils and the National Marine Fisheries Service (NMFS) should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted, based on available information (50 CFR 600.815(a)(10)). This review included evaluating published scientific literature and unpublished reports, soliciting input from interested parties, and searching for previously unavailable information on groundfish stocks identified in the Pacific Coast Groundfish FMP. The Council may provide suggested changes to existing EFH to NMFS for their approval, if the information warrants changes. The regulatory guidance provides that a complete review should be conducted periodically, but at least once every five years. Pacific Coast Groundfish EFH was first designated in 1998 by the Council as part of Amendment 11 to the groundfish FMP. This review was initiated in 2010.

This Phase 1 report summarizes the results of the review of information that is new or newly available since the last Groundfish EFH Review was concluded in 2006. The report includes a description of the general requirements and elements of EFH, including guidance for periodic reviews; a summary of existing descriptions of EFH for Pacific Coast groundfish; updated maps of seafloor habitat types and bathymetry; the currently available information on the distribution of Pacific Coast groundfish; a summary of models to predict groundfish distribution relative to habitat types, as well as trophic and ecosystem models useful for groundfish EFH; summaries of new information on the life history and habitat requirements of the 91 species in the Pacific Groundfish FMP; updated information on threats to groundfish EFH and prey species, both from fishing and non-fishing activities; and identification of research needs to further refine groundfish EFH.

The second phase of this review will consider potential changes to EFH, based on the new information produced in Phase 1, and presents those to the Council. The EFH review is concluded at that point. In Phase 2, the Council may issue a request for proposals (RFP) to all interested parties for changes to the identification and description of EFH that are based on the information in the Phase 1 report. If the Council determines that changes to EFH identification and descriptions are necessary, it then proceeds with a third phase that utilizes the appropriate management tool to revise EFH.

ES-2: CURRENT DESIGNATIONS FOR PACIFIC COAST GROUNDFISH EFH, HAPC, AND ECOLOGICALLY IMPORTANT HABITAT CLOSED AREAS

Section 2 summarizes existing EFH for Pacific Coast Groundfish contained in Amendment 19 (Figure ES-1) (PFMC 2008; NMFS 2005) and the 2006 Final Rule (71 FR 27408), including habitat areas of particular concern (HAPC) (Figure ES-2) and EFH closed areas (Figure ES-3. Amendment 19 provided descriptions of EFH for each species and life stage that were developed through an extensive review and synthesis of the literature available in 2005 (PFMC 2008). Appendix B provided a review of life history for each species, text descriptions, and tables that summarize, for each species, the habitats used by each life history stage and the important features of those habitats.

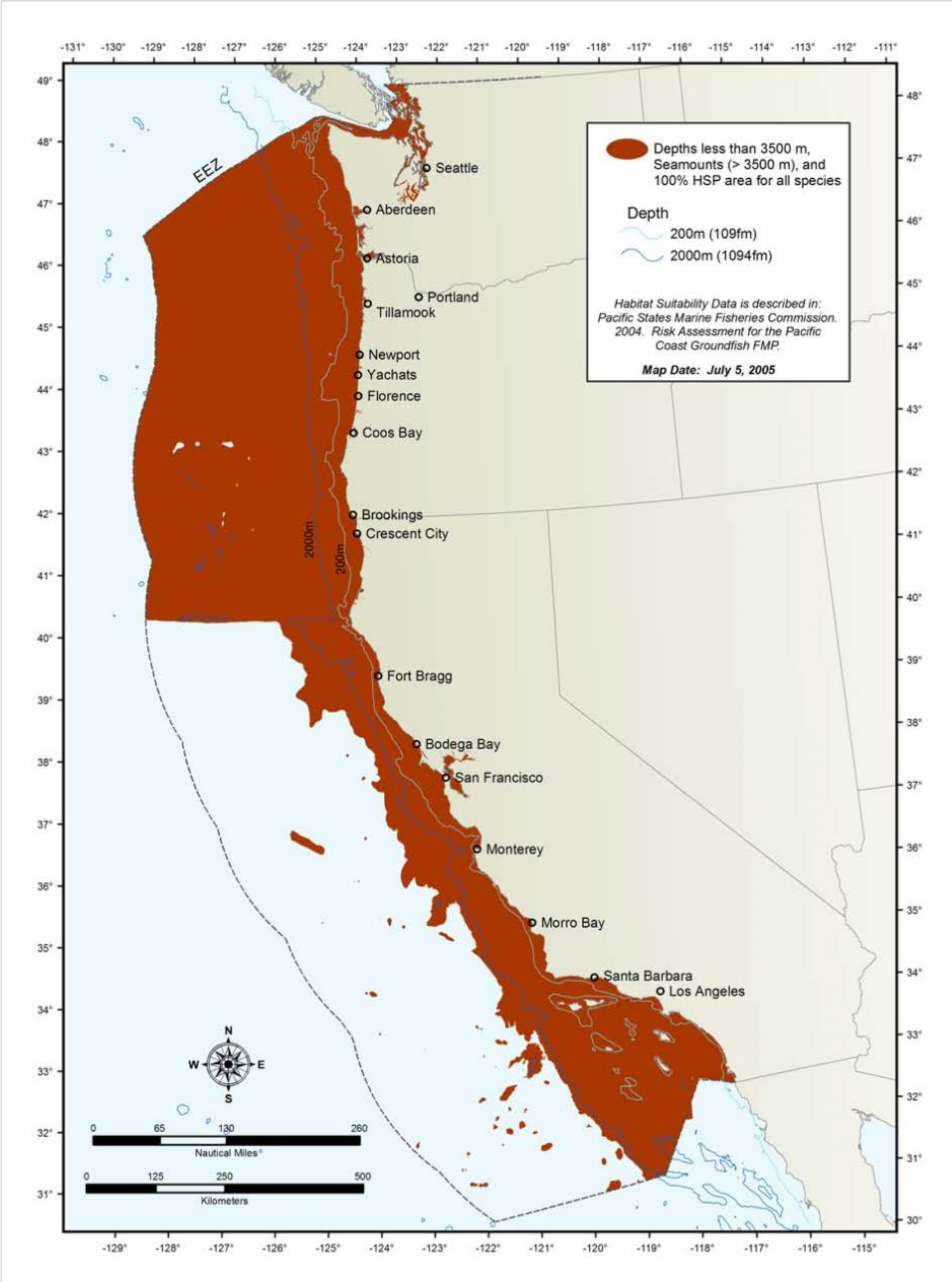


Figure ES-1. Current essential fish habitat description for the Pacific Coast groundfish.

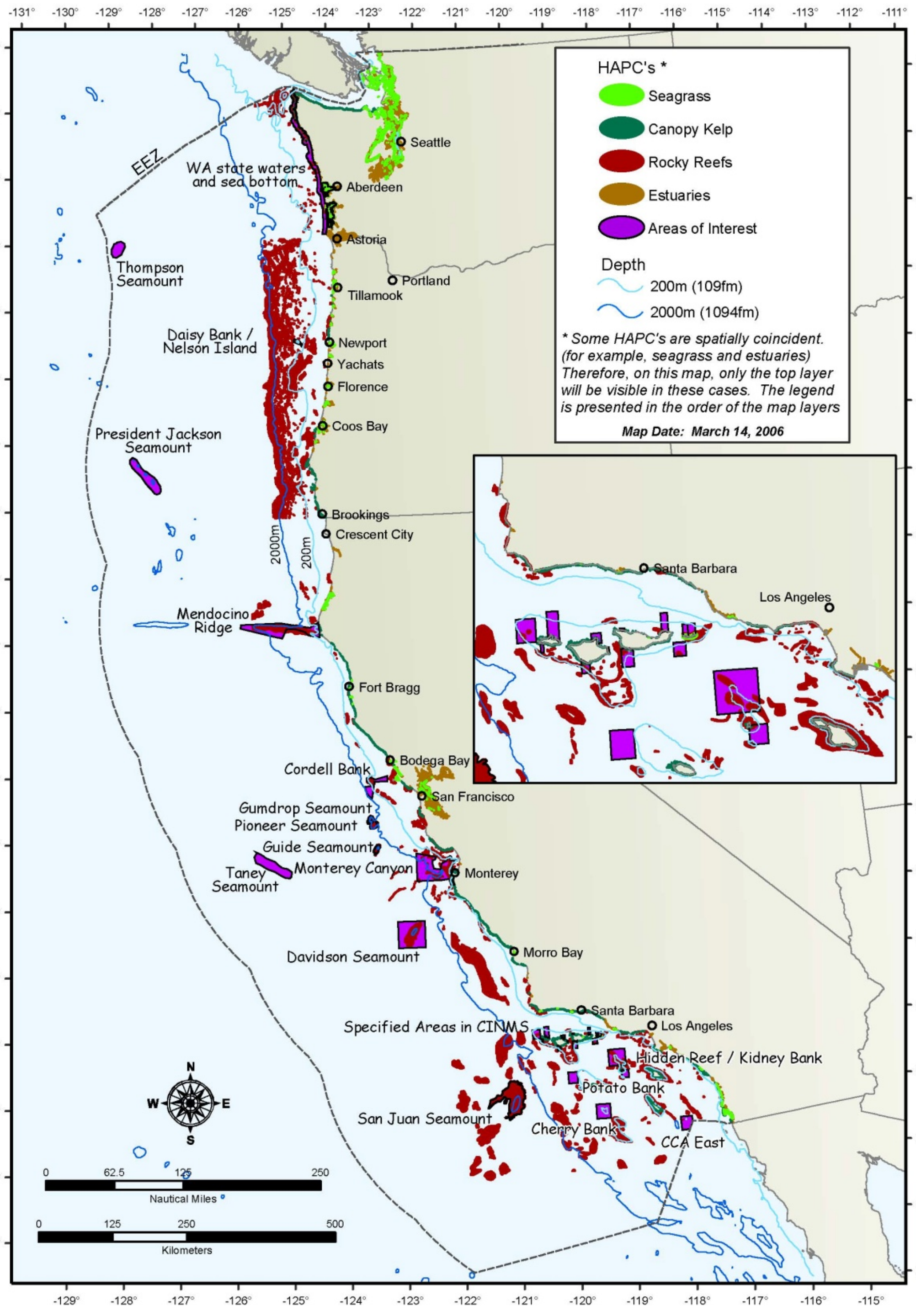
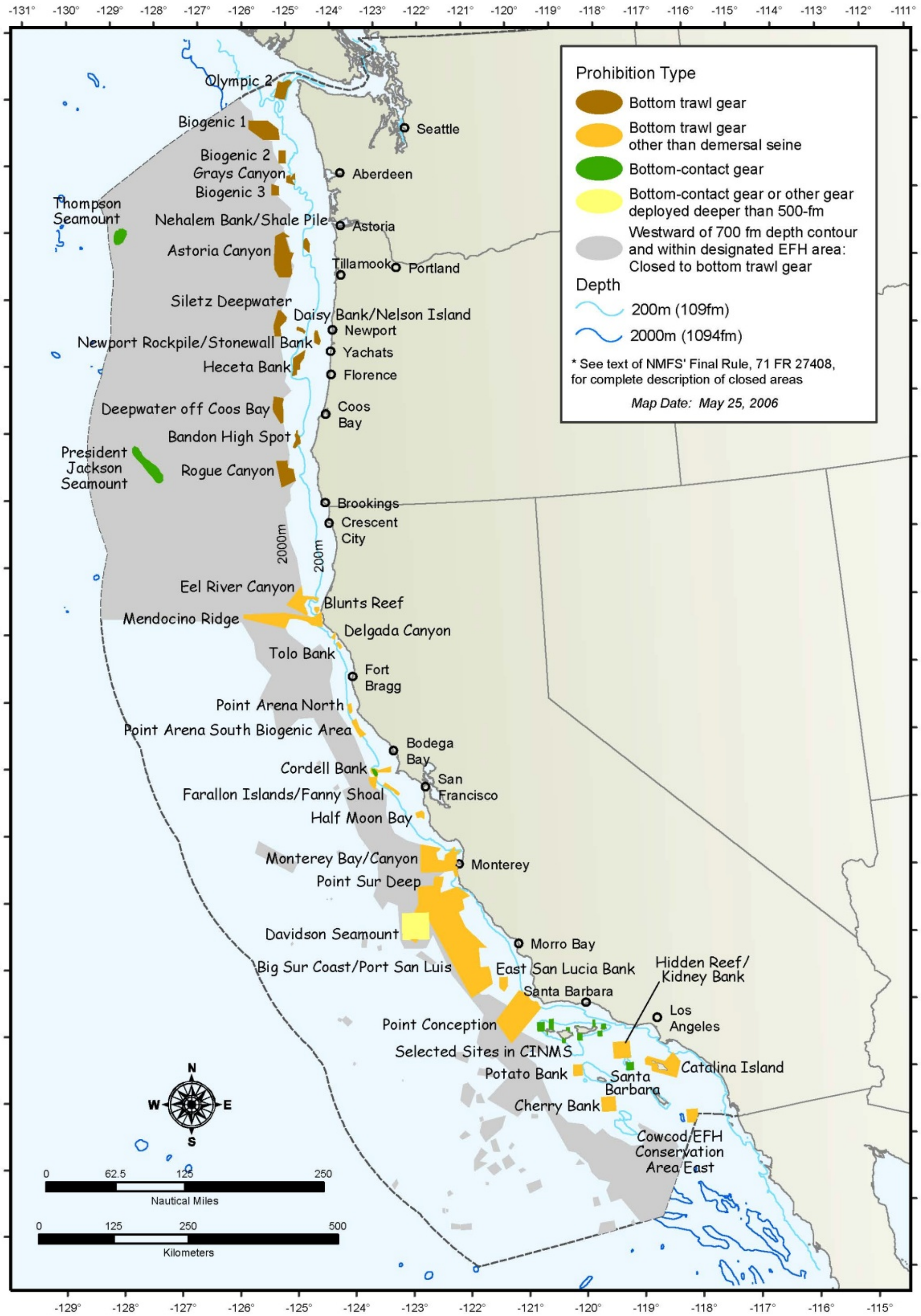


Figure ES-2. Groundfish HAPC.



EFH area closures to protect Pacific Coast groundfish habitat - Coastwide.

Figure ES-3. Ecologically important habitat closed areas.

ES-3 REVIEW OF NEW INFORMATION ON GROUNDFISH ESSENTIAL FISH HABITAT

Section 3 presents new information on habitats that has become available since the EFH designation in 2006 for the 91 species of Pacific coast groundfishes. There are five sub-sections, each accompanied by comprehensive Appendices:

- Section 3.1 summarizes an inventory of responses to the NMFS data call (Appendix B).
- Section 3.2 describes (in both text and maps) new information on the distribution of seafloor habitat types, including data on bathymetry, physical habitat interpretations, and biogenic components of habitat (Appendices C, D, E, and F).
- Section 3.3 includes summaries of recent information related to habitats for each life-history stage of the five species groups designated in the FMP for Pacific Coast groundfishes (i.e., flatfishes, other flatfishes, rockfishes, other rockfishes, and other groundfishes) (Appendix G).
- Section 3.4 is a review of new modeling efforts relevant to the determination and designation of EHF for Pacific groundfishes (Appendix H).
- Section 3.5 is an update on the Habitat Use Database (HUD) (Appendix I).

ES-3.1 Inventory of Responses to NMFS Data Call

Thirty-nine sources of data relevant to groundfish EFH that had become available since 2006 were received through the NMFS data call (see Appendix B for details on each item). All of these data can be used to revise the descriptions of EFH and HAPC or to evaluate risk to EFH. Information associated with the NMFS data call comprised four general categories:

1. Four sources of new information on the distribution and extent of seafloor maps, seafloor data, and interpreted Pacific Coast groundfish habitat types were received.
2. Eight sources of new and updated fishery-independent data were received on groundfish species and associated components of habitat.
3. Twenty sources of new and updated information or data were received on the distribution of habitats, including two coast-wide oceanographic datasets, 12 surveys of deepwater, structure-forming invertebrates, two models of deep coral distributions, an assessment of 146 West Coast estuaries, an online data library and maps of California, and two visual surveys of fish and habitats.

Seven sources of new and updated information were received on existing and emerging threats to Pacific Coast groundfish EFH. These included five fishery-dependent datasets and two sources of information on non-fishery threats.

ES-3.2: Bathymetry and Seafloor Habitat Maps

Pacific coast-wide comparative maps of bathymetry (Figure ES-4) acoustic coverage (Figure ES-5) and seafloor substrate (Figure ES-6) and biogenic habitat observations (ES-7 to ES-9) in 2005 and 2011 were compiled for the Exclusive Economic Zone (EEZ) off Washington, Oregon and California from all available sources. Seafloor imagery consisted of gridded bathymetry data sets (Digital Elevation Models or DEMs), and backscatter imagery. Contour data, either interpolated or derived from DEMs, were not included.

The map products displayed in this report were intended to provide a coast-wide overview of available data, and the methods chosen for display were designed to illustrate the range of values on that scale. There are other methods for displaying the same data that may provide alternative interpretations of temporal or spatial differences depending on such factors as geographic scale, value bins, or display algorithms. A data portal is available to allow access to maps and data from this report so that interested parties can manipulate data for specific purposes: http://efh-catalog.coas.oregonstate.edu/overview/.

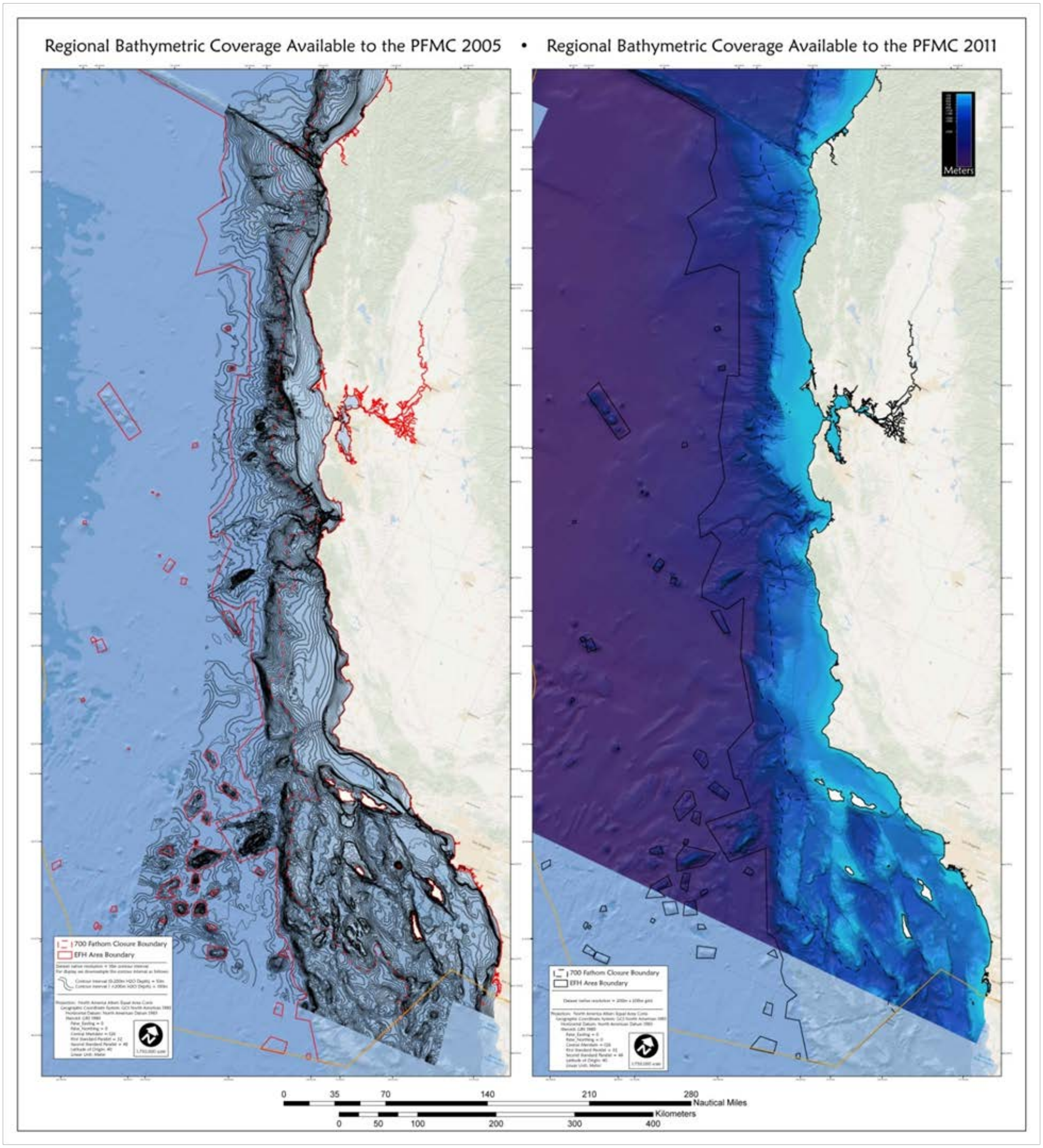


Figure ES-4. California regional bathemetry pre-2005 and post 2005; from Appendix C-3.

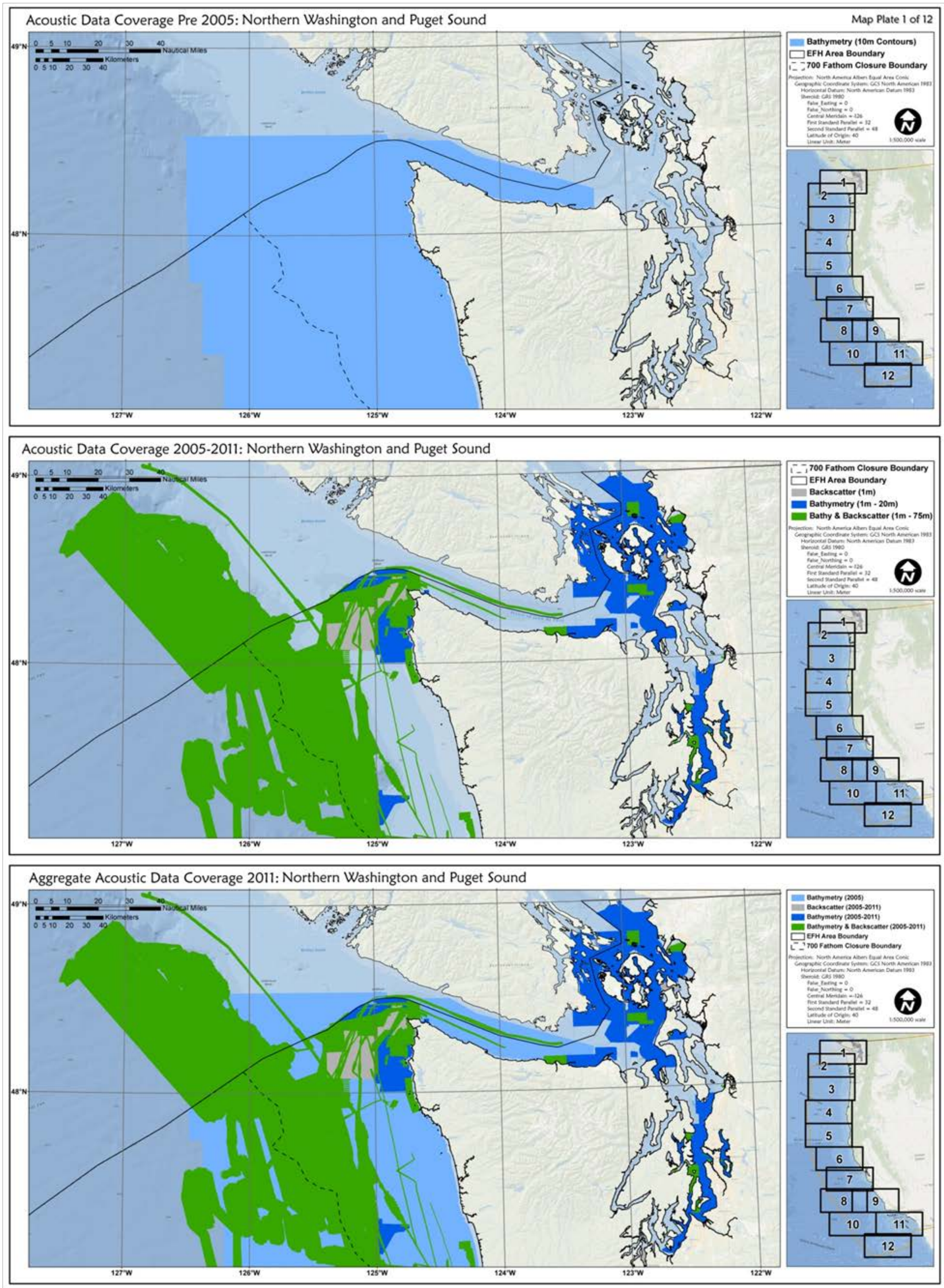


Figure ES-5. Example of imagry plate From Appendix C-1.

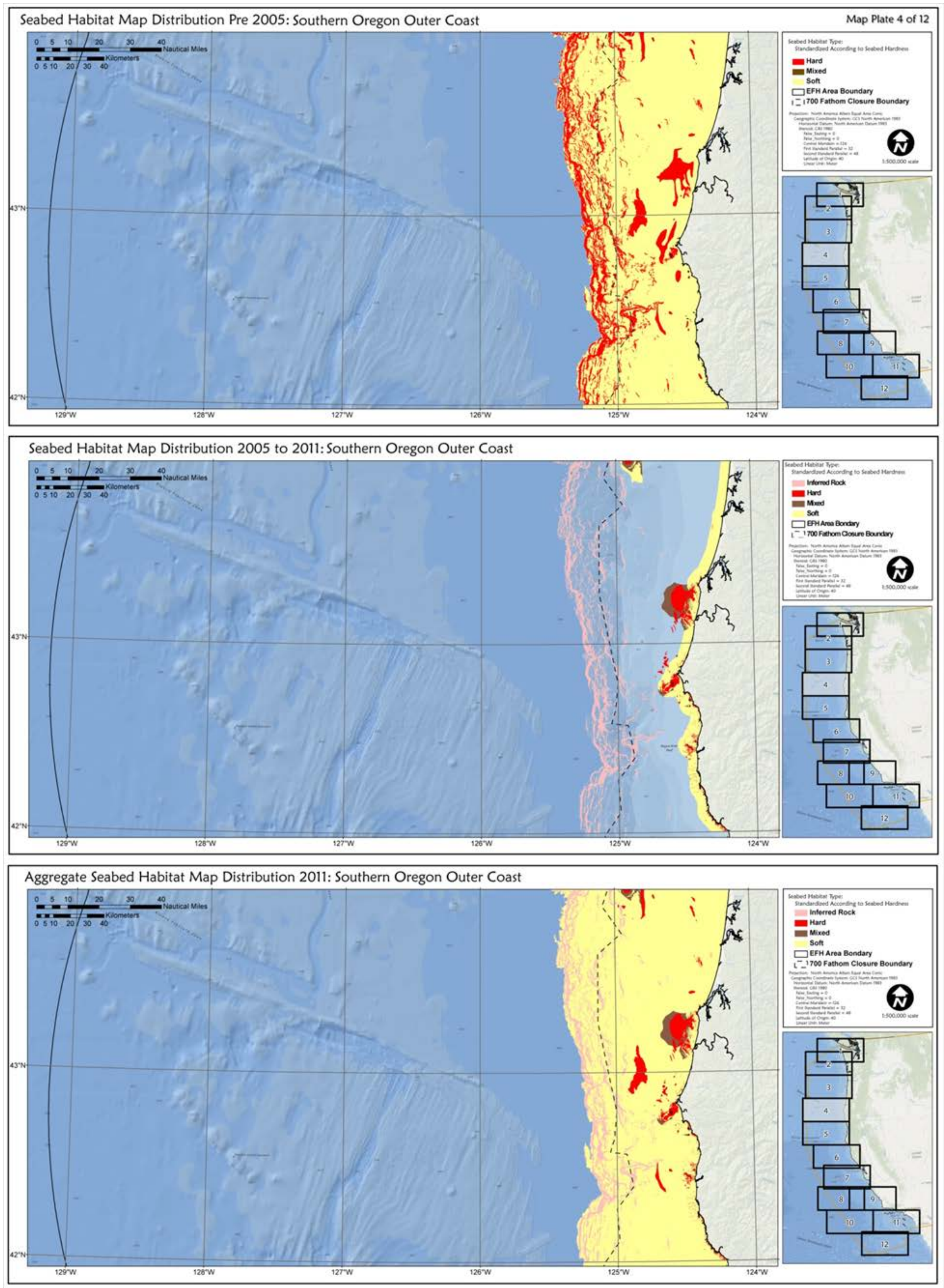


Figure ES-6. Example of bathymetry/substrate habitat plate from Appendix C-2.

Appendix D maps depict the spatial distribution of selected observations of corals and sponges from visual surveys conducted by a number of agencies and institutions and by a variety of collection methods. Many of the locations of observations are included in a national database prepared under the auspices of NOAA's Deep-Sea Coral Research and Technology Program (NOAA 2011). Although there are a number of records of additional observations recorded at various research institutes, this database is currently the most comprehensive source of electronically available records of coral and, to a lesser extent, sponge observations in the region.

Compared to the 2006 groundfish EFH review, this database represents a major advancement in access and dissemination of records of coral and sponge presence in the region. Furthermore, this database was not available during the Amendment 19 process.

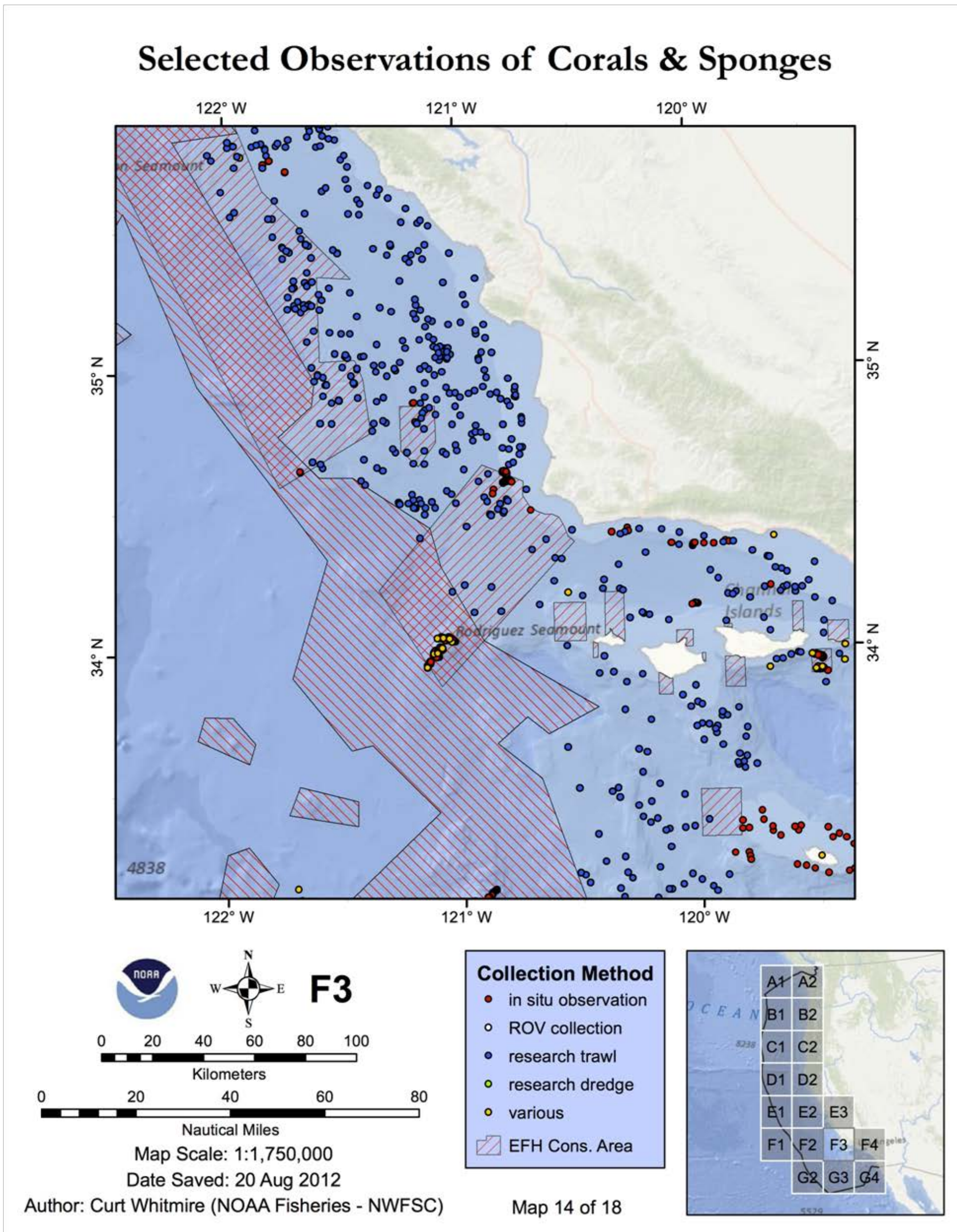


Figure ES-7. Example of map from Appendix D, selected observations of corals and sponges.

Appendix E plates depict the spatial distribution of standardized survey catch of corals and sponges within two time periods: "Before" (2003-05 survey cycles) and "After" (2006-10 survey cycles) implementation of Amendment 19 regulations. The sole data source for the map layers is catch records from the WCGBTS.

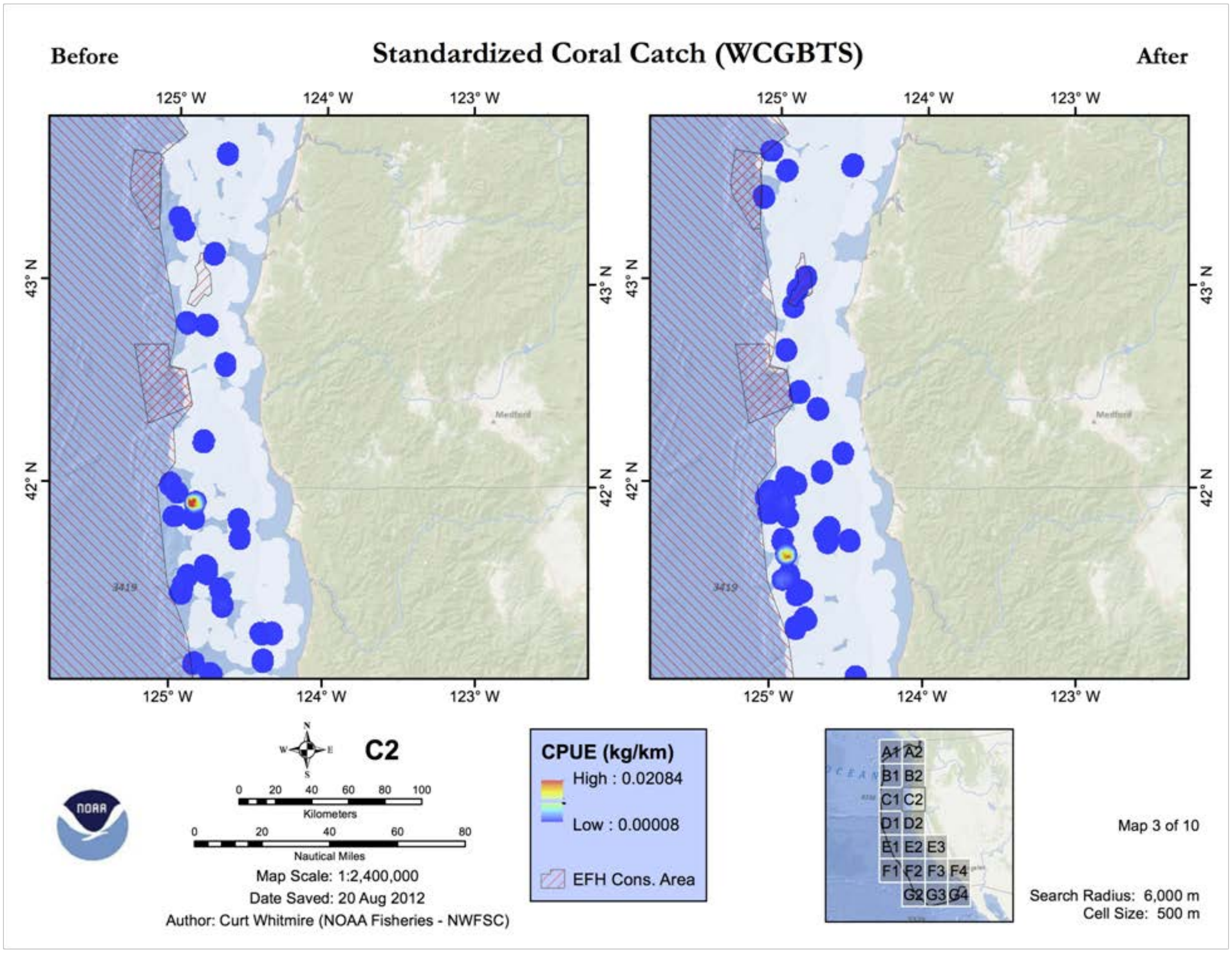


Figure ES-8. Example of plate from Appendix E-2 showing the distribution of coral CPUE (excluding sea pen/whips) off the Northern California Coast pre- and post- Amendment 19.

Appendix F Plates depict the spatial distribution of standardized commercial bycatch of corals and sponges within two time periods: "Before" (3 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of limited-entry trawl tows were compiled from one source: observer records from the WCGOP database. The WCGOP database includes records of trips for vessels using a variety of bottom trawl gear configurations, including small and large footrope groundfish trawl, set-back flatfish net, and double rigged shrimp trawl, to name a few. Records of tows using mid-water trawl gear were not included in this analysis, since observers recorded no bycatch of corals or sponges using this gear type.

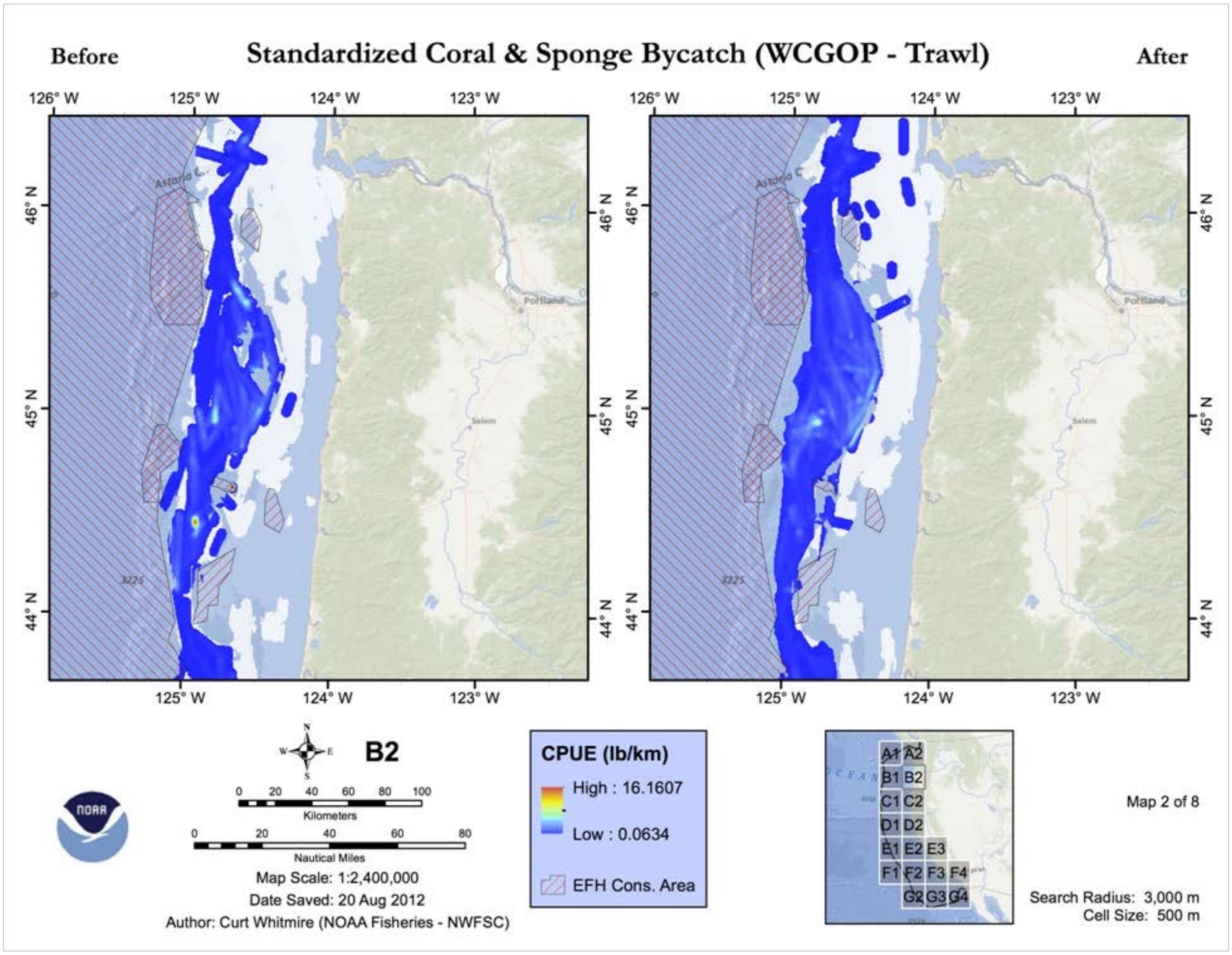


Figure ES-9. Example plate from Appendix F-1: the distribution of coral and sponge CPUE (lb/km) as bycatch from the West Coast Groundfish Trawl Observer Program before and after the implementation of Amendment 19 regulations.

ES-3.3: Associations of Groundfish with Habitats

Knowledge of spatial associations (e.g., range and depth designations, distribution and abundance estimates, habitat associations, environmental correlates) and trophic interactions (e.g., diet composition, predators, foraging habitat, trophic position) is necessary for an accurate description of EFH. A thorough search was conducted for each of the 91 current FMP species in order to identify and compile all relevant new literature.

Thorough species accounts that incorporate all relevant information for each life stage (i.e., eggs, larvae, juveniles, adults) were constructed for the four flatfish species (Appendix G-1), Other Flatfish (Appendix G-2), Rockfishes (Appendix G-3), Other Rockfishes (Appendix G-4), and Other Groundfish (Appendix G-5). These are included as analogs to the species accounts provided by McCain et al. 2005 (incorporated into the groundfish FMP) as a way to gauge the possible future utility of such an effort for all 91 species. The summaries generally synthesize new information on spatial associations and trophic interactions that are pertinent to the designation of EFH for each of the five designated groundfish groups.

ES-3.4: Modeling Distribution of Seafloor Habitat Types

Since 2005, a significant amount of research and modeling has been conducted regarding biogenic habitat. Habitat surveys have been conducted using sidescan and multibeam sonar, human-occupied submersibles, and remotely operated vehicles (ROVs). Several surveys have documented the interactions between groundfishes, other demersal fishes, invertebrates, and benthic habitats. Of particular importance in the future will be the determination of the distribution and abundance of biogenic species including deep water corals and their role and importance to the groundfish ecosystem.

The EFHRC considered using new modeling applications that could be useful for assessing groundfish habitat suitability. Models can be used to infer distribution of habitats or species in areas that lack data and to increase the precision of distribution maps.

A habitat suitability probability (HSP) model, termed the "EFH Model" (PFMC 2011a), was developed in 2004 by NMFS and outside contractors, and used in the 2008 West Coast Groundfish FMP (MRAG Americas Inc. et al. 2004). The model incorporated three basic variables (seafloor substratum type, depth, and location) to describe and identify EFH for each life stage of federally managed groundfishes and presents this information graphically as an HSP profile (PFMC 2011a). Based on the observed distribution of a groundfish species/life–stage in relation to the input variables, locations along the West Coast were assigned a suitability value between 0 and 100 percent in the creation of the HSP profile. These scores and their differences among locations were used to develop a proxy for the areas that can be regarded as "essential." The EFH Model provided spatially explicit HSP estimates for 160 of 328 groundfish species/life stage combinations, including the adults of all FMU species (PFMC 2011a). The remaining 168 species/life stages were not completed because of insufficient data. In 2005, when the HSPs of all species/life stages were combined, all waters and bottom areas at depths less than 3,500 m were determined to be groundfish EFH.

Ecopath, typically coupled with the dynamic companion model Ecosim, has become the standard for trophodynamic modeling not only off the West Coast but also throughout the world's marine and freshwater regions. Ecopath is a static (typically steady–state) mass balance model of trophic structure that integrates information from diet composition studies, bioenergetics models, fisheries statistics, biomass surveys, and stock–assessments (Field 2004). It represents the initial or reference state of a food web. Ecosim is a dynamic model in which biomass pools and vital rates change through time in response to simulated perturbations. Different species or functional groups are represented in Ecopath as biomass pools with their relative sizes regulated by gains (consumption, production, immigration) and losses (mortality, emigration). Biomass pools are typically linked by predation, though in some cases reproduction and maturation information is also included. Fisheries act as super–predators, removing biomass from the system. The Ecopath model framework allows investigators to evaluate how well conventional wisdom about a system of interest holds when basic bookkeeping tools are applied, to pool together species and into a coherent food web, and to evaluate trophic interactions (Field 2004). The combined model allows users to simulate ecological or management scenarios, such as the response of the system to changes in primary productivity, habitat availability, climate change, or fishing intensity (Harvey et al. 2010).

The primary tool used in integrated ecosystem modeling (especially in Australia and the United States) is the Atlantis Model (Fulton et al. 2004). Although it was originally focused on biophysical and fisheries aspects of an ecosystem, Atlantis has been further developed to consider all parts of marine ecosystems (i.e., biophysical, economic and social). The systematic exploration of the optimum level of model complexity is one of the key strengths of the Atlantis Model. It can be used to identify which aspects of spatial and temporal resolution, functional group aggregation, and representation of ecological processes are vital to model performance. The Atlantis modeling approach primarily has been used to address fisheries management questions, but increasingly is being implemented to consider other facets of marine ecosystem use and function (CSIRO 2011).

ES-3.5: Habitat Use Database

The Habitat Use Database (HUD) was developed byNMFS NWFSC scientists as part of the 2005 Pacific Coast Groundfish Essential Fish Habitat Environmental Impact Statement (EFH EIS) (NMFS 2005). Specifically, the HUD was designed to address the need for habitat-use analysis supporting groundfish EFH, HAPCs, and fishing and non-fishing impacts components of the EFH EIS. The 2005 database captured information on habitat use by groundfishes covered under the FMP as documented in the updated life history descriptions found in Appendix B.2 of the EFH Final EIS, (NMFS 2005). The groundfish life history descriptions are the product of a literature review that collected and organized information on the range, habitat, migrations and movements, reproduction, growth and development, and trophic interactions for each of the FMU species by life stage.

In addition to providing wide public access to the HUD through PaCOOS, the NWFSC also made data updates and amendments, platform changes, and taxonomic additions to the database over the period from 2006 to present. The 2011 HUD now includes species other than FMP species, specifically species identified under Oregon's Nearshore Strategy (Don et al., 2006).

Since 2005, 126 new species from the potential list of 247 species were added to the HUD as new species records (Appendix I-2). Therefore, in summary the taxonomic richness or "scope" of the 2011 HUD grew from 193 to 323 with the addition of the four new species to the groundfish FMP, the four coastal pelagic species, and the 126 Oregon Nearshore Plan species (Appendix I-3; note the loss of four predator species in the 2011 HUD).

ES-4.0: FISHING ACTIVITIES THAT MAY AFFECT EFH

The MSA requires FMCs for each FMP to identify fishing activities that may adversely affect EFH and to minimize adverse effects of those activities to the extent practicable. Fishing activities should include those regulated under the Pacific Coast Groundfish FMP that affect EFH identified under any FMPs, as well as those fishing activities regulated under other FMPs that affect EFH designated under the Pacific Coast Groundfish FMP.

Sections 4.1 and 4.2 document Fishing Effects on EFH by Gear Type and by Habitat Type, respectively.

ES-4.3: Information on Habitat Effects of Fishing Gear

Since 2005, there have been several new publications, including peer-reviewed literature, white papers and technical memorandums, relevant to West Coast groundfish fisheries that have studied: 1) the effects of fishing gear on benthic habitats; 2) predictive modeling of biogenic habitats; and 3) the effects of fishing gear-related marine debris on habitats. An annotated bibliography of recent articles is presented in Appendix J.
The recent studies on the effects of fishing gear on benthic habitats are primarily focused on the effects of trawling and marine debris

ES-4.4: Magnuson Act Fisheries Effects

Figures in Appendix K-1 depict the spatial distribution of commercial bottom trawl effort within two time periods: "Before" (1 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Appendix K-2 depicts similar comparisons for mi-water trawl fisheries and Appendix K-3 depicts similar comparisons for fixed gear fisheries.

ES-4.5: Non-Magnuson Act Fisheries Effects

The EFHRC requested spatial footprints of state-managed bottom contact gear fisheries, for use in the groundfish EFH review. Information was either provided or available on line for the Washington's Dungeness crab and spot prawn fisheries, the Oregon's Dungeness crab, hagfish, and pink shrimp fisheries, and California's California halibut fishery.

ES-5.0: Newly Identified Threats to EFH

The MSA requires FMCs and NMFS to identify non-fishing activities that may adversely affect EFH, as well as actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, mitigate, or otherwise offset the adverse effects. Appendix D to the FMP includes 31 such activities and associated conservation measures, and The EFHRC identified four additional non-fishing activities: alternative energy development, liquefied natural gas projects, desalination, and activities that contribute to climate change and ocean acidification. The report contains sections on potential adverse effects to EFH and potential conservation measures for the newly identified threats.

ES-6.0: PREY SPECIES

The EFH guidance does not explicitly specify criteria for identifying "major" prey species. However, even with clear guidance, identifying which prey items constitute major prey for Pacific Coast groundfishes is highly dependent on the quality and availability of data on diet composition. While some groundfish species have diet composition samples taken over a broad geographic and temporal range, diet analysis for many species has been limited to a single time of year at a single location with a small sample size, and for some groundfish there is no diet data available. This makes broader generalizations about the diet across the range of the species uncertain, even when the studies are aggregated across species. Therefore, even where quantitative data do exist, the EFHRC did not attempt to identify "major" prey or distinguish "major" prey from other prey. For this report, the EFHRC took a general approach and identified prey at broader taxonomic levels, based on a pre-existing literature reviews.

There is not a large body of literature on Pacific groundfish diets since 2006; however significant details on diet composition from the literature were not included in the Amendment 19 documentation. In addition, several groundfish stock assessments were completed in 2009 and 2011, some of which included information on groundfish diet composition.

ES-7: INFORMATION AND RESEARCH NEEDS

The following information and research are recommended in order to improve the designation, monitoring, and effectiveness of groundfish EFH:

1. Recommendations to analyze the new information gathered in the EFHRC groundfish EFH Phase 1 Report, in order to inform decisions to modify the 2006 groundfish EFH regulations.

2. Recommendation to conduct visual, no-take surveys of fishes and habitats inside and outside current EFH closures in order to evaluate the effectiveness of these conservations areas.

3. Recommendation to conduct high-resolution seafloor mapping (bathymetry, back-scatter, and associated interpreted substrata types), particularly on the shelf and slope associated with groundfish EFH conservation areas.

4. Recommendation to improve the Habitat Use Database (HUD):

5. Recommendation to improve our understanding of habitat condition, including adverse effects of fishing gear to EFH, across the geographic range of groundfish,

6. Recommendation to advance our understanding of the affects of a changing climate on West Coast groundfishes.

7. Recommendation to evaluate potential adverse effects from fishing and non-fishing activities on the major prey species in the diets of west coast groundfish.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASHOP	At-Sea Hake Observer Program
ATSML	Active Tectonics and Seafloor Mapping Lab
AUV	autonomous underwater vehicle
BCCA	bottom contact closed area
BTCA	bottom trawl closed area
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CDFG	California Department of Fish and Game
CHS	Center for Habitat Studies
CHTG	California halibut trawl grounds
CPS	coastal pelagic species
CPUC	catch per unit catch (of groundfish)
CPUE	catch per unit effort
CRCP	Coral Reef Conservation Program
CSMP	California Seafloor Mapping Project
CSUMB	California State University Monterey Bay (SFL:) (SML: Seafloor Mapping Lab)
DEM	digital elevation models
DSC	deep-sea coral
DSCRTP	Deep Sea Coral Research and Technology Program
EEZ	exclusive economic zone
EFH	essential fish habitat
EFHRC	Essential Fish Habitat Review Committee
EIS	environmental impact statement
EMF	electromagnetic field
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FMC	Fishery Management Council
FMP	fishery management plan
FMU	fishery management unit
GHG	greenhouse gases
GIS	geographic information system
HAPC	habitat area of particular concern
HSP	habitat suitability probability
HU	hydrologic unit
HUD	Habatat Use Database
IP	intrinsic potential
LEI	long-term effect index
LNG	liquefied natural gas
LWD	large woody debris
MHHW	mean high high water (sea level)
MPA	marine protected area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSF	multi-stage flash (distillation)
mt	metric ton
NCC	Northern California Current
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

NWFSC Northwest Fisheries Science Center (NMFS)
NWR Northwest Region (NMFS)
OCNMS Olympic Coast National Marine Sanctuary
ONMS Office of National Marine Sanctuaries
PaCOOS Pacific Coast Ocean Observing System
PFMC Pacific Fishery Management Council
ppt parts per thousand
PS Puget Sound
PSMFC Pacific States Marine Fisheries Commission
RO reverse osmosis (distillation)
ROV remotely operated vehicle
SAV submerged aquatic vegetation
SCV submerged combustion vaporization
SFMI structure forming marine invertebrates
SGH surficial geologic habitat
SWFSC Southwest Fisheries Science Center (NMFS)
SWR Southwest Region (NMFS)
USGS United States Geological Survey
WCGBTS West Coast groundfish bottom trawl survey
WCGOP West Coast Groundfish Observer Program

1.0 INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 USC 1801 et seq) defines essential fish habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and requires Fishery Management Councils (FMCs) to describe and identify EFH in fishery management plans (FMPs). The FMPs should identify EFH based on current distribution, habitat components, historical presence, or other factors, and should also identify habitat requirements at each life stage and research needs. FMPs must evaluate potential adverse impacts from both fishing and non-fishing activities, as well as minimize adverse effects of fishing to the extent practicable. FMPs should identify habitat areas of particular concern (HAPC) within EFH based on the habitat's ecological function, sensitivity to human-induced disturbance, rarity, or whether development activities may stress a particular habitat. The National Marine Fisheries Service (NMFS) has approval authority for the designations provided by the FMCs.

The Pacific Fishery Management Council (Council) has, in Amendment 19 of the Groundfish FMP (Amendment 19) (PFMC 2008), identified EFH for over 80 species of Pacific Coast groundfish. In estuarine and marine areas, groundfish EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the limits of the exclusive economic zone (EEZ) offshore of Washington, Oregon, and California or to depths of 3,500 m, whichever is nearer shore, plus some seamounts in greater depths HAPC. As recommended by the Council, the Secretary of Commerce (Secretary) designated Pacific Coast groundfish EFH as all waters out to the limit of the EEZ in 1998 (FMP Amendment 11, Appendix B) (64 FR 6597), then made major revisions under Amendment 19 (71 FR 27408; PFMC 2008)).

This Phase 1 report summarizes the results of the review of information that is new or newly available since the last Groundfish EFH Review was concluded in 2006. The report includes a description of the general requirements and elements of EFH, including guidance for periodic reviews; a summary of existing descriptions of EFH for Pacific Coast groundfish; updated maps of seafloor habitat types and bathymetry; the currently available information on the distribution of Pacific Coast groundfish; a summary of models to predict groundfish distribution relative to habitat types, as well as trophic and ecosystem models useful for groundfish EFH; summaries of new information on the life history and habitat requirements of the 91 species in the Pacific Groundfish FMP (Table 1); updated information on threats to groundfish EFH and prey species, both from fishing and non-fishing activities; and identification of research needs to further refine groundfish EFH.

Appendix A lists the people that contributed to this report, including members of the EFHRC, and their affiliations, and a chronology of EFHRC meetings and results.

Table 1. List of groundfish species and stocks managed under the Pacific Coast Groundfish Fishery Management Plan (species added to the FMP since 2005 marked with **).

Flatfishes	**Other rockfishes**
Arrowtooth flounder, *Atheresthes stomias*	Aurora rockfish, *Sebastes aurora*
Dover sole, *Microstomus pacificus*	Bank rockfish, *Sebastes rufus*
English sole, *Parophrys vetulus*	Black-and-yellow rockfish, *Sebastes chrysomelas*
Petrale sole, *Eopsetta jordani*	Blue rockfish, *Sebastes mystinus*
	Bronzespotted rockfish, *Sebastes gilli*
Other flatfishes	Brown rockfish, *Sebastes auriculatus*
Butter sole, *Isopsetta isolepis*	Calico rockfish, *Sebastes dallii*
Curlfin sole, *Pleuronichthys decurrens*	California scorpionfish, *Scorpaena guttata*
Flathead sole, *Hippoglossoides elassodon*	**Chameleon rockfish, *Sebastes phillipsi*
Pacific sanddab, *Citharichthys sordidus*	China rockfish, *Sebastes nebulosus*
Rex sole, *Glyptocephalus zachirus*	Copper rockfish, *Sebastes caurinus*
Rock sole, *Lepidopsetta bilineata*	Dusky rockfish, *Sebastes ciliatus*
Sand sole, *Psettichthys melanostictus*	**Dwarf-red rockfish, *Sebastes rufinanus*
Starry flounder, *Platichthys stellatus*	Flag rockfish, *Sebastes rubrivinctus*
	**Freckled rockfish, *Sebastes lentiginosus*
Rockfishes	Gopher rockfish, *Sebastes carnatus*
Black rockfish, *Sebastes melanops*	Grass rockfish, *Sebastes rastrelliger*
Blackgill rockfish, *Sebastes melanostomus*	Greenblotched rockfish, *Sebastes rosenblatti*
Bocaccio, *Sebastes paucispinis*	Greenspotted rockfish, *Sebastes chlorostictus*
Canary rockfish, *Sebastes pinniger*	Greenstriped rockfish, *Sebastes elongates*
Chilipepper, *Sebastes goodie*	**Halfbanded rockfish, *Sebastes semicinctus*
Cowcod, *Sebastes levis*	Harlequin rockfish, *Sebastes variegatus*
Darkblotched rockfish, *Sebastes crameri*	Honeycomb rockfish, *Sebastes umbrosus*
Longspine thornyhead, *Sebastolobus altivelis*	Kelp rockfish, *Sebastes atrovirens*
Pacific ocean perch, *Sebastes alutus*	Mexican rockfish, *Sebastes macdonaldi*
Shortbelly rockfish, *Sebastes jordani*	Olive rockfish, *Sebastes serranoides*
Shortspine thornyhead, *Sebastolobus alascanus*	Pink rockfish, *Sebastes eos*
Splitnose rockfish, *Sebastes diploproa*	**Pinkrose rockfish, *Sebastes simulator*
Widow rockfish *Sebastes entomelas*	**Puget Sound rockfish, *Sebastes emphaeus*
Yelloweye rockfish, *Sebastes ruberrimus*	**Pygmy rockfish, *Sebastes wilsoni*
Yellowtail rockfish, *Sebastes flavidus*	Quillback rockfish, *Sebastes maliger*
	Redbanded rockfish, *Sebastes babcocki*
Other groundfishes	Redstripe rockfish, *Sebastes proriger*
Cabezon, *Scorpaenichthys marmoratus*	Rosethorn rockfish, *Sebastes helvomaculatus*
Lingcod, *Ophiodon elongatus*	Rosy rockfish, *Sebastes rosaceus*
Pacific cod, *Gadus macrocephalus*	Rougheye rockfish, *Sebastes aleutianus*
Pacific hake, *Merluccius productus*	**Semaphore rockfish, *Sebastes melanosema*
Sablefish, *Anoplopoma fimbria*	Sharpchin rockfish, *Sebastes zacentrus*
Big skate, *Raja binoculata*	Shortraker rockfish, *Sebastes borealis*
California skate, *Raja inornata*	Silvergray rockfish, *Sebastes brevispinis*
Kelp greenling, *Hexagrammos decagrammus*	Speckled rockfish, *Sebastes ovalis*
Leopard shark, *Triakis semifasciata*	Squarespot rockfish, *Sebastes hopkinsi*
Longnose skate, *Raja rhina*	Starry rockfish, *Sebastes constellatus*
Pacific flatnose, *Antimora microlepis*	Stripetail rockfish, *Sebastes saxicola*
Pacific grenadier, *Coryphaenoides acrolepis*	**Swordspine rockfish, *Sebastes ensifer*
Spiny dogfish, *Squalus acanthias*	Tiger rockfish, *Sebastes nigrocinctus*
Spotted ratfish, *Hydrolagus colliei*	Treefish, *Sebastes serriceps*
Tope, *Galeorhinus galeus*	Vermilion rockfish, *Sebastes miniatus*
	Yellowmouth rockfish, *Sebastes reedi*

1.1 Essential Fish Habitat Consultation

Federal agencies must consult with NMFS on activities that may adversely affect EFH, regardless of whether or not those activities occur within designated EFH. In other words, an activity can adversely affect EFH without occurring within EFH. An adverse effect means any impact that reduces either the quantity or quality of EFH (50 CFR 600.810). For those activities that would adversely affect EFH, NMFS then provides EFH conservation recommendations to the Federal agency to avoid, minimize, or offset those adverse effects. The Federal agency must respond to NMFS within 30 days of receiving EFH conservation recommendations, including a description of measures proposed for avoiding, mitigating, or offsetting the impact to EFH. For responses that are inconsistent with the EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects. Fishery Management Councils may also comment on proposed actions that may adversely affect EFH of a fishery resource curently withing an FMP. Although state agencies are not required to consult with NMFS on activities that may adversely affect EFH, NMFS is obligated to provide conservation recommendations to state agencies if NMFS receives information that an activity will adversely affect EFH. Whenever possible, NMFS utilizes existing coordination procedures to transmit EFH conservation recommendations.

The designations and detailed descriptions of EFH in the FMPs are used during the EFH consultation process to determine where and for what species EFH has been designated in the project area. The analyses of the adverse effects from the proposed action, and potential conservation measures that avoid, minimize, or offset those effects, are informed by the information contained in the FMP.

1.2 Essential Fish Habitat Periodic Reviews

The regulatory guidelines for implementing the EFH provisions of the MSA state that Regional FMCs and NMFS should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted, based on available information (50 CFR 600.815(a)(10)). This review included evaluating published scientific literature and unpublished reports, soliciting input from interested parties, and searching for previously unavailable information on groundfish stocks identified in the FMP. The Council may provide suggested changes to existing EFH to NMFS for their approval, if the information warrants changes. The regulatory guidance provides that a complete review should be conducted periodically, but at least once every five years. Pacific Coast groundfish EFH was first designated in 1998 by the Council as part of Amendment 11 to the Pacific Coast Groundfish FMP. The current review was initiated in 2010.

Since EFH for Pacific Coast groundfish was first designated, NMFS has taken steps to clarify the process for designating and refining EFH. In 2002, NMFS published final rules to implement the EFH provisions of the MSA (50 CFR Part 600), and, in 2006, issued a memo providing additional guidance to refine the description and identification of EFH (NMFS 2006). The 5-year review presented was guided by these two clarifying documents.

The primary purpose of an EFH review is to examine new or newly available information, especially as it relates to the information that was used as the basis for the current EFH designations. The review should focus on the components of EFH identified in the regulatory guidance (50 CFR 600.815):

(1) EFH description and identification
(2) MSA fishing activities
(3) Non-MSA fishing activities
(4) Non-fishing activities
(5) Cumulative impacts analysis
(6) Conservation and enhancement
(7) Identification of major prey species
(8) Identification of HAPCs
(9) Research and information needs

The periodic review provides FMCs and NMFS with the information that may lead to improvements in the identification and description of EFH. For this review, the Council has adopted a phased approach, in which the first phase consists of issuing a data call and compiling new and newly available information, then, when possible, comparing it with the suite of information that was available at the previous review. The second phase considers potential changes to EFH, based on the new information produced in the

Phase 1, and presents those to the Council. In Phase 2, the Council may issue a request for proposals (RFP) to all interested parties for changes to the identification and description of EFH that are based on the information in the Phase 1 report. If the Council determines that changes to EFH identification and descriptions are necessary, it then proceeds with a third phase that utilizes the appropriate management tool to revise EFH.

1.3 Methods/Approach

The NWFSC and SWFSC received funding from the NMFS Office of Habitat Conservation to support two part-time researchers through NOAA cooperative institutes. These contractors assisted NMFS in identifying, gathering, summarizing, reporting, and serving data that are relevant to the 5-year review of Pacific Coast groundfish EFH. This included data that were identified in response to a NMFS data request issued in February 2011. These researchers, along with NMFS researchers and the EFHRC identified and summarized new and updated information on:

- the distribution and extent of seafloor maps of bathymetry and interpreted Pacific Coast groundfish habitat types;
- the distribution and extent of groundfish fishing effort;
- the distribution of biogenic habitat;
- spatial management boundaries;
- prey species for groundfish; and
- associations of groundfish with habitats of different types.

In addition to the contractors, NMFS researchers, and members of the EFHRC, significant contributions to Phase 1 of the review were received from the Deep Sea Coral Status Report and the NOAA-led effort for Integrated Ecosystem Assessment of the California Current. The NWFSC and SWFSC, in collaboration with the NMFS Regions and the Council's EFHRC, provided assistance and direction in accomplishing the overall task of identifying and summarizing new and updated information and data relevant to the 5-year review of Pacific Coast groundfish EFH.

A schedule to complete Phase 1 of the groundfish EFH review, while subject to modification as necessary, was approved by the Council at its April 2012 meeting (Table 2).

Table 2. Working schedule for Phase 1 of the Pacific Council groundfish EFH review.

Timing/Due Date	**Action**
April 2011	Council approves the process, and solicits for information and data (deadline: July 1, 2011)
Summer 2011	NMFS Science Center (or contractor) compiles and synthesizes data and information, initiates review. EFHRC starts reviewing interim products
Dec 31, 2011	NMFS Science Center (or contractor) product due
April, 2012	EFHRC provides progress update to Council
Jan-August 2012	EFHRC drafts report summarizing new data and information; including how it compares with existing information, maps, etc.
September 2012	Council adopts interim report and consideres revised RFP
Sept 2012-Mar 2013	NMFS NWFSC synthesizes information in Phase 1 Report
April 2013	NMFS NWFSC presents synthesis report to Council; Council decides whether or not to issue an RFP for any changes to existing GF EFH, HAPCs, etc. (END PHASE I)

1.3.1 Phase 1

Phase 1 of the groundfish EFH review is intended primarily to inform the Council of significant changes in knowledge since the last EFH review was completed in 2006. Phase 1 was not intended to develop alternatives to groundfish EFH for Council consideration. Some issues to consider when evaluating new information used to support existing EFH designations include changes in the number of species in the

Groundfish FMP, fishery status of the species (e.g., overfished or rebuilt), and errors to current EFH descriptions or identifications. While Phase 1 will not include a comprehensive analysis of data to develop alternatives, examples of applications of new information are provided to demonstrate their utility, inform development of proposals, and set priorities for modification of EFH components.

1.3.2 Phase 2

The Council may solicit proposals to modify EFH components, based on the new and newly available information presented to the Council, its advisory bodies, and the public during Phase 1. The EFHRC will review these proposals and may generate additional proposals if it determines that 1) submitted proposals do not address obvious candidates for changes to EFH, and 2) if the available information warrants it. The EFHRC will prepare a Phase 2 report for presentation to the Council at the November 2013 meeting. The Council will consider the report, public comment, and advisory body recommendations, and decide whether new information warrants changes to groundfish EFH. The EFH periodic review is effectively concluded when the Council accepts the Phase 2 report from the EFHRC. Should the Council recommend changes to existing EFH identification or descriptions, it will determine an appropriate process (e.g., FMP amendment, management measure specifications, SAFE Report, etc.) for further analysis and consideration of proposals

1.3.3 Phase 3

If the Council decides to adopt changes to groundfish EFH, Phase 3 of this review will include a process to identify relevant issues, develop and analyze alternatives in a NEPA document, and take final action to amend the Groundfish FMP. Identification of relevant issues will be based largely on the Phase 1 EFH Review and subsequent Phase 2 proposals. Selection of alternatives will be based on Phase 2 proposals and additional input from agencies, advisory bodies, and the public. Analysis of alternatives may use information from Phase 1 and 2, but will also include more specific and detailed analysis of biological, economic, and cumulative effects.

2.0 CURRENT DESIGNATIONS FOR PACIFIC COAST GROUNDFISH EFH, HAPC, AND ECOLOGICALLY IMPORTANT HABITAT CLOSED AREAS

This section summarizes existing EFH for Pacific Coast Groundfish contained in Amendment 19 (NMFS 2005; PFMC 2008) and the 2006 Final Rule (71 FR 27408). Amendment 19 provided descriptions of EFH for each species and life stage that were developed through an extensive review and synthesis of the literature available in 2005 (PFMC 2008). Appendix B provided a review of life history for each species, text descriptions, and tables that summarize, for each species, the habitats used by each life history stage and the important features of those habitats.

2.1 Description and identification of EFH for Pacific Coast Groundfish

The Pacific Coast Groundfish FMP manages 90-plus species over a large and ecologically diverse area. Information on the life histories and habitats of these species varies in completeness, so while some species are well-studied, there is relatively little information on certain other species. Information about the habitats and life histories of the species managed by the FMP will certainly change over time, with varying degrees of improvement in information for each species. For these reasons, it was impractical for the Council to include descriptions identifying EFH for each life stage of the managed species in the body of Amendment 19. Therefore, the FMP included a description of the overall area identified as groundfish EFH and described the assessment methodology supporting this designation. Life histories and EFH identifications for each of the individual species are provided in Appendix B to Amendment 19.

The overall extent of groundfish EFH for all FMU species (Figure 1) is identified as all waters and substrate within the following areas:

- Depths less than or equal to 3,500 m (1,914 fathoms) to mean higher high water level (MHHW) or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow.
- Seamounts in depths greater than 3,500 m as mapped in the EFH assessment GIS.
- Areas designated as HAPCs not already identified by the above criteria.

This EFH identification was precautionary because it was based on the then-known maximum depth distribution of all life stages of FMU species (50 CFR 600.815(a)(1)(B)).. This precautionary approach was taken because uncertainty existed about the relative value of different habitats to individual groundfish species/life stages, and thus the actual extent of groundfish EFH. This approach incorporated all areas for which the habitat suitability probability (HSP) values were greater than 0% for any species or life stage. The HSP model characterizes habitat in terms of three variables: depth, latitude, and substrate (both physical and biogenic substrate, where possible). For the purposes of the model, these three characteristics provide a reasonable representation of the essential features of habitat that influence the occurrence of fish.

Depending on these characteristics and the observed distributions of fish in relation to them, each location (a parcel or polygon of habitat in the GIS) is assigned a suitability value between zero and 100 percent. The higher the HSP, the more likely the habitat is suitable for the habitat needs of a given groundfish species (see Amendment 19 for a more detailed discussion of the HSP model).

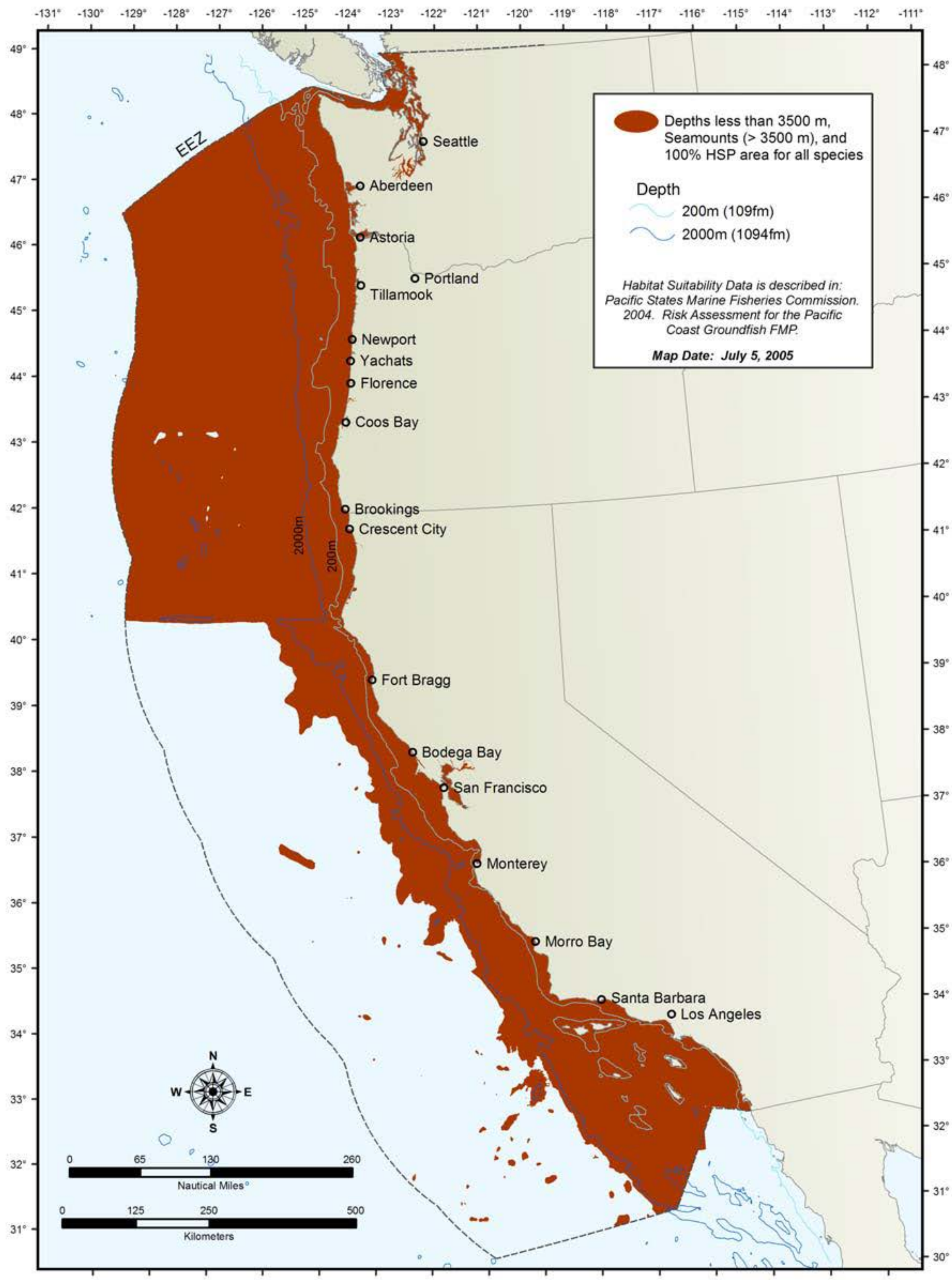

Figure 1. Current essential fish habitat description for the Pacific Coast groundfish.

2.1.1 Habitat Areas of Particular Concern

According to the regulations that implement the EFH provisions of the MSA, FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations (50 CFR 600.815(a)(8)):

- The importance of the ecological function provided by the habitat.
- The extent to which the habitat is sensitive to human-induced environmental degradation.
- Whether, and to what extent, development activities are or will be stressing the habitat type.
- The rarity of the habitat type.

Based on these considerations, the Council designated both areas and habitat types as groundfish HAPCs. In some cases, HAPCs identified by means of specific habitat type may overlap with the designation of a specific area. The HAPC designation covers the net area identified by habitat type or area. Designating HAPCs facilitates the consultation process by identifying ecologically important, sensitive, stressed or rare habitats that should be given particular attention when considering potential fishing and nonfishing impacts. Their identification is a valuable tool the Council can use to address these impacts.

HAPCs based on habitat type may vary in location and extent over time. For this reason, the mapped extent of these areas offers only a first approximation of their location. Defining criteria of habitat-type HAPCs are described below, which may be applied in specific circumstances to determine whether a given area is designated as a groundfish HAPC. HAPCs include all waters, substrates, and associated biological communities falling within the area defined by the criteria below.

Figure 2 shows the location of these HAPCs. For HAPCs defined by habitat type, as opposed to discrete areas, this map offers a first approximation of their location and extent. The precision of the underlying data used to create these maps, and the fact that the extent of HAPCs defined by key benthic organisms (canopy kelp, seagrass) can change along with changes in the distribution of these organisms, means that at fine scales the map may not accurately represent their location and extent. Defining criteria are provided in the following descriptions of HAPCs, which can be used in conjunction with the map to determine if a specific location is within one of these HAPCs. The areas of interest HAPCs are defined by discrete boundaries. The coordinates defining these boundaries are listed in Appendix B to the groundfish FMP (PFMC 2011a). Figure 2 shows the location and extent of the HAPC described below. See Amendment 19 for a more detailed description of these HAPCs.

2.1.1.1 Estuaries

Estuaries are protected nearshore areas such as bays, sounds, inlets, and river mouths, influenced by ocean and freshwater. Because of tidal cycles and freshwater runoff, salinity varies within estuaries and results in great diversity, offering freshwater, brackish and marine habitats within close proximity (Haertel and Osterberg 1967). Estuaries tend to be shallow, protected, nutrient rich, and are biologically productive, providing important habitat for marine organisms, including groundfish.

Defining Characteristics

The inland extent of the estuary HAPC is defined as MHHW, or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow. The seaward extent is an imaginary line closing the mouth of a river, bay, or sound; and to the seaward limit of wetland emergents, shrubs, or trees occurring beyond the lines closing rivers, bays, or sounds. This HAPC also includes those estuary-influenced offshore areas of continuously diluted seawater. This definition is based on Cowardin, et al. (1979).

2.1.1.2 Canopy Kelp

Of the habitats associated with the rocky substrate on the continental shelf, kelp forests are of primary importance to the ecosystem and serve as important groundfish habitat. Kelp forest communities are found relatively close to shore along the open coast or the shore if ishland and inland seas. These subtidal communities provide vertically-structured habitat throughout the water column: a canopy of tangled blades from the surface to a depth of ten feet, a mid-water, stipe region, and the holdfast region at the seafloor. Kelp stands provide nurseries, feeding grounds, and shelter to a variety of groundfish species and their prey (Ebeling, *et al.* 1980; Feder, *et al.* 1974). Kelp forest communities are highly productive relative to other habitats, including wetlands, shallow and deep sand bottoms, and rock-bottom artificial reefs (Bond, *et al.* 1998). Their net primary production is an important component to the energy flow within food webs. Foster and Schiel (1985) reported that the net primary productivity of kelp beds may be the highest of any marine community. The net primary production of seaweeds in a kelp forest is available to consumers as living tissue on attached plants, as drift in the form of whole plants or detached pieces, and as dissolved organic matter exuded by attached and drifting plants (Foster and Schiel 1985).

Defining Characteristics
The canopy kelp HAPC includes those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species (e.g., *Macrocystis* spp. and *Nereocystis* spp.).

2.1.1.3 Seagrass

Seagrass species found on the West Coast of the U.S. include eelgrass species (*Zostera* spp.), widgeongrass (*Ruppia maritima*), and surfgrass (*Phyllospadix* spp.). These grasses are vascular plants, not seaweeds, forming dense beds of leafy shoots year-round in the lower intertidal and subtidal areas. Eelgrass is found on soft-bottom substrates in intertidal and shallow subtidal areas of estuaries and occasionally in other nearshore areas, such as the Channel Islands and Santa Barbara littoral. Surfgrass is found on hard-bottom substrates along higher energy coasts. Studies have shown seagrass beds to be among the areas of highest primary productivity in the world (Herke and Rogers 1993; Hoss and Thayer 1993).

Defining Characteristics
The seagrass HAPC includes those waters, substrate, and other biogenic features associated with eelgrass species (*Zostera* spp.), widgeongrass (*Ruppia maritima*), or surfgrass (*Phyllospadix* spp.). [1]

2.1.1.4 Rocky Reefs

Rocky habitats are generally categorized as either nearshore or offshore in reference to the proximity of the habitat to the coastline. Rocky habitat may be composed of bedrock, boulders, or smaller rocks, such as cobble and gravel. Hard substrates are one of the least abundant benthic habitats, yet they are among the most important habitats for groundfish.

Defining Characteristics
The rocky reefs HAPC includes those waters, substrates and other biogenic features associated with hard substrate (bedrock, boulders, cobble, gravel, etc.) to MHHW. A first approximation of its extent is provided by the substrate data in the groundfish EFH assessment GIS. However, at finer scales, through

[1] The extent and effect of non-native species in seagrass HAPC, such as *Zostera japonica*, may be considered in conservation recommendations NMFS makes to other Federal and state agencies.

direct observation, it may be possible to further distinguish between hard and soft substrate in order to define the extent of this HAPC.

2.1.1.5 Areas of Interest

Areas of interest are discrete areas that are of special interest due to their unique geological and ecological characteristics. The following areas of interest are designated HAPCs (see Amendment 19 for a more detailed description of these areas of interest):

- Off of Washington: All waters and sea bottom in state waters shoreward from the three nautical mile boundary of the territorial sea shoreward to MHHW.
- Off of Oregon: Daisy Bank/Nelson Island, Thompson Seamount, President Jackson Seamount.
- Off of California: all seamounts, including Gumdrop Seamount, Pioneer Seamount, Guide Seamount, Taney Seamount, Davidson Seamount, and San Juan Seamount; Mendocino Ridge; Cordell Bank; Monterey Canyon; specific areas in the Federal waters of the Channel Island National Marine Sanctuary; specific areas of the Cowcod Conservation Area.

Defining Characteristics

As noted above, the shoreward boundary of the Washington State waters HAPC is defined by MHHW while the seaward boundary is the extent of the three-mile territorial sea. The remaining area-based HAPCs are defined by their mapped boundaries in the EFH assessment Environmental Impact Statement (EIS) (NMFS 2005). The coordinates defining these boundaries may be found in Appendix B to the FMP.

2.1.2 Ecologically Important Habitat Areas

Amendment 19 identified discrete areas that are closed to fishing with specified gear types, or are only open to fishing with specified gear types; however, these areas were not designated as HAPCs. These ecologically important habitat closed areas are intended tominimize the adverse effects of fishing on groundfish EFH. They may be categorized as bottom trawl closed areas (BTCAs) and bottom contact closed areas (BCCAs) (Figure 3). For the purpose of regulation each type of closed area should be treated differently. For the purposes of BTCAs, the definition of bottom trawl gear in Federal regulations applies (PFMC 2011a). For the purposes of BCCAs, the definition of bottom contact gear in the FMP (PFMC 2011a) and in Federal regulations applies.

The extent and configuration of these areas do not vary seasonally and they are not usually modified through in season or biennial management actions. The location and extent of these areas are described by a series of latitude-longitude coordinates enclosing a polygon published in permanent Federal regulations (May 11, 2006, 71 FR 27408). There are 51 such closures, described in Chapter 4 Minimizing Effects.

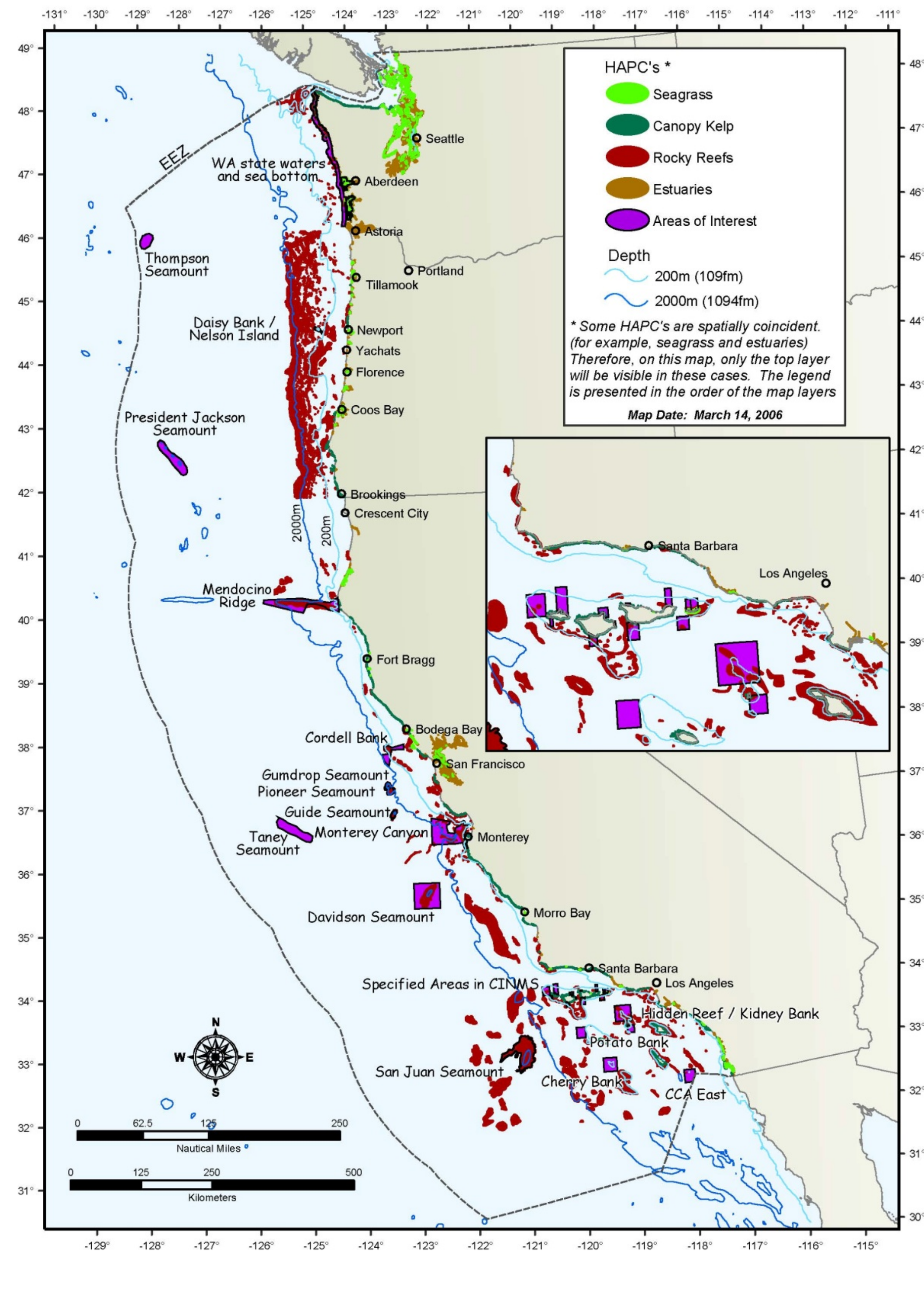

Figure 2. Groundfish HAPC.

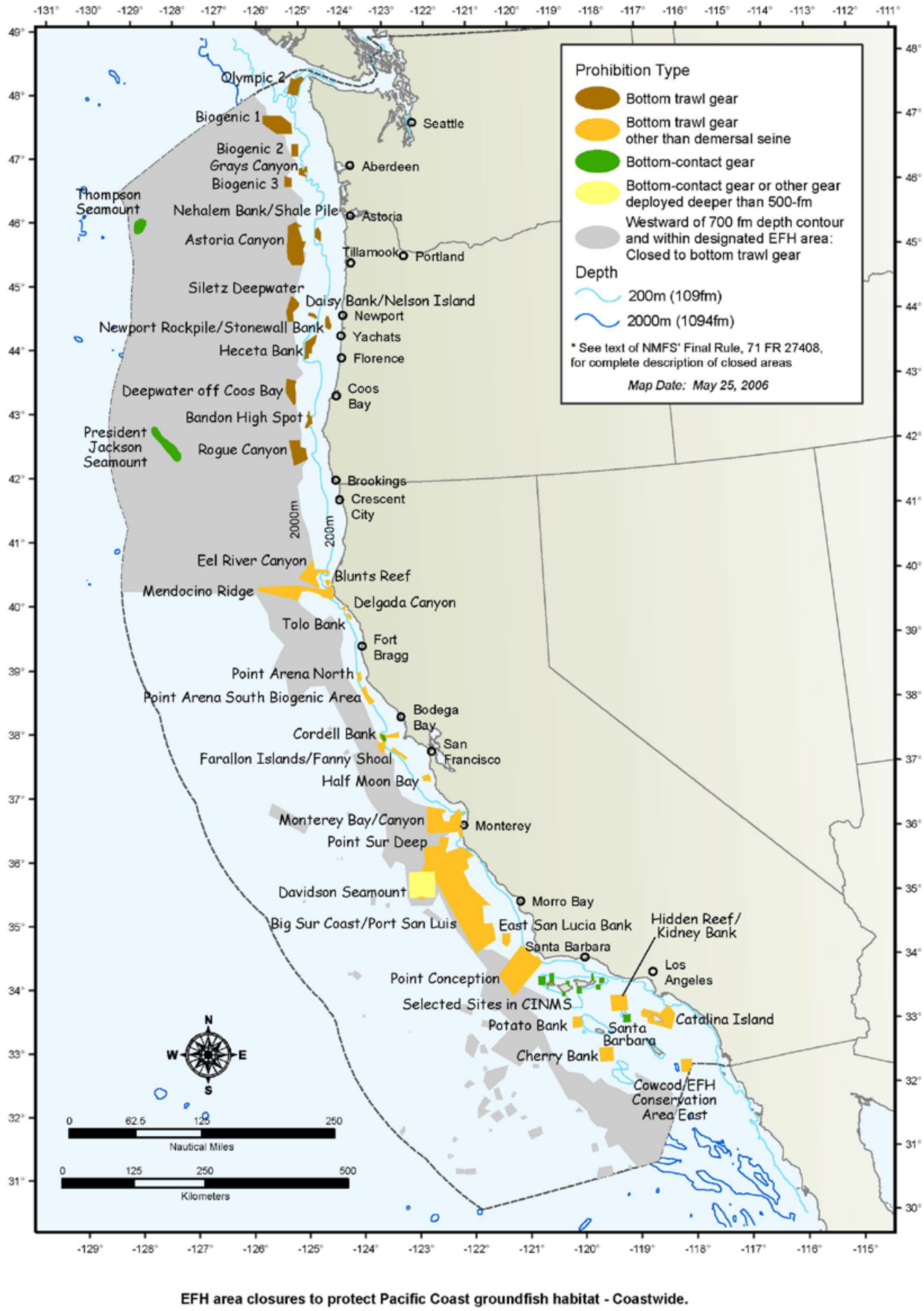

Figure 3. Ecologically important habitat closed areas.

3.0 REVIEW OF NEW INFORMATION ON GROUNDFISH ESSENTIAL FISH HABITAT

The primary purpose of an EFH review is to examine new or newly-available information, especially as it relates to the information that was used as the basis for the original EFH designation. A means to organize and report on this information is provided in the EFH regulatory guidance, which suggests describing EFH for each species based on the highest of four levels of data (50 CFR 600.815(a)(1)(B)). These levels are:

Level 1:Distribution data are available for some or all portions of the geographic range of the species. At this level, only distribution data are available to describe the geographic range of a species (or life stage).

Level 2:Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage.

Level 3:Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life stage.

Level 4:Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, and location.

The available data on the habitat of Pacific Coast groundfishes includes data from all four levels. The 91 species in the Pacific Coast groundfish FMP are distributed over a wide geographic range, with populations adapted to local habitat conditions that can vary widely across this range. Current distribution data (Level 1) is generally available across the entire geographic range. However, data on historical distribution are lacking in certain parts of the range for some species, and particularly in areas where populations have been extirpated. Information related to the other EFH levels, on the other hand, is usually limited to smaller geographic areas. Habitat-specific information from one location does not necessarily apply across the entire range. Therefore, it is appropriate to determine the geographic distribution of EFH for Pacific Coast groundfish using Level 1 information, and incorporate information from the other levels, when possible, in the species- and life-stage-specific descriptions of EFH.

Section 3 presents new information on habitats that has become available since the EFH designation in 2006 for the 91 species of Pacific coast groundfishes. There are five sub-sections, each accompanied by comprehensive Appendices. Section 3.1 summarizes an inventory of responses to the NMFS data call. Section 3.2 describes (in both text and maps) new information on the distribution of seafloor habitat types, including data on bathymetry, physical habitat interpretations, and biogenic components of habitat. Section 3.3 includes summaries, and associated citations, of recent information related to habitats for each life-history stage of the five species groups designated in the FMP for Pacific Coast groundfishes (i.e., flatfishes, other flatfishes, rockfishes, other rockfishes, and other groundfishes). Section 3.4 is a review of new modeling efforts relevant to the determination and designation of EHF for Pacific groundfishes, and Section 3.5 is an update on the Habitat Use Database (HUD).

3.1 Inventory of Responses to NMFS Data Call

To initiate Phase I of the Council's 5-year review of Pacific Coast groundfish EFH, NMFS Science Centers and Regions issued a data call to interested parties, soliciting habitat information that has become available since the EFH designation in 2006 for the FMU species. Information was requested on data type, source, time frame, spatial and temporal scale, metric, format, point of contact, and key references. This data call was posted on NMFS websites (NWFSC, SWFSC, NWR, and SWR) and in the Fishnews Digest, as well as distributed to researchers, managers, and conservation entities through email lists associated with the Western Groundfish Conference (over 60 people) and the West Coast Governors Agreement (over 850 people); the call was open from March through November 2011.

Thirty-nine sources of data relevant to groundfish EFH that had become available since 2006 were received through the NMFS data call (see Appendix B for details on each item). All of these data can be used to revise the descriptions of EFH and HAPC or to evaluate risk to EFH. Information associated with the NMFS data call comprised four general categories:

4. Four sources of new information on the distribution and extent of seafloor maps, seafloor data, and interpreted Pacific Coast groundfish habitat types were received.
5. Eight sources of new and updated fishery-independent data were received on groundfish species and associated components of habitat.
6. Twenty sources of new and updated information or data were received on the distribution of habitats, including two coast-wide oceanographic datasets, 12 surveys of deepwater, structure-forming invertebrates, two models of deep coral distributions, an assessment of 146 West Coast estuaries, an online data library and maps of California, and two visual surveys of fish and habitats.
7. Seven sources of new and updated information were received on existing and emerging threats to Pacific Coast groundfish EFH. These included five fishery-dependent datasets and two sources of information on non-fishery threats.

3.2 Bathymetry and Seafloor Habitat Maps

Pacific coast-wide comparative maps of bathymetry (i.e., seafloor imagery) and seafloor habitat types in 2005 and 2011 were compiled for the EEZ off Washington, Oregon and California from all available sources. Seafloor imagery consisted of gridded bathymetry data sets (Digital Elevation Models or DEMs), and backscatter imagery. Contour data, either interpolated or derived from DEMs, were not included. For reference purposes, any available sidescan sonar data were grouped with backscatter imagery. Seafloor habitat data consisted of automated habitat (i.e., substrate) classification data or geologic habitat interpretations, either represented in raster (i.e., grids) or vector (i.e., polygon shapefiles) format. Although the initial EFH map products were published in 2005, input data for those products was incorporated through mid-2002. Therefore, the current data search encompassed the years 2002-2011 and reference to 2005 maps implies that these maps contain data produced during or prior to 2002.

In addition to bathymetry, both sidescan sonar imagery and multibeam sonar backscatter imagery data types are included in the section 3.2 comparison maps. Sidescan sonar and multibeam backscatter are tools that measure the intensity of acoustic energy returned from an ensonified seafloor and are useful for understanding the distribution and abundance of seafloor habitats. Mapped variations in returned energy (backscatter images) may correlate to or result from variations in local seabed geology and are often used together with bathymetry imagery to determine seabed habitat type.

The map products displayed in this report were intended to provide a coast-wide overview of available data, and the methods chosen for display were designed to illustrate the range of values on that scale. There are other methods for displaying the same data that may provide alternative interpretations of temporal or spatial differences depending on such factors as geographic scale, value bins, or display algorithms. A data portal is available to allow access to maps and data from this report so that interested parties can manipulate data for specific purposes: http://efh-catalog.coas.oregonstate.edu/overview/.

3.2.1 Bathymetry and Substrate Maps

A set of 24 comparison map panels layouts (hereafter termed "plates") were constructed at a scale of 1:500,000 and encompassed the EEZ of the southern U.S. Pacific Coast. Each plate presents a geographic comparison of project components (Imagery; Appendix C-1, and Habitat; Appendix C-2) over three time intervals: Pre 2005, 2005-2011, and Aggregate 2011 (combined overlay of Pre 2005 and 2005-2011 data).

Note that plates are meant to be printed at full size (44” wide by 60” tall). Shrinking a plate to fit on an 8.5” by 11” letter size page will change the map scale to approximately 1:2,588,235. It will also result in a loss of resolution due to resampling and printing limitations. See Appendices C-1 and C-2 for a compendium of the plates.

Two additional plates were constructed to depict regional and spatially contiguous (but lower resolution) bathymetry data that are currently available for the northwest region off Oregon and Washington, and for offshore California (Figures 4 and 5; Appendix C-3). These data were not included as part of the plates (above) because they do not include all sources of new bathymetry identified through this review. Instead, they represent the best available spatially continuous product. The maps are presented at 1:1,000,000 (Oregon and Washington) and 1:1,300,000 (California) to show the contrast between the official 2005 bathymetry contour map and a true regional grid file available now.

A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently in available online at: http://efh-catalog.coas.oregonstate.edu/overview/.

Seafloor imagery and habitat types were color-coded so that the composition of the available data associated with each survey region could be easily distinguished. Survey regions were divided into three categories, those that contained only bathymetry data (blue), those that contained bathymetry and backscatter data (green), and those that contained only backscatter data (grey) (e.g., Figure 6). Habitat types were distinguished as probable soft sediment (yellow), probable rock (red), or a mixture of soft sediment and rock (brown) (e.g., Figure 7). Given that this effort compiled habitat maps from a variety of sources, it is essential to understand that mapping methods varied widely among sources and that it was our task to display the sources under some common scheme.

A special habitat type case exists for Oregon and Washington. During the 2002 mapping effort, seafloor below 150m water depth and of 10 degrees slope or greater were mapped as rock outcrop (red). This mapping was made based upon expert observation that steep slopes in this region do not hold unconsolidated sediments well and are often rocky. To call attention to the facts that: 1) similar mapping was not done for California, 2) the mapping technique only infers rock outcrop through a simple >10 degrees of slope angle rule, and 3) the rule when applied classifies a large quantity of seafloor as rocky, this habitat type was mapped as “Inferred Rock” using a light red color. The extent of inferred rock in the current pre-2005 map plates is identical to that depicted in the 2002 West Coast Oregon and Washington substrate map; however, it is colored differently in the current pre-2005 map plates so that it may be distinguished from rock that was determined based on geologic interpretations or more rigorous automated classification techniques (Figure 7).

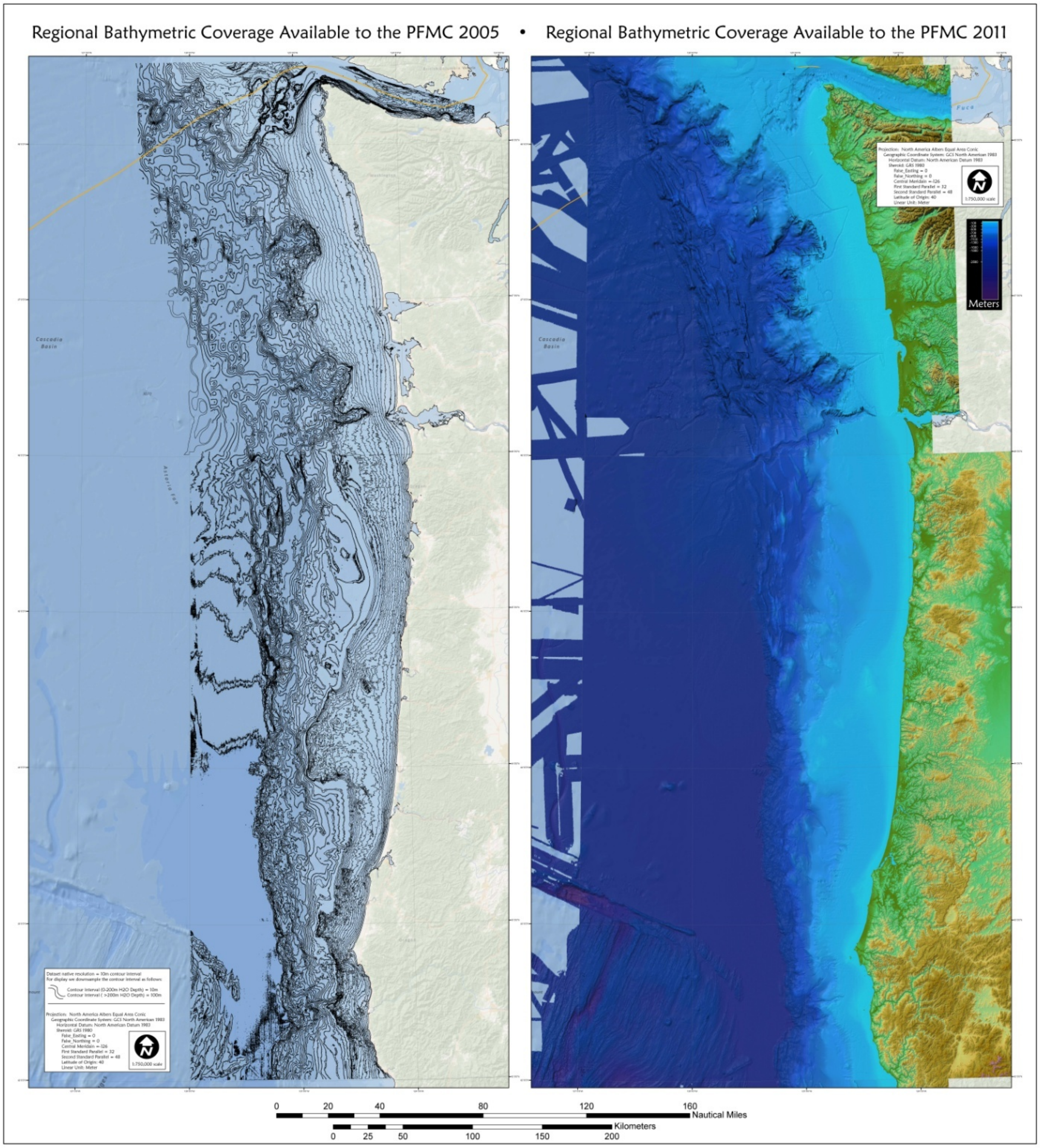

Figure 4. Washington and Oregon regional bathemetry pre-2005 and post 2005; from Appendix C-3.

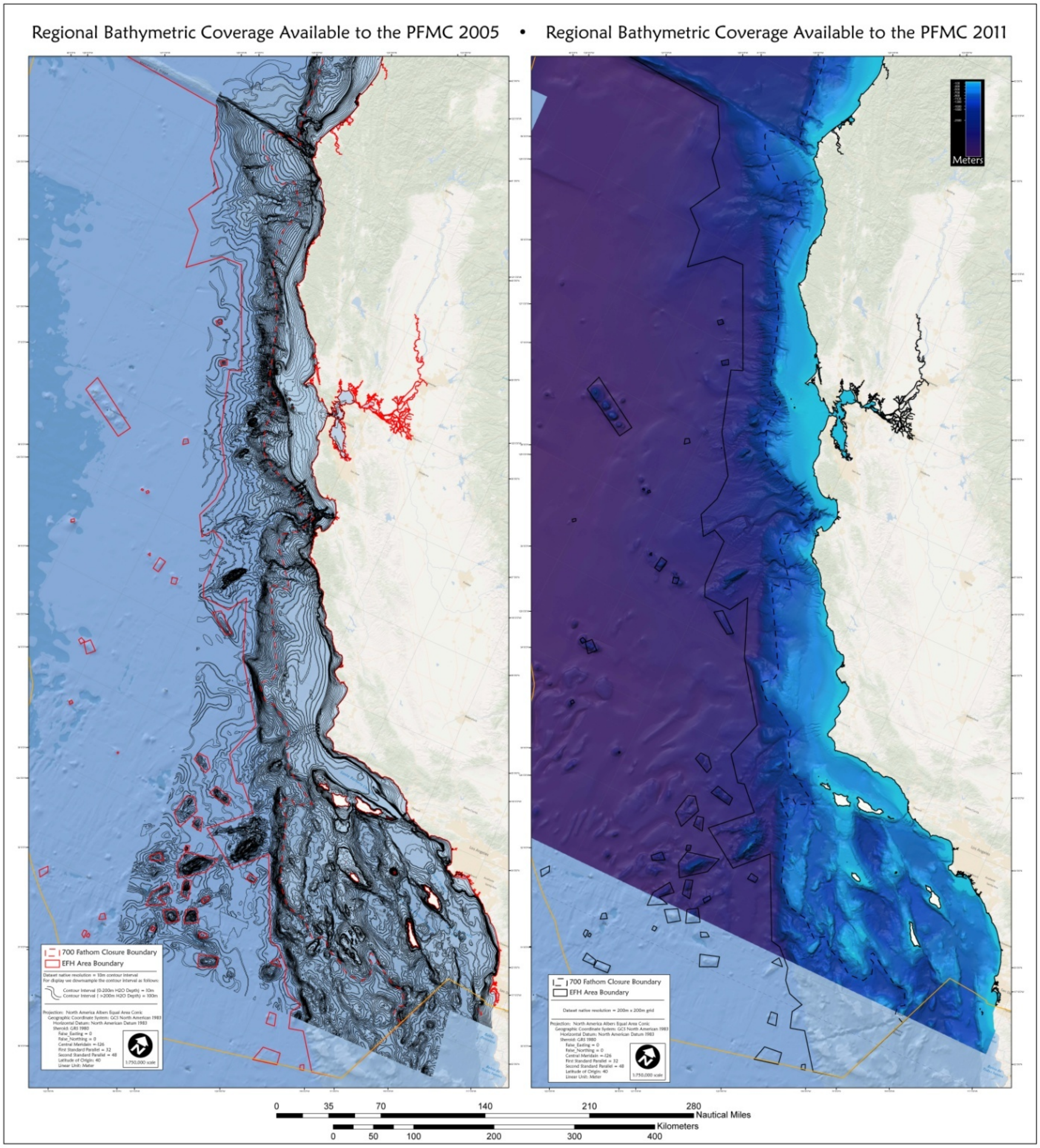

Figure 5. California regional bathemetry pre-2005 and post 2005; from Appendix C-3.

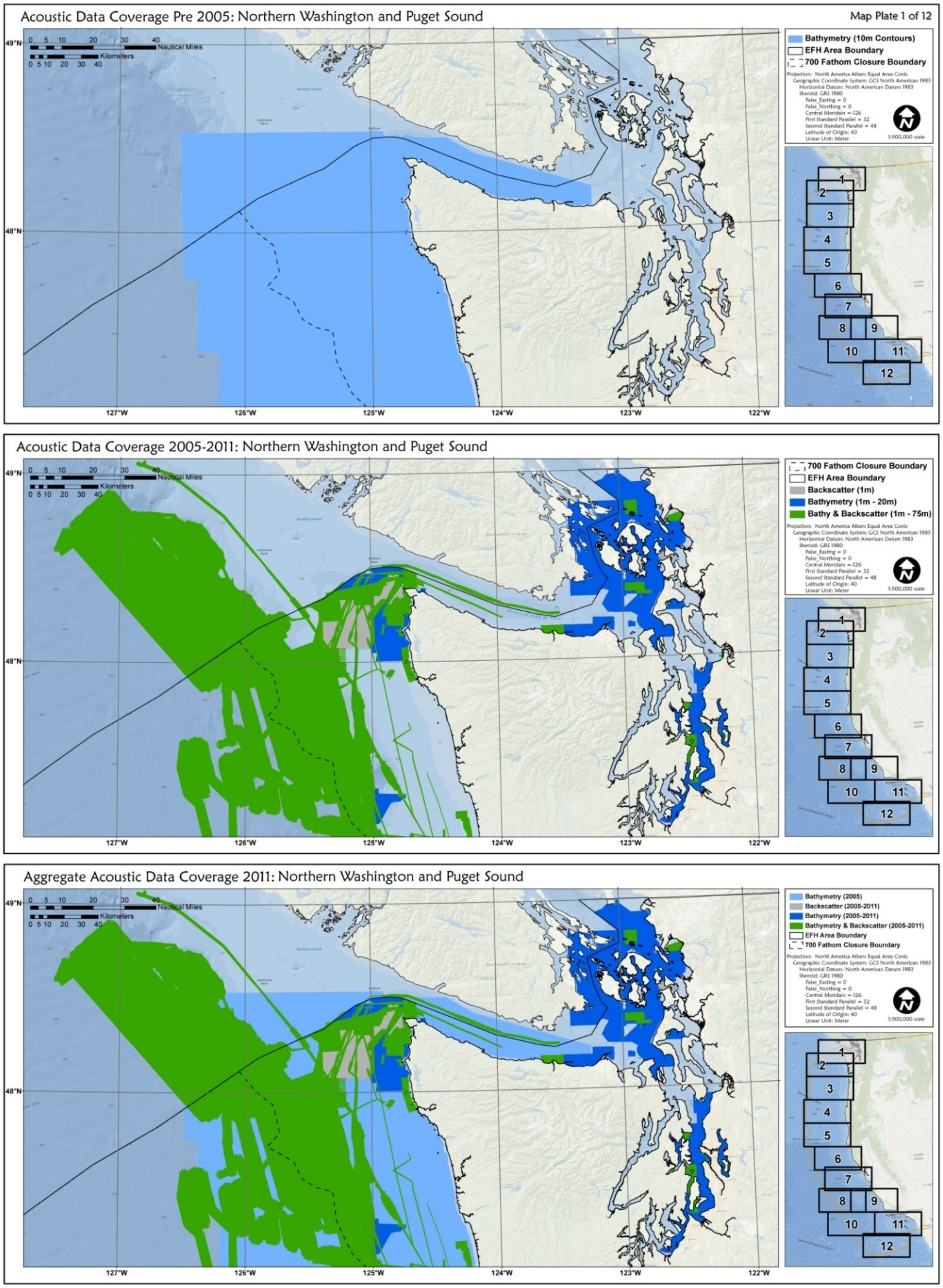

Figure 6. Example of imagry plate From Appendix C-1.

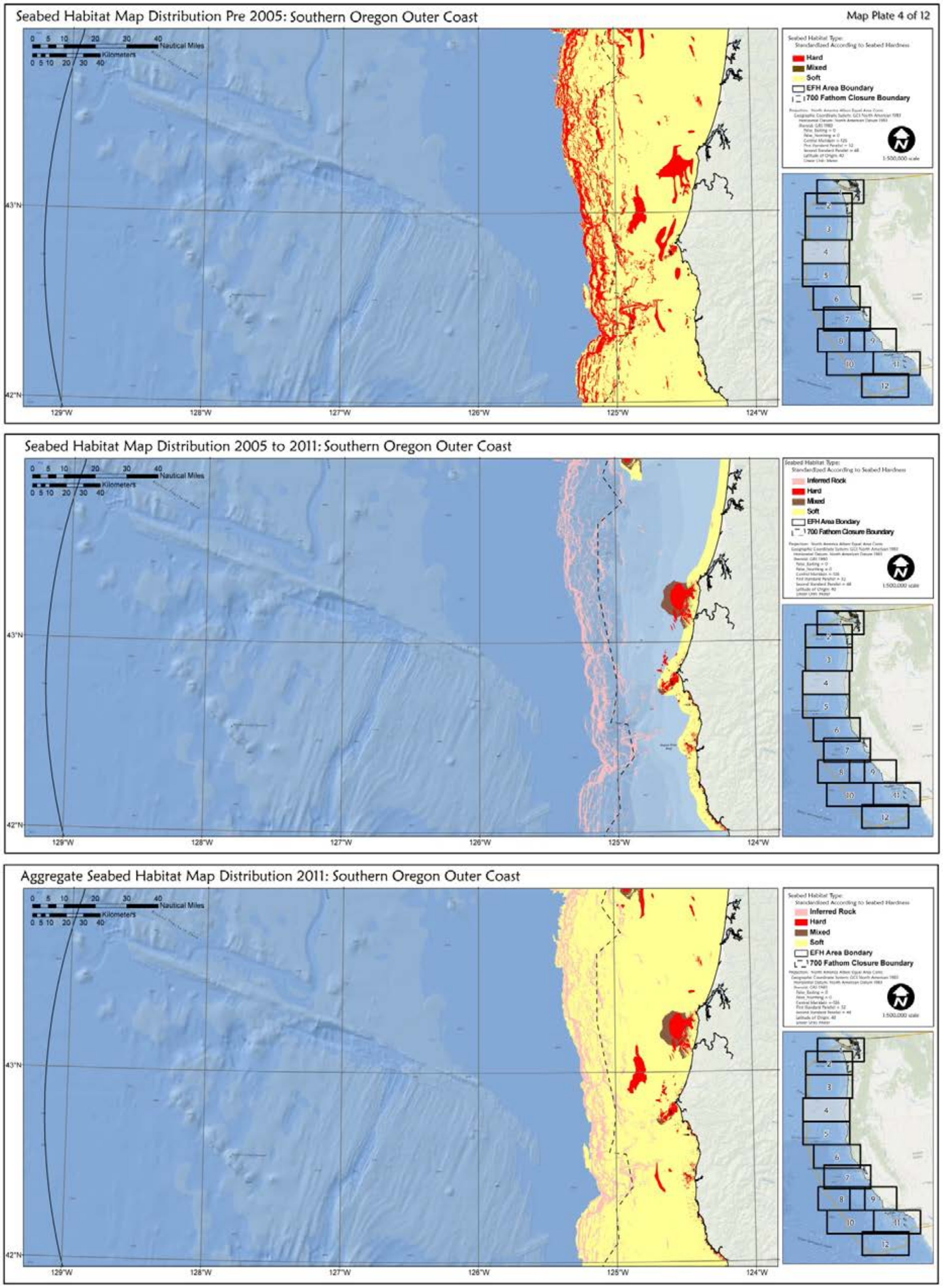

Figure 7. Example of bathymetry/substrate habitat plate from Appendix C-2.

3.2.1.1 Specific Notes by Region or Data Type

Oregon and Washington Surficial Geologic Habitat Maps
This product is an outgrowth and continuation of the original habitat maps created by the Active Tectonics & Seafloor Mapping Lab and The Center for Habitat Studies during the Amendment 19 (2006 EFH review) process. They are interpretive and regional, drawing input from any and all sources available. The coding scheme has changed little since 2005 and is considered a modification of Greene (1999).

Olympic Coast National Marine Sanctuary
Habitat Polygons were derived using a variety of automated image classification methods relying on seafloor samples and in-situ images for reference. Resultant image classifications were coded using Greene (1999).

Oregon State Waters
Habitat polygons were mapped using a hybrid of Supervised Image Classification techniques and geologic interpretation guided by sediment samples and seafloor imagery. Habitat codes explicitly discriminate rock outcrop from sedimentary habitats but do not follow Greene (1999) or any other standard coding scheme.

California State Waters
It should be noted that automated habitat classifications were based on comparative local depth values and therefore actually distinguish "smooth" and "rough" seafloor regions. These regions are predicted to consist of soft and hard substrate types, respectively. Interpreted habitat classifications were determined by geologists with appropriate expertise and based on a combination of the available seafloor imagery and any seafloor video or sediment samples.

3.2.1.2 Specific Notes By Comparison Plate

Plate 1: Northern Washington and Puget Sound
Plate 1 includes 118 new high-resolution seafloor imagery surveys published during or after 2002. Of these, 30 include bathymetry and backscatter data, 33 include only backscatter or sidescan data, and 55 include only bathymetry data (Figure 6; Appendix C-1, Plate 1). The primary source of seafloor imagery in this region is the NOAA National Ocean Service and the NOAA Olympic Coast National Marine Sanctuary (OCNMS) (Appendix C Table C-1). Plate one includes 39 new habitat maps (Appendix C-2 Plate 1).

The OCNMS has been actively mapping the northern portion of the sanctuary since 2000. Habitat map products became publically available in 2005, and are published periodically as new maps are completed. In total, 25 new habitat maps are now available in the northern OCNMS (Appendix C Table C-1) significantly modifying our regional understanding of the distribution and abundance of rocky habitats in the northern OCNMS. Taken as a complete set or individually, the OCNMS habitat maps show that the extent of rocky habitat in this area was greatly underrepresented by the Version 1 Surficial Geologic Habitat (SGH) map for Washington (Appendix C-2 Plate 1).

The Center for Habitat Studies, Tombolo Institute, and Geosciences Canada jointly produced an extensive habitat map of the Washington San Juan and Canadian Gulf Islands. This habitat map provides seafloor knowledge over an area previously unmapped by the Version 1 SGH Map for Washington (Figure 6; Appendix C-1 Plate 1, Appendix C-2, Plate 1). The USGS is currently engaged in a habitat mapping effort within the "inner" Puget Sound, though no habitat maps for this region have been officially published (Guy Cochrane, USGS, pers. comm., February 7th, 2012).

Regionally, significant updates have been made to the nearshore seafloor habitats of the Washington Outer Coast and within the Strait of Juan de Fuca in the Version 3.2 SGH map for Washington and Oregon. These regional habitat map edits modify the current state of knowledge of rocky outcrop distribution and abundance in nearshore state waters. New outcrops are identified and mapped along the outer coast from Cape Flattery south to Grays Harbor, Washington and with the Strait of Juan De Fuca from Cape Flattery, WA east to Dungeness Spit, Washington. The outcrops were identified using historic NOAA NOS hydrographic survey sheets and from air photo interpretations.

Plate 2: Washington Outer Coast

Plate 2 includes 22 new high-resolution seafloor imagery surveys. Of these, 18 include bathymetry and backscatter data, two include backscatter or sidescan data, and two include only bathymetry data (Appendix C Table C-1). The primary source of seafloor imagery in this region has been the National Science Foundation, including work completed under the Ocean Observing Initiative. Plate 2 includes six new habitat maps.

As in Plate 1 above, Plate 2 includes new nearshore mapping. Therefore, the abundance of nearshore rocky outcrops along the outer coast of Washington from Cape Flattery south to Grays Harbor has increased (Appendix C-2 Plate 2). Several large patches of mixed seafloor substrate have been mapped with multibeam sonar in the vicinity of Grays Harbor just outside of the nearshore zone and also in mid and outer shelf regions. Bathymetry surveys conducted during 2009, 2010, and 2011 show a large rocky reef along the southern border of the OCNMS and offshore of Grays Harbor in 60-100m of water. The Grays Harbor vicinity bathymetry surveys have not been mapped for seafloor habitat type.

For deepwater slope environments, the SGH map for Oregon and Washington has changed little since 2005. In May of 2011 the NSF sponsored a bathymetry mapping expedition for Washington, Oregon, and Northern California. A significantly improved map of Washington slope bathymetry resulted but has not been mapped for seafloor habitat.

Plate 3: Northern Oregon Outer Coast

Plate 3 includes 29 new sources of high-resolution seafloor imagery; 27 bathymetry and backscatter data surveys and two bathymetry data (only) surveys (Appendix C Table C-1). The primary source of new information in Plate 3 is the Oregon State Waters Mapping Program. Plate 3 includes 20 new habitat maps.

Locally, new multibeam mapping from the Oregon State Waters Mapping Project shows much greater abundance of rocky outcrop within the State Waters (0-3nm) of Oregon than was known in the Version 1 SGH map for Oregon. A new habitat map has been produced by NOAA NWFSC for Heceta Bank, Oregon providing greater information about the distribution of both rocky and mixed habitats than was previously available.

Regionally, a large rocky outcrop on mid continental shelf southeast (inshore) of Nehalem Bank is newly mapped. This feature was mapped as rock outcrop in the Version 1 SGH map for Oregon but at a more limited spatial extent. Submersible observations verified high relief outcrop as well as complex mixed seafloor habitats at the feature. Authegenic carbonate rocky ridgetop habitats are identified along upper continental slope ridges in northern Oregon. Similar habitat types were mapped in the Version 1 SGH map for Oregon in the vicinity of Hydrate Ridge and are now extended to include geologically similar ridge crests from Hydrate Ridge north to the Astoria Canyon. There has been no additional development of the “Predicted Rock Outcrop” data layer since the Version 1 SGH map for Oregon. The predicted rock outcrop map identifies local seafloor slopes (within a 300m by 300m analysis neighborhood) greater than 10 degrees. Any areas of 10 degrees or greater are classified as Inferred Rock.

Plate 4: Southern Oregon Outer Coast

Plate 4 includes 16 new sources of high-resolution seafloor imagery; 14 bathymetry and backscatter data surveys and two bathymetry data only surveys (Appendix C Table C-1). The primary source of new information in Plate 4 is the Oregon State Waters Mapping Program. Plate 4 includes 11 new habitat maps.

Re-mapping of the Bandon High Spot for habitat type was performed to address misclassifications identified in previous SGH map for Oregon versions. Although no new multibeam bathymetry was available for the re-mapping, existing seismic reflection profiles of the area were re-examined and re-interpreted yielding a more conservative rocky outcrop mapping and including a significant amount of mixed habitat type along the perimeter of the feature. The Version 3.6 SGH map for Oregon also includes updated rock outcrop mapping in Oregon neashore waters from NOAA NOS hydrographic survey sheets and from air photo interpretations.

New (2010) multibeam mapping of the adjacent Oregon State Waters at Cape Aragon and Bandon Reef reveals a large rocky reef, possibly an inshore extension of the Bandon High Spot. Habitat maps for Redfish Rocks and Island Rock provides updated rock outcrop mapping within the southern Oregon State Waters and nearshore zone while Oregon State Waters Mapping Program habitat maps are newly available for areas adjacent to Redfish Rocks and Island Rock.

Plate 5: Northern California and Mendocino Ridge

Plate 5 includes 20 new sources of high-resolution seafloor imagery coverages, encompassing 19 regions where bathymetry and backscatter data were collected and one region where only bathymetry data were collected (Appendix C Table C-1). In addition, habitat maps were constructed for 14 regions, including 13 that also had new bathymetry and backscatter coverages (Appendix C Table C-1). The northernmost coverage included in this plate (Pelican Bay) also extends to Plate 4 and is therefore not directly incorporated into this summary. The great majority of the regions in Plate 5 were surveyed and mapped by the Seafloor Mapping Lab at California State University, Monterey Bay (CSUMB-SML). NOAA-NOS additionally produced high-resolution imagery for three surveyed regions, and the Center for Habitat Studies (CHS) generated a habitat map for one region (Appendix C Table C-1).

New, high-resolution acoustic imagery in Plate 5 is restricted to nearshore and insular waters, with the great majority of new data collected and produced as part of the California Seafloor Mapping Project (CSMP). Sponsored by the California Ocean Protection Council, State Coastal Conservancy, Department of Fish and Game, and several branches of the NOAA, the CSMP is being conducted as a public/private partnership involving industry, resource management agencies and academia. In association with this project, the entire nearshore region of Northern California depicted in Plate 5 has been surveyed, and coupled bathymetry and backscatter coverages have been produced. In addition, a bathymetry coverage for Humboldt Bay was produced by CSUMB-SML in 2005, along with two higher-resolution, smaller bathymetry and backscatter coverages that detail portions of the northern and southern Bay. NOAA-NOS produced three small bathymetry and backscatter coverages in highly trafficked coastal regions off Northern California during 2008 and 2009 (Appendix C Table C-1).

The great majority of the seafloor habitat maps in Plate 5 were generated from the acoustic imagery collected as part of the CSMP project, and is therefore also restricted to nearshore waters. These maps were produced via automated habitat classification, conducted by personnel at CSUMB-SML. No CSMP habitat map products have been published for this or any region to date; geological map interpretations were used instead. CSUMB-SFL maps predict the occurrence of rocky regions mainly offshore of coastal points and promontories (e.g., Point St. George, Trinidad Head, Cape Mendocino, Punta Gorda, Point Delgado). A notably extensive region of unconsolidated sediments is predicted to occur from Trinidad Head to just north of Cape Mendocino. The new, higher-resolution (1:24,000 vs. 1:250:000) habitat maps in the nearshore region substantially refine the extent of hard and soft habitats along the Northern California coast. They greatly reduce and more precisely depict the extent of rocky habitats off Trinidad Head, whereas they substantially increase the amount of predicted habitat in other coastal regions. In addition to the automated habitat maps produced by CSUMB-SML, a single, interpreted coverage was produced offshore in the Eel River Basin region by H. Gary Greene and colleagues at Moss Landing Marine Laboratories' CHS. The mapped portion of Eel River Basin consists mainly of mixed habitat types, although a large amount of contiguous rock bottom is depicted in the central region.

Plate 6: Northern California Mendocino Coast

Plate 6 includes 101 new coverages, of which 35 represent bathymetry data, 34 represent backscatter data, and 32 are habitat maps. In total, these data are derived from 38 surveyed regions (Appendix C Table C-1). The primary source of seafloor imagery and habitat maps in this region CSUMB-SML. In addition, three regions were mapped for benthic habitats by CHS, and regional imagery products were additionally generated by NOAA-NOS (N=2) and USGS (N=1). The northernmost coverage included in this plate (Punta Delgada) also extends to Plate 5 and is therefore not directly incorporated into this summary.

New, high-resolution acoustic imagery in Plate 6 is largely restricted to nearshore and insular waters, with the great majority of new data collected and produced as part of CSMP efforts. The entire nearshore region depicted in Plate 6 has been surveyed, and coupled bathymetry and backscatter coverages were produced. In addition, bathymetry and backscatter coverages were created for Tomales Bay by USGS in 2008. A coverage that extends along the offshore region adjacent to Tomales Bay was generated by NOAA-NOS in 2007. NOAA-NOS also published a bathymetry layer that ranges along the coast from south of Point Reyes to north of San Francisco Bay. This region is obscured in Plate 6 because other bathymetry and backscatter data coverages overlap it. As part of NOAA's Ocean Exploration and Research Program, Active Tectonics and Seafloor Mapping Lab (ATSML) produced bathymetry and backscatter data coverages in 2010 that depict an offshore extension of San Andreas Fault between Point Arena and Cape Mendocino.

The great majority of the seafloor habitat maps in Plate 6 were generated by CSUMB-SFL from the acoustic imagery collected as part of the CSMP project. They are, therefore, largely restricted to nearshore waters. As previously described for Plate 5, new, higher-resolution maps greatly refine the amount and location of rocky habitats that are predicted to occur throughout the extent of their coverage. This refinement is particularly evident in the region between Point Reyes and Bodega Bay, where CHS has produced an expansive new coverage (Pt. Reyes) in addition to an older map (Bodega Basin (inshore). The original (2005) EFH substrate map depicted a large, contiguous rock bottom in this region, whereas the newer data displays a more punctuated, though extensive, distribution of rocky habitats. Locations of rocky habitats occur throughout the coastal region depicted in this plate, as opposed to their greater concentration in the northern region of Plate 5. In addition to nearshore regions, a sizeable portion of Bodega Basin (offshore) was also mapped by CHS. This map and its inshore complement were originally produced in 2001 but are included because they were not incorporated into the 2005 substrate map. The offshore region of Bodega Basin shows widespread, detailed areas of hard and mixed bottom where only coarse depictions of hard rock or soft bottom were previously evident.

Plate 7: San Francisco and Monterey Bay

Plate 7 includes 70 regions where high-resolution seafloor imagery was collected. Of these, 40 contain bathymetry and backscatter coverages, 27 consist solely of bathymetry layers, and one region includes only backscatter data (Appendix C Table C-1). In addition, habitat maps were constructed for 37 regions, including 33 that also had new bathymetry and backscatter coverages (Appendix C Table C-1). The majority of the regions in Plate 7 were surveyed and mapped by CSUMB-SML. However, NOAA-NOS and USGS produced acoustic imagery products for eight and seven regions, respectively (Appendix C Table C-1). Habitat maps were additionally produced for two regions each by CHS and USGS (Appendix

C Table C-1). Fifteen surveyed regions in the northern portion of Plate 7 were previously included in the description for Plate 6 and are not incorporated in this summary.

Much of the new, high-resolution acoustic imagery in Plate 7 was collected and produced as part of CSMP efforts. However, a great deal of additional data is available in this region and is especially concentrated in Monterey Bay, San Fransicso Bay and offshore regions located inside the 700 fathom boundary between Pacifica and Bodega Bay. The entire nearshore region displayed in Plate 7 has been surveyed, and coupled bathymetry and backscatter coverages were produced. There is one region just north of San Francisco Bay, however, where backscatter data only encompass a small portion of the available bathymetry coverage. Many bathymetry surveys were conducted in Monterey Bay since the last EFH review and a great deal of (often overlapping) coverages are therefore available (Appendix C Table C-1). One of the more interesting of these is a time series (2002-2008) of Monterey Canyon produced seasonally by CSUMB-SML. New USGS bathymetry and backscatter data covers a large portion of this region. Additional USGS bathymetry grids have recently been produced for Rittenburg Bank (2011) and Farallon Escarpment (2012), and corresponding backscatter data are currently being processed. NOAA-NOS data in Plate 7 largely consist of bathymetry coverages that are concentrated in the Gulf of the Farallons region and offshore of San Francisco Bay. Cordell Bank has been extensively surveyed (bathymetry and backscatter) by CSUMB-SML, and a backscatter coverage has been produced by USGS for a large region to the southeast of Rittenburg Bank.

New habitat maps have been produced throughout the nearshore regions encompassed by Plate 7, as well as in offshore regions between San Francisco and Bodega Bay. In nearshore regions, areas of rock are evident in association with the Monterey Peninsula and to the south, but much of Monterey Bay consists of soft bottom habitats. Between Monterey Bay and Pacifica, however, rocky habitats are prevalent in coastal regions. The region between Pacifica and Point Reyes is largely depicted as soft bottom, with the notable exception of a substantial hard bottom region off Stinson Beach. An extensive, detailed coverage was produced by CHS for the Golden Gate National Recreation Area and shows a great deal of hard and mixed seafloor. The new, higher-resolution maps greatly refine the amount and location of rocky habitats that are predicted to occur throughout the extent of their coverage in Plate 7. They generally reduce the amount of rock that was originally depicted, especially from Half Moon Bay to Pescadero, off Stinson Beach, and between Point Reyes and Tomales Bay. This trend is also evident in the northern offshore, region, where more precise habitat mapping has occurred on Rittenburg (USGS) and Cordell (CSUMB-SFL) Banks. A region southeast of Rittenburg Bank, however, was mapped by the USGS in 2005 and continues to show a large, contiguous area of rock bottom.

Plate 8: Central California Offshore

No new bathymetry, backscatter, or habitat coverages have been produced in the region encompassed by Plate 8 since the 2006 EFH review.

Plate 9: Central California

Plate 9 includes 189 new coverages, of which 64 represent bathymetry data, 60 represent backscatter data, and 65 are habitat maps. In total, these data are derived from 73 surveyed regions (Appendix C Table C-1). The primary source of seafloor imagery and habitat maps in this region CSUMB-SFL. However, USGS produced acoustic imagery products for seven regions and NOAA-NOS generated bathymetry and backscatter coverages in various regions Santa Barbara Channel (Appendix C Table C-1). Habitat maps were additionally produced for eight regions by CHS and two regions by USGS (Appendix C Table C-1). This summary does not incorporate four surveyed regions in the northern portion of Plate 9 that were previously included in the description for Plate 7.

New, high-resolution acoustic imagery in Plate 9 is restricted to nearshore waters, with the majority of new data collected and produced as part of CSMP efforts. The nearshore waters displayed in Plate 9 have been surveyed, and coupled bathymetry and backscatter coverages were produced for most regions. However, a notable exception is the region from Lopez Point to just north of San Simeon. CSUMB-SFL has collected bathymetry and backscatter data in this region but it has not yet been processed into grids and geotiffs for display. In addition, backscatter coverage is somewhat uneven in the coastal region south of Point Arguello. Many of the recently completed high-resolution surveys in the vicinity of the Santa Barbara Channel are-located in the southernmost portion of Plate 9. These include a small, coastal coverage off Ventura produced by NOAA-NOS, and several larger USGS coverages located throughout nearshore regions in northern Santa Barbara Channel. The northern extension of a large USGS data set in the northeastern Channel Islands regions also is depicted further offshore.

Most of the seafloor habitat maps in Plate 9 were generated by CSUMB-SFL from the acoustic imagery collected as part of the CSMP project. However, several interpreted habitat maps were produced (though not yet published) by CHS from a portion of the same data set, and these are overlaid where they occur in the Point Buchon and Santa Barbara Channel regions. Additional geologically interpreted coverages were created by USGS in the Northeastern Santa Barbara Channel and Southern Vandenberg Reserve. Habitat maps are absent in the north-central coastal portion of Plate 9 where seafloor imagery is not yet available, and in a small portion of the western Santa Barbara Channel. Rocky areas are abundant from Pismo Beach to San Simeon, and off Big Sur (to the north) and Point Sal (to the south). Diffuse rocky areas are also depicted off Point Conception, with mixed and rocky habitats located throughout the surveyed area in Santa Barbara Channels, mainly in deeper waters outside of coastal regions. The new, higher-resolution mapping efforts expand the known rocky areas throughout the coast, and more precisely depict their occurrences. For example, rocky areas are absent from the 2005 EFH map between Point Sal and Cape San Martin but present in the newer data. The extent of coastal rocky areas in the Santa Barbara Channel, however, has been reduced by newer mapping efforts, especially along the eastern and western margins depicted in Plate 9.

Plate 10: Southern California Offshore I

No new bathymetry, backscatter, or habitat coverages have been produced in the region encompassed by Plate 10 since the 2006 EFH review.

Plate 11: Southern California Borderland

Plate 11 includes 63 regions where high-resolution seafloor imagery was collected. Of these, 30 contain bathymetry and backscatter coverages, 26 consist solely of bathymetry layers, and 7 include only backscatter data (Appendix C Table C-1). In addition, habitat maps were constructed for 43 regions, including 21 that also had new bathymetry and backscatter coverages (Appendix C Table C-1). The majority of the regions in Plate 11 were surveyed and mapped by CSUMB-SFL. However, the following organizations also produced bathymetry and/or backscatter coverages in this region: USGS (N=12), Oregon State University's Active Tectonics and Seafloor Mapping Lab (ATSML) (N=6), and NOAA-NOS (N=4) (Appendix C Table C-1). Habitat maps were additionally produced for seven regions by USGS and six regions by ATSML (Appendix C Table C-1). This summary does not incorporate four surveyed regions in the northern portion of Plate 11 that were previously included in the description for Plate 9.

New, high-resolution acoustic imagery is abundant and widespread throughout the Southern California Bight region depicted in Plate 11. In this region, and evident throughout California waters, most of the new high-resolution acoustic data has been collected and imaged by CSUMB-SML. Coastal coverage in Southern California is, however, more sparse in terms of available new backscatter data than in other California regions. This situation is especially evident south of Newport Beach, where the only coastal backscatter available is located between Torrey Pines and La Jolla. In addition, the region between Dana Point and Torrey Pines is also largely devoid of new bathymetry imagery. However, expansive coastal bathymetry and backscatter coverages that extend far offshore have been produced by USGS in the southern border region and throughout the north-central Bight, and in the northeast Channel Islands region. In contrast to other California regions, offshore areas (especially those associated with islands and important fishing banks) have been well surveyed in Southern California. Much of the Channel Islands region contains bathymetry and backscatter coverages, produced by CSUMB, or backscatter data, produced by USGS. Extensive bathymetry and couple bathymetry and backscatter data, both collected by CSUMB-SML, surround Santa Barbara and Santa Catalina Islands, respectively. Bathymetry coverage, also produced by CSUMB-SML, is also evident along the west coast of San Clemente Island. Bathymetry data also have been collected and imaged by ATSML in several important offshore fishing regions, as contracted by NMFS SWFSC (Appendix C Table C-1). Additional offshore imagery was recently produced by CSUMB-SML for Cortes Banks (bathymetry and backscatter) and Tanner Bank (bathymetry). NOAA-NOS has produced four small, coupled bathymetry and backscatter coverages in highly trafficked coastal regions such as San Pedro Bay and Los Angeles Harbor.

New habitat map coverage in offshore areas of Southern California is more substantial and detailed than that of coastal regions, a condition that is unique to this region. The increased emphasis on mapping offshore regions in the Southern California Bight is a direct consequence of the importance of this area as EFH for commercially important rockfishes. Nearshore habitat coverages extend throughout the mainland coast with a notable absence in Santa Monica Bay and Long Beach Harbor. They depict primarily soft bottom, with rocky areas largely associated with promontories in the greater San Diego and border regions. These rocky areas are substantial, however, and were not previously depicted in the 2005 EFH substrate map. Santa Catalina Island is largely fringed by soft sediment, though some isolated rock is evident off the southern and western coasts. Extensive habitat coverage in the Channel Islands depicts a great deal of rocky habitat, especially off northern Santa Rosa Island (CSUMB-SML) and in association with Anacapa Island and the Anacapa Passage (USGS). In addition, mixed sediment is the dominant habitat type in Anacapa Passage and off eastern Anacapa Island (USGS). The USGS maps, especially, are quite detailed and consist of habitat interpretations based on acoustic imagery and geologic data. The offshore banks, surveyed by ATSML and, to a lesser extent, CSUMB-SML contain high concentrations of rocky and mixed habitats. This is to be expected, since these banks are known to provide important habitat for rockfishes. Among them, the more offshore banks (e.g., Tanner, Cherry, Potato) contain a much higher proportion of rocky and mixed habitats than their inshore counterparts. The contrast between the new, higher-resolution offshore habitat coverages and the same areas displayed on the 2005 EFH map is stark and highlights the greater utility of the newer data. For example, the 2005 EFH map shows contiguous rocky habitat around the totality of Santa Catalina Island, whereas soft sediment is dominant on the new coverages. Similarly, rocky regions have been defined in much greater detail and considerably reduced in association with Anacapa Island and Tanner Bank. By contrast, substantially rocky habitats on Cherry Bank are displayed as soft sediment in the 2005 EFH substrate map.

Plate 12: Southern California and International Border

No new bathymetry, backscatter, or habitat coverages have been produced in the region encompassed by Plate 12 since the 2006 EFH review.

3.2.2 Biogenic Habitat Maps

Biogenic habitat maps were developed from three sources of data:

- Selected Observations of Corals and Sponges, which are presented from various sources on regional plates (Appendix D).
- NMFS West Coast Groundfish Bottom Trawl Survey (WCGBTS), from which separate observations of corals (Appendix E1), sponges (Appendix E2), sea pens/whips (Appendix E3), and combined corals and sponges (Appendix E4) are presented on regional plates for pre-and post-Amendment 19 periods.

- West Coast Groundfish Observer Program (WCGOB) Commercial Bottom Trawl Bycatch, from which regional plates of similar taxa have been developed, and further stratified by lbs/km (Appendices F1-F4) and lbs/ton of groundfish (Appendices F5-F8).

3.2.2.1 Selected Observations of Corals and Sponges

Appendix D maps depict the spatial distribution of selected observations of corals and sponges from visual surveys conducted by a number of agencies and institutions (Table 3). Many of the locations of observations are included in a national database prepared under the auspices of NOAA's Deep-Sea Coral Research and Technology Program (NOAA 2011). Although there are a number of records of additional observations recorded at various research institutes, this database is currently the most comprehensive source of electronically available records of coral and, to a lesser extent, sponge observations in the region. Development of this database is ongoing and additional records of observations will be added as they become available. Appendix D plates also depict records from two other database query results: 1) selected observations of corals and sponges from submersible and remotely operated vehicle (ROV) surveys off southern California (NMFS SWFSC [M. Yoklavich]), and 2) a database maintained by Brian Tissot (Washington State University Vancouver) containing records of coral observations from submersibles and ROV surveys off Oregon and central and southern California (Bianchi, 2011; Bright, 2007; Pirtle, 2005). These additional records were added to the map figures because they were not yet included in the version of the national database. Compared to the 2006 groundfish EFH review, this database represents a major advancement in access and dissemination of records of coral and sponge presence in the region. Furthermore, this database was not available during the Amendment 19 process.

The Appendix D maps depict point locations of observations of corals and sponges recorded via a variety of collection methods (Table 3). Records with the label "in situ observation" were made using direct count methods utilizing submersible, ROV, or camera sled platforms. The precision of these point locations varies between data sets, ranging from very precise estimates of vehicle position at the location of the individual coral or sponge specimen observed in situ, to more general representations of a vehicle dive transect. Almost all records of corals and sponges collected via "trawls" or "dredges" originate from surveys conducted by NMFS during the past three decades; however, numerous records from museum collections within the "various" category also originate from very early NMFS trawl surveys conducted over the last century. Trawl and dredge records exhibit less locational precision, because trawls often operate over 100's of meters to 10's of kilometers. It is very difficult to estimate over the course of a trawl or dredge track when and where a particular specimen was collected. As mentioned above, records termed "various" most often are part of museum collections, for which the original collection method varies between the other four general categories or is not specified. The final category, "ROV collection" refers to specimens that were physically extracted from their benthic habitat by an ROV. Often times, these specimens are accessed in a museum collection. Consequently, this database of observations may contain duplicate records. Due to the varying and often unrecorded precision of the location information, particularly from trawl samples, users of these data should exercise caution when conducting any fine scale spatial analysis.

These records of selected coral and sponge observations are presented in map view to highlight the geographic scope of the observations (e.g., Figure 8; Appendix D). The spatial distribution of these locations of coral and sponge presence is largely driven by survey effort. The largest number of records originates from in situ observations (red) at discrete survey sites. Major areas of direct count *in situ* studies include sites in the Olympic Coast National Marine Sanctuary, numerous rocky banks off Oregon, central California (e.g., Cordell Bank National Marine Sanctuary) and in the southern California Bight, and submarine canyons off Oregon and central California, including a very large number of records from sites in and around Monterey Bay.

The second most numerous category of records comes from trawl surveys (blue), which were conducted mostly by the NMFS starting in the mid 1970's and continuing through 2010, at least for the current version of the database. These observations are limited to "trawlable" areas of the continental shelf and slope, while survey focus was often to make fishery-independent estimates of groundfish biomass. It is important to note that most trawl gear is not designed to sample sessile benthic invertebrates, nor is it designed to access the types of habitats in which these organisms typically reside. The exception is sea pens and sea whips, since they don't require hard substrate for attachment. For this reason, sea pens and sea whips are encountered much more frequently in the catch of trawl surveys than any other coral taxa (see Whitmire and Clarke, 2007).

Lastly, records in the "various" category (yellow) are less numerous and occur in areas off Washington and central and southern California. When they appear in dense clusters around a feature such as seamounts (e.g., Figure 8), they almost certainly originate from ROV or submersible surveys. Such records would have been members of the "*in situ* observation" had the data attributes indicated this. Often times, these records were provided as queries of museum specimen collections or online databases for which observations are compiled from a variety of sources.

In contrast to the existing databases of observations described above, the last review of groundfish EFH that concluded in 2006 utilized significantly fewer records of observations. A summary of data sources, total records reviews, and numbers of observations used during the last review is detailed in Appendix B of the Final Environmental Impact Statement (NMFS, 2005).

Table 3. Summary of records of coral and sponge observations depicted in map views (Figure 8; Appendix D) and categorized by collection method. Data sources include 1) a national database of deep-sea coral and sponge records maintained by NOAAs Deep-Sea Coral Research and Technology Program, 2) records from various submersible and ROV surveys conducted by the NMFS SWFSC (M. Yoklavich), 3) records from various submersible and ROV surveys conducted by OCNMS (C. E. Bowlby; Brancato et al. 2006; Brancato and Bowlby 2005) and 4) a database maintained by Brian Tissot (Washington State University Vancouver) containing records of coral observations from submersibles and ROV surveys off Oregon and central and southern California (Bianchi, 2011; Bright, 2007; Pirtle, 2005). Many specimens extracted from their benthic substrate via ROV are also included in the "various" category; however, the national database does not always include details about the collection method.

Collection Method	# Database Records *
in situ observation	304,069
research trawl	8,268
various	271
ROV collection	3
research dredge	1
Total	**312,612**

*Some database records may represent multiple observations of corals and/or sponges.

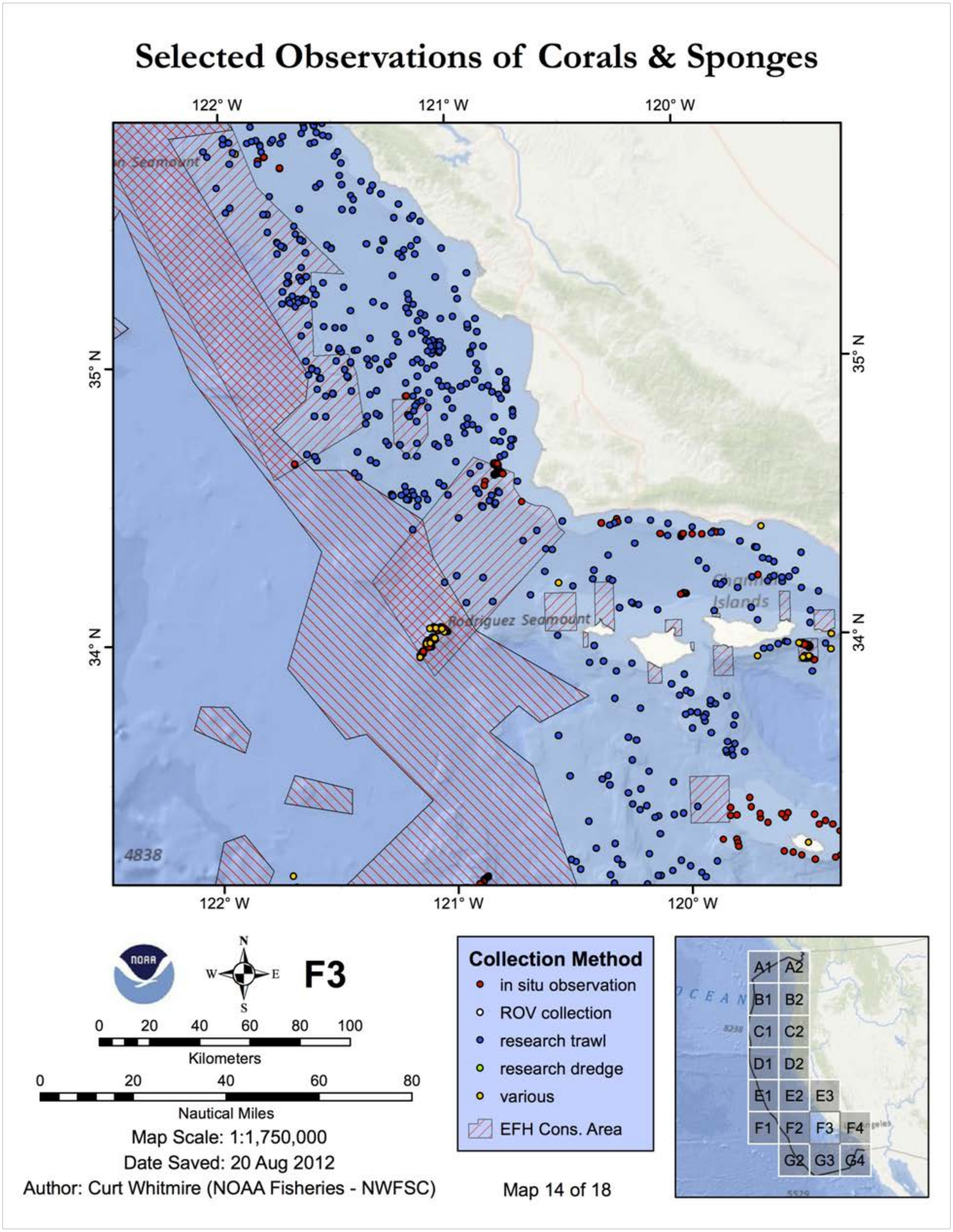

Figure 8. Example of map from Appendix D, selected observations of corals and sponges.

3.2.2.2 Distribution of Corals and Sponges from Standardized Catch in the NMFS West Coast Groundfish Bottom Trawl Survey Conducted Before and After the 2006 EFH Review

Appendix E plates depict the spatial distribution of standardized survey catch of corals and sponges within two time periods: "Before" (2003-05 survey cycles) and "After" (2006-10 survey cycles) implementation of Amendment 19 regulations. The sole data source for the map layers is catch records from the WCGBTS. Since 2003, the WCGBTS has been a combined survey of demersal species residing in both continental shelf (i.e., 30-100 fm) and slope (i.e., 100-700 fm) habitats. Each year, the WCBGTS sampled about 750 stations during two passes (May-July, August-October) operating north to south from the Canadian to Mexican maritime borders. Tow durations were targeted at 15 minutes, with a mean tow distance of 1.4 km. Invertebrates in the catch were sorted, weighed and identified down to the lowest possible taxonomic level. Consequently, taxonomic resolution was dependent upon the expertise of onboard biologists. A full description of the survey design and protocols can be found in past cruise reports at: http://www.nwfsc.noaa.gov/research/divisions/fram/index.cfm. A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online-at: http://efh-catalog.coas.oregonstate.edu/overview/.

Standardized catch was defined as the total weight of organisms (kg) per linear distance towed (km) witin a standard area and calculated for four taxonomic groupings of organisms: 1) corals (excluding sea pens and sea whips) and sponges, 2) corals (excluding sea pens and sea whips), 3) sponges, and 4) sea pens and seas whips (Appendix E-1 to E-4). The numerator (catch) was calculated using a kernel density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California). The kernel density algorithm distributes catch over a surface that is defined by a user-specified distance from the line, where the catch is highest on the line and dimishes proportionally with distance from the line (Figure 9). Each kernel surface encompasses the toal catch value for a given tow. The denominator (effort) was calculated using a line density algorithm that sums the total portions of lines intersecting a circular search area (Figure 10). Both density values are assigned to grid cells of user-specified dimensions. Cells with values greater than zero indicate areas of positive catch, while cells of zero value indicate areas where effort occurred but no corals and/or sponges were present in the catch. The density parameters used for calculating both catch and effort were a 6 km search radius and a 500x500 m cell size. By standardizing catch by effort, the resulting catch outputs were standardized over both space and time. Since density outputs are highly sensitive to the specified radius and cell size, the absolute values are less important than the relative nature of them. The benefit of this output over depicting towlines themselves is that the density output better identifies areas where catch is concentrated.

Sponges (Appendix E-3) were more common in the catch than corals (Appendix E-2), and accounted for the top six taxa by standardized weight (CPUE) in the period from 2003-10 (Table 4). Two pennatulid taxa were the next most abundant, with gorgonians and then black corals being the most frequently recorded of all non-pennatulid coral taxa. Any significant changes in the frequency or standardized catch of taxa between the two time periods should be interpreted with caution, as the ability of onboard biologists to identify corals in the catch has improved throughout time.

In order to evaluate how fishing effort has changed between the two time periods, the color ramps for the intensity layers are scaled to the same range of values in each panel (e.g., Figure 9). Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. The value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

In the maps showing standardized catch of corals excluding sea pens/whips (Appendix E-2), areas of highest relative CPUE occurred off northern California (Figure 11) in both time periods. Two areas off northern Washington show moderate CPUE, one within the Olympic 2 EFH conservation area in the recent time period (Figure 12).

In the maps showing sponges only (Appendix E-3), the areas of highest relative CPUE occurred off southern California, two sites in the before period and one in the after (Plate F3). The one area of highest CPUE in the recent time period also showed relative moderate catches of sponges in the before period. Other areas of moderate catch of sponges occurred near the Eel River Canyon (Plate D2, before) and off central Oregon in both time periods (Plate B2).

Areas of highest CPUE for sea pens/whips (Appendix E-4) occurred off northern and central Oregon (Plate B-2) and central California (Plate F3). Other areas of moderate CPUE are apparent off San Francisco in the recent time period (Plate E2) and central (Plate F3) and southern California (Plates F4 and F5).

One important consideration when evaluating catch records of invertebrates from trawl surveys is the sampling gear itself. Bottom trawl gear used in the WCGBTS is not designed to sample sessile invertebrates, nor is it designed to access many of the preferred habitats for coral and sponge settlement or habitats known to support corals and sponges. Regardless of the limitations of the gear, corals or sponges were recorded in almost half of all survey tows (Table 4; Appendix E-1). The average length of survey tows is much shorter in duration than commercial tows, and vessel captains can often prosecute a tow in areas where they normally would not during commercial operations. This may in part account for the fact that corals and sponges are recorded more frequently in survey catches (see Section 3.2.2.3, Table 5 and Appendix F).

Table 4. Summary of coral and sponge taxa recorded during tows as part of the West Coast Groundfish Bottom Trawl Survey (WCGBTS), comparing two time periods: "Before" (2003-05) and "After" (2006-10). "#" denotes number of tows with recorded bycatch; "FREQ" denotes ratio of tows with catch to total tows recorded; "CPUE" denotes catch per unit of effort (units: kg/ha). Tow counts represent only those where corals or sponges were present in the catch. Taxa are listed in descending order of CPUE for combined time period.

	BEFORE			AFTER			BEFORE + AFTER		
	#	**FREQ**	**CPUE**	**#**	**FREQ**	**CPUE**	**#**	**FREQ**	**CPUE**
Porifera	359	21.7%	1,852.90	647	19.0%	2,297.41	1,006	19.9%	4,150.31
Hexactinosida	103	6.2%	810.13	295	8.7%	2,371.76	398	7.9%	3,181.89
Rossellinae	53	3.2%	154.01	91	2.7%	698.79	144	2.8%	852.80
***Suberites* spp.**	3	0.2%	425.77	9	0.3%	2.90	12	0.2%	428.67
***Hyalonema* spp.**	47	2.8%	49.17	95	2.8%	174.32	142	2.8%	223.49
Hexactinellida	17	1.0%	77.80	0	0.0%	0.00	17	0.3%	77.80
Pennatulacea	245	14.8%	16.18	417	12.3%	24.44	662	13.1%	40.62
Anthoptilum grandiflorum	98	5.9%	6.64	289	8.5%	30.58	387	7.7%	37.22
***Chrysopathes* spp.**	0	0.0%	0.00	31	0.9%	29.24	31	0.6%	29.24
Antipatharia	66	4.0%	23.85	25	0.7%	1.77	91	1.8%	25.61
***Halipteris* spp.**	0	0.0%	0.00	161	4.7%	13.11	161	3.2%	13.11
Gorgonacea	58	3.5%	2.56	82	2.4%	10.34	140	2.8%	12.90
Anthomastus ritteri	16	1.0%	3.09	69	2.0%	8.04	85	1.7%	11.13
Ptilosarcus gurneyi	28	1.7%	2.48	62	1.8%	5.64	90	1.8%	8.12
Alcyonacea	14	0.8%	0.89	15	0.4%	3.53	29	0.6%	4.42
***Anthomastus* spp.**	19	1.2%	3.00	11	0.3%	1.29	30	0.6%	4.29
Callogorgia kinoshitae	4	0.2%	0.06	22	0.6%	4.09	26	0.5%	4.15
***Umbellula* spp.**	23	1.4%	1.38	94	2.8%	2.47	117	2.3%	3.84
***Paragorgia* spp.**	6	0.4%	0.56	14	0.4%	2.68	20	0.4%	3.24
***Isidella* spp.**	1	0.1%	0.06	9	0.3%	3.05	10	0.2%	3.11
Scleractinia	4	0.2%	2.43	3	0.1%	0.14	7	0.1%	2.57
***Farrea* spp.**	5	0.3%	0.76	3	0.1%	0.85	8	0.2%	1.61
Anthoptilum murrayi	4	0.2%	0.06	29	0.9%	1.01	33	0.7%	1.07
Flabellidae	2	0.1%	0.03	9	0.3%	0.82	11	0.2%	0.84
Caryophylliidae	1	0.1%	0.09	5	0.1%	0.35	6	0.1%	0.45
***Bathypathes* spp.**	6	0.4%	0.05	25	0.7%	0.37	31	0.6%	0.42
***Keratoisis* spp.**	2	0.1%	0.41	0	0.0%	0.00	2	0.0%	0.41
Stylasteridae	1	0.1%	0.00	4	0.1%	0.37	5	0.1%	0.37
***Lillipathes* spp.**	3	0.2%	0.08	9	0.3%	0.20	12	0.2%	0.28
***Callogorgia* spp.**	1	0.1%	0.02	4	0.1%	0.17	5	0.1%	0.19
Pennatula phosphorea	1	0.1%	0.01	10	0.3%	0.10	11	0.2%	0.12
Acanthogorgiidae	0	0.0%	0.00	1	0.0%	0.01	1	0.0%	0.01
	749	**45.3%**	**3,434.45**	**1,554**	**45.7%**	**5,689.85**	**2,303**	**45.5%**	**9,124.30**
	1,652			**3,404**			**5,056**		

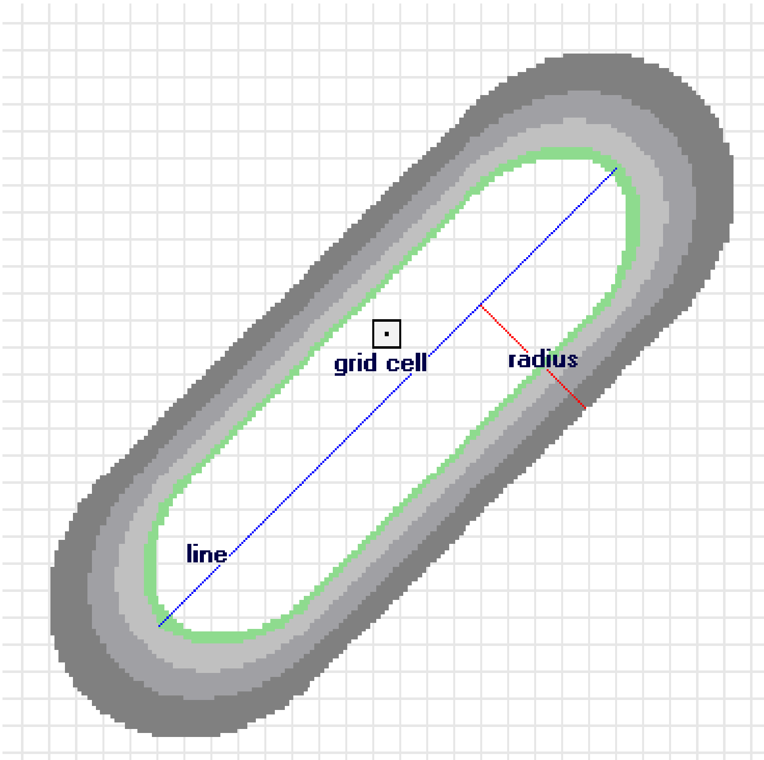

Figure 9. Conceptual drawing of how the ArcGIS kernel density algorithm works, showing application of the user specified parameter values: search radius and grid cell size. Image source: Environmental Systems Research Institute, Inc.

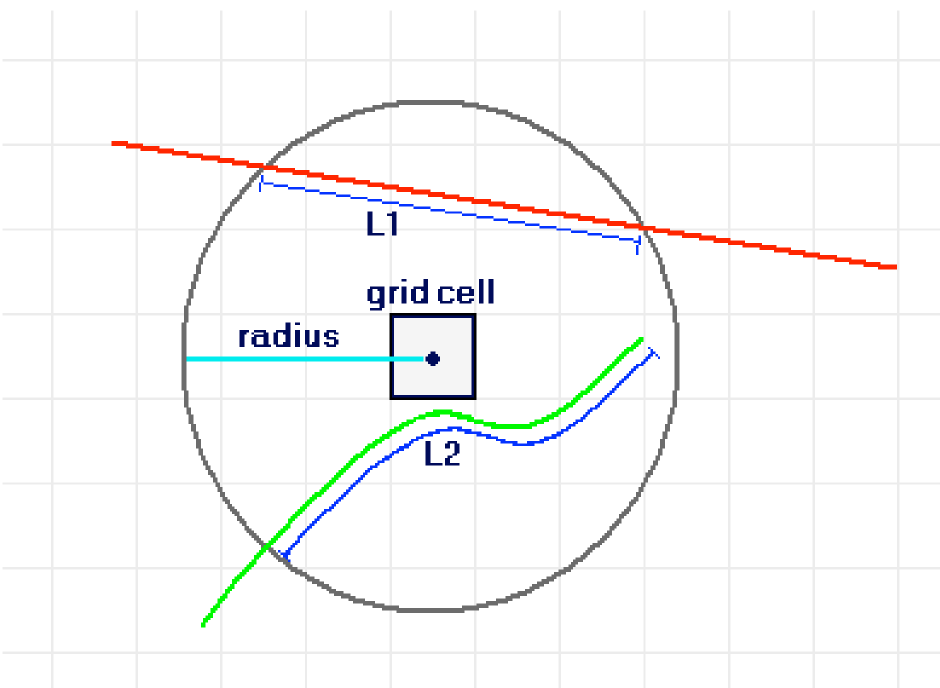

Figure 10. Conceptual drawing of how the ArcGIS line density algorithm works, showing application of the user specified parameter values: search radius and grid cell size. "L1" and "L2" represent hypothetical line inputs to the density algorithm. Image source: Environmental Systems Research Institute, Inc.

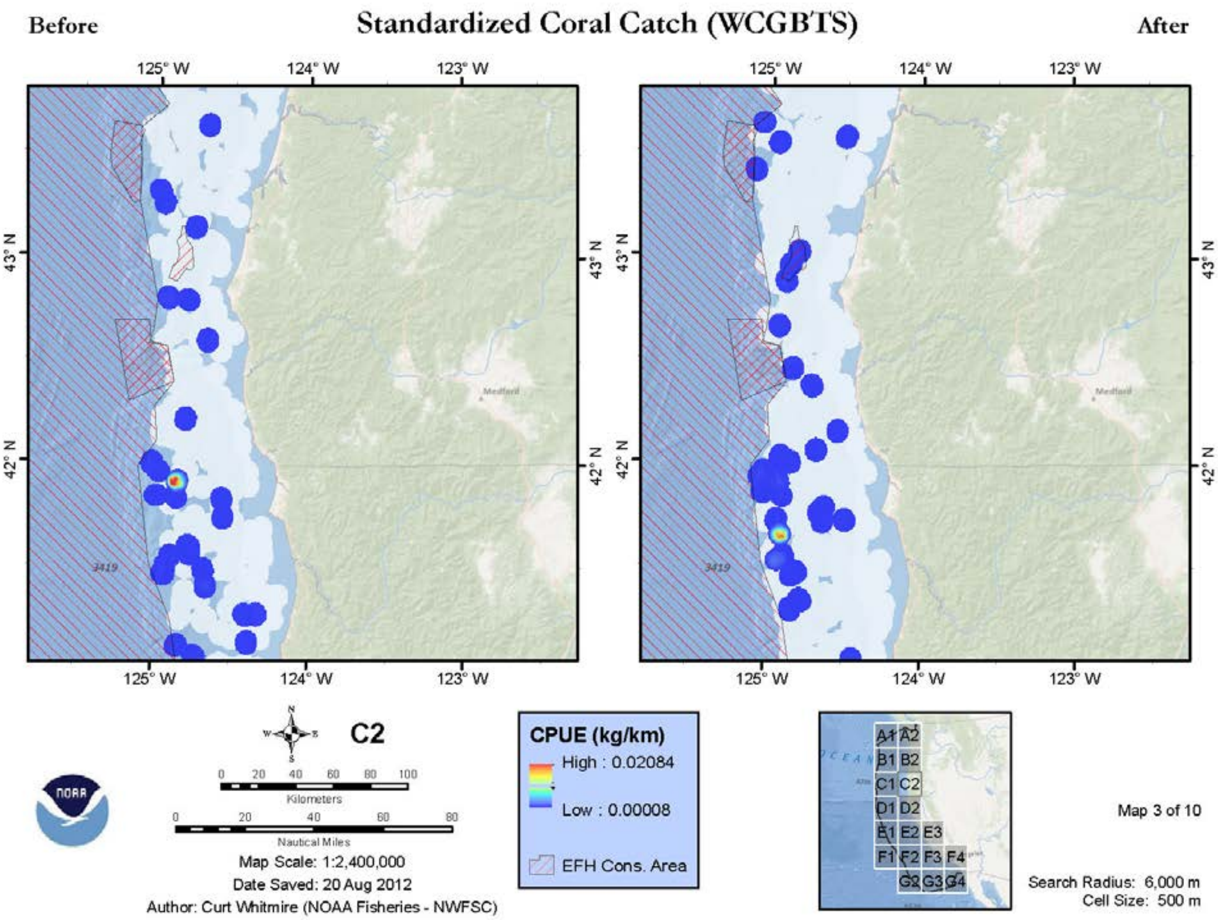

Figure 11. Example of plate from Appendix E-2 showing the distribution of coral CPUE (excluding sea pen/whips) off the Northern California Coast pre- and post- Amendment 19 from the West Coast Groundfish Bottom Trawl Survey.

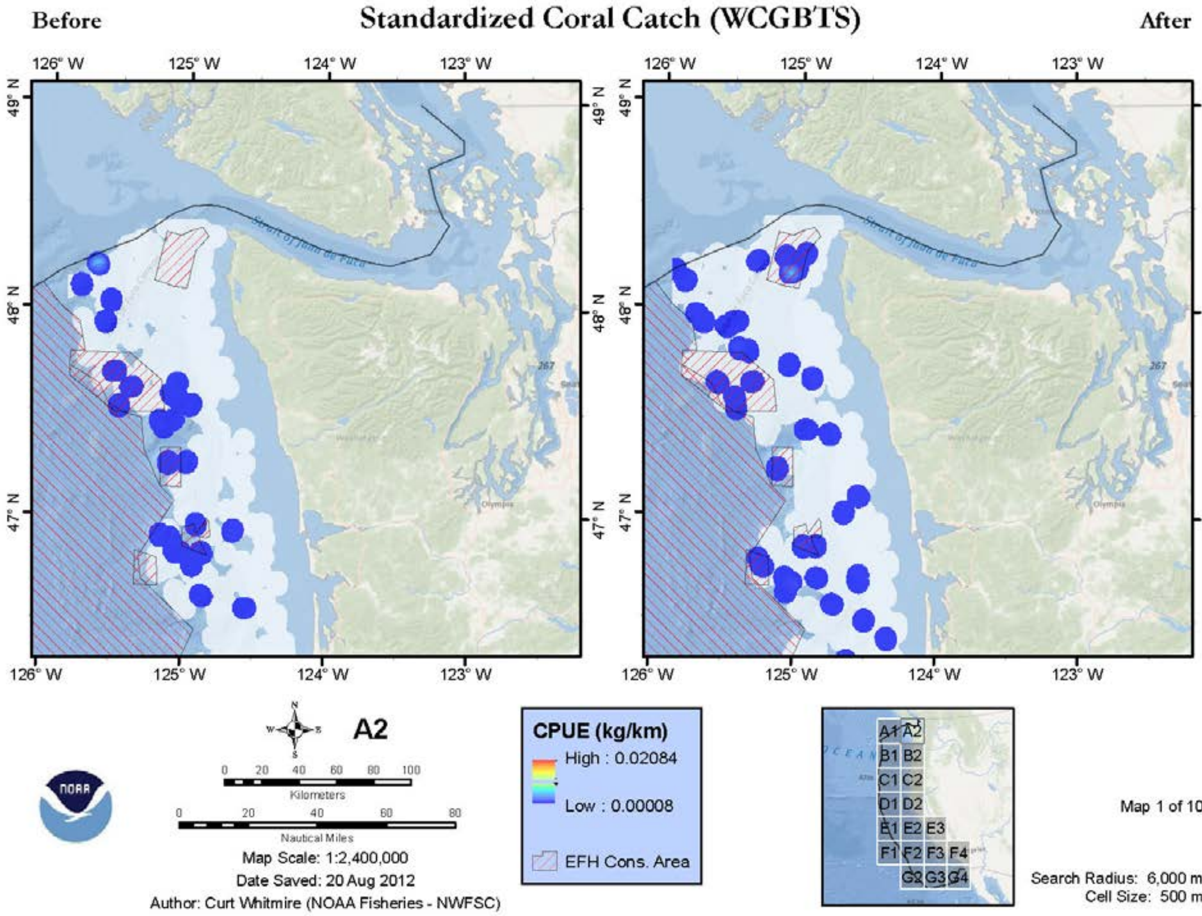

Figure 12. Example of plate from Appendix E-2 showing the distribution of coral CPUE (excluding sea pen/whips) off the Northern Washington Coast pre- and post- Amendment 19 from the West Coast Groundfish Bottom Trawl Survey.

3.2.2.3 Distribution of Corals and Sponges in Standardized Commercial Bycatch from West Coast Groundfish Observer Program Conducted Before and After the 2006 EFH Review

Appendix F Plates depict the spatial distribution of standardized commercial bycatch of corals and sponges within two time periods: "Before" (3 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of limited-entry trawl tows were compiled from one source: observer records from the WCGOP database. The WCGOP database includes records of trips for vessels using a variety of bottom trawl gear configurations, including small and large footrope groundfish trawl, set-back flatfish net, and double rigged shrimp trawl, to name a few. Records of tows using mid-water trawl gear were not included in this analysis, since observers recorded no bycatch of corals or sponges using this gear type. Furthermore, since all fishing operations are not observed, neither the maps nor the data can be used to characterize bycatch completely. We urge caution when utilizing these data due to the complexity of groundfish management and fleet harvest dynamics. Annual WCGOP coverage of the limited-entry trawl sector can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm. A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/.

Trawl events were represented by a straight line connecting the start and end points. Towlines intersecting land, outside the U.S. EEZ, deeper than 2,000 m, or with a calculated straight-line speed over 5 knots were removed from the spatial analysis. Bycatch was analyzed for four taxonomic groupings of organisms: 1) corals (excluding sea pens and sea whips) and sponges, 2) corals (excluding sea pens and sea whips), 3) sponges, and 4) sea pens and seas whips. For each of the four taxonomic groups, two standardized bycatch metrics were calculated: 1) standardized CPUE (units: lb/km; Appendix F-1 to F-4), and 2) catch-per-unit-of groundfish catch (i.e., CPUC, units: lb/ton of groundfish; Appendix F-5 to F-8).

The numerator for both bycatch metrics was catch density, calculated using a kernel density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California). Catch density was calculated for all tows with presence of one of the four taxonomic groups of corals and sponges.

The denominator for either the CPUE or CPUC was calculated using the same line density algorithm utilized in the two trawl effort intensity layers. For the CPUC metric, the line density algorithm weights each linear feature representing a tow by the weight of groundfish catch (tons). Effort density of density of groundfish catch was calculated for all tows, regardless of presence of corals or sponges in the catch.

By standardizing catch by either amount of effort (km/km^2; Appendix F-1 to F-4) or catch of groundfish (lb/km^2; Appendix F-5 to F-8), the resulting bycatch outputs were standardized over both space and time. In order to maintain the confidentiality of individual vessels, any cells with density values calculated from fewer than three vessels were removed from the final map layers. This did not significantly change how bycatch was represented since almost all bycatch occurred within areas where more than two vessels were operating. The density parameters used for calculating standardized bycatch were a 3 km search radius and a 500x500 m cell size.

Before interpreting the data and map figures, there are a few points about the methods used to create them that are important to consider. First, trawl tracks are only represented by straight lines connecting start and end points. Trawls rarely follow straight lines; therefore, the longer the line the higher the uncertainty as to its actual path. Second, since we are uncertain as to when bycatch occurred during the course of a trawl, bycatch was assumed to occur consistently and proportionally over the entire course of the straight trawl line. Third, only observed trips are represented. Fourth, different trawl gear configurations will access different types of habitats and topographic relief. Fifth, the boundaries of the trawl rockfish conservation areas have changed throughout both of these time periods, effectively changing access to trawlable (and biogenic) habitats within these areas. Lastly, implementation of the EFH conservation areas in June 2006 significantly curtailed access to some known biogenic habitats. The effects of these closures on protection of biogenic habitats are not fully understood.

Based on observer records of the limited-entry trawl sector, recorded bycatch of corals and sponges has changed significantly, both in frequency and standardized amount, since implementation of Amendment 19 regulations in June 2006 Table 5). Both the frequency (percent observed hauls) of bycatch and total weight (lb) of all three taxonomic groups combined have about doubled in the recent time period. Although this may seem alarming at first glance, this statistic is very likely influenced by a more concerted effort by observers to identify biogenic-structure forming invertebrates in commercial catches. Curiously, standardized bycatch (CPUE and CPUC) of corals has decreased over 5-fold since June 2006, while the frequency of occurrence has remained fairly consistent. What's even more perplexing is that the frequency of occurrence and standardized bycatch (CPUE and CPUC) of sea pens/whips have seen a

2-fold change, but in opposite directions (up for frequency and down for standardized bycatch). During the last decade of the observer program, sponges dominated the weight of bycatch for all three taxonomic groups, but this was not always the case. Sponge and corals were caught at relatively equal rates in the early time period, but in more recent times sponges are encountered four times more frequently and at much higher standardized catch rates compared to corals. Since observers in recent years have been trained to give equal attention to recording bycatch of both taxonomic groups, the large difference in magnitude may reflect either an increased level of impact by limited-entry trawlers on sponges compared to corals, or a greater relative abundance of sponges in "trawlable" habitats, or the more accurate records of sponge bycatch in recent years.

Eight (four taxonomic groups by two bycatch metrics) sets of map figures (Plates) were created to show temporal comparisons of standardized bycatch, (Appendix F). In order to evaluate how bycatch has changed between two time periods in any given map set, the color ramps for the density layers in each time period were scaled to the same range of values. Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. The upper value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

One apparent feature of all map figures is that few areas of high relative bycatch are evident. This is a result of having to scale the color ramps for each panel to facilitate temporal comparison. Since the range of standardized bycatch values between each time period is significantly different and since many values are very low (near zero), most areas of the map layers appear dark blue (zero to low bycatch). The areas of the map that appear lighter blue (teal) or red represent areas where bycatch was higher in one time period versus the other.

For sponges (Appendices F-3 and F-7) and corals/sponges combined (Appendices F-1 and F-5), areas that show consistently higher relative amounts of bycatch are located on the northern Oregon slope (Figure 13; Plate B2) and a couple areas off southern Oregon (Figure 14; Plate C2). Areas of decreased bycatch for sponges (Appendix F-3) and corals/sponges combined (Apendix F-1 and F-5) occur at two small areas on the central Oregon slope (Plate B2) and near the Eel River Canyon (Plate D2). One area of increased bycatch of these taxonomic groups is evident off Cape Arago, Oregon (Plate C2). For corals (Appendicies F-2 and F-6), bycatch has decreased significantly in many areas, especially at one small area off the Columbia River mouth and a number of areas off northern Oregon (Plate B2), and two areas off southern Oregon (Plate C2). Bycatch has only increased in one area off Crescent City, California (Plate C2). And finally, bycatch of sea pens/whips (Appendices F-4 and F-8) has decreased significantly in three areas off northern Oregon (Plate B2) and one small area shoreward of the Bandon High Spot (Plate C2).

Table 5. Summary of coral and sponge bycatch metrics for observed tows using bottom trawls as part of the West Coast Groundfish Observer Program (WCGTOP), comparing two time periods: "Before" (3 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. "#" denotes number of hausl; "FREQ" denotes ratio of hauls with positive catch of taxon to total hauls observed; "Weight" denotes catch (lb); "CPUE" denotes catch per unit effort (units: lb/km); "CPUC" denotes catch per unit of groundfish catch (units: lb/ton GF). Haul counts represent only those hauls where corals or sponges were present in the catch. Annual WCGOP coverage of the limited-entry trawl sector can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm.

	Before					**After**					**Before + After**				
	#	**FREQ**	**Weight**	**CPUE**	**CPUC**	**#**	**FREQ**	**Weight**	**CPUE**	**CPUC**	**#**	**FREQ**	**Weight**	**CPUE**	**CPUC**
Coral	319	2.0%	9,309	4.9E-02	1.9E-04	335	1.8%	2,197	9.0E-03	3.7E-05	654	1.9%	11,507	2.7E-02	1.1E-04
sea pen/ whip	198	1.3%	232	1.2E-03	4.8E-06	474	2.5%	145	5.9E-04	2.5E-06	672	1.9%	377	8.7E-04	3.5E-06
sponge	469	3.0%	10,025	5.3E-02	2.1E-04	1,444	7.6%	45,383	1.9E-01	7.7E-04	1,913	5.5%	55,408	1.3E-01	5.1E-04
	903	5.7%	19,567	1.0E-01	4.0E-04	2,003	10.5%	47,725	2.0E-01	8.1E-04	2,906	8.4%	67,292	1.6E-01	6.2E-04

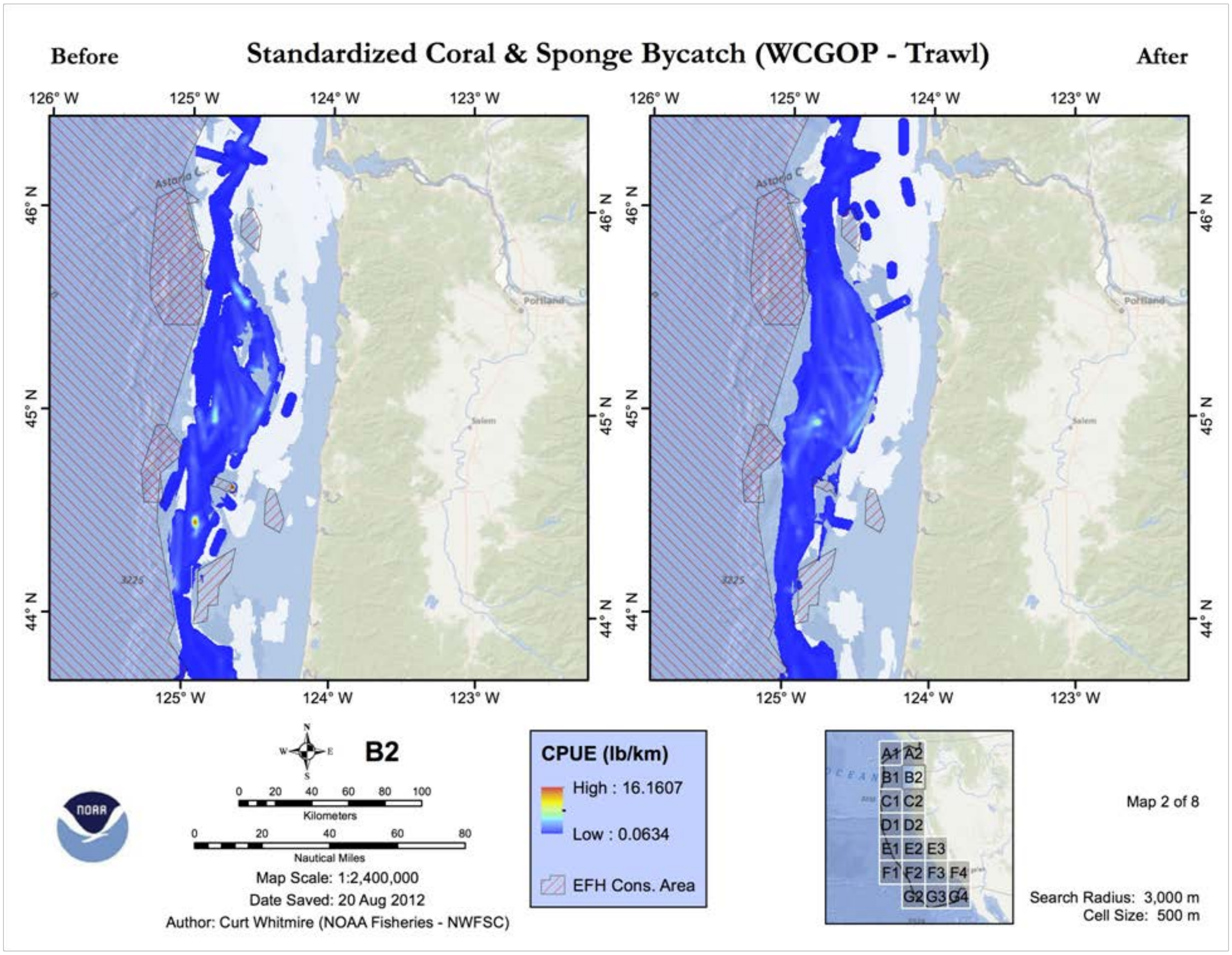

Figure 13. Example plate from Appendix F-1: the distribution of coral and sponge CPUE (lb/km) as bycatch from the West Coast Groundfish Trawl Observer Program before and after the implementation of Amendment 19 regulations.

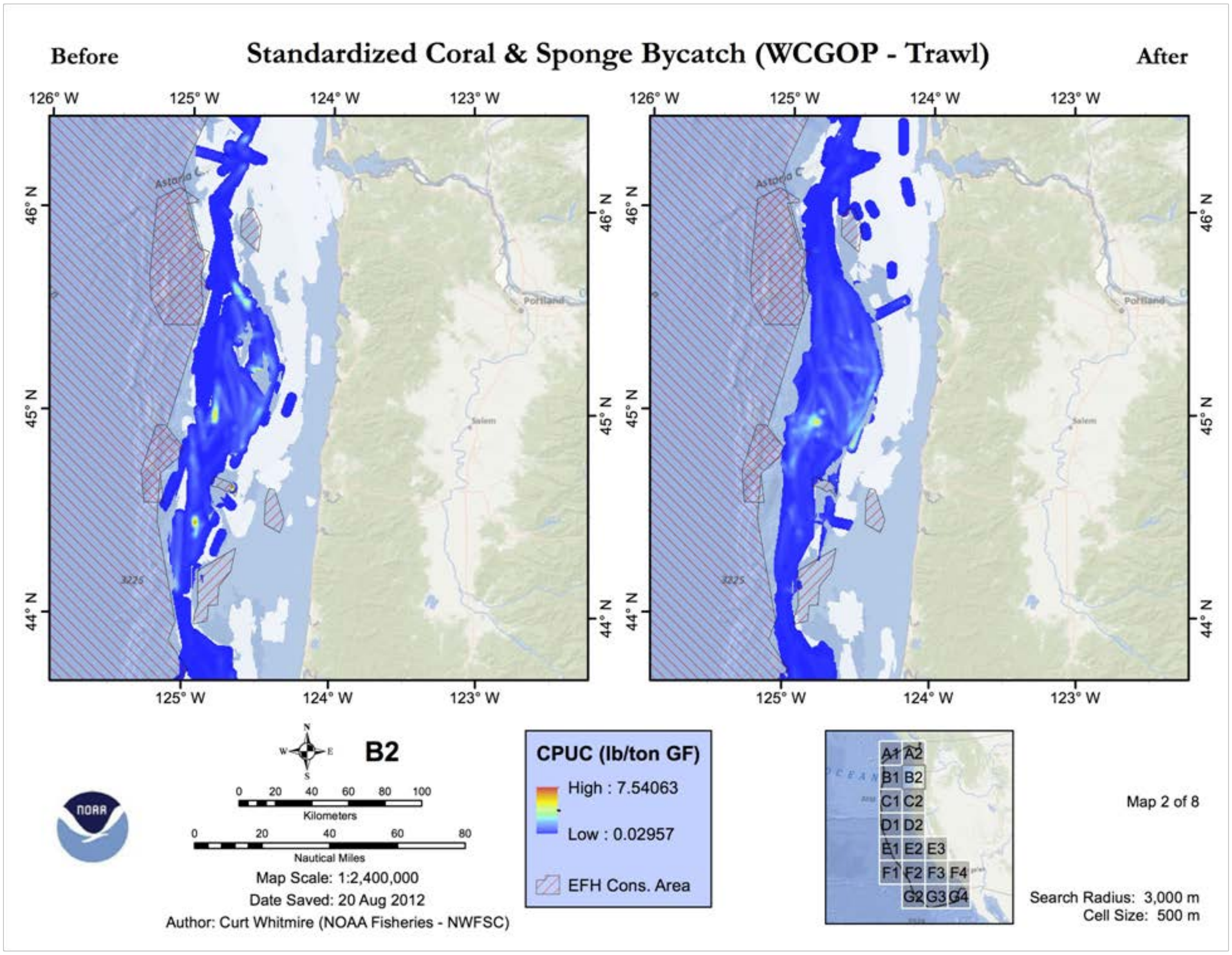

Figure 14. Example plate from Appendix F-5: the distribution of coral and spong CPUE (lb/ton groundfish) as bycatch from the West Coast Groundfish Trawl Observer Program before and after the implementation of Amendment 19 regulations.

3.2.2.4 Information on Commercial Bycatch of Corals and Sponges from West Coast Groundfish Observer Program Fixed Gear and At-sea Hake Sectors Before and After the 2006 EFH Review

Along with the limited-entry bottom trawl sector, the WCGOP observes vessels using fixed gears, including those participating in the following sectors: limited entry sablefish-endorsed primary season, limited entry non-sablefish endorsed, open access fixed gear, Oregon and California nearshore. Gear types where corals and sponges have been recorded as bycatch include longlines, set nets, fish pots and pole to name a few. Not all fixed gear trips are observed, so the data should not be used to characterize bycatch of corals and sponges completely. As with many observer data products, we urge caution when utilizing them due to the complexity of groundfish management and fleet harvest dynamics. Annual WCGOP coverage of the fixed gear sectors can be found online at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm.

Because of the dearth and sparseness of bycatch records of corals and sponges during observed trips using fixed gears, bycatch records were unable to be summarized spatially. Since implementation of Amendment 19 regulations in June 2006, coastwide, combined bycatch of corals, sea pens/whips and sponges has decreased by at least 40 percent both in frequency and standardized amount (Table 6). For corals and sponges separately, both metrics of bycatch (frequency, standardized weight) have decreased. Since June 2006, only standardized weight (CPUC) of sea pens/whips has increased, that by 19 percent. Compared to observer records for the limited-entry trawl sector, the frequency of bycatch of corals and sponges in fixed gear sectors is markedly less.

Unlike the fixed gear and limited-entry trawl sectors, observer coverage in the at-sea hake fleet is very near 100 percent. Like the fixed gear sectors, bycatch of corals and sponges in the at-sea hake fleet, as recorded by observers of the At-Sea Hake Observer Program (ASHOP), is relatively rare (Table 7). This is most likely due to the fact that the at-sea hake fleet uses mid-water trawl gear, which typically does not contact the seafloor. Between 2000 and 2010, only 38 kg of combined bycatch of corals, bryozoans, sea pens/whips and sponges have been recorded for vessels in the at-sea sector. Bycatch was only recorded in 0.4 percent of all observed tows in that 11-year period. Although frequency and standardized catch (CPUE) have decreased in the last 5 years, the relatively low rate of bycatch makes it difficult to interpret any meaning from that change.

Table 6. Summary of coral and sponge bycatch metrics for observed sets using fixed gears as part of the West Coast Groundfish Observer Program (WCGOP), comparing two time periods: "Before" (3 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. "#" denotes number of sets with recorded bycatch; "FREQ" denotes ratio of sets with bycatch to total sets observed; "Weight" denotes bycatch (lb.); "CPUC" denotes bycatch per unit of groundfish catch (units: lb./ton GF). Set counts represent only those where corals or sponges were present in the catch.

	Before				After				Before + After			
	#	FREQ	Weight	CPUC	#	FREQ	Weight	CPUC	#	FREQ	Weight	CPUC
coral	49	1.0%	68	2.2E-02	39	0.6%	25	6.5E-03	88	0.7%	93	1.3E-02
sea pen/whip	18	0.4%	8	2.6E-03	7	0.1%	12	3.1E-03	25	0.2%	20	2.9E-03
sponge	36	0.7%	131	4.3E-02	41	0.6%	110	2.8E-02	77	0.7%	241	3.5E-02
	102	2.0%	207	6.8E-02	83	1.2%	147	3.8E-02	185	1.6%	354	5.1E-02

Table 7. Summary of coral and sponge bycatch metrics for observed tows using mid-water trawl gears as part of the At-Sea Hake Observer Program (ASHOP), comparing two time periods: 2000-05 and 2006-10. "#" denotes number of tows where bycatch was recorded; "FREQ" denotes ratio of tows with bycatch to total tows observed; "Weight" denotes bycatch (kg); "CPUE" denotes bycatch per unit of effort (units: kg/hr.). Tow counts represent only those where corals or sponges were present in the catch.

	2000-05				2006-10				2000-10			
	#	FREQ	Weight	CPUE	#	FREQ	Weight	CPUE	#	FREQ	Weight	CPUE
			9.8	3.6E-04			0.4	1.1E-05			10.2	1.7E-04
			17.3	6.4E-04			10.9	3.2E-04			28.1	4.6E-04
			0.1	1.9E-06			0.0	NA			0.1	8.2E-07
	67	0.5%	27.2	1.0E-03	33	0.2%	11.2	3.3E-04	100	0.4%	38.4	6.3E-04

3.3 Associations of Groundfish with Habitats

Appendix B.2 (McCain et al. 2005) of the Groundfish FMP (PFMC 2011a) includes composite life history, geographical distribution, and habitat association information for 82 FMU species. Appendix B2 was intended to be a "living" document, and includes information published prior to or during 2004 for 82 FMP species (McCain et al. 2005). Relevant new spatial and trophic information published during 2004-2011 was compiled and summarized for the 91 currently designated FMP species.

Knowledge of spatial associations (e.g., range and depth designations, distribution and abundance estimates, habitat associations, environmental correlates) and trophic interactions (e.g., diet composition, predators, foraging habitat, trophic position) is necessary for an accurate description of EFH. A thorough search was conducted for each of the 91 current FMP species in order to identify and compile all relevant new literature. Initially, a species' synonymy was reviewed using the California Academy of Science's Catalog of Fishes (Eschmeyer and Fricke 2011) to determine if any changes in the scientific name had occurred since the last review. If a recent name change was indicated, the prior scientific name was included in literature searches. The pertinent FishBase (Froese and Pauly 2011) species profile was then accessed and reviewed for information and literature relevant to EFH. Aquatic Science and Fisheries Abstracts, Biosis, Web of Science, and Zoological Record databases were used to locate any peer–reviewed publications, technical reports, student theses, book chapters, or other relevant literature that were produced during 2004–2011. All applicable new information, regardless of study region or publication language, was amassed from directed scientific research, fishery–independent surveys, and pertinent laboratory trials. Only field studies occurring in the eastern North Pacific were considered to restrict extraneous literature pertaining to species with amphi-Pacific or cosmopolitan distributions. A synthesis of new trophic and spatial information for each life stage (i.e., eggs, larvae, juveniles, adults) of the 91 designated groundfish species is included in Appendix G of this report. Results of predictive modeling efforts and literature restricted to these methods were not included and instead are covered in Section 3.4.1 of this report ("Description of Available Models"). A bibliography consisting of the totality of the identified literature is included as Appendix G.

3.3.1 Groundfish Species Group Summaries

The general structure of this Section and Appendix G is consistent with the composition and relative order of the species groups designated in the FMP for Pacific Coast groundfishes. These groups include: Flatfishes (N = 4 species), Other Flatfishes (N = 8), Rockfishes (N = 15), Other Rockfishes (N = 49), and Other Groundfishes (N = 15). However, the level of detail provided in this chapter is much more limited than that of McCain et al. 2005 by necessity and design. Thorough species accounts that incorporate all relevant information for each life stage (i.e., eggs, larvae, juveniles, adults) were constructed for the four flatfish species (Appendix G-1), Other Flatfish (Appendix G-2), Rockfishes (Appendix G-3), Other Rockfishes (Appendix G-4), and Other Groundfish (Appendix G-5). These are included as analogs to the species accounts provided by McCain et al. 2005 as a way to gauge the possible future utility of such an effort for all 91 species. The summaries below generally synthesize new information on spatial associations and trophic interactions that are pertinent to the designation of EFH for each of the five designated groundfish groups.

3.3.1.1 Flatfishes

New literature on spatial associations and trophic interactions of the Flatfishes group consisted of 64 publications, with several publications providing information for multiple species (Appendix G-1). Arrowtooth flounder was the most studied flatfish (39 publications), whereas petrale sole was the least studied (12 publications). Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al.

2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). However, directed studies provided more specific information that often built upon previous research and was of greater relevance for the description of EFH. Several such studies integrated contemporary and historic physical and biological data to provide detailed explanations for observed life–stage specific spatial patterns (e.g., Abookire et al. 2007; Bailey et al. 2008). More new spatial information was available when compared to trophic information, a situation that reflects the relative amount of scientific attention as well as the substantial contribution of newly published fishery-independent survey data.

A common element of contemporary spatial studies involving flatfishes is the integration of physical, environmental, and biological data. Integrated data sets were commonly used to explain distribution and abundance patterns, especially as they related to reproductive movements and environmental tolerances. Knowledge of seasonal and ontogenetic movements of arrowtooth flounder, Dover sole, and English sole was considerably enhanced, with research conducted in Alaskan (e.g., Logerwell et al. 2005; Blood et al. 2007) and West Coast (Chittaro et al 2009; Toole et al. 2011) regions. In addition, focused research greatly expanded knowledge regarding estuarine use of (primarily juvenile) English sole and emphasized the likely importance of these environments to population maintenance (Rooper et al. 2004; Brown et al. 2006a, b). Hypoxic conditions were found to be especially deleterious to petrale sole, but did not adversely affect English sole or Dover sole (Keller et al. 2010). Dover sole was also resilient to trawling disturbance (Hixon and Tissot 2007). Arrowtooth flounder populations in the eastern Bering Sea appear to be expanding as a result of ocean warming (Zador et al. 2011).

New information on trophic interactions was available for all members of the Flatfishes group to a variable degree (Appendix G-1). Arrowtooth flounder diet composition has been extensively studied in recent years throughout Alaskan (e.g., Yang et al. 2006; Knoth and Foy 2008) and Canadian (Pearsall and Fargo 2007) waters. These studies demonstrated the prevalence of piscivory, which increased with size, and a high proportion of pelagic prey. Dover sole in the Gulf of Alaska (Yang et al. 2006) and Hecate Strait (Pearsall and Fargo 2007) and English Sole in Hecate Strait (Pearsall and Fargo 2007) exhibited very similar diets consisting mainly of polychaetes and other benthic invertebrates and fed at a lower trophic level than Arrowtooth flounder. The prey composition of these species reflected foraging in unconsolidated habitats, especially those composed of mud. A single study indicated that petrale sole diet composition in Hecate Strait consisted primarily of fishes (especially Pacific herring) (Pearsall and Fargo 2007), in contrast to historic studies that showed a greater reliance on decapod crustaceans. Several new trophic linkages were established between the described flatfishes and their predators, which included seabirds (Iverson et al. 2007), pinnipeds (Reimer and Mikus 2006; McKenzie and Wynne 2008), and fishes (Trites et al. 2007; Pearsall and Fargo 2007). Food web modeling efforts in the Gulf of Alaska revealed the considerable importance of arrowtooth flounder to regional trophic dynamics, including a predator/prey feedback loop with walleye pollock (Aydin and Mueter 2007; Gaichas and Francis 2008; Gaichas et al. 2010).

Some biases and limitations were evident among relevant, recent publications and should be considered when interpreting results. Several studies distinguished juvenile and adult life stages based on size-at-maturity information rather than more cumbersome external inspection. Size may not be an accurate proxy for maturity, however, especially when reference information is derived from a different region. Trawl surveys were mainly conducted during spring and summer months on unconsolidated substrate, which restricts a comprehensive understanding of temporal or habitat-based variability. Tests of sample size sufficiency were limited to a single Steller Sea Lion diet composition study. These tests are especially important in diet composition research as most groundfishes are generalist predators with considerable intraspecific dietary variation. In addition, all diet studies used pooled rather than individual–specific prey data. This practice precludes the determination of intraspecific variability in diet composition and biases results to samples with high numerical or gravimetric contributions. Finally, only basic spatial information was provided for most diet studies, which prevented a detailed understanding of the relative use of foraging habitats.

3.3.1.2 Other Flatfishes

New literature on spatial associations and trophic interactions of the Other Flatfishes group consisted of 66 publications, with several publications providing information for multiple species (Appendix G-2). Most Other Flatfishes were well studied, with rex sole (41 publications), flathead sole (38 publications), and rock sole (31 publications) foremost among them. Curlfin sole (10 studies) and sand sole (12 publications) were referenced least among the accumulated literature, with most relevant information contained in survey reports. Data on Pacific and speckled sanddabs and southern and northern rock sole were occasionally pooled because of uncertain identification (e.g., Love and York 2005; McKenzie and Wynne 2008) or for convenience during multi–species analyses (e.g., Hoff 2006; Gaichas and Francis 2008). To avoid confusion, the current designation of "rock sole" should be changed to the proper common name of "southern rock sole" in accordance with American Fisheries Society guidelines. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). In addition, many directed studies provided information on a wide variety of topics related to EFH (e.g., habitat associations, physiological tolerances, trophic relationships), at various levels of detail. Much more new spatial information was available when compared to trophic information, and no new diet composition information was produced along the West Coast.

3.3.1.3 Rockfishes

From 2004–2011, 90 publications that contain information on spatial associations and/or trophic interactions were located for the Rockfishes group (Appendix G-3). Most publications reported information for multiple species and species were occasionally combined for convenience or because identification was uncertain (e.g., Lauth et al. 2004; Wilson et al. 2008; Marilave and Challenger 2009). Shortspine thornyhead (34 publications) and Pacific ocean perch (30 publications) were the most studied rockfishes, whereas blackgill (6 publication) and chilipepper (8 publications) were the least studied. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). However, the great majority of this information was derived from trawl surveys, which are limited in their capability to sample rocky substrates and therefore under–represent the distribution and abundance patterns of most rockfishes (PFMC 2011a). Results of these surveys should therefore be interpreted cautiously for the Rockfishes group. In addition, many directed studies focused on specific aspects of resource utilization (i.e., spatial associations, trophic relationships) and provided detailed information that was relevant for the description of EFH. Only 15 of the 89 contemporary publications contained trophic information, and there is a dearth of recent diet composition information for Rockfishes throughout the eastern North Pacific.

3.3.1.4 Other Rockfishes

New literature on spatial associations and trophic interactions of the Other Rockfishes group consists of 85 publications, with several publications providing information for multiple species (Appendix G-4). Species were sometimes combined for convenience or because identification was uncertain (e.g., Beaudreau and Essington 2007; Wilson et al. 2008; Frid and Marliave 2010). The most studied Other Rockfishes were rougheye (26 publications), copper (25 publications), greenstriped (25 publications), and redbanded (25 publications). Many species received sparse scientific attention, and no information was available for bronzespotted, California scorpionfish, chameleon, and semaphore rockfishes. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). In addition, many directed studies were published and provided information on a wide variety of topics related to EFH (e.g., habitat associations, genetics/distribution, and movement patterns). Although a substantial amount new spatial information was available, trophic information was comparatively sparse; a situation that reflects the relative amount of scientific attention as well as the substantial contribution of newly published fishery–independent survey data. Nine new species were added to the Other Rockfishes group since the last EFH review was conducted (chameleon, dwarf–red, freckled, halfbanded, pinkrose, Puget Sound, pygmy, and semaphore, and swordspine rockfishes). Literature reviews for these species were performed from 2002–2011 and references published during 2002–2003 (Bernardi et al. 2009; Johnson et al. 2009) are listed below. For historic information on these species, refer to Love et al. (2002). In addition, the species name of the dusky rockfish is listed incorrectly as Sebastes ciliatus in the current list of FMP groundfish species. Sebastes ciliatus refers to the more northernly distributed dark rockfish, whereas the dusky rockfish (*S. variabilis*) ranges throughout most of the U.S. West Coast (Orr and Blackburn 2004). The information and literature referenced here therefore refers to the dusky (S. variabilis), not dark (*S. ciliatus*), rockfish.

3.3.1.5 Other Groundfishes

The Other Groundfishes group contains 15 species that, unlike the other groups, are not monophyletic (i.e., derived from a single, common ancestral species). Therefore, for the purposes of this review, the following subcategories were established based on taxonomic relatedness: 1) chondrichthyan, or cartilaginous, fishes (big skate, California skate, leopard shark, longnose skate, spiny dogfish, spotted ratfish, tope), 2) gadiform fishes, or cods (Pacific cod, Pacific flatnose, Pacific grenadier, Pacific hake), and 3) scorpaeniform, or mail–cheeked, fishes (cabezon, kelp greenling, lingcod, sablefish). New literature on spatial associations and trophic interactions of Other Groundfishes consisted of 120 publications, with the designated subgroups receiving comparable scientific attention (Chondrichthyes, N = 58; Gadiformes, N = 64; Scorpaeniformes, N = 63) (Appendix G-5). Among species, lingcod (N = 42), Pacific cod (N = 42), and Pacific hake (N = 34) were most studied, whereas few publications contained relevant information about cabezon (N = 2), tope (N = 5), or California skate (N = 5). Most of the available information, and certainly the most comprehensive, was obtained from directed studies. However, fishery–independent surveys provided general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g., Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). The North Pacific spiny dogfish population was recently determined to be distinct from other global populations of spiny dogfish, *Squalus acanthias*, and renamed the spotted spiny dogfish, *S. suckleyi* (Ebert et al. 2010). This name change should be reflected in future documents. More new spatial information was available when compared to trophic information, a situation that reflects the relative amount of scientific attention as well as the substantial contribution of newly published fishery–independent survey data.

3.4 Modeling Distribution of Seafloor Habitat Types

Since 2005, a significant amount of research and modeling has been conducted regarding biogenic habitat. Habitat surveys have been conducted using sidescan and multibeam sonar, human-occupied submersibles, and remotely operated vehicles (ROVs). Several surveys have documented the interactions between groundfishes, other demersal fishes, invertebrates, and benthic habitats. Of particular importance in the future will be the determination of the distribution and abundance of biogenic species including deep water corals and their role and importance to the groundfish ecosystem.

Guinotte and Davies modeled significant areas of highly suitable deep-sea coral habitat both within and outside existing NMS and EFH area closure boundaries. Total summed model values highlight existing EFH area closures encompass the majority of predicted suitable habitat for Order Antipatharia and Suborders Alcyoniina, Calcaxonia and Scleraxonia. However, the majority of suitable habitat for Suborder Holaxonia and Order Scleractinia was predicted in areas outside of existing EFH area closure boundaries. This study is significant in the context of the EFH review, as no habitat suitability models for West Coast corals were available in 2005.

The EFHRC considered using new modeling applications that could be useful for assessing groundfish habitat suitability. Models can be used to infer distribution of habitats or species in areas that lack data and to increase the precision of distribution maps.

3.4.1 Description of Available Habitat Models

A model is a simplified, sometimes theoretical, representation of a real–world system. In any modeling effort, there is a trade–off between simplicity and complexity that is typically contingent on the question of interest and the amount and quality of the input data. A key to understanding the utility of a model, no matter the degree of complexity, is the acknowledgement that the model will not fully describe the study system completely or correctly, and acceptance of the possibility that many presumed interactions may not represent reality (Field 2004). Consequently, model results are best treated in a general sense to pinpoint major findings, key processes or drivers in study systems, and to direct future research. Three general categories of models (spatially explicit, trophodynamic, and integrated ecosystem), relevant to the determination and designation of EFH for Pacific groundfishes, are summarized in this section and comprehensively considered in Appendix H.

3.4.1.1 Habitat Suitability Probability Model

A habitat suitability probability (HSP) model, termed the "EFH Model" (PFMC 2011a), was developed in 2004 by NMFS and outside contractors, and used in the 2008 West Coast Groundfish FMP (MRAG Americas Inc. et al. 2004). The model incorporated three basic variables (seafloor substratum type, depth, and location) to describe and identify EFH for each life stage of federally managed groundfishes and presents this information graphically as an HSP profile (PFMC 2011a). Based on the observed distribution of a groundfish species/life–stage in relation to the input variables, locations along the West Coast were assigned a suitability value between 0 and 100 percent in the creation of the HSP profile. These scores and their differences among locations were used to develop a proxy for the areas that can be regarded as "essential." The EFH Model provided spatially explicit HSP estimates for 160 of 328 groundfish species/life stage combinations, including the adults of all FMU species (PFMC 2011a). The remaining 168 species/life stages were not completed because of insufficient data. In 2005, when the HSPs of all species/life stages were combined, all waters and bottom areas at depths less than 3,500 m were determined to be groundfish EFH.

The data used to determine HSP values exhibited some biases and limitations, and have been subject to continued refinement. Among the primary concerns regarding the validity of model outputs are the use of disparate data sets and data of variable quality. The EFH Model has remained static and has not been used since its original construction. However, modification of the model is currently underway by personnel at Oregon State University's Active Tectonics and Seafloor Mapping Laboratory and industry collaborators through support of the Bureau of Ocean Energy Management (C. Goldfinger, Oregon State University, pers. comm.). In addition, updates to the HUD (see Section 3.5.4 of this report) and significant amounts of new spatial and trophic information associated with Pacific groundfishes and life stages (see Section 3.3 of this report) also can be used to improve the predictive capabilities of the HSP Model.

Accurate estimates of groundfish distributions are critical for effective spatial management through improved stock assessments and the design of marine protected areas (MPAs) and EFH closed areas. Strong, consistent benthic habitat associations of many groundfishes, in conjunction with recent advances in acoustic seafloor mapping techniques, suggest that habitat determination may serve as a proxy for predicting groundfish distribution and abundance at broad regional scales (Anderson et al. 2009). Therefore, it should be possible to model and predict these spatial patterns using habitat maps and quantified habitat relationships. The previously described EFH Model represents one such effort to model groundfish distributions based on selected habitat variables. Four additional modeling efforts that attempt to explain or predict groundfish distributions off the West Coast recently have been published. Three of these were conducted in continental shelf waters off central California using presence/absence observation data (Iampietro et al. 2005, 2008; Young et al. 2010). In a more expansive study, Tolimieri and Levin (2006) examined composition and variation in West Coast groundfish assemblage structure on the upper continental slope in relation to temperature, year, depth, latitude, and longitude. Results of these fish–habitat modeling efforts were generally promising in their potential application to current management efforts and for the development of future studies. However, there are some caveats and limitations that should be considered (Appendix H, Section 2.2). For example, it is important to recognize that predictive distribution models estimate potential habitat suitability, rather than realized, habitat suitability, which represents a more limited spatial area.

Biogenic habitat modeling techniques have typically been developed for data–rich, terrestrial systems. However, recent increases in the quality and quantity of physical and biological seafloor data have supported development and application of these models in marine benthic systems. Off the West Coast, biogenic habitat modeling recently has been used to predict distribution and abundance patterns of structure–forming marine invertebrates (SFMI) (e.g., corals, sponges). SFMI have received considerable scientific attention because of their potential role as EFH for groundfishes and because they are generally vulnerable to human impacts.

Biogenic habitat modeling efforts relevant to the West Coast are less than 10 years old, but interest is growing and the field is rapidly advancing. At least six research efforts have utilized models to predict coral distributions on a coastwide or global scale, using coarse taxonomic categories and presence–only data (e.g., Clark et al. 2006; Bryan and Metaxas 2007; Tittensor et al. 2009). However, three regional studies incorporating presence–absence data and more specific taxonomic categories recently have been conducted (Graham et al. 2010; Etherington et al. 2011; Krisgman et al. 2012). Modeling techniques may provide the best available estimates of distribution, abundance, and habitat characteristics for SFMI, at least until more empirical data become available. However, many limitations and challenges exist that may impact the accuracy of model results, including: highly correlated and potentially incomplete environmental variables, the selection of appropriate spatial and temporal resolutions, and limited distribution and abundance data for SFMI (Appendix H, Section 2.3). Therefore, careful consideration should be taken when using modeling results for management and conservation purposes, especially those derived from presence–only models.

3.4.1.2 Ecopath/Ecosim Models

Ecopath, typically coupled with the dynamic companion model Ecosim, has become the standard for trophodynamic modeling not only off the West Coast but also throughout the world's marine and freshwater regions. Ecopath is a static (typically steady–state) mass balance model of trophic structure that integrates information from diet composition studies, bioenergetics models, fisheries statistics, biomass surveys, and stock–assessments (Field 2004). It represents the initial or reference state of a food web. Ecosim is a dynamic model in which biomass pools and vital rates change through time in response to simulated perturbations. Different species or functional groups are represented in Ecopath as biomass pools with their relative sizes regulated by gains (consumption, production, immigration) and losses (mortality, emigration). Biomass pools are typically linked by predation, though in some cases reproduction and maturation information is also included. Fisheries act as super–predators, removing biomass from the system. The Ecopath model framework allows investigators to evaluate how well conventional wisdom about a system of interest holds when basic bookkeeping tools are applied, to pool together species and into a coherent food web, and to evaluate trophic interactions (Field 2004). The combined model allows users to simulate ecological or management scenarios, such as the response of the system to changes in primary productivity, habitat availability, climate change, or fishing intensity (Harvey et al. 2010). Off the West Coast, the Ecopath model has been used to investigate the trophic role of large jellyfish in the Oregon inner–shelf ecosystem (Ruzicka et al. 2007), and the combined Ecopath/Ecosim model has been used to evaluate dynamic food web structure in the Northern California Current (NCC) (Field 2004) and Puget Sound (Harvey et al. 2010). These modeling efforts provided important information for an improved understanding of ecosystem dynamics. However, a lack of adequate data is the most pervasive limitation of food web models, which results in many unknown or generally estimated input parameters.

3.4.1.3 Atlantis Model

The primary tool used in integrated ecosystem modeling (especially in Australia and the United States) is the Atlantis Model (Fulton et al. 2004). Although it was originally focused on biophysical and fisheries aspects of an ecosystem, Atlantis has been further developed to consider all parts of marine ecosystems (i.e., biophysical, economic and social). All integrated ecosystem models require massive data inputs and must therefore strike a balance between simplicity and complexity, or tractability and realism. The systematic exploration of the optimum level of model complexity is one of the key strengths of the Atlantis Model. It can be used to identify which aspects of spatial and temporal resolution, functional group aggregation, and representation of ecological processes are vital to model performance. The Atlantis modeling approach primarily has been used to address fisheries management questions, but increasingly is being implemented to consider other facets of marine ecosystem use and function (CSIRO 2011). Off the West Coast, the Atlantis framework was recently used to construct a preliminary spatially explicit ecosystem model of the NCC (Horne et al. 2010), and is a fundamental tool in use by the Integrated Ecosystem Assessment Team to meet the goals of the Ecosystem Plan Development Team. Field's (2004) food web model (Ecopath) was incorporated as the foundation for model creation, building on prior results and parameterization. The NCC Atlantis Model is currently being refined and expanded by the Integrated Ecosystem Assessment Team. Once complete, it is expected to be a powerful management tool, providing a platform to address important hypotheses relating to the effects of perturbations (e.g., fisheries exploitation), characterize the potential trade–offs of management alternatives, and test the utility of ecosystem indicators for long–term monitoring programs (Horne et al. 2010). Ultimately, the model should have substantial utility in identifying which policies and methods have the most potential to inform ecosystem–based management on the U.S. West Coast.

3.4.1.4 Summary

Modeling efforts are being developed to meet NOAA's overall management goals and to specifically inform policy decisions regarding the determination and designation of EFH. These efforts have advanced substantially since the Amendment 19 process. Although the construction and application of spatially explicit, trophodynamic, and integrated ecosystem models mainly have been prompted by management needs, recent modeling studies have been facilitated by a considerable increase in the amount of available input data. Long–term NMFS surveys are an important source of biological data on species occurrence, biomass, and population changes. However, rapid advances in the collection and quality of seafloor acoustic data are the main drivers of contemporary modeling efforts in the marine demersal environment.

Recent advancements aside, the greatest limitation to the success of current and future modeling efforts remains the quantity and quality of input data for the West Coast marine region. The accuracy and consistency of model outputs are directly contingent on the input data that are used. When input data are sparse, generalized, or interpolated, model results should be viewed skeptically. Data limitation is an unfortunate consequence of modeling in marine environments, but its effects can be mitigated. A key element when dealing with limited data inputs is to formulate appropriate objectives and hypotheses. This practice will produce more reliable results even if the scope of the study must be limited. In addition, model construction can serve as a gap analysis to identify data limitations and inform future research needs and priorities. As data gaps are identified and filled, model results will become more robust and have increased utility for ecosystem understanding, management strategy evaluation, and policy formation.

3.5 Habitat Use Database

The Habitat Use Database (HUD) was developed byNMFS NWFSC scientists as part of the 2005 Pacific Coast Groundfish Essential Fish Habitat Environmental Impact Statement (EFH EIS) (NMFS 2005). Specifically, the HUD was designed to address the need for habitat-use analysis supporting groundfish EFH, HAPCs, and fishing and non-fishing impacts components of the EFH EIS. The 2005 database captured information on habitat use by Pacific Coast groundfishes covered under the FMP as documented in the updated life history descriptions found in Appendix B.2 of the EFH Final EIS, (NMFS 2005). The groundfish life history descriptions are the product of a literature review that collected and organized information on the range, habitat, migrations and movements, reproduction, growth and development, and trophic interactions for each of the FMU species by life stage.

Thus, the scope of the 2005 HUD was narrow and specific, well integrated with the EFH EIS, and provided a flexible and logically structured information base. The HUD was implemented during the Pacific Coast Groundfish EFH EIS by providing habitat preference and species distribution information to the HSP model (PFMC 2011a) for a subset of FMP species where catch or fishery independent data was insufficient for modeling. That is, fishery independent survey data (WCGBTS) was used preferentially for HSP modeling when possible.

After the 2005 EFH EIS was published, the NWFSC placed selected HUD tables and summary database "views" online through the Pacific Coast Ocean Observing System (PaCOOS) West Coast Habitat Server (deployed in Jan. 2006). The PaCOOS site provides OPeNDAP (a framework and software solution for scientific data networking) access to live database tables served from NWFSC. PaCOOS also provides a web map interface to the HUD through its spatial query tool. In addition to providing wide public access to the HUD through PaCOOS the NWFSC also made data updates and amendments, platform changes, and taxonomic additions to the database over the period from 2006 to present. The 2011 HUD now includes species other than FMP species, specifically species identified under Oregon's Nearshore Strategy (Don et al., 2006). Additionally, a HUD workshop team at OSU identified important benthic invertebrate species that represented a key taxonomic gap in the HUD. This list of candidate benthic invertebrate species awaits further development of habitat associations, range, and distribution information before incorporation into the HUD.

Despite open and public access to the HUD it is not in wide use for research or management purposes outside of the PaCOOS implementation or the current EFH 5-Year Review. Although the HUD has undergone growth in taxonomic richness over the past five years, one potential reason the HUD has not seen much application in Integrated Ecosystem Management or Marine Spatial Planning yet is that the database remains FMP species centric and is summary in nature. Conventional deterministic modeling techniques use presence/absence, abundance, and density inputs, and are not well matched to this summary format. Renewed development of a probabilistic, Bayesian Network model for Pacific Coast groundfish habitat suitability by the Oregon State Active Tectonics and Seafloor Mapping Lab is helping to maintain the HUD (Chris Romsos, Oregon State University, pers. comm., Feb. 10, 2012).

3.5.1 Data Structure and Software Platform

The HUD was originally developed as a Microsoft Access® relational database application by MRAG Americas Inc. consultants to the 2005 EFH EIS. The 2005 Microsoft Access® HUD was a complete database package and included forms for data entry, stored procedures to check database and referential integrity, and a reference document. The MS Access database format also provided a Graphical User Interface to the database thus allowing fisheries research scientists to build and maintain the database. In 2006, the database was migrated to an Oracle® enterprise class database to better support public access and the internet application needs of the PaCOOS West Coast Habitat Server. This platform migration provided a more stable technology stack to build web applications upon, but also moved management and maintenance out of the hands of fisheries research staff and under the control of IT and Database Administrator staff at the NWFSC. Regrettably, this change has made it more difficult for fisheries scientists to interact with the database by including additional layers of management and technical complexity.

Despite the somewhat higher technical and administrative walls around the HUD, the underlying data structure of the 2005 HUD remains intact in the current installation (Bob Gref, NMFS NWFSC pers. comm., Aug. 29, 2011). Entity Attribute Relationship diagrams from both the 2005 and 2011 databases (Appendix I-1, Figures I-1.1 and I-1.2) show that the original structure of 24 tables and attributes have been maintained through the software platform migration. Appendix I-1 Table I-1.1 provides a listing and a short description of each HUD table.

3.5.2 Comparing the 2005 and 2011 HUD

The 2005 HUD was designed and constructed to keep data redundancy to a minimum. Information about habitat preference and use by species is broken down into tables (relations) of entities and unique attributes. Taken together these relations provide a platform for developing interrelated lines of analysis in the HUD (NMFS 2005). However, this computing structure can obfuscate, making it difficult to accurately describe what's inside the database. For example, a simple query of the species table yields total species counts (species richness), but no other information about the level of completeness for the habitat associations underlying each record. The query must be further specified by including additional tables to understand the extent of information in the HUD. Therefore, in contrasting the 2005 and 2011 HUD, we describe the HUD in terms of both its scope (number of taxa recorded) and its extent (completeness of related data).

3.5.2.1 The 2005 HUD: Scope and Extent

As previously stated, the 2005 HUD was developed from the Groundfish Life History Descriptions which was a revision of life history descriptions completed in 1998 (Casillas et al. 1998). The Pacific Coast groundfish taxonomic richness of the 2005 HUD included 87 species of groundfish, all 82 2005 FMU species plus five species soon to be included as Pacific Coast groundfish under the FMP (Appendix I-2 Table I-2.1). In addition to these 87 groundfish species, the 2005 HUD included 24 species identified as groundfish predators, 73 species identified as groundfish prey, two species identified as both groundfish predators and prey, and seven ungrouped species. Total species richness of the 2005 HUD was 193 species.

Only 81 of the 193 species in the 2005 HUD have corresponding habitat preference and distribution information (Table B.2). None of the non-groundfish species (i.e. predators, prey, predator and prey, or ungrouped species) have habitat preference or association information. This is, however, an expected level of completion, because the 2005 HUD was developed from the Updated Life History Documents covering only FMU species. It is therefore not surprising that any of the other species groups are incomplete in terms of habitat association or distribution information because there had not been any formal review of predator or prey life histories in Amendment 19.

In addition to providing an accounting of groundfish range and habitat preferences, the HUD was also designed to record information about groundfish prey items and about groundfish as prey. The source of prey information is the Groundfish Life History Descriptions found in Appendix B.2 of the EFH Final EIS (NMFS 2005) and the groundfish FMP (PFMC 2011a). HUD predator and prey tables were not intended to be comprehensive for West Coast marine communities at the time the HUD was created, but they provide a flexible database framework to build this knowledge upon now.

The HUD records any unique combination of Predator, Predator Gender, Predator Lifestage, Prey, Prey Gender, Prey Lifestage, and the Habitat Type where predation occurs as a row in the Prey (groundfish as predators) or Predators (groundfish as prey) tables. There are 1,348 records of groundfish as predators and 510 accounts of groundfish as prey in the 2005 HUD. Records occur in one of the two HUD predation tables and correspond to any account of predation noted from the literature during the review. It was not known if all accounts of predation were uniformly reported or if efforts were made to standardize the taxonomic reporting level across the body of work. For this reason it is important to understand that this accounting of groundfish predation in the HUD should be considered developmental and not comprehensive.

Appendix I-2, Table I-2.3 shows prey items for groundfish adults, juveniles, and larvae illustrating the application cautions noted above. Non-uniform taxonomic groupings were found throughout the Predator and Prey tables. For example, a dark grey color is used to highlight the mixed reporting level for fish in the Adult Groundfish Prey group. Despite this limitation, the prey tables in Appendix I-2 do reveal general and important prey item differences across groundifsh developmental stages. The top 10 prey items occurring most frequently in the literature have been shaded light grey showing that adult groundfish feed on higher trophic level prey while the earlier developmental stage groundfish are feed on lower trophic level planktonic prey. Further review of the predator and prey tables within the HUD is needed to determine their application for identifying EFH.

3.5.2.2 The 2011 HUD: Scope and Extent

The first additions to the HUD, post 2005 EFH EIS, were to increase the Pacific Coast groundfish species count from 82 to 91 by adding the additional four new FMP groundfish species: *Sebastes phillipsi* (chameleon rockfish), *Sebastes lentiginosus* (freckled rockfish), *Sebastes semicinctus* (halfbanded rockfish), *Sebastes simulator* (pinkrose rockfish), *Sebastes rufinanus* (dwarf-red rockfish), *Sebastes emphaesus* (Puget Sound rockfish), *Sebastes melanosema* (semaphore rockfish), *Sebastes wilsoni* (pygmy rockfish), *Sebastes melanosema* (semaphore rockfish), and *Sebastes ensifer* (swordspine rockfish). Subsequently, four other coastal pelagic species and their life history information (habitat, depth, and latitude associations) were added: *Clupea pallasii* (Pacific herring), *Engraulis mordax* (Northern anchovy), *Loligo opalescens* (market squid), and *Sardinops sagax* (Pacific sardine).

The ODFW *Oregon Nearshore Strategy* (ODFW, 2006) provided summary habitat associations with various species, but lacked distribution information or indexed references for the associations. In 2007, the PaCOOS West Coast Habitat Server development team (now informally overseeing the HUD) identified these species as important for diversifying the HUD. The addition of these species addressed obvious taxonomic gaps in the HUD and enhances the potential uses of the HUD, specifically as a tool suitable for applications in ecosystem assessment or marine spatial planning. The life history information for these species was formally reviewed by NWFSC staff before being added to the HUD. Distribution information was developed from the literature and references for habitat associations were collected during this review.

This update created three new levels within the "Plans" table of the HUD and provided 247 potential new species records to the HUD. However, many of the species from the *Oregon Nearshore Strategy* (Appendix I-3) were already accounted for in the HUD under the Pacific Coast Groundfish FMP, the Coastal Pelagic Species FMP, or Predator groupings, creating significant species overlap among plans in the HUD. Ultimately, 126 new species from the potential list of 247 species were added to the HUD as new species records (Appendix I-2). Therefore, in summary the taxonomic richness or "Scope" of the 2011 HUD grew from 193 to 323 with the addition of the four new FMP Groundfish, the four coastal pelagic species, and the 126 Oregon Nearshore Plan species (Appendix I-3; note the loss of four predator species in the 2011 HUD).

The species group by life stage summaries presented in Appendix I-2 Tables I-2.5a-d and I-2.6a-d provide glimpses into the "Extent" or level of life history completeness of the current 2011 HUD. The tables presented under I-2.5 describe the level of habitat association completeness while the I-2.6 tables describe the distribution (Latitude & Depth Range) completeness. In general, adult life stage has the highest level of HUD completeness; 213 of 323 adult life stage species have habitat distribution information and 148 of 323 adult life stage species have latitude and depth distribution information. Juvenile life stage species have 80 species with habitat associations and 80 species with distribution information. Larvae and egg life stages have 65 and 26 species with habitat associations and 65 and 26 species with distribution information respectively. Thus, level of completeness in the HUD increases with each successive level of development.

Findings for adult life stages (Appendix I-2 Tables I-2.5a and I-2.6a) show that FMP species have complete habitat association and distribution information. There remains no habitat association or distribution information for predator or prey species groups in the 2011 HUD (unchanged from 2005). *Oregon Nearshore Strategy* species (Appendix I-3) have a high level of completeness across Habitat Association and Distribution domains with the exception of Commonly Associated List species, which has no available distribution information (Appendix I-2 Table I-2.5a).

3.5.3 Using the HUD with Geographic Information Systems (GIS)

The HUD stores spatial information in the OCCURRENCE (Habitat Associations) and SPECIESLIFESTAGE (Depth, Latitude, Temperature, and Oxygen, requirements and preferences) tables. Latitude and depth preferences and requirements can be readily mapped over bathymetry within a GIS. Therefore, both latitude and depth may be used to define range envelopes for any species with complete distribution information in the database. Habitat Association information on the other hand is much more difficult to map because HUD habitat codes (PLACETIME IDs) are unique and do not conform to any geographic habitat mapping standard or scheme in use today.

A "crosswalk" table has been developed for the 2005 EFH EIS HSP modeling effort so that HUD PLACETIME habitat codes could be matched to codes from the Washington, Oregon, and California seafloor habitat maps (MRAG, 2005). This matching allows for a specific Habitat Association to be mapped spatially over a seafloor habitat map.

The nature of the relationships between HUD codes and the seafloor habitat codes is many-to-many. However, because the Access database does not support many-to-many relationships, a one-to-one crosswalk table is implemented (Appendix I-4). Note that despite the one-to-one table format, the crosswalk table maintains the many-to-many relationship. In 2005, 24 unique HUD PLACETIME codes were mapped to 36 unique seafloor habitat codes in 59 one-to-one relations.

The crosswalk table has undergone several updates since 2005. The first update was prompted when the PaCOOS West Coast Habitat Portal was published. The portal includes a tool to lookup species given a geographic map selection. To accommodate this lookup the crosswalk table had to be improved so that each seafloor habitat type from the Oregon and Washington Version 2 SGH map was accounted for in the crosswalk table. The crosswalk table has also been updated each time a new habitat map version was released. Currently the crosswalk has grown to include 108 unique seafloor habitat codes (from Oregon and Washington SGH Map Version 3.2 and the original California regional habitat map) and 116 unique HUD codes in 639 one-to-one relations (Appendix I-5).

3.5.4 Pending Updates

On May 6th, 2009 a HUD workshop was held at Oregon State University. The purpose of the workshop was to gather marine scientists from State, Federal, and Academic sectors and local Oregon fishermen, review the content of the HUD, identify possible taxonomic gaps, and examine the geographic lookup capabilities of the PaCOOS tool. The exercise was carried out in a "live" format by running spatial range and habitat queries against the HUD (over known habitats and familiar fishing grounds) and examining the species, life stage, and association level outputs against the experiential knowledge base gathered for the meeting. Comments were collected and summarized in the meeting report (Romsos 2009).

This meeting provided the first HUD review external to the EFH EIS process and was productive in terms of identifying taxonomic gaps and also for developing a set of improvement objectives. Alan Shanks and Brian Tissot noted the low diversity of plant and invertebrate species in the HUD. To remedy this, Alan and Brian provided a list of common invertebrates that should be included in the HUD (Shanks and Tissot, Appendix F). The invertebrate list is not comprehensive, but is meant to provide a minimum accounting of invertebrate species that could be used as indicator species. This list has yet to be added to the HUD; additional work to identify species distributions, habitat associations, preferences, and reference indexing remains to be completed before the species can be included in the HUD.

4.0 FISHING ACTIVITIES THAT MAY AFFECT EFH

The MSA requires FMCs for each FMP to identify fishing activities that may adversely affect EFH and to minimize adverse effects of those activities to the extent practicable. Fishing activities should include those regulated under the Pacific Coast Groundfish FMP that affect EFH identified under any FMPs, as well as those fishing activities regulated under other FMPs that affect EFH designated under the Pacific Coast Groundfish FMP.

The most common and direct effect of fishing on groundfish EFH results from fishing gear coming in contact with bottom habitats. Fishing gears can cause physical harm to corals, sponges, rocky reefs, sandy ocean floor, eelgrass beds, and other components of seafloor habitats.

A variety of fishing and other vessels can be found in estuaries, and the marine environment of the Pacific Coast. Vessel size ranges from small single-person vessels used in streams and estuaries, to mid-size commercial or recreational vessels, to large-scale vessels limited to deep-draft harbors and marine waters.

Fishing vessels can adversely affect EFH by affecting physical, chemical, or biological componentss. Physical effects can include physical contact with propeller wash in eelgrass beds (estuaries). Derelict, sunk, or abandoned vessels can cause physical damage to any bottom habitat.

Chemical effects from fishing activities could derive from anti-fouling paint, oil or gas spills, bilge waste, or other potential contaminants associated with commercial or recreational vessels operating in freshwater, estuaries, or the marine environment.

Biological effects include introducing invasive species from bilge waters in fishing vessels that can disrupt communities upon which managed fish species rely.

4.1 Fishing Effects on EFH by Gear Type

Fishing gear used in groundfish fisheries that have the potential to adversely affect EFH for Pacific Coast groundfish are shown in Table 8. These include fishing activities not managed under the MSA that may adversely affect groundfish EFH.

Table 8. Gear Types Used in the West Coast Groundfish Fisheries.[a/]

	Trawl and Other Net	Longline, Pot, Hook and Line	Other
Limited Entry Fishery (commercial)	Bottom trawl Mid-water trawl Whiting trawl Scottish seine	Pot Bottom Longline	
Open Access Fishery Directed Fishery (commercial)	Set gillnet Sculpin trawl	Pot Bottom Longline Vertical hook/line Rod/reel Troll/dinglebar Jig Drifted (fly gear) Stick	
Open Access Fishery Incidental Fishery (commercial)	Exempted trawl (pink shrimp, spot and ridgeback prawn, CA halibut, sea cucumber) Setnet Driftnet Purse seine (round haul net)	Pot (Dungeness crab, CA sheephead, spot prawn) Bottom Longline Rod/reel Troll	Dive (spear) Dive (with hook and line) Poke pole
Tribal	as above	As above	As above
Recreational	Dip net, Throw net (within 3 miles)	Hook and line methods Pots (within 3 milesfrom shore), private boat, commercial passenger vessel	Dive (spear)

Adapted from Goen and Hastie (2002). Most fishing gear used to target non-groundfish species (such as salmon, shrimp, prawns, scallops, crabs, sea urchins, sea cucumbers, California and Pacific Halibut, herring, market squid, tunas, and other coastal pelagic and highly migratory species) are similar to those used to target groundfish. These gears include trawls, trolls, traps or pots, longlines, hook and line, jig, set net, and trammel nets. Other gear that may be used includes seine nets, brush weirs, and mechanical collecting methods used to harvest kelp and sea urchins.

4.1.1 Bottom Trawling

Bottom trawling activity is conducted primarily by the West Coast groundfish fishery, harvesting over 90 species. Bottom trawling is managed under biennial specifications and includes a complicated matrix of sectors, seasons, and spatial limitations. There are many areas closed to bottom contact gear, including bottom trawling, many based on the designated HAPCs in the groundfish FMP EFH designations. (PFMC 2011a).

Appendix C to the Pacific Coast Groundfish FMP (PFMC 2011a) presents a risk assessment framework, including a sensitivity index and recovery rates for a variety of groundfish habitats. Impacts of bottom trawling to physical and biogenic habitats include removal of vegetation, corals, and sponges that may provide structure for prey species; disturbance of sediments; and possible alteration of physical formations such as boulders and rocky reef formations (PFMC 2011a).

4.1.2 Mid-Water Trawling

Mid-water trawls are used to harvest Pacific whiting, shrimp, and other species (PFMC 2011a). Like bottom trawling, it is managed under the Pacific groundfish FMP. Effects are generally limited to the effects of (1) removal of prey species, (2) direct removal of adult and juvenile groundfish, (3) occasional, usually unintentional, contact with the bottom (Devit 2011), and (4) effects resulting from loss of trawl gear, potentially resulting in impacts to bottom habitats and ghost fishing.

4.1.3 Bottom Long Line

Pelagic and bottom long-line fishing in the marine environment is prevalent on the Pacific Coast. Pelagic long-lining targets chiefly tuna and swordfish, while bottom long lining targets halibut, sablefish, and other species. Both types of long lining can incidentally harvest managed species as well as prey species. If long-line gear breaks loose and is lost, it can continue ghost fishing and potentially harm bottom habitat (see Derelict gear section).

4.1.4 Pot and Trap Gear

This gear type is dominated by commercial and recreational crab fisheries prevalent in estuaries and the marine environment along the entire West Coast. Lobster traps are used in California, but not typically north of the central California coast. To a lesser extent, pot gear is used in the sablefish fishery (NWFSC 2009).

Pot and trap gear can adversely affect EFH by smothering estuarine eelgrass beds and other marine/estuarine benthic habitats such as cobble and vegetated surfaces utilized by groundfish and can distrub biogenic habitat. Although typically placed in areas of sandy bottom, gear can also be deployed in areas of rocky habitat and may be dragged across the benthos by strong tidal or ocean currents. Lost trap and pot gear also can affect EFH and is discussed below under derelict gear.

4.1.5 Roundhaul Gear

Fisheries for coastal pelagic and highly migratory species use purse seines, lampara nets, dip nets, and drum seines to target Pacific sardine, northern anchovy, Pacific mackerel, jack mackerel, market squid, and tuna. Most tuna fishing occurs in the western and central Pacific, and tropical eastern Pacific. However, tuna are highly migratory and are present off the U.S. West Coast. They are therefore included in this consideration of habitat impacts from fishing activities.

Roundhaul gear can affect EFH through managed harvest of species that are prey for Pacific groundfish, as well as for other managed species. It can also affect squid EFH if nets are allowed to contact the benthos of squid spawning areas.

4.1.6 Derelict Commercial Gear

When gear associated with commercial or recreational fishing breaks free, is abandoned, or becomes otherwise lost in the aquatic environment, it becomes derelict gear. This phenomenon occurs in fishing activities managed under all four Pacific Coast FMPs, as well as recreational fishing and fishing activities not managed by the Council. In commercial fisheries, trawl nets, long lines, purse seines, crab and lobster pots, and other material, are occasionally lost to the aquatic environment. Recreational fisheries also contribute to the problem, mostly from lost crab pots and other fishing gear.

Derelict fishing gear, as with other types of marine debris, can directly affect groundfish habitat and can directly affect managed species via "ghost fishing." Ghost fishing is included here as an impact to EFH because the presence of marine debris affects the physical, chemical, or biological properties of EFH. For example, once plastics enter the water column, they contribute to the properties of the water. If debris is ingested by fish, it would likely cause harm to the individual. Another example is in the case of a lost net that becomes not only a potential barrier to fish passage, but also a more immediate entanglement threat to individual fish.

Along the Pacific Coast, Dungeness crab pots are especially prevalent as derelict gear (NWSI 2010). Commercial pots are required to use degradable cord that allows the trap lid to open after some time.

This is thought to significantly reduce the effects of ghost fishing. There was no reliable information regarding the numbers or impacts of lost recreational derelict crab pots.

Derelict gear can adversely affect groundfish EFH directly by such means as physical harm to eelgrass beds or other estuarine benthic habitats; harm to coral and sponge habitats or rocky reefs in the marine environment; and by simply occupying space that would otherwise be available to support managed species. Derelict gear also causes direct harm to groundfish (and potentially prey species) by entanglement. Once derelict gear becomes a part of the aquatic environment, it affects the utility of the habitat in terms of passive use and passage to adjacent habitats. More specifically, if a derelict net is in the path of a migrating fish, that net can entangle and kill the individual fish.

In Puget Sound, derelict fishing nets (primarily gillnets) as well as lost crab traps constitute a significant problem. And estimated 2,493 lost nets were removed recently during 18 months of a project funded under the American Recovery and Reinvestment Act. The Northwest Straits Initiative estimates that these nets were entangling 1.5 million animals annually. The nets are typically made from non-degradable nylon or plastic monofilament and persist in the aquatic environment for years (NWSI 2010). Hundreds of crab pots have also been removed (NWSI 2010).

4.2 Fishing Effects on EFH by Habitat Type

The degree of impact that affects a habitat is dependent upon several conditions including the inherent dynamics (dynamic vs. static), history of disturbances (disturbed vs. non-disturbed), and recovery of fished habitats and the relationships of adjoining habitats.

4.2.1 Dynamic Habitats

Dynamic seafloor conditions generally consist of soft, unconsolidated sediment that migrates across the seafloor and is mobilized by bottom currents. Submarine bedforms such as dunes, mobile sand sheets, sediment waves and ripples are the common habitat types that represent dynamic bottom conditions. These features may be foraging habitats for groundfish and long-term disturbances may disrupt habitation of prey species. Chronic or severe impacts may reduce the abundance of some prey species, such as Pacific Sand Lance (*Ammodytes hexapterus*), whereas they may make others more available to groundfishes through suspension (e.g., epifauna) or exposure (e.g., infauna). Some soft, unconsolidated habitats, especially those that have resulted from rising sea level during the early Holocene, may be relict (static) at deeper depths (>30 m). By contrast, others in shallow water (<30m) may seasonally cover or expose hard bedrock outcrops (dynamic). Hard gravel/pebble/cobble pavements, ridges, boulder fields, and pinnacles are generally considered to be static habitats that only typically vary as a result of punctuated, high energy events (e.g., geologic activity, tsunamis).

4.2.2 Disturbed Habitats

Historic and, to a lesser degree, contemporary fishing activities have been concentrated at specific areas on the continental shelf and slope. This repetitive fishing activity disturbs the seafloor to various degrees depending on gear types used. Most of the current trawling activities occur on soft, unconsolidated sand and mud seafloor and adjacent to hard bedrock outcrops, whereas longlines, fish traps (or pots) and other gear types are often also fished on hard-bottom regions.

4.2.3 Recovery of Habitats

Recovery of benthic habitats after disturbances occur is critical to the sustainability of a fishery. Many habitats such as soft, unconsolidated, dynamic, sedimentary bedforms can recover rapidly (within days or months) after disturbance, but it may take longer for the reoccupation of interstitial and other benthic organisms that make the seafloor a good foraging habitat. If a habitat is static then recovery after disturbance may be long-term (years to decades). Attached and sessile biogenic habitats associated with hard bedrock exposures may require considerable time to recover after fishing disturbance. Recovery times of these organisms depend upon the extent of removal and damage, as well as growth and recolonization rates.

4.2.4 Habitat Relationships

The degree of adverse impacts by fishing activities upon a benthic habitat is associated with the concentration and abundances of diverse habitats at fishing grounds. In regions where a fishing ground is homogenous and fairly extensive the impact may be low, while in regions of highly diverse benthic habitats consisting of foraging and various bottom fish life stage habitats disturbances may be acute, as it may interrupt feeding, predation avoidance, and reproduction activities of certain species.

4.3 Information on Habitat Effects of Fishing Gear

4.3.1 Information in the Groundfish FMP

As part of the Amendment 19 process, the Council issued an Impacts Model for Groundfish Essential Fish Habitat (PFMC 2011a) in 2005, which was adapted from the *Risk Assessment for the Pacific Groundfish FMP* (NMFS 2005). The Risk Assessment describes the EFH Model used to identify and describe EFH, an Impacts Model developed to evaluate anthropogenic impacts to EFH, and a data gaps analysis. Only two studies from the West Coast were found that had useful information for the analysis, therefore the review relied on studies from the global literature based on similar gear and habitat combinations as the West Coast. There was very little quantitative information describing the relationship between habitat type, structure, and function and the productivity of managed fish species. In particular, the level of information for most species-habitat associations remained at Level 1 as defined in the NMFS EFH Final Rule Guidance. Appendix J has additional detail on the results of the Amendment 19 analyses.

4.3.2 New Information on Habitat Effects

Since 2005, there have been several new publications, including peer-reviewed literature, white papers and technical memorandums, relevant to West Coast groundfish fisheries that have studied: 1) the effects of fishing gear on benthic habitats; 2) predictive modeling of biogenic habitats; and 3) the effects of fishing gear-related marine debris on habitats. An annotated bibliography of recent articles summarized below is presented in Appendix J.

The recent studies on the effects of fishing gear on benthic habitats are primarily focused on the effects of trawling. There have been several new studies off the West Coast of the contiguous U.S., Canada, and Alaska that have focused on otter trawls in unconsolidated substrate including sand and mud that contain biogenic habitat on the seafloor (Brown et al. 2005; De Marignac et al. 2008; Lindholm et al. 2008; Hixon and Tissot 2007; Hannah et al. 2010). Additionally, general effects of fishing with mobile, bottom-contact fishing gear (such as otter trawls) are increasingly well established through studies worldwide (Kaiser et al. 2006). There was also at least one publication that discussed the effects of bottom longlines Baer et al. 2010). Relative to the information available in 2005 the new studies, including those performed on the U.S. West Coast, found significant impacts of trawling on soft sediment habitats. Several of these pubilcations have noted that little has been written about recovery of seafloor habitat from the effects of fishing and that there is a lack of long-term studies, control sites, or research closures, which hinder the ability to fully evaluate impacts; however, some control sites are now available for monitoring recovery processes.

Fujioka (2006) documented the impacts model used in the Alaska EFH process. This model offered several advantages over the impacts model used in the Amendment 19 process. In particular the model addressed spatial heterogeneity in trawl effort and habitat types and trawl intensity, using empirical trawl effort data from the region.

Fujioka (2006) recommended using longer estimates of recovery time for hard corals, on the order of 100 years, and developmed a Long-term Effect Index (LEI), which calculated an estimate of the proportion of each habitat type in each cell impacted over the long-term under current levels of effort. Tthe LEI results for hard corals were typically greater than 50 percent even under low levels of trawl effort and that substantial long-term impacts could occur to soft sediment habitats depending on trawl intensity. While this approach employed a model with several underlying assumptions, it provided quantitative estimates of fishing impacts in a spatially explicit manner, which would be a significant improvement over the qualitative nature of the impacts model used in the Amendment 19 process.

Watters et al. (2010) provided the first quantitative assessment of marine debris and its impacts to the seafloor in deep submarine canyons and continental shelf locations off California and the U.S. They discerned only a few negative impacts to benthic organisms. Entanglement of fishes in other types of debris was not observed. Some debris caused physical disturbance to habitats (including common structure-forming macroinvertebrates) was observed. In another study Keller et al. (2010) documented the composition and abundance of man-made, benthic marine debris at 1,347 randomly selected stations along the U.S. West Coast during Groundfish Bottom Trawl Surveys in 2007 and 2008. Anthropogenic debris was observed in 469 of 469 stations at depths of 55 to 1,280 m. Plastic and metallic debris occurred in the greatest number of hauls followed by fabric and glass. Debris densities observed along the U.S. West Coast were comparable to those seen elsewhere and provide a valuable backdrop for future comparisons. Chiappone et al. (2005) found that less than 0.2 percent of the available invertebrates were affected by lost hook-and-line fishing gear, even though this gear caused 84 percent of the documented impacts (primarily tissue abrasion) to sponges and cnidarians. Debris was found to alter the seafloor by providing artificial habitat to demersal organisms; the majority of the debris was colonized by encrusting invertebrates.

4.4 Magnuson Act Fisheries Effects

4.4.1 Distribution of Commercial Fishing Effort

4.4.1.1 Bottom Trawl Effort

Figures in Appendix K-1 depict the spatial distribution of commercial bottom trawl effort within two time periods: “Before” (1 Jan 2002 – 11 Jun 2006) and “After” (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Each of the three coastal states administers a commercial logbook program, for which records are uploaded to the PacFIN regional database. Database records were utilized for commercial trips using bottom trawl gear types (e.g., “small” footrope, “large” footrope, flatfish, selective flatfish, and roller trawl) regardless of fishery sector (e.g., limited entry, open access). Records from the majority of state-managed trawl fisheries (e.g., pink shrimp, ridgeback prawn, sea urchin) are not included in PacFIN and thus are not represented in the figures. Tows targeting one state-managed trawl fishery – California halibut – are submitted to PacFIN and thus are included in the bottom trawl effort summaries.

In order to analyze the effort data spatially, a straight line connecting the start and end points was used to represent each tow event. Towlines intersecting land, outside the U.S. EEZ, deeper than 2,000 m, or with a calculated straight-line speed greater than five knots were removed from the spatial analysis. Two complimentary data products were created with these records: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than three vessels were operating, and 2) an extent polygon that shows the gross spatial extent of effort.

The first data product, intensity, was calculated as the total length of all towlines intersecting a standardized area. To calculate this metric, a line density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) was used. The line density algorithm calculates density within a circular search area (radius = 3 km) centered at a grid cell (size 500 m x 500 m). The value (units: km/km^2) for each grid cell is the quotient of total towline portions intersecting the circular area per grid cell area (Figure. 10). Since density outputs are highly sensitive to the specified radius and cell size, the absolute values are less important than the relative nature of them. The benefit of this output over depicting towlines themselves is that the density output better identifies areas where fishing effort is concentrated, while still ensuring confidentiality of individual fishing locations (e.g., Figure 15). The initial density output was more spatially extensive than the one shown in Appendix K-1, because it included cells with density values calculated from tows made by less than three vessels. Those "confidential" cells were removed for the final published data product. Density parameters were chosen in order to minimize data exclusion (due to confidentiality mandates) while still providing a fairly high spatial resolution (500 x 500 m). For the bottom trawl effort maps, only 1.1 and 1.8 percent of all effort (i.e., length of towlines) was excluded within a given time period, although the proportion varies considerably in certain areas along the coast (Table 9).

The second data product, the extent polygon, was created using an algorithm known as a convex hull. Convex hulls are a type of minimum extent polygon that forms an "envelope" around a group of points, or in this case, straight lines representing tows (Figure 16). The algorithm can be applied at various spatial scales. In this case, we grouped towlines into 0.5° latitude x 0.5° longitude blocks. The algorithm was then applied to each set of towlines within each block. Finally, all convex hull polygons were merged together for each time period. The resulting polygon encloses all towlines within each time period (e.g., Figure 15). The best way to interpret this data product is that no bottom trawling occurred outside of the extent polygon within a particular time period. In order to ensure that each extent polygon encompasses towlines from at least three vessels, the result is an overestimation of the areas of seafloor actually contacted by trawl gear. In fact, there are many areas within the extent polygon where no trawling occurred; hence this product is only intended to represent the gross "footprint" of trawling for each time period. However, there are several alternative approaches to determining the "footprint" of fishing effort resulting in very different spatial extents and interpretations, such as identifying the minimum area encompassing a certain percentage of all tows (e.g., Ban and Vincent 2009).

These spatial summaries of bottom trawl effort were developed from data represented only by start and end points of tows. It is recognized that tows rarely follow straight-line paths; however, this was the best information available on the spatial distribution of effort for vessels using bottom trawl gears. Because of this limitation and due to prohibitions of trawling within state waters, representatives of the states of Washington and California requested that any portions of the spatial summaries that intersect prohibited state waters be removed. In addition, Washington requested that effort occurring within both state and federal waters of the Salish Sea be removed since they felt that this information was incomplete and may not be representative of fishing effort within those areas. However, NMFS General Counsel has advised the EFHRC that there is not justification to limit access/display of these data from state waters so they are included in the map products.

In order to evaluate how fishing effort has changed between the two time periods, the color ramps for the intensity layers are scaled to the same range of values in each panel (e.g., Figure 15). Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. The upper value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

Areas of high relative effort in the former time period are apparent off northern Washington (Appendix K-1, Plate A2), in Monterey Bay, CA (Appendix K-1, Plate E3) and south of Los Angeles, CA (Appendix K-1, Plate F4). In the recent time period, only one area in deeper waters off northern Washington (Appendix K-1, Plate A2) shows up with relatively high bottom trawl effort. There are a number of areas of medium to medium-high relative effort that show up in the map panels for both time periods. They are distributed throughout the region over both the shelf and slope, often showing some persistence between the two time periods.

A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/

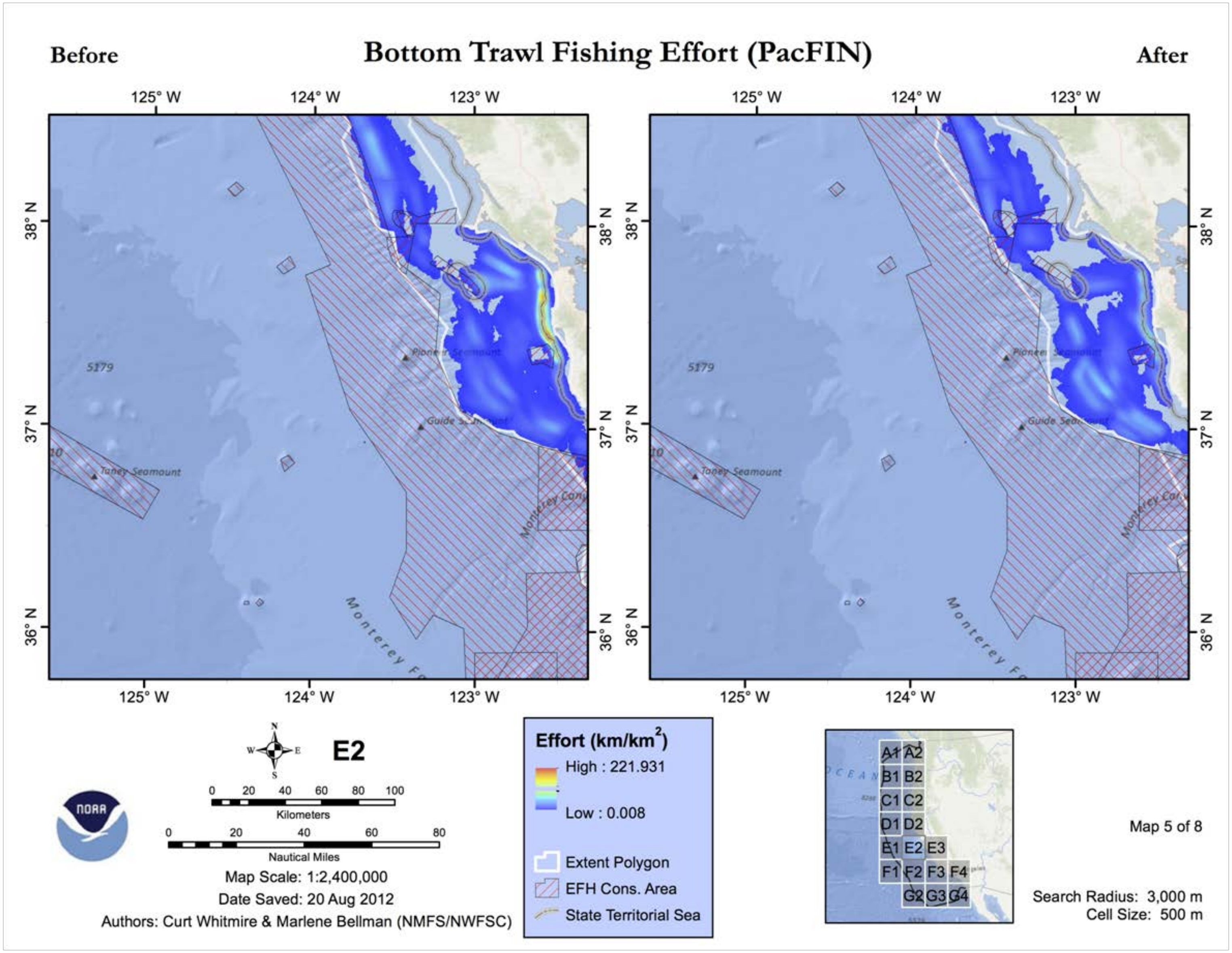

Figure 15. Example of Appendix K-1 bottom trawl effort from commercial logbook records in the PacFIN regional database.

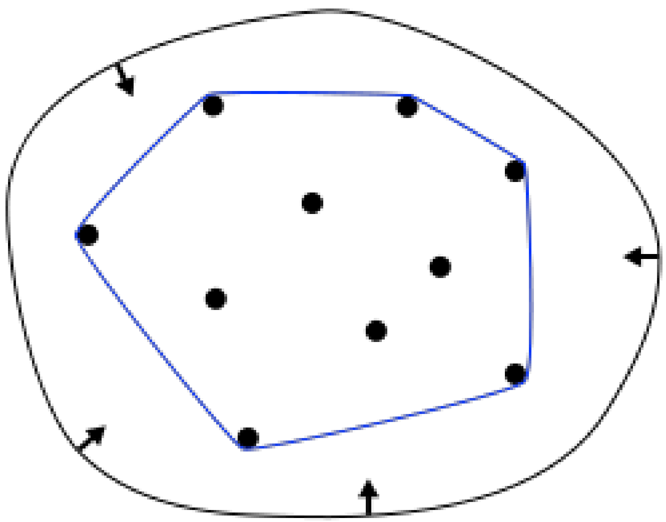

Figure 16. Conceptual drawing of a convex hull of a set of points. Imagine a rubber band being stretched around a set of points of lines. When the rubber band is released, the resulting shape is a convex hull. Image source: http://en.wikipedia.org/wiki/File:ConvexHull.svg (3 Jun 2008).

Table 9. Summary of commercial bottom trawl effort (i.e., length of towlines [km]) both inside and outside of density layer, summarized by degree of latitude and for two time periods: "before" (1 Jan 2002 – 11 Jun 2006) and "after" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures. The significance of this table is that it shows total recorded effort within the fishery (Inside+Outside), plus amount within each degree of latitude not represented in the fishing intensity layer (Outside), due to confidentiality considerations. Almost all recorded effort, however, is still represented in the extent polygon. "NA" means no records of bottom trawl trips exist for that latitude range and time period.

	Inside + Outside				Outside	
Latitude Range	BEFORE	% Coast	AFTER	% Coast	BEFORE	AFTER
48 - 49	83,719	8.3%	32,379	2.9%	1.0%	6.9%
47 - 48	87,351	8.7%	117,673	10.7%	0.5%	0.4%
46 - 47	106,758	10.6%	151,336	13.8%	0.1%	0.1%
45 - 46	87,864	8.7%	150,592	13.7%	0.8%	1.4%
44 - 45	57,119	5.7%	95,984	8.7%	1.1%	0.5%
43 - 44	58,631	5.8%	105,058	9.6%	1.7%	0.5%
42 - 43	57,289	5.7%	61,419	5.6%	2.1%	3.1%
41 - 42	93,191	9.2%	94,557	8.6%	0.1%	0.2%
40 - 41	72,037	7.1%	79,091	7.2%	0.2%	0.2%
39 - 40	50,802	5.0%	41,962	3.8%	0.4%	0.5%
38 - 39	38,028	3.8%	31,016	2.8%	1.4%	1.6%
37 - 38	90,268	8.9%	69,626	6.3%	0.4%	1.9%
36 - 37	46,183	4.6%	20,613	1.9%	0.5%	12.0%
35 - 36	19,774	2.0%	4,880	0.4%	4.5%	58.8%
34 - 35	52,194	5.2%	39,560	3.6%	6.7%	9.4%
33 - 34	8,434	0.8%	2,022	0.2%	2.2%	4.6%
32 - 33	0	NA	0	NA	NA	NA
Coastwide	1,009,642	100.0%	1,097,767	100.0%	1.1%	1.8%

4.4.1.2 Mid-Water Trawl Effort

Appendix K-2 Plates depict the spatial distribution of mid-water trawl effort within two time periods: “Before” (1 Jan 2002 – 11 Jun 2006) and “After” (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of mid-water trawl tows were compiled from two data sources: 1) Logbook data originating from the state logbook programs and uploaded to the PacFIN regional database, and 2) observer records from the ASHOP. These two data sources represent the shoreside and at-sea hake fleets, respectively. Included in the ASHOP data are observations of tribal fishing in the at-sea hake sector.

In order to analyze the effort data spatially, a straight line connecting the start and end points was used to represent each tow event. Towlines intersecting land, outside the EEZ, deeper than 2,000 m, or with a calculated straight-line distance greater than 20 km were removed from the spatial analysis. Because of their patchy spatial distributions, towlines for mid-water trawls occurring south of Cape Mendocino were removed from the analysis at the request of the state of California. Similar to the bottom trawl effort maps, two complimentary data products were created with these towlines: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than three vessels were operating, and 2) an extent polygon that shows the gross extent of effort. Please refer to the description of methods used to create the bottom trawl effort Plates (Section 4.4.1.1), as they were very similar to the methods used for the mid-water trawl plates. The initial density output was more spatially extensive than the one shown in the Plates because it included cells with density values calculated from tows made by less than three vessels. For the published layer, grid cells were removed where tows from less than three vessels intersected the circular search area. These “confidential” cells only represent 1.6 and 3.1 percent of all towlines within a given time period, although the proportion varies considerably in certain areas along the coast (Table 10).

Similar to the bottom trawl effort figures, these spatial summaries of mid-water trawl effort were developed from data represented only by start and end points of tows. It is recognized that tows rarely follow straight-line paths; however, this was the best information available on the spatial distribution of effort for vessels using mid-water trawl gears. Because of their patchy spatial distributions, towlines for mid-water trawls occurring south of Cape Mendocino were removed from the analysis at the request of the state of California.

AppendixK-2 Plates show areas of high relative effort in the before time period are apparent off northern Washington and central and southern Oregon. In the after time period, areas of high relative effort show up again off northern Washington, off south-central Oregon, and near the Oregon-California maritime border (e.g., Figure 17, Plate A2). There are a number of areas of medium to medium-high relative effort that show up in the map panels for both time periods, but appear more widespread in the recent period. Those areas show little spatial consistency between the two time periods, possibly due to the migratory nature of the target species.

Table 10. Summary of commercial mid-water trawl effort (i.e., length of towlines [km]) both inside and outside of density layer, summarized by degree of latitude and for two time periods: "before" (1 Jan 2002 – 11 Jun 2006) and "after" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures. The significance of this table is that it shows total recorded effort within the fishery, plus amount within each degree of latitude not represented in the fishing intensity layer, due to confidentiality considerations. Most recorded effort, however, is still represented in the extent polygon (see below for exception). "NA" means no records of mid-water trawl trips exist for that latitude range and time period.

	Inside + Outside				Outside	
Latitude Range	BEFORE	% Coast	AFTER	% Coast	BEFORE	AFTER
48 - 49	15,366	13.1%	11,160	6.7%	2.3%	5.4%
47 - 48	8,625	7.3%	32,584	19.4%	3.7%	1.6%
46 - 47	11,750	10.0%	30,904	18.4%	2.0%	0.7%
45 - 46	17,278	14.7%	25,151	15.0%	5.3%	1.1%
44 - 45	30,189	25.7%	25,320	15.1%	0.6%	0.9%
43 - 44	18,504	15.7%	25,006	14.9%	1.0%	0.7%
42 - 43	12,143	10.3%	13,081	7.8%	3.9%	0.9%
41 - 42	1,240	1.1%	3,014	1.8%	9.4%	1.3%
40 - 41	1,767	1.5%	872	0.5%	5.3%	7.9%
39 - 40	8	0.0%	126	0.1%	100.0%*	100.0%*
38 – 39	70	0.1%	NA	NA	100.0%*	NA
37 - 38	466	0.4%	NA	NA	100.0%*	NA
36 - 37	32	0.0%	NA	NA	100.0%*	NA
35 - 36	74	0.1%	NA	NA	100.0%*	NA
34 - 35	87	0.1%	366	0.2%	100.0%*	100.0%*
33 - 34	NA	NA	NA	NA	NA	NA
32 - 33	NA	NA	NA	NA	NA	NA
Coastwide	**117,598**	**100.0%**	**167,585**	**100.0%**	**3.1%**	**1.6%**

* Denotes areas south of Cape Mendocino, CA (~40.5 deg. lat.) where effort data were removed from the analysis at the request of the state of California.

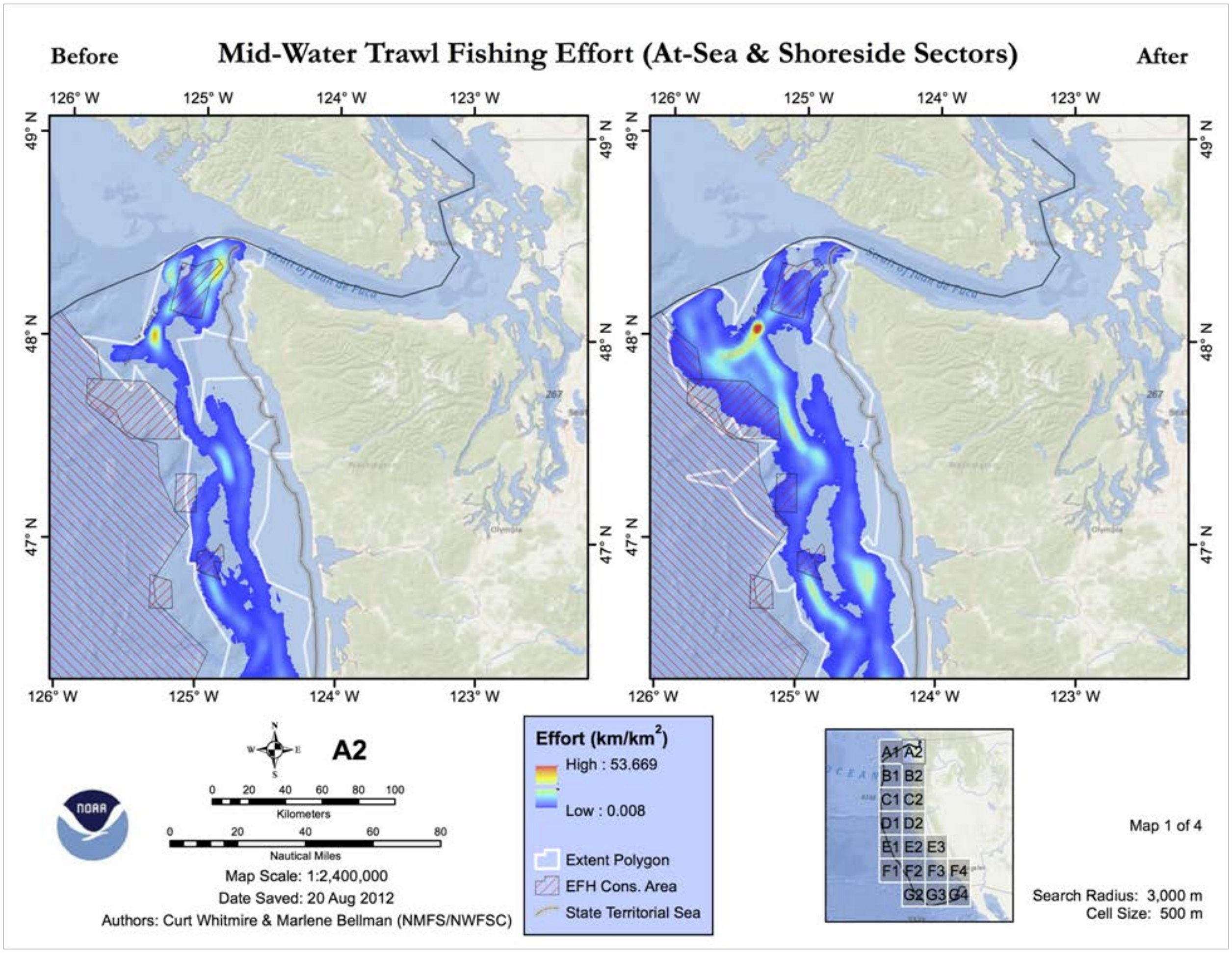

Figure 17. Example of Appendix K-2 mid-water trawl effort from commercial logbook records in the PacFIN regional database.

A GIS project was constructed in ArcCatalog and ArcMap in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/

4.4.1.3 Fixed Gear Effort

Appendix K-3 figures depict the spatial distribution of observed fixed gear effort within two time periods: "Before" (1 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of fixed gear fishing locations were compiled from one source: observer records from the West Coast Groundfish Observer Program (WCGOP database. The WCGOP database includes records of trips for vessels participating in the following sectors: limited entry sablefish-endorsed primary season, limited entry non-sablefish endorsed, open access fixed gear, Oregon and California nearshore. Annual WCGOP coverage of fixed gear sectors can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm. Since all fishing operations are not observed, neither the maps nor the data can be used to characterize the fishery completely. We urge caution when utilizing these data due to the complexity of groundfish management and fleet harvest dynamics.

Since fishing does not occur continuously between set and haul points for fixed gears, the WCGOP fixed gear data products are based on spatial locations of both set and haul coordinates (referred to as "fishing locations"). This is in contrast to the trawl effort data products, where a straight line connecting the start and end points was used to represent each tow event. Fishing locations where either set or haul points were either on land, outside the EEZ, or deeper than 2,000 m were removed from the spatial analysis. Similar to the bottom trawl effort maps, two complimentary data products were created with these fishing locations: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than 3 vessels were operating, and 2) an extent polygon that shows the gross extent of effort. Please refer to the description of methods used to create the bottom trawl effort maps, as they were very similar to the methods used for the bottom trawl and mid-water trawl figures. The main difference for the fixed gear data is that a point density, rather than a line density, algorithm was used to quantify density of effort (units: locations/km2; Figure 18). The density parameters used for calculating standardized effort for observed fixed gear fishing locations was a 5 km search radius and a 1,000x1,000 m cell size. As with the two trawl data products, the initial density output was more spatially extensive than the one shown in the figures, because it included cells with density values calculated from fishing locations of less than three vessels. For the published layer, we removed those grid cells where fishing locations from less than 3 vessels intersected the circular search area. These "confidential" cells represent 15.3 and 22.4 percent of all fishing locations within a given time period, although the proportion varies considerably in certain areas along the coast (Table 11).

As with the two trawl effort maps, the color ramps for the intensity layers are scaled to the same range of values in each panel

AppendixK-3 map plates show areas of high relative effort in the before time period are apparent off northern Washington, Cape Blanco, OR, and Crescent City, CA. In the after time period, areas of high relative effort show up again off northern Washington, off the Columbia River mouth, and off Cape Blanco, OR (e.g., Figure 14). There are a number of areas of medium to medium-high relative effort that show up in the map plates for both time periods; however, compared to the two sets of trawl figures, there appear to be little spatial consistency between the two periods.

Another stark contrast between the fixed gear figures and the two trawl figures is the characteristic of the extent polygons. The extent polygons for fixed gear effort (Figure 18) extend greater distances from the intensity layers than trawl effort (Figures 15 and 17). There are a couple probable explanations for this phenomenon. First, the fixed gear data comes from observers who are present only on a subset of all fixed gear trips, in contrast to the bottom trawl and mid-water trawl data sources which are a mostly complete record of all trips using those gear types (see exceptions detailed in methods). Second, due to a more patchy nature of the spatial distribution of effort, the fixed gear intensity layer represents a smaller portion of locations within the extent polygon. In other words, a higher proportion of density cells were considered confidential because the values for those cells were calculated from only one or two vessels (Table 11). The overall objective of the fixed gear intensity layer development was to ensure adequate coastwide representation (in which over 80 percent or more of the data are represented). Compared to the bottom and mid-water trawl summaries, the extent polygon for observed fixed gear effort encompasses a large majority of observed fishing locations; however, some points were excluded due to confidentiality considerations.

Table 11. Summary of observed fixed gear effort (i.e., number of fishing locations) both inside and outside of density layer, summarized by degree of latitude and for two time periods: “before” (1 Jan 2002 – 11 Jun 2006) and “after” (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulatory measures. The significance of this table is that it shows total observed effort within the fishery, plus amount within each degree of latitude not represented in the fishing intensity layer, due to confidentiality considerations. Most observed effort, however, is still represented in the extent polygon.

	Inside + Outside				Outside	
Latitude Range	BEFORE	% Coast	AFTER	% Coast	BEFORE	AFTER
48 - 49	1,079	10.0%	1,488	10.3%	4.9%	0.9%
47 - 48	1,033	9.6%	785	5.5%	7.9%	8.4%
46 - 47	508	4.7%	1,512	10.5%	10.8%	5.4%
45 - 46	867	8.0%	1,094	7.6%	46.1%	25.2%
44 - 45	1,205	11.2%	1,539	10.7%	23.3%	17.0%
43 - 44	689	6.4%	751	5.2%	20.5%	7.7%
42 - 43	845	7.8%	1,912	13.3%	6.5%	1.3%
41 - 42	1,028	9.5%	837	5.8%	31.0%	16.6%
40 - 41	259	2.4%	224	1.6%	35.1%	48.7%
39 - 40	366	3.4%	218	1.5%	12.3%	8.3%
38 - 39	173	1.6%	228	1.6%	26.0%	93.0%
37 - 38	220	2.0%	428	3.0%	65.0%	37.4%
36 - 37	302	2.8%	300	2.1%	7.6%	13.0%
35 - 36	360	3.3%	333	2.3%	18.1%	53.8%
34 - 35	196	1.8%	125	0.9%	28.6%	63.2%
33 - 34	956	8.9%	1,984	13.8%	43.1%	17.9%
32 - 33	704	6.5%	640	4.4%	21.3%	19.4%
Coastwide	**10,790**	**100.0%**	**14,398**	**100.0%**	**22.4%**	**15.3%**

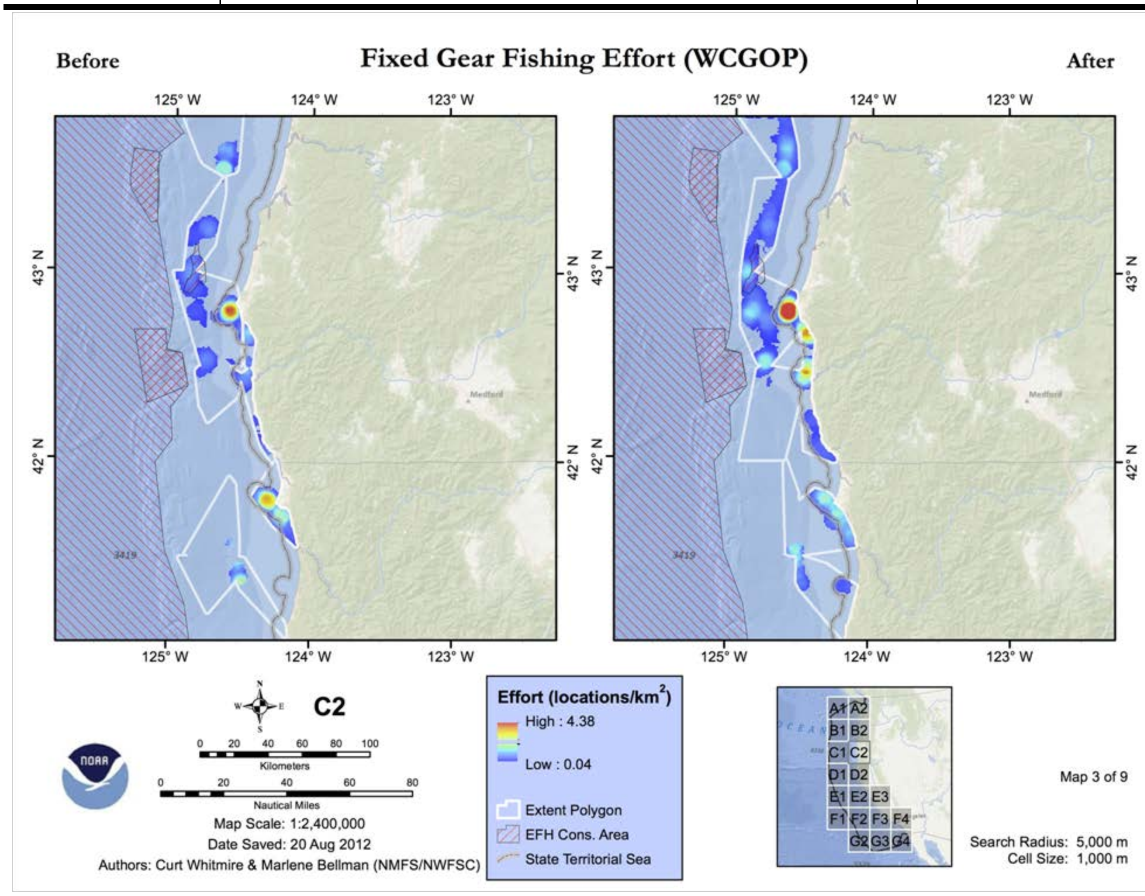

Figure 18. Example of Appendix K-3 fixed gear effort from commercial logbook records in the PacFIN regional database.

A GIS project was constructed in ArcCatalog and ArcMap in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/

4.4.2 Recreational Fishing

Hook and line gear and pots are the most widely used and most likely sources of potential recreational fishing gear impacts to EFH. Hook and line gear often involves use of large (usually lead) weights when trolling for salmon or fishing groundfish such as halibut, lingcod, and rockfish species. Metal recreational weights can impact biogenic habitat and soft and hard substrate when lost or when making contact with the bottom. Hooks, lines, and smaller weights can be lost and become entangled in rocky and biogenic habitat. Recreational pot gear can damage habitat when making initial bottom contact while fishing or drag across the bottom causing more widespread damage when lost.

Biogenic habitats are most at-risk from recreational fishing gear impacts followed by hard substrate and lastly, soft sediments. Impacts would proportionally be larger in areas of high recreational activity. Many areas of vulnerable biogenic habitat are located far offshore lessening chance of recreational gear and vessel impacts such as anchoring.

Lost gear may remain in-place and adversely affect organism growth while continuing to fish. Ghost fishing can occur but is limited for hook and line gear by number of hooks. Recreational pots can continue to fish until required biodegradable cord opens escape hatches disabling the fishing ability of the gear.

Cumulative impacts from recreational fishing gear will be most pronounced in heavily fished areas but little is known since minimal visual monitoring or inspections have been conducted; research is needed in this area. Due to the relatively small gear and spatial footprint of recreational fisheries overall, impacts are minimal compared to commercial fisheries. Though dive fishing with spears and spear-guns are addtional forms of recreational gear their impacts are minimal to EFH.

4.4.3 Minimizing Effects

Fishery Management Plans are required to minimize adverse affects to EFH to the extent practicable. Minimization measures can include, but are not limited to, time/area closures, fishing equipment restrictions, harvest limits, and effort control. Adverse impacts to benthic habitats associated with bottom fishing activities have been considerably reduced during the last two decades. These reduction were achieved primarily in three areas; fleet reduction, gear modifications and area closures.

4.4.3.1 Fleet Reduction

Prior to 1994, the Pacific Coast groundfish trawl fleet numbered over 500 vessels. Through a number of capacity reduction measures, which included limited entry, the groundfish buyback program, and the rationalization of the trawl fleet (individual quota shares), has reduced the trawl groundfish fleet by nearly 80 percent (Table 12). In this same time period, the limited entry fixed gear fleet was also reduced by almost 30 percent.

Table 12. Counts of vessels participating in groundfish fishery sectors: 2005-2011.[a/]

Groundfish Sector	2005	2006	2007	2008	2009	2010	2011
Catcher-Processors	6	9	9	8	6	7	9
Mothership whiting CVs	17	20	20	19	19	22	18
Shoreside whiting trawl CVs	29	37	39	37	34	36	26
Nonwhiting trawl CVs[b/]	123	122	121	120	117	105	129
Sub total trawl vessels	175	188	189	184	176	170	182
Limited Entry fixed gear	126	132	136	135	139	140	166
Open Access fixed gear	670	764	696	650	660	578	682
Sub total fixed gearl vessels	796	896	832	785	799	718	848
Incidental Open Access	537	462	449	274	280	294	284
Total Groundfish Vessels [c/]	**1,232**	**1,219**	**1,178**	**1,011**	**1,025**	**965**	**1,041**
Vessels participating in both shoreside whiting and nonwhiting fisheries	20	27	27	28	26	24	14
Vessels participating in both shoreside and at-sea whiting fisheries	7	12	15	13	13	15	13

a/ Source: PacFIN. Vessel counts for 2011 are preliminary.
b/ The increase in the number of nonwhiting trawl CVs in 2011was due to fixed gear vessels with trawl permits utilizing gear switching provisions.
c/ Vessels may participate in more than one fishery sector, so this total exceeds the number of West Coast groundfish vessels.

4.4.3.2 Gear Modification

In the early 2000's, the need to constrain the catch of overfished rockfish species brought about regulatory changes to limit the footrope size to less than 8 inches inside of 100 fathoms. This gear regulation not only helped restrict catches of overfished rockfish species, it dramatically changed the spatial footprint of the trawl fishery, out of rocky habitat areas. Additional regulations as a result of Amendment 19 further restricted gear types to footropes less than19 inches outside of 100 fathoms, and banned use of dredges and beam trawls. The actual trawl footprint has been further reduced by the trawl rationalization program, which allows gear switching (i.e., trawl-permitted vessel can use fixed gear to capture groundfish). Improved electronics and technology have also allowed the fishing fleet to better position themselves and avoid sensitive habitats.

4.4.3.3 Area Closures

Bottom Contact Closed Areas

In 2006, the Council and NMFS took action to close the following areas to specific bottom contact gear (trawl gear only or all bottom contact gear), based on the outcome of the Amendment 19 process.

Off of Washington:

1. Olympic_2
2. Biogenic_1
3. Biogenic_2
4. Grays Canyon
5. Biogenic_3

Off of Oregon:

1. Nehalem Bank / Shale Pile
2. Astoria Canyon
3. Siletz Deepwater
4. Daisy Bank / Nelson Island
5. Newport Rockpile / Stonewall Bank
6. Heceta Bank
7. Deepwater off Coos Bay
8. Bandon High Spot
9. Rogue Canyon

Off of California:

1. Eel River Canyon
2. Blunts Reef
3. Mendocino Ridge
4. Delgada Canyon
5. Tolo Bank
6. Point Arena Offshore
7. Cordell Bank
8. Biogenic Area 12
9. Farallon Islands / Fanny Shoal
10. Half Moon Bay
11. Monterey Bay / Canyon
12. Point Sur Deep
13. TNC/ED Area 2
14. TNC/ED Area 1
15. TNC/ED Area 3
16. Potato Bank
17. Cherry Bank
18. Hidden Reef / Kidney Bank
19. Catalina Island
20. Cowcod Conservation Area East

Bottom Contact Closed Areas

Off of Oregon:

1. Thompson Seamount
2. President Jackson Seamount

Off of California:

1. Cordell Bank (within 50 fm isobath)
2. Davidson Seamount (fishing below 500 fathoms prohibited, see below)
3. Anacapa Island MCA
4. Anacapa Island MR
5. Carrington Point
6. Footprint
7. Gull Island
8. Harris Point
9. Judith Rock
10. Painted Cove
11. Richardson Rock
12. Santa Barbara
13. Scorpion
14. Skunk Point
15. South Point

These closed areas are summarized in Figure 3.

All of the BCCAs off of California occur within the Cordell Bank, Monterey, or Channel Islands National Marine Sanctuaries. Mitigation measures implemented under MSA authority are also intended to support the goals and objectives of these sanctuaries. In the case of Davidson Seamount, it is unlawful for any person to fish with bottom contact gear, or any other gear that is deployed deeper than 500 fathoms (~914m), within the area defined in Federal regulations. These gear restrictions address Sanctuary goals and objectives while practicably mitigating the adverse effects of fishing on groundfish EFH.

Bottom Trawl Footprint Closure

As a precautionary measure to mitigate the adverse effects of fishing on groundfish EFH, Amendment 19 closed the West Coast EEZ seaward of a line approximating the 700 fm (~1,280m) isobaths to bottom trawling (PFMC 2011a). However, NMFS disapproved the closing of areas within the EEZ that are not designated as EFH (i.e., deeper than 3,500 m), and closure was subsequently limited to designated EFH that is seaward of the line approximating the 700 fm isobath (May 2006, 71 FR 27408). This is referred to as the footprint closure because the 700 fm isobath is an approximation of the historic extent of bottom trawling in the management area. This closure is therefore intended to prevent the expansion of bottom trawling into areas where groundfish EFH has not historically been adversely affected by bottom trawling.

4.5 Non-Magnuson Act Fisheries Effects

The EFHRC requested spatial footprints of state-managed bottom contact gear fisheries, for use in the groundfish EFH review.

4.5.1 Fisheries Managed by the State of Washington

Logbook datat for state managed fisheries were aggregated into 10-minute blocks and indicate where fishing occurred by a minimum of three vessels (i.e., "rule of three"), consistent with other requests from non-fishery management agencies for commercial logbook data. As such, areas or blocks that are not shaded do not necessarily represent areas where fishing did not occur, but rather may not have met the "rule of three" standard.

For the Dungeness crab fishery, logbook data collection began in the 2009-2010 season and specific fishing location data prior then was unavailable. Data for each fishing season is presented separately (Figures 19a and 19b).

For the spot prawn fishery, prior to 2003, both trawl and pot gear could be used; however, beginning in 2003, trawl gear was prohibited. Therefore, trawl fishing location data were excluded because inclusion could give a false impression of where the fishery occurs. There are very few participants in this fishery, so applying the "rule of three" resulted in a display of only a few discrete areas; as such, data were aggregated across all years (2003-2011) to better display the extent of the spot prawn fishing footprint (Figure 20).

The Washington hagfish fishery has such few participants that it was difficult to meet the "rule of three" minimum standard to display any useful data, so no maps were included.

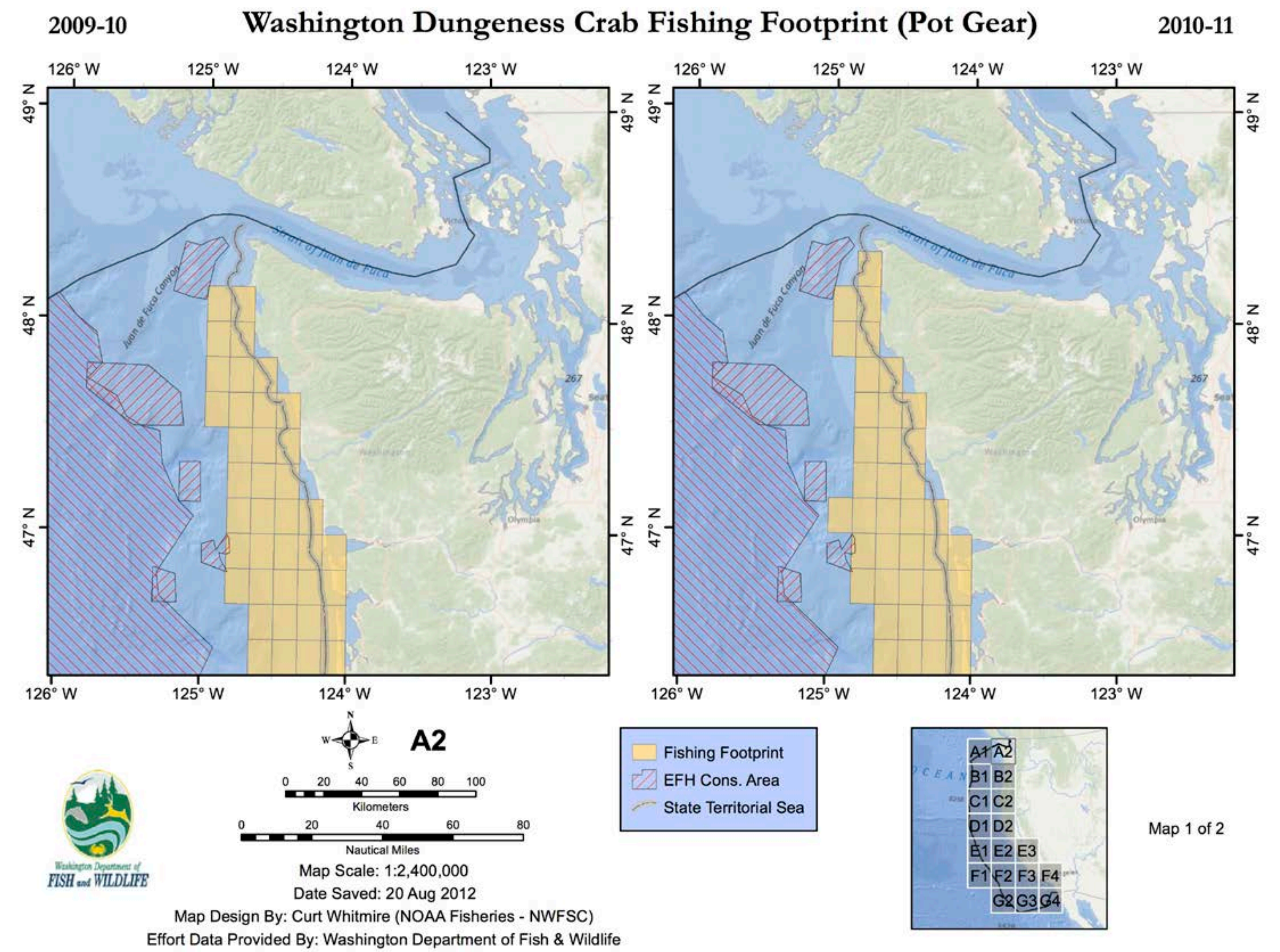

Figure 19a. Washington Dungeness crab fishery footprint during the 2009-2010 and 2010-2011 seasons.

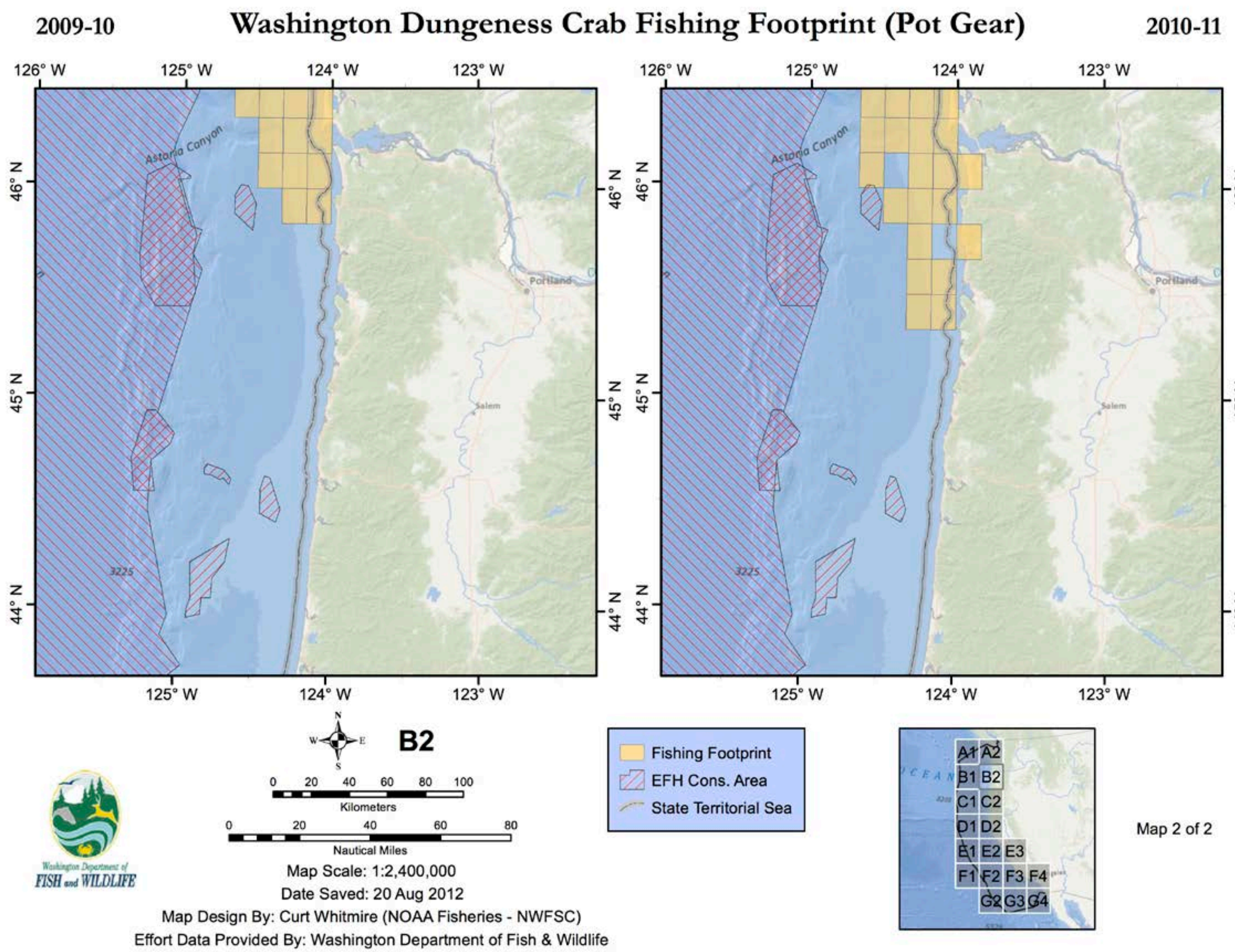

Figure 19b. Washington Dungeness crab fishery footprint during the 2009-2010 and 2010-2011 seasons.

Washington Spot Prawn Fishing Footprint (Pot Gear)

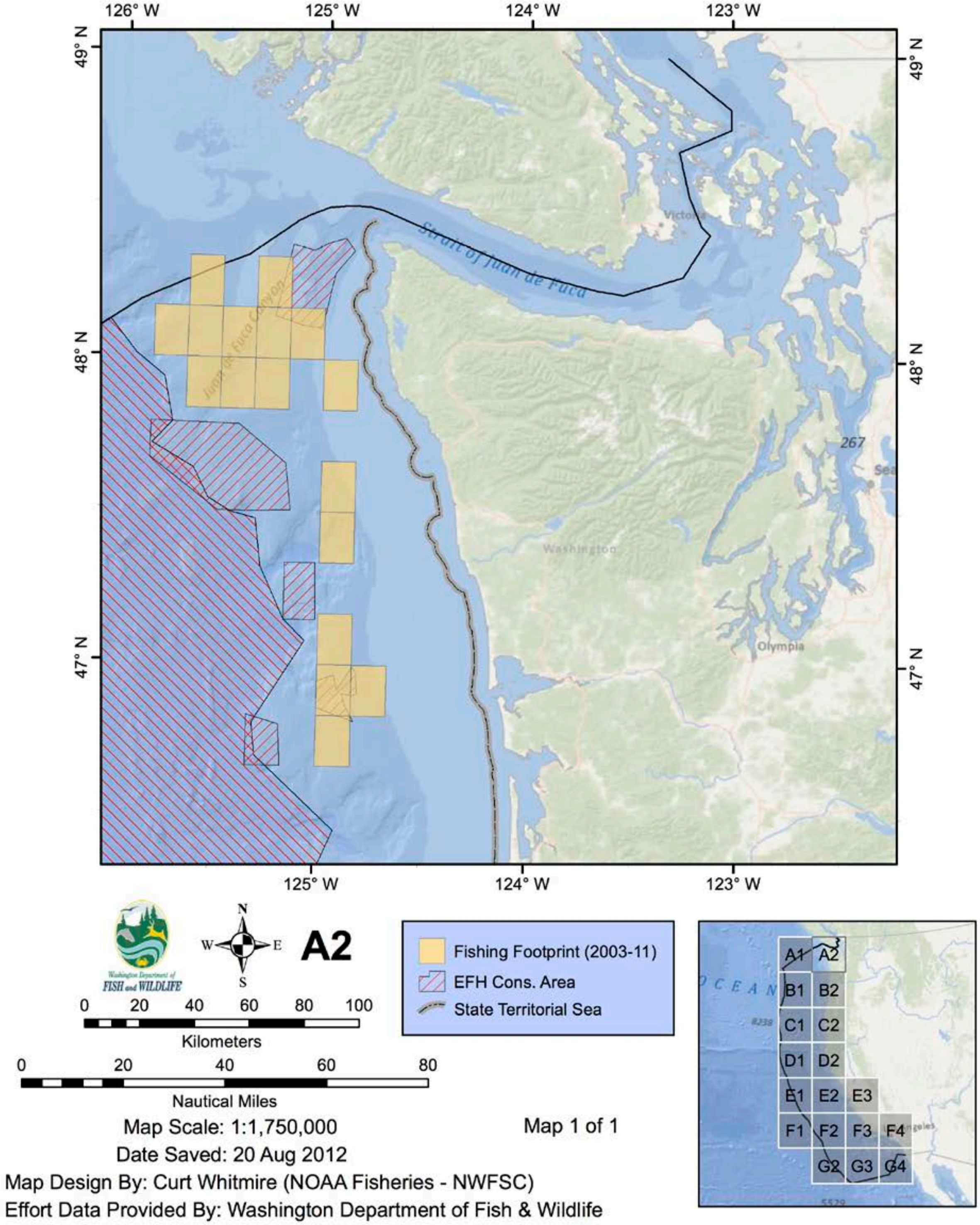

Figure 20. Washington spot prawn pot gear fishery footprint during the 2003-2011 seasons.

4.5.2 Fisheries Managed by the State of Oregon

Oregon Department of Fish and Wildlife provided fishery footprints created from state fishery logbook information for Dungeness crab (Figure 21), hagfish (Figure 22) and pink shrimp (Figures 23a-d) fisheries. Three crab seasons are represented in this footprint – 2007-08, 2009-10 and 2010-11. Catches from Oregon hagfish fisheries are presented for 1993-1998, 1999, part of 2001, 2002-2011 (limited catch reported in 2006). Prior to 2002 catch was reported sporadically, but reporting improved from 2002 onward. Pink shrimp bottom trawl footprint was based on logbook data from five large stock size years, 1987, 1989, 1992, 2005 and 2011.

Each data product represents a multiple year aggregate view of the extent of effort (or footprint) for each fishery. These were developed by taking a series of steps using ArcGIS, based on the methods used by NWFSC analysts to develop the trawl fishery footprint for the EFH process. Each fishery's logbook data was spatially joined to a 0.5° latitude X 0.5° longitude grid. Polygons were then created using the 'Minimum Bounding Geometry' tool with the convex hull bounding type selected for each grid cell. The polygons were then buffered by 1 nm for Dungeness crab and pink shrimp, and by 3 nm for hagfish, then the boundaries between each polygon were dissolved. The resulting polygons enclose >99% of all set string locations for each fishery. To maintain confidentiality, polygons with locations from fewer than three vessels were eliminated, as were arms on polygons that contained a single sample. These products are only intended to represent the general "footprint" of each fishery for the different time periods specified.

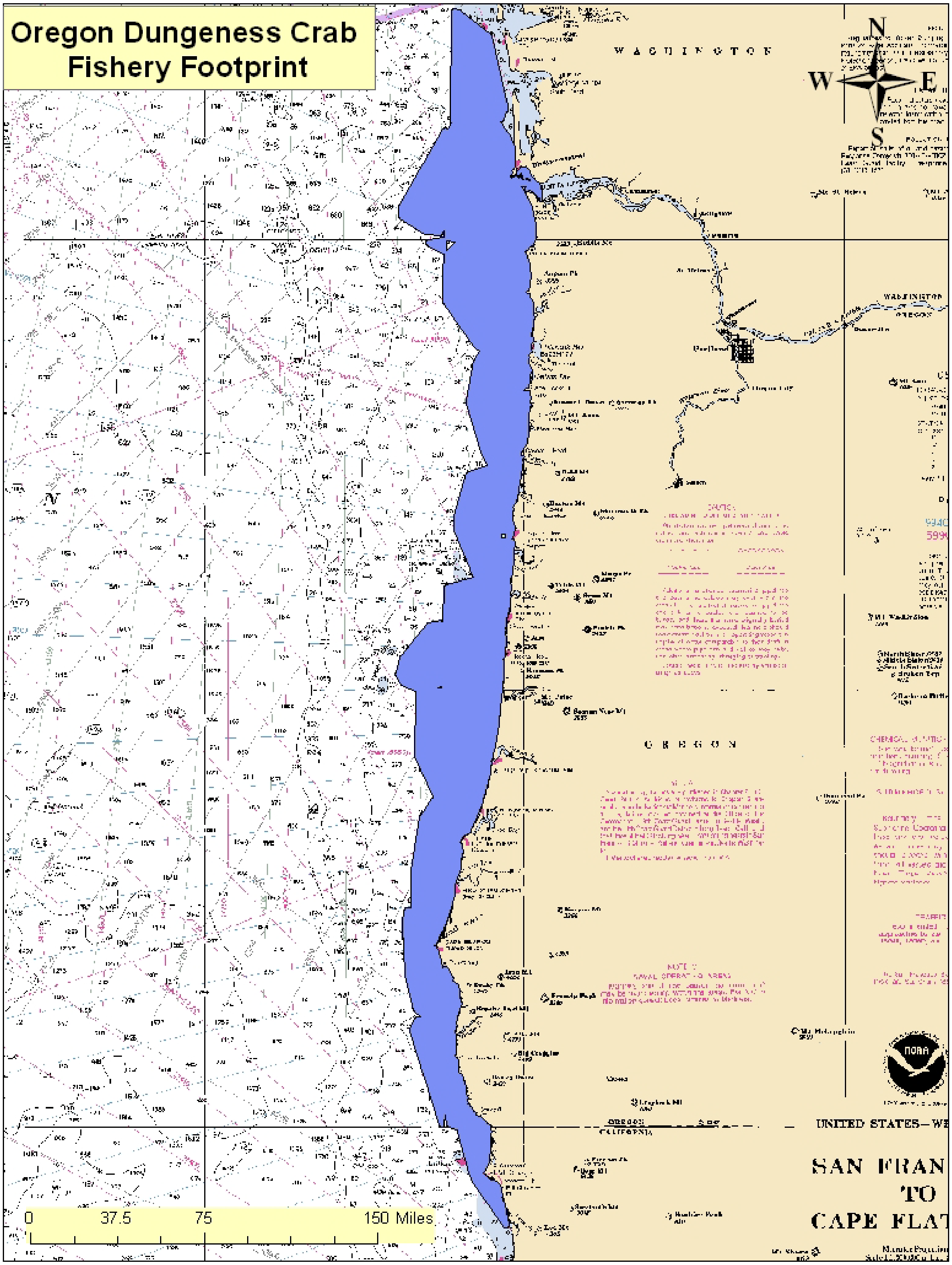

Figure 21. Oregon Dungeness crab pot fishery footprint for the 2007-08, 2009-10 and 2010-11 seasons.

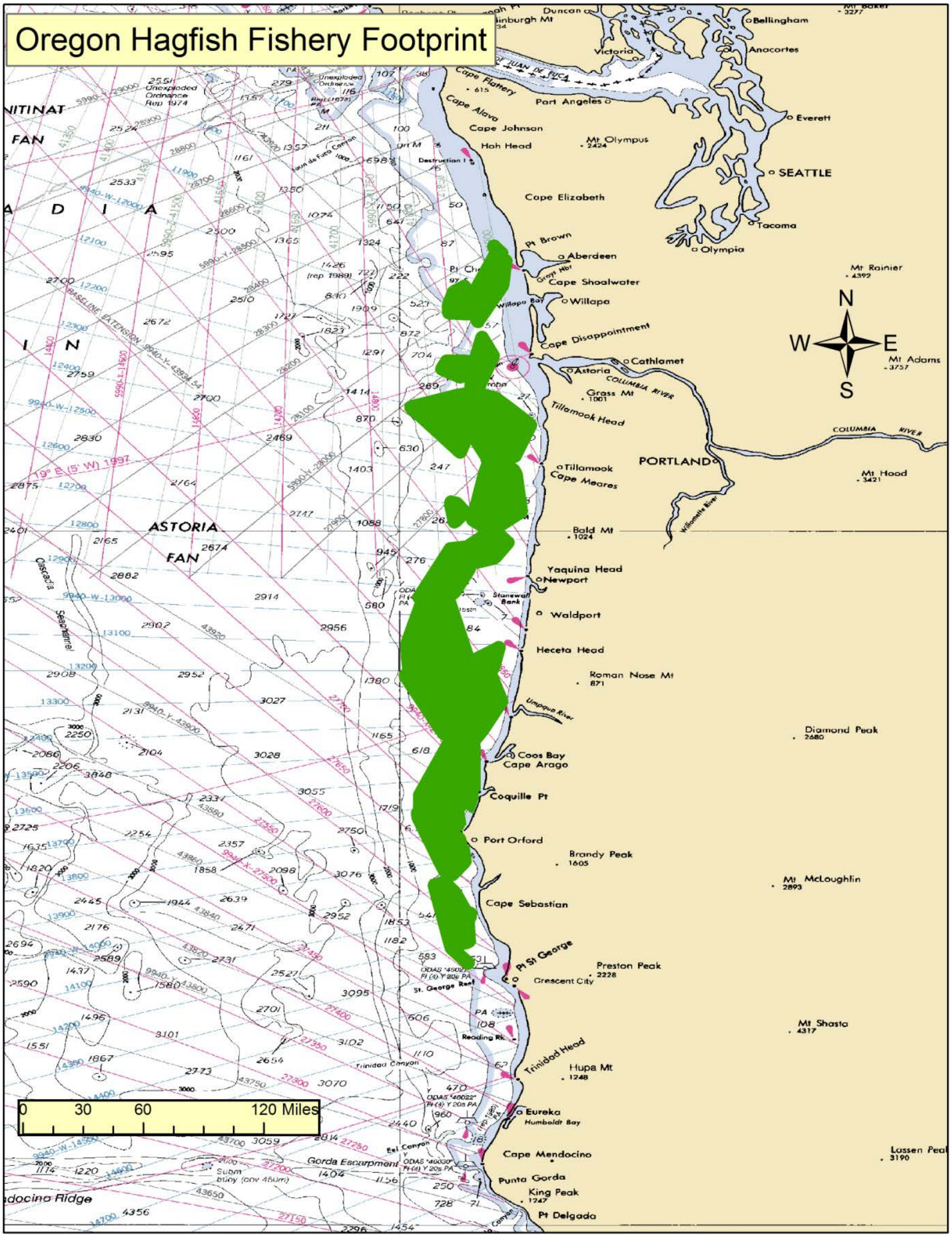

Figure 22. Oregon hagfish pot fishery footprint from 1998-1993, 1999, part of 2001, 2002-2011 (limited catch reported in 2006). Prior to 2002 catch reported sporadically, but reporting improves from 2002 onward.

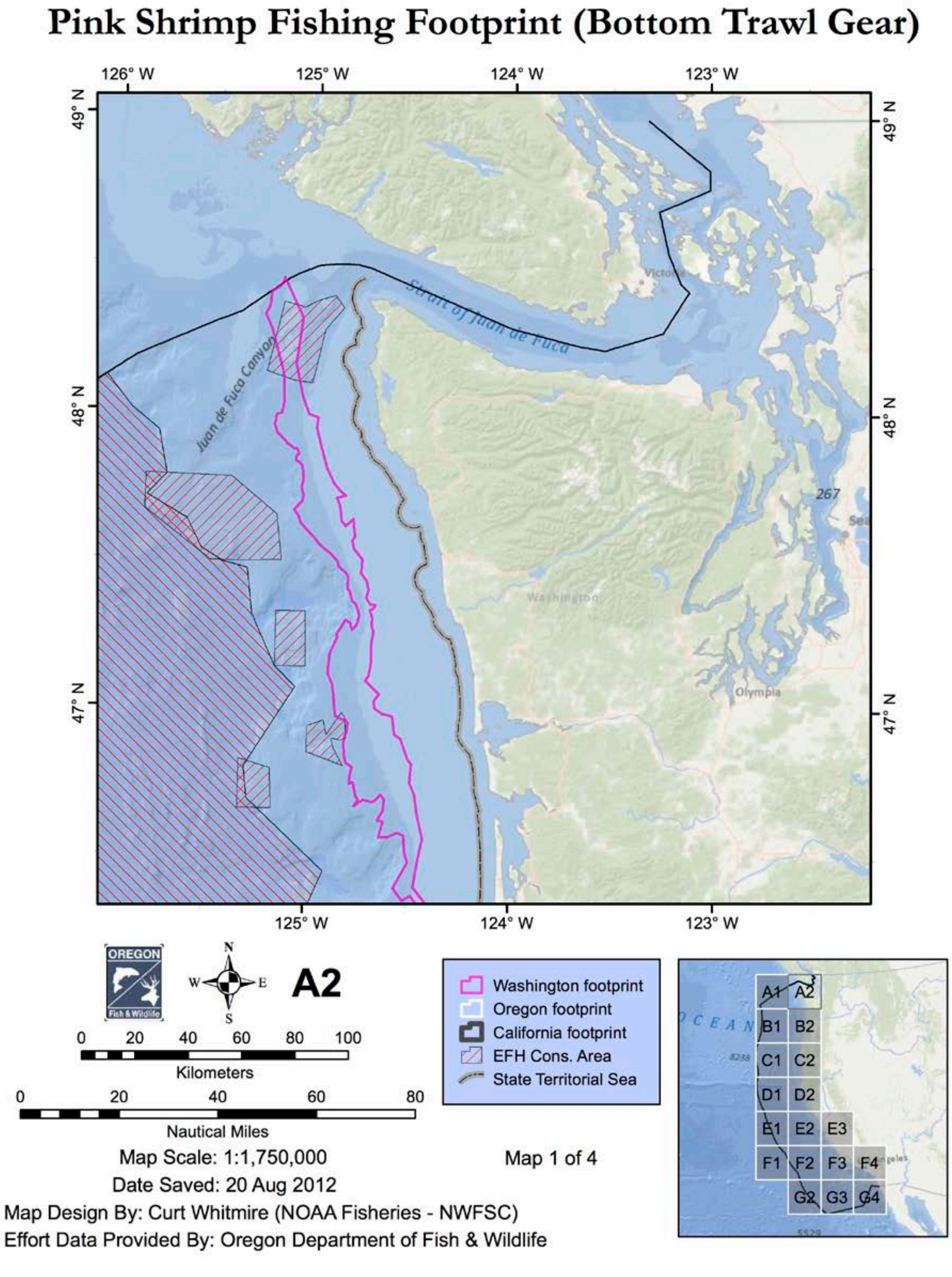

Figure 23a. Oregon pink shrimp bottom trawl fishery footprint from the 1987, 1989, 1992, 2005 and 2011 seasons.

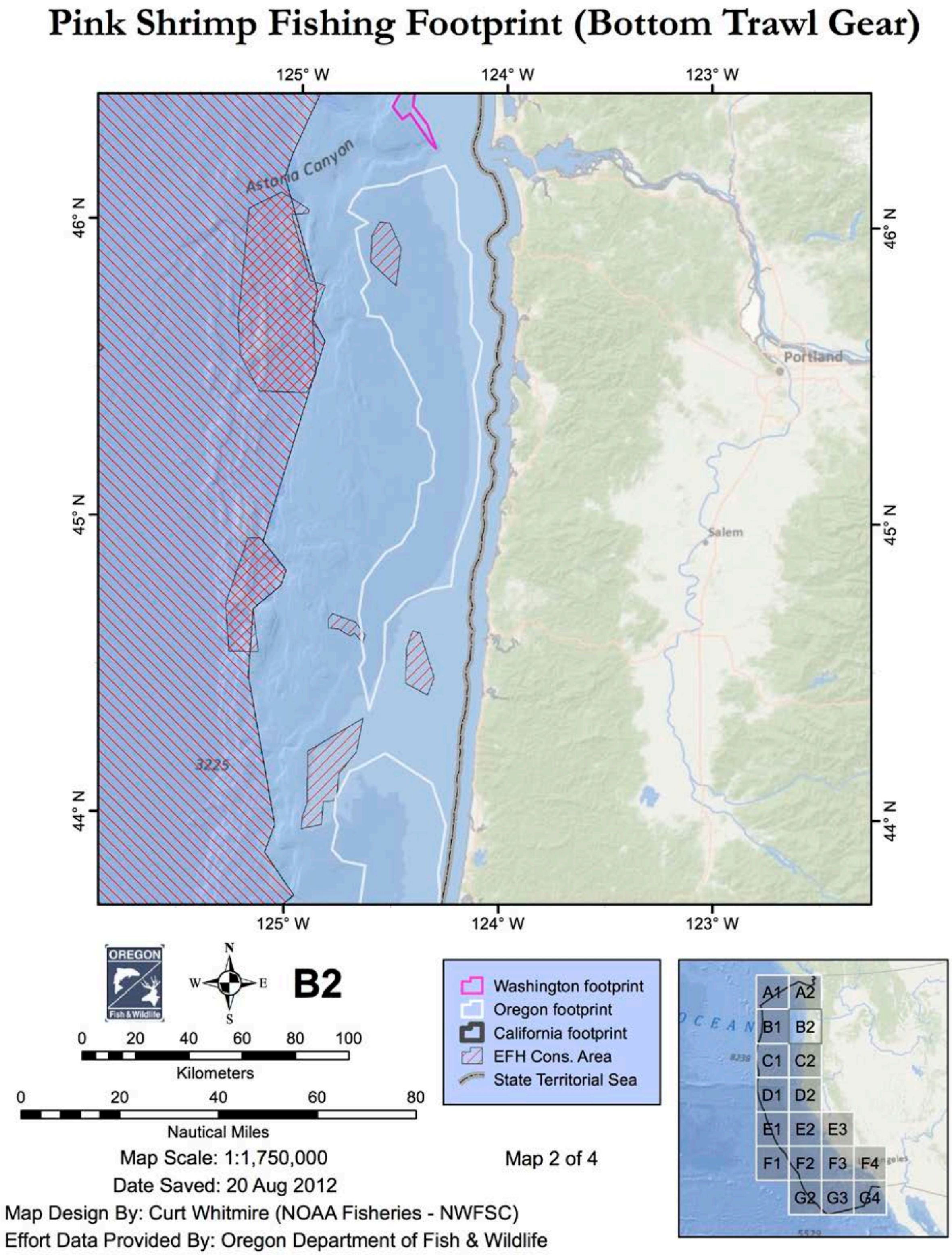

Figure 23b. Oregon pink shrimp bottom trawl fishery footprint from the 1987, 1989, 1992, 2005 and 2011 seasons.

Pink Shrimp Fishing Footprint (Bottom Trawl Gear)

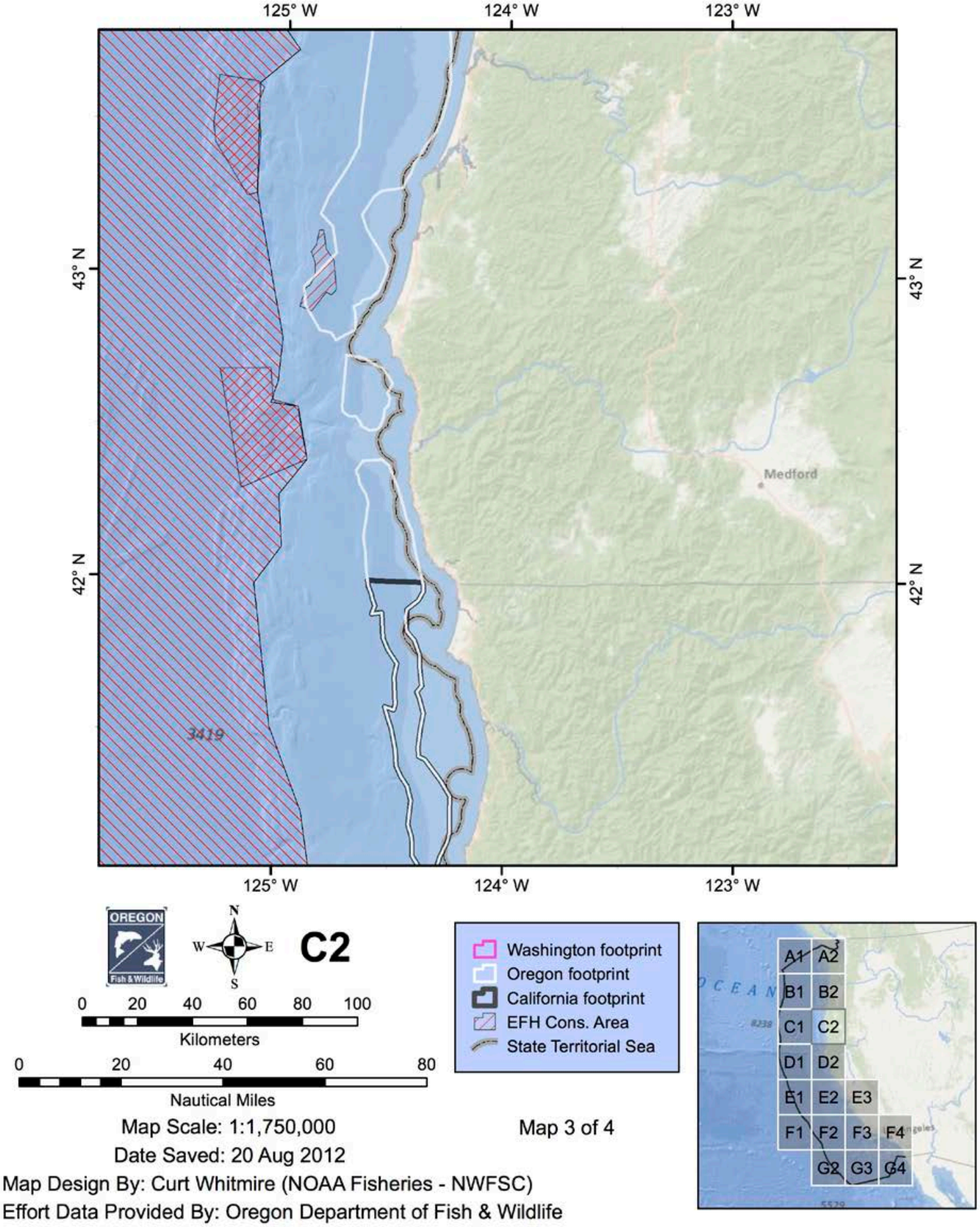

Figure 23c. Oregon pink shrimp bottom trawl fishery footprint from the 1987, 1989, 1992, 2005 and 2011 seasons.

Pink Shrimp Fishing Footprint (Bottom Trawl Gear)

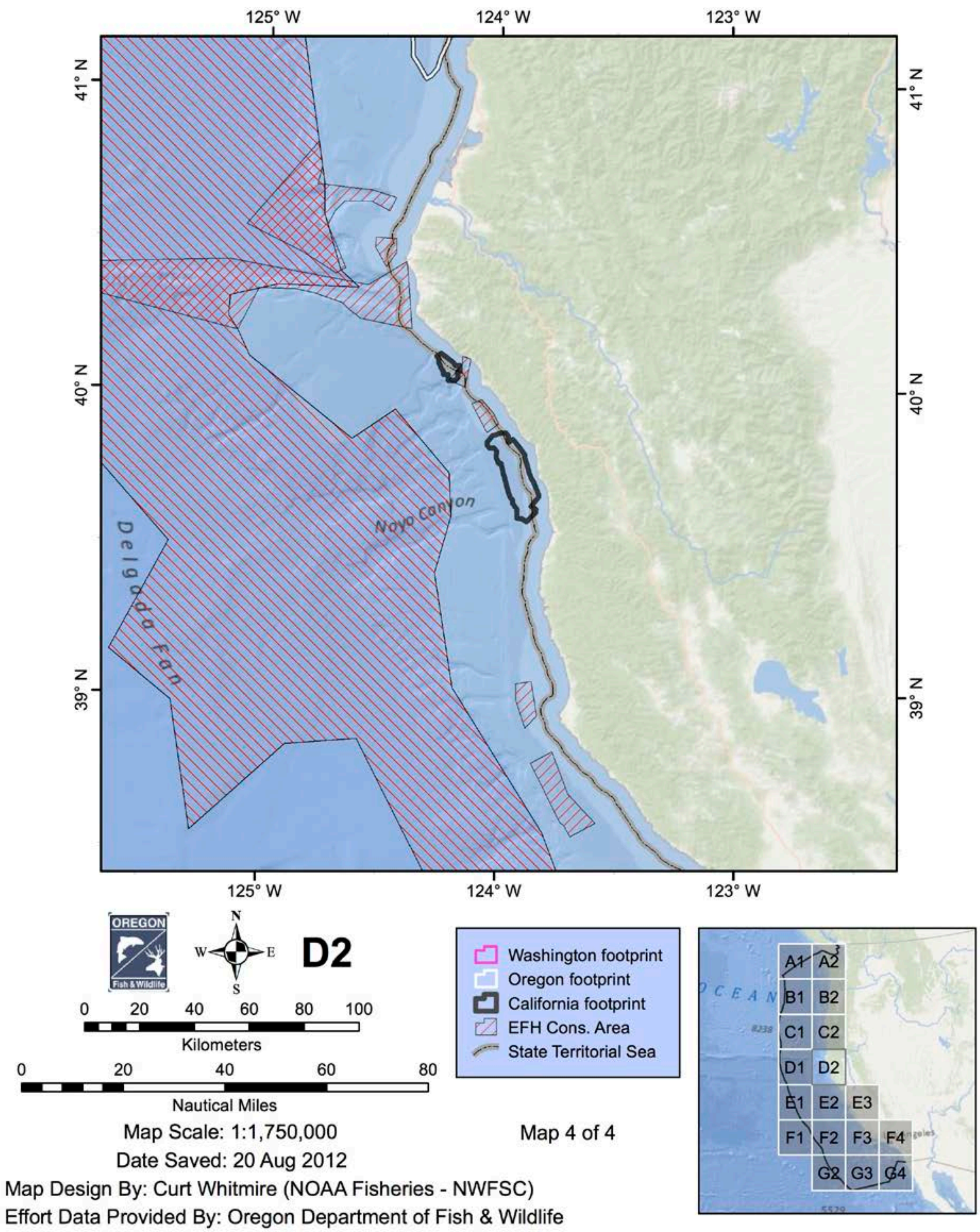

Figure 23d. Oregon pink shrimp bottom trawl fishery footprint from the 1987, 1989, 1992, 2005 and 2011 seasons.

4.5.3 Fisheries Managed by the State of California

The CDFG issued a report in 2008 that described the nature and extent of the California halibut fishery and to a lesser extent, then California sea cucumber trawl fishery (CDFG 2008). This was concurrent with the closure of California Halibut Trawl Grounds (CHTG), which have certain performance criteria associated with them, to be met prior to re-opening the CHTG. The criteria relate to bycatch, damage to seafloor habitat, ecosystem health, and restoration of biogenic habitats. While the report does not draw specific conclusions, it makes clear that there was a conservation concern

All citations in the report are from 2007 and before, and the EFHRC has not received any subsequent information in response to its request to the CDFG. While this report may not represent the most up to date information, it nonetheless provides an indicator of the location (Figure 24), nature, and intensity (Figure 25) of California halibut trawling; as well an insight into the potential adverse effects to marine habitat (Figure 26).

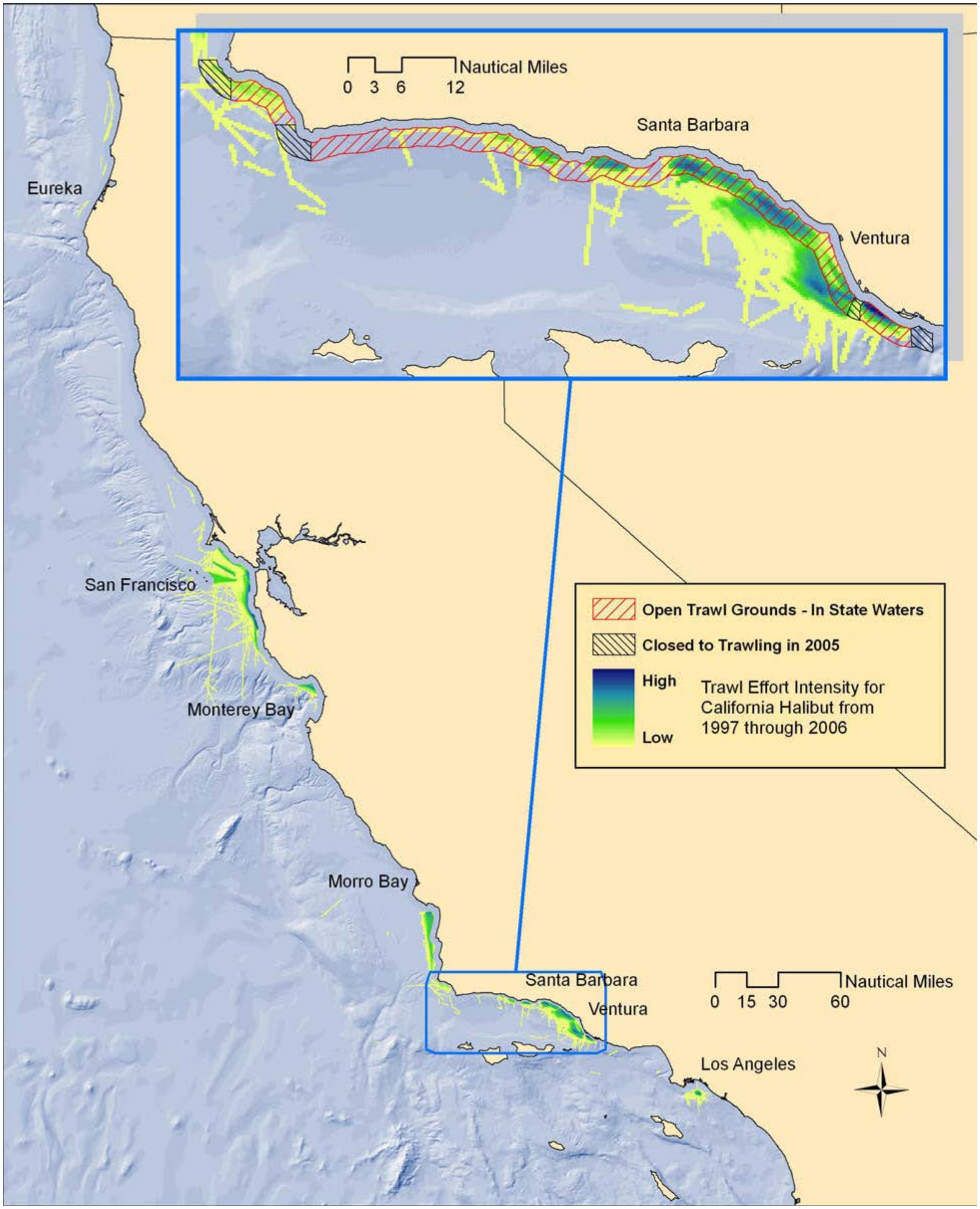

Figure 24. California historical statewide bottom trawl effort from 1997 to 2006.

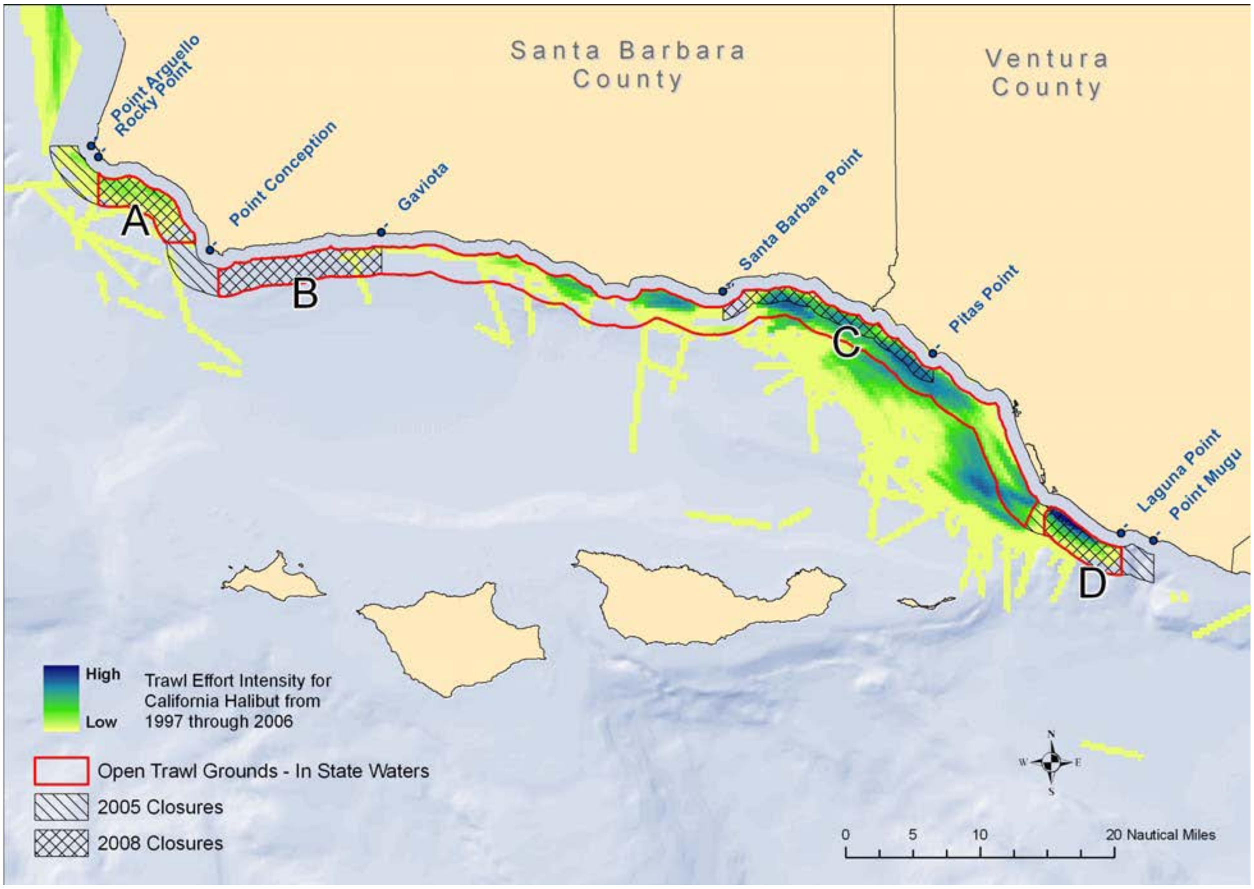

Figure 25. Bottom trawl intensity in the area of four California halibut trawl grounds proposed (as of 2008) for closure.

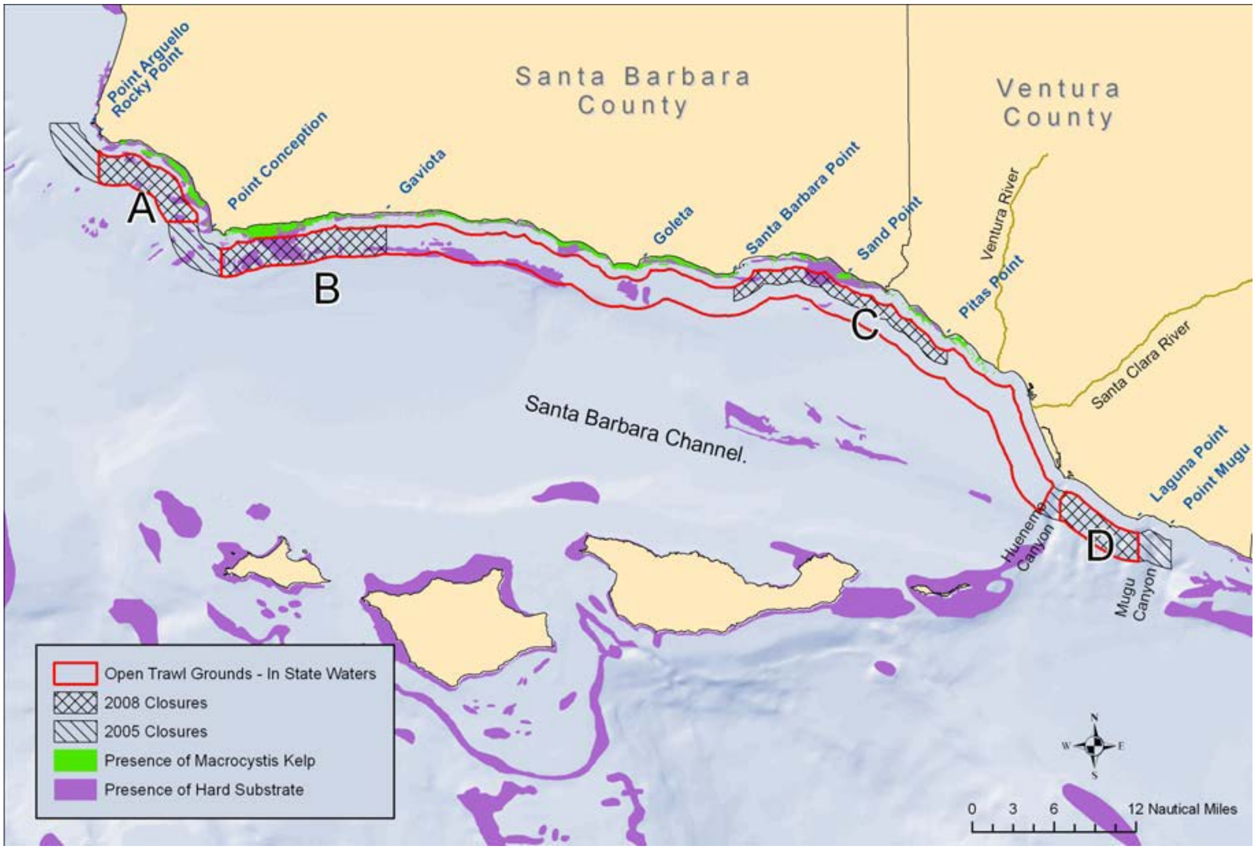

Figure 26. Depiction of hard or mixed substrate, kelp habitat, and two submarine canyons.

5.0 NON-FISHING ACTIVITIES THAT MAY AFFECT EFH

The MSA requires FMCs and NMFS to identify non-fishing activities that may adversely affect EFH, as well as actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, mitigate, or otherwise offset the adverse effects. Appendix D to the FMP includes 31 such activities and associated conservation measures, and the EFHRC identified four additional non-fishing activities (Table 13). This section provides a description of the non-fishing activities to EFH that have gained attention since Appendix D was published. The threats posed by these activities include direct effects to managed species, such as impingemnt on intake screens, and indirect effects to these species, such as loss important habitat for prey species. Some activities are more developed than others, and some include preliminary conservation measures while others do not. However, each activity description contains the information necessary to, at a minimum, inform the Council on the potential severity of the adverse effects from these activities. See FMP Appendix D for a description of the 31 threats to EFH of Pacific Coast groundfish identified in 2006. It is important to note that many projects consist of more than one of these activities, and the aggregate effects of those activities should be considered when making EFH Conservation Recommendations.

The EFHRC anticipates that, should the Council amend the Pacific Coast Groundfish FMP, the descriptions of all activities, including those identifed in FMP Appendix D, will be expanded upon and refined, and that conservation measures will be developed for each activity. In addition, the Council may determine that activities in addition to those in Table 13 merit inclusion in the amendment.

Table 13. Non-fishing activities that may adversely affect Pacific Coast groundfish EFH . Detailed description of the threats identified in 2005 can be found in Appendix D to the FMP.

Activities Identified in Amendment 19 (2005)	**New Activities Identified During EFH Review**
Agriculture/Nursery Runoff	Alternative energy development
Silviculture/Timber Harvest	Liquefied natural gas projects
Pesticide Application	Desalination
Urban/Suburban Development	Activities that contribute to climate change and ocean acidification
Road Building and Maintenance	
Upland Mineral Mining	
Sand and Gravel Mining	
Debris Removal	
Dam Operation	
Commercial and Domestic Water Use	
Dredging and	
Dredged Spoil Disposal	
Landfills	
Vessel Operation/Transportation/Navigation	
Introduction of Exotic Species	
Pile driving	
Pile removal	
Over-water structures	
Flood control/shoreline protection	
Water control structures	
Log transfer facilities/In-water log storage	
Utility line/Cables/Pipeline installation	
Commercial utilization of habitat	
Artificial Propagation of Fish and Shellfish	
Bank Stabilization	
Point source discharge	
Fish processing waste – Shoreside and Vessel operation	
Water intake structures/discharge plumes	
Oil/Gas Exploration/development/production	
Habitat restoration/enhancement	
Marine mining	

5.1 Newly Identified Threats to EFH

5.1.1 Alternative Energy Development

Marine, estuarine, and freshwater hydrokinetic energy refers to electrical energy that comes from “waves, tides, and currents in oceans, estuaries, and tidal areas; free flowing water in rivers, lakes, and streams; free flowing water in man-made channels; and differentials in ocean temperatures (ocean thermal energy conversion)” (US DOE 2009). For the purpose of considering threats to designated groundfish EFH on the West Coast of the United States, this report focuses on nearshore wave energy and tidal turbine energy development because it is the most likely form of hydrokinetic technology to move forward within the next five years. Ocean thermal energy and offshore wind development are not considered in this discussion because they are not likely to be proposed off the West Coast of the United States in the near future.

Wave energy conversion devices can be grouped by the design features to capture wave energy, into six main types: point absorbers, attenuators, oscillating wave surge converters, oscillating water column, overtopping devices, and submerged pressure differential devices (U.S.DOE 2009). Tidal turbines are placed on the bottom and can have an exposed or closed blade. Although each design is unique, these devices are typically attached to the seafloor, channel bottom, or some type of structure and deployed at or near the water's surface or at depth.

In order to develop and operate wave or tidal hydrokinetic projects, there are four phases of activities that can potentially affect groundfish EFH. The potential effects of each phase of a hydrokinetic project (preconstruction, construction, operation and maintenance, and decommissioning) need to be considered (Boehlert and Gill 2010; Gill 2005; Kramer et al. 2010; Previsic 2010; U.S.DOE 2009). In addition to the design features and footprint of an individual device, the spatial and temporal scales of a project (single device /short-term; single device /long term; multiple devices /short term; multiple devices /long term) are important considerations when evaluating effects to groundfish EFH (Boehlert and Gill 2010). The potential cumulative effects of the spatial arrangement (vertical and horizontal) of multiple devices in the water column also need to be evaluated.

Construction activities typically include: horizontal directional drilling to land cables from the device to the shoreline; laying of subsea transmission cable; foundation/mooring installation; deployment and commissioning of device(s). Operation and maintenance include the mechanical functioning of the devices and appurtenances, as well as inspection and repair of equipment. Decommissioning at the end of the project (typically 5-30 years) involves removal of all equipment in the water column and transmission cables and restoration of the site, if needed.

Related activities that pertain to both the construction and operations phases include installation and maintenance of navigation buoys to mark the deployment area; and reliable port infrastructure to accommodate work vessels as well as delivery and retrieval of large hydrokinetic devices to pier-side for repair and maintenance, if necessary.

5.1.1.1 Potential Adverse Impacts

Because the majority of hydrokinetic renewable energy technologies remain at the conceptual stage and have not yet been developed as full-scale prototypes or tested in the field, there have been few studies of their environmental effects. Currently, identification of the potential environmental effects have been developed from: (1) predictive studies; (2) workshop reports from expert panels; and (3) report syntheses prepared from published literature related to other technologies, e.g., noise generated by similar marine construction activities, measurements of electromagnetic fields (EMFs) from existing submarine cables, environmental monitoring of active offshore wind farms in Europe, and turbine passage injury reduction mechanisms employed in conventional hydropower turbines.(Boehlert and Gill 2010; Kramer et al. 2010; Nelson et al. 2008; U.S. DOE 2009).

The majority of potential effects to groundfish EFH are from the presence and operation of a wave energy convertor device or turbine, although construction and installitaion of devices can also adversely affect EFH. Those effects are covered under the specific activity shch as pile driving.. Although all phases of an individual project will alter the physical marine environment, the types and duration of those changes are varied. Numerous reviews (Kramer et al. 2010; U.S.DOE 2009) have identified the following potential effects of the wave energy converter devices, all of which may affect the quality and quantity of groundfish EFH: (1) alteration of current and wave strengths and directions; (2) alteration of substrates and sediment transport and deposition; (3) interference with animal movements and migrations, including fish (prey and predators) and invertebrate attraction to subsurface components of device, concentration of displaced fishing gear; (4) presence of rotor blades or other moving parts; and attraction and concentration of predators on surface components of device; (5) alteration of habitats for benthic organisms; (6) sound and vibration in water column during construction and operation; (7) generation of EMFs by electrical equipment and transmission lines; (8) release into water column of toxic chemicals from paints, lubricants, antifouling coatings, as well as spills of petroleum products from service vessels. These potential effects to groundfish EFH apply to tidal turbines as well.

Presence of subsurface structures may affect water movements, as well as sediment transport, erosion, and deposition at a local scale. During construction and decommissioning, the installation and removal of the foundations, anchors, and transmission cables will disturb and suspend sediments, and may mobilize contaminants, if present. Disturbances to the benthic habitat will occur during temporary anchoring of construction vessels; clearing, digging and refilling trenches for power cables; and installation of permanent anchors, pilings, and other mooring devices. Prior to installation of a buried cable, any debris is typically cleared from the cable route using a ship-towed grapnel (Carter et al. 2009). Cables are buried using a ship mounted plow, whereas buried cables are usually exposed and reburied using a water-jetting technique when needing repair (Carter et al. 2009). Water quality will be temporarily affected by: (1) increased suspended sediments and resultant increased turbidity and decreased water clarity; (2) localized reduction of dissolved oxygen where anoxic sediments are suspended; and (3) mobilization of anoxic or buried contaminated sediments during cable route clearing and installation of cables.

The physical structures associated with ocean and tidal energy operations could potentially interfere with the migration, spawning, and rearing habitat functions for juveniles and adults from a variety of groundfish species (U.S.DOE 2009). The floating and submerged structures, mooring lines, and transmission cables may create complex structural habitat that could act as a fish aggregation/attraction device (FAD), as well as provide substrate for attachment of invertebrates (considered biofouling where unwanted). Groundfish may be attracted to the physical structure itself, and/or to forage fish attracted to the structure. Floating offshore wave energy facilities could potentially (1) create artificial haul-out sites for marine mammals (pinnipeds) and roosting of seabirds; and (2) trap floating vegetation (e.g., kelp, eelgrass, large wood), and lost fishing gear (e.g., nets, traps, and crab pots). Aggregation of predators (e.g., fish, marine mammals, sea birds) near FADs may reduce the safe passage attribute of a migration corridor by subjecting juvenile or adult groundfish or their prey to increased predation. Drifting nets and other fishing gear that may become entangled on mooring lines or the devices may decrease the mortality of groundfish due to capture from passive fishing of gear. Deposition of organic matter from biofouling on the structure can change the chemical properties and biological communities near the structures. There will be new lighted, fixed surface structures (devices and navigation buoys marking the project area) in the marine environment which may attract prey and predators of juvenile and adult groundfish.

Depending on the frequency and amplitude of the sound of the moving parts of the device, as well as how far the sound waves propagate, the operational sounds of the devices may affect spawning, rearing, and migration corridor habitat. There is limited information on sound levels produced during construction (e.g., offshore pile driving) and operation of ocean energy conversion devices, as well as the spatial extent of any altered acoustic environment. Turbines with exposed rotor blades may impede or entraine groundfish or their prey.

Migrating adult, juvenile, larval, and eggs of groundfish may be exposed to EMFs generated at a project site, which may affect movement and survival. The electric current in the cables will induce a magnetic field in the immediate vicinity (U.S.DOE 2009). During transmission of produced electricity, the matrix of vertical and horizontal cables will emit low-frequency EMFs. The source and effects of EMFs in the marine environment are limited and uncertain (Gill 2005).

Accidental, but acute, release of chemicals from leaks or spills (e.g., hydraulic fluids from a wave energy conversion device, drilling fluids during horizontal drilling) could have adverse effects to water quality. Anti-fouling coatings inhibit the settling and growth of marine organisms, and chronic releases of dissolved metals or organic compounds could occur from these compounds (U.S.DOE 2009). The rish of cumulative effects to groundfish and their prey from decreased water quality associated with the release of toxic chemicals could vary substantially depending upon the number of units deployed, type of antifouling coating used, and the maintenance frequency of the coating.

5.1.1.2 Recommended Conservation Measures

- Structural and operational mitigation options are often unique to the technology or issue of concern.
- Locate and operate devices at sites and times of the year, to avoid groundfish migration routes and spawning seasons, respectively. Structures should also be located to avoid sensitive habitats (e.g., rocky reef, kelp beds)
- Schedule the noisiest activities, i.e., pile driving, at times of the year to minimize exposure of juvenile and adult groundfish.
- Schedule transmission cable installation to minimize overlap with groundfish migration and spawning seasons. Structures should also be located to avoid sensitive habitats (e.g., rocky reef, kelp beds)
- Conduct pre-construction contaminant surveys of the sediment in excavation and scour areas.
- To avoid concentration of predators, above water structures could have design features to prevent or minimize pinniped haul-out and bird roosting.
- Sheath or armor the vertical transmission cable to reduce transmission of EMF into the water column.
- Bury transmission cables on the sea floor to minimize benthic and water column EMF exposure.
- Align transmission cables along the least environmentally damaging route. Avoid sensitive habitats (e.g., rocky reef, kelp beds) and critical life history pathways.
- Use horizontal drilling where cables cross nearshore and intertidal zones to avoid disturbance of benthic and water column habitat.
- Design the mooring systems to minimize the footprint by reducing anchor size, and cable/chain sweep.
- Develop and implement a device/array maintenance program to remove entangled derelect fishing gear and other materials that may increase mortality.
- Use non-toxic paints and lubricating fluids where feasible.
- Limit the number of devices and size of projects until effects are better understood and minimization measures tested.

5.1.2 Desalination

Global population growth continues to place high demand on available supplies of potable water, and areas with limited supplies of this essential resource are turning to desalination (Roberts et al. 2010). Recent estimates suggest that up to 24 million cubic meters of desalinated water are produced daily (Latterman and Hoepner 2008). Expansion of desalination capacity can be found in the U.S., Europe, China, and Australia. California is leading the way in the U.S., with projections indicating that up to 20 new desalination plants, with a capacity of 2 million cubic meters per day, will be constructed by 2030. Desalination plants have a strong potential to detrimentally impact the ecology of marine habitats through water extraction and discharge of effluent. The following discussion is taken, unless otherwise cited, from a recent critical review by Roberts et al. (2010) of the available, peer-reviewed literature on the effects of effluent discharge.

Desalination of seawater to produce potable water uses one of two basic processes: thermal distillation such as multi-stage flash (MSF) distillation, and reverse osmosis (RO). Both of these methods have a saltwater intake and an effluent discharge. The effluent is water remaining after desalination and the concentrated salts from the seawater, commonly referred to as "brine." The brine also may contain various chemicals used in the desalination process, heavy metals from the machinery, and concentrated contaminants that were in the seawater. Reverse osmosis plants are increasingly common compared to the MSF plants.

5.1.2.1 Potential Adverse Effects

The potential effects are largely concerned with intake of seawater, which can entrain and impinge marine organisms, and discharge of the brine, which can affect the physiochemistry and, therefore, the ecology at the discharge site and beyond. The effects from intake water would be similar to those expected from Water Intake Structures (Table 13).

The discharge of brine can affect the salinity, temperature, and contaminant loading of the receiving body. Changes to salinity have been the most studied of these potential effects. Depending on the desalination method used, the design of the plant, and the salinity of the intake water, the salinity of the brine can range from as low as 37.3 parts per thousand (ppt) to as high as 75 ppt. In general, for an RO plant, the salinity of the brine will be roughly double that of the intake water. Published research shows that the extent of the brine plume (the area where the salinity is elevated) varies greatly, from 10s of meters, to 100s of meters, or in extreme cases, to several kilometers from the discharge point. The extent of the plume depends on a variety of factors, including the capacity of the plant, the salinity of the brine, the location of the discharge, the design of the diffuser, and local hydrologic conditions. However, in most cases studied, the intensity of the plume diminishes rapidly with distance from the outfall and is usually no greater than 2 ppt above background salinity within 20 m of the outlet.

Brine is usually denser than seawater and will, therefore, sink to the bottom and extend farther along the seafloor than at the surface. Where prevailing currents carry the plume further alongshore than offshore, the coastal fringe may be especially susceptible to impacts. During times of high tide, the brine may be concentrated around outfalls. Thus, the area impacted by the plume is likely to be both spatially and temporally variable.

A number of studies have shown that discharge of brine can lead to detectable ecological impacts to seagrass habitats, as well as phytoplankton, invertebrate and fish communities. The effects to seagrasses are the most widely studied. However, the results of these studies are highly variable. Several studies on the Mediterranean seagrass, *Posidonia oceana,* showed clear adverse effects, with significant increases in mortality and leaf necrosis at increases of only 1-2 ppt. Others found no significant effects, even six years after plant operations began. A study on eelgrass (*Zoster marina*) from marine and estuarine waters of the Netherlands found increased mortality at salinities 30 ppt and 25 ppt respectively, which are at the upper end of the salinity range in these habitats (van Katwijk et al. 1999). This suggests that eelgrass, a species of particular importance to Pacific Coast fisheries, is sensitive to salinity changes and could be at risk if exposed to a brine plume.

Infaunal and epifaunal invertebrate communities were found to be impacted by the brine plume in several studies. Close to the outfall, nematodes dominated the community and reduced diversity of other taxa up to 400 meters from the outfall. The diversity and abundance of benthic diatoms may also be reduced near the outfall. These communities are an important part of the food web upon which juvenile and adult groundfish depend, and could be at risk from exposure to brine plumes. In contrast, other studies found no change in the macrobenthic organisms where the brine dissipated within 10 m from the outfall. Some of the studies that showed changes to the benthic community were associated with older plants that discharged excessive levels of copper, an issue that is largely avoidable.

Salinities of 55 ppt or higher were found to be acutely toxic to juvenile sea bream and larval flounder. The implications of this for Pacific Coast groundfish are not clear, but brine discharge could affect their survival, depending on the location of the outfall.

Depending on the design of the plant, the brine may be warmer than the receiving waters. This is primarily limited to MSF plants, while RO plants tend to result in plumes that are near ambient temperature. Because RO plants are becoming more common, relative to the MSF plants, this is a lesser problem than in the past. MSF plants can produce brines that are 10-15° C warmer than the receiving waters. However, most studies have found that the thermal impacts dissipate quickly, typically diminishing to background levels within tens of meters of the outfalls. The extent and severity of the thermal plume is dependent upon a variety of factors, such as the temperature of the discharge and receiving waters, the plant capacity, and local hydrologic conditions. Given the potentially high water temperatures in the immediate vicinity of the plume, there is a potential for groundfish, particularly juveniles, to be affected.

Desalination can clearly impact the ecology of the receiving waters, but the extent of those effects depend on a variety of factors, such as plant capacity, discharge location and design, temperature and salinity differences between effluent and receiving water, and hydrologic conditions at the discharge site. Such variables should be considered when assessing the effects of these plants.

5.1.3 Activities that Contribute to Climate Change and Ocean Acidification

Human activities that emit greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases contribute to a changing climate. Global climate change is correlated to the residence time of these compounds in the atmosphere and their ability to warm the planet. Examples of human activities that contribute to GHG emissions include burning fossil fuels, deforestation, and land development.

Pacific Northwest temperatures have increased by about 0.8° C, and models project warming of 2.0° C by the 2040s and 3.3° C by the 2080s (Mote and Salathé 2009). Precipitation is also projected to increase with a more intense seasonal cycle - autumns and winters may become wetter and summers may become drier. Regional climate models indicate that overall extreme precipitation in western Washington will increase and the snowpack in the Cascades will decrease (Mote and Salathé 2009).

In the marine environment, increased water temperatures would promote stratification between warmer surface waters and cooler, nutrient rich deep waters. The resulting thermocline could prevent nutrient cycling between regions diminishing growth of phytoplankton that form the base of marine food webs (Climate Impacts Group 2004; Scheuerell and Williams 2005).

The ocean is a major sink for atmospheric CO_2, and changes in atmospheric concentrations will affect oceanic conditions. Specifically, as the level of CO_2 in the atmosphere increases, it will dissolve more readily in the ocean, increasing the concentration of carbonic acid and lowering the pH of seawater. Whether or not this change will directly harm groundfish is not known, but their ecosystem may be far less productive. Planktonic organisms that form the base of many marine food webs secrete $CaCO_3$ shells necessary for survival. Lower pH will dissolve or prevent the formation of these shells causing mortality (Orr et al. 2005). Groundfish juveniles and prey species rely on plankton as a food source and decreased plankton abundance could affect growth and survival. Changing ocean temperatures may alter groundfish behavior, distribution, and migrations.

5.1.4 Liquefied Natural Gas Projects

Liquefied natural gas (LNG) is expected to provide a large proportion of the future energy needs in the United States. In recent years there has been an increase in proposals for new LNG facilities along the West Coast including a number of onshore and offshore facilities in Oregon and California. The LNG process cools natural gas to its liquid form at approximately -162°C. This reduces the volume of natural gas to approximately 1/600th of its gaseous state volume, making it possible for economical transportation with tankers. Upon arrival at the destination the LNG is either vaporized onshore or offshore and sent out into an existing pipeline infrastructure or transported onshore for storage and future vaporization. The process of vaporization occurs when LNG is heated and converted back to its gaseous state. LNG facilities can utilize open loop, closed loop, combined loop, or ambient air systems for vaporization. Open loop systems utilize warm water for vaporization, and closed loop systems generally utilize a recirculating mixture of ethylene glycol for vaporization. Another type of closed-loop system is submerged combustion vaporization (SCV), which provides a water bath with submerged pipe coils. Combined loop systems utilize a combination of these systems.

Onshore LNG facilities generally include a deepwater access channel, land-based facilities for vaporization and distribution, storage facilities, and a pipeline to move the natural gas. Offshore facilities generally include some type of a deepwater port with a vaporization facility and pipelines to transport natural gas into existing gas distribution pipelines or onshore storage facilities. Deepwater ports and onshore terminals require specific water depths and include an exclusion zone for LNG vessel and/or port facility security.

5.1.4.1 Potential adverse effects to EFH

Construction and operation of LNG facilities can affect the habitat of groundfish in a variety of ways. Direct conversion and loss of habitat can occur through dredging and filling, construction of overwater structures, placement of pipelines, and shoreline armoring. Construction-related effects to habitat include generation of underwater noise from pile driving and vessel operations, turbidity, and discharge of contaminants. Long-term degradation of habitat can result from impingement and entrainment at water intakes for vaporization water and ballast and engine cooling water for LNG vessels, discharge of contaminants, and discharge of cooled water from open-loop systems. Short- and long-term habitat degradation can result from accidental spills of LNG and other contaminants. With the exception of the discharge of contaminated water, discharge of vaporization water, and accidental spills of LNG, these effects are covered under other threats described in either this document or the Groundfish FMP.

Contaminants can enter aquatic habitats through accidental releases associated with onshore and offshore operations, discharge of water containing biocides used to control fouling of piping systems, and discharges of the condensates from heat exchangers. A rapid phase transition can occur when a portion of LNG spilled onto water changes from a liquid to a gas virtually instantaneously. The rapid change from a liquid to vapor state can cause locally large overpressures ranging from a small pop to a blast large enough to potentially damage structures (Luketa et al. 2008). Because rapid phase transition would occur at the surface of the water it would be unlikely to affect fishes that are several feet under the surface. However, any fish present at or near the surface of the water would likely be killed. Effects on the aquatic environment from an LNG spill include thermal shock from the initial release (cold shock from the cryogenic liquid) and thermal shock from ignition of the vapor (Hightower et al. 2004). Condensates from heat exchanger such as SCV systems are generally acidic and require buffering with alkaline chemicals (FERC 2010). The condensate can include a wide range of metals and other contaminants. These contaminants may include copper, a known disruptor of olfactory function in fishes (e.g., Baldwin et al. 2003). Dissolved copper is also toxic to many invertebrate species, which may affect the prey base for groundfishes. The concentration of these chemicals will vary depending on the water source and facility design.

The operation of LNG facilities can result in the alteration of temperature regimes. Water utilized for the purposes of vaporization could be discharged at temperatures that differ significantly from the receiving waters and can be 5-10°C below ambient temperature. Changes in water temperatures can alter physiological functions of marine organisms including respiration, metabolism, reproduction, and growth; alter migration pathways; and increase susceptibility to disease and predation. Thermal effluent in inshore habitat can cause severe problems by directly altering the benthic community or adversely affecting marine organisms, especially egg and larval life stages (Pilati 1976, cited in NMFS 2008; Rogers 1976, cited in NMFS 2008).

5.1.4.2 Potential Conservation Measures

- Site LNG facilities in areas that minimize the loss of habitat such as naturally deep waters adjacent to uplands that are not in the floodplain.
- Recommend the vaporization systems that do not rely on surface waters as a heat source, such as an ambient air system. This will avoid impingement and entrainment of living resources. If a water-sourced system must be used, recommend closed loop systems over open loop systems. This will minimize water withdrawals and the associated impingement and entrainment of living marine resources.
- Locate facilities that use surface waters for vaporization and engine cooling purposes away from areas of high biological productivity, such as estuaries.
- Design intake structures to minimize entrainment or impingement.
- Regulate discharge temperatures (both heated and cooled effluent) such that they do not appreciably alter the temperature regimes of the receiving waters. Strategies should be implemented to diffuse this effluent.
- Avoid the use of biocides (e.g., aluminum, copper, chlorine compounds) to prevent fouling where possible. The least damaging antifouling alternatives should be implemented.

6.0 PREY SPECIES

The EFH regulatory guidance (50 CFR §600.815) states that loss of prey species may be an adverse effect on EFH and managed species because the presence of prey makes waters and substrate function as feeding habitat. Both fishing and non-fishing actions that reduce the availability of a major prey species may be considered as adverse effects on EFH, if they reduce the quality or quantity of EFH. Chapters 4 (Fishing Activities that May Affect EFH) and 5 (Non-fishing Activities that May Affect EFH) describe human-caused activities that may adversely affect EFH, including prey species.

The regulatory guidance also states that FMPs should list the major prey species and discuss the location of prey species' habitat. Appendix B3 of the groundfish FMP (PFMC 2011) lists prey species for each managed groundfish species. However, it does not discuss the location of the habitat, or identify fishing and non-fishing activities that may adversely affect groundfish prey and/or its habitat, as called for in the EFH regulatory guidance.

A guidance memorandum from NMFS (Montanio 2006) sought to clarify the question of prey as EFH. The regulatory guidance states that, as part of "associated biological communities", prey may be considered a component of EFH. However, the guidance memorandum further states that "prey species alone should not be described as EFH." This subtle distinction is important, and does not preclude the requirement of FMPs to identify adverse impacts to prey species.

The EFH guidance does not explicitly specify criteria for identifying "major" prey species. However, even with clear guidance, identifying which prey items constitute major prey for Pacific Coast groundfishes is highly dependent on the quality and availability of data on diet composition. While some groundfish species have diet composition samples taken over a broad geographic and temporal range, diet analysis for many species has been limited to a single time of year at a single location with a small sample size, and for some groundfish there is no diet data available. This makes broader generalizations about the diet across the range of the species uncertain, even when the studies are aggregated across species. Therefore, even where quantitative data do exist, the EFHRC did not attempt to identify "major" prey or distinguish "major" prey from other prey. For this report, the EFHRC took a general approach and identified prey at broader taxonomic levels, based on a pre-existing literature reviews conducted by Dufault et al. 2009, which was compiled for a different purpose. More detailed information and a comprehensive literature review, particularly the identification of prey at the species level, will be required to adequately describe and identify the major prey for Pacific Coast groundfishes.

6.1 Prey Species Listed in the Groundfish FMP

Appendix B3 of the groundfish FMP (PFMC 2011a) provides prey items associated with each FMP groundfish species and each life stage, but does not distinguish between "major" prey items and general prey. Table 14 below lists the entire suite of prey items included in the FMP.

Table 14. List of prey species from the Gourndfish FMP (PFMC 2011a).

Fish	Arthropods	Others
Fish	Crustaceans	Algae
Fish larvae	Invertebrate nauplii	Gelatinous plankton
Small fishes	Crustacean zoea	Diatoms
Hydrologus colliei	Cladocerans	Dinoflagellates
Clupeids	Ostracods	Tintinnids
Gadids	Copepods	Invertebrate eggs
Theragra chalcograma	Barnacle Cypriots	Hydroids
Merluccius productus	Amphipods	Jellyfish
Cottids	Isopods	Sea urchin
Juvenile rockfish	Shrimp	Seastars
	Krill	Brittle stars
	Euphausiids	Salps
	Mysids	Tunicates
	Crabs	Annelids
		Polychaetes
		Mollusks
		Nudibranchs
		opisthobranchs
		Snails
		Cephalopods
		Squids
		Octopi

6.2 New Information on Prey Species

There is not a large body of literature on Pacific groundfish diets since 2006; however significant details on diet composition from the literature were not included in the Amendment 19 documentation. In addition, several groundfish stock assessments were completed in 2009 and 2011, some of which included information on groundfish diet composition. Selected stock assessments are referenced in Table 15 below. Aside from those cited in Table 15, the 2009 and 2011 stock assessments generally corroborate the information contained in Dufault et al. (2009), as well as prior stock assessments on the same species.

This section summarizes the major prey items for the species managed under the groundfish FMP, based on a 2009 review by Dufault et al (2009) that described the diets of selected California Current species. By reviewing over 75 publications on diet studies, Dufault et al. were able to describe predator/prey relationships in a more refined way than in Amendment 19. They used a hierarchical cluster analysis to identify distinct feeding guilds of the California Current and present quantitative relative abundance of various prey categories for each species. While not comprehensive of all species managed under the Groundfish FMP, it represents newly available synthesis of information that was not included in Amendment 19. Table 15 summarizes the Dufault et al. synthesis for relevant FMP groundfish species.

Appendix G (Species Summaries) includes several relevant publications since 2006. However, while many diet composition studies break out individual species of prey, the Dufault et al. (2009) analysis groups prey into categories (as the primary purpose was the establishment of feeding guilds to inform the Atlantis model), so obtaining information on specific species of prey requires examination of the original literature used in Dufault et al. (2009). Recently published diet studies for Pacific Coast groundfish generally corroborate the synthesis by Dufault et al (2009).

Species comprising the groundfish FMP exhibit a wide range of prey preferences, ranging from phyto- and zoo-plankton, to small crustaceans, cephlapods, and other finfish. Some species are characterized by a preference for a very few prey items (e.g., canary rockfish) while others show a much wider range of prey items (e.g., longspine thornyhead, yelloweye rockfish).

In some cases, FMP groundfish species show preference for categories of prey (fish, benthic invertebrates, etc), but appear to be opportunistic within those groups. For example, arrowtooth flounder is primarily piscivorous, but preys on different fish species depending on geographic location and (presumably) prey availability (Pearsall and Fargo 2007).

Pacific sardine has a large volume of data on population and biomass. Emmett et al. (2001) found one Pacific sardine and seven northern anchovy in 2,200 hake stomach samples, although 1,627 stomachs were empty. Emmett et al. (2005) found that nine of 12 hake stomach samples contained Pacific sardine. The extent to which Pacific sardines serve as prey for hake and other groundfish has not been thoroughly assessed. Pacific sardine is managed in the Coastal Pelagic Species FMP, and the stock is also fished in Mexico and Canada; there is no international management agreement.

Table 15. Major prey components from selected species groups, based on Dufault et al. (2009).

Guild (from Dufault et al. 2009)	Species	Prey species (approx % of diet; includes prey comprising ~>15% of diet)* from Dufault et al. 2009	Additional Sources/Notes
Define Guilds/Legend	Canary rockfish	Large zooplankton (95%)	
A	Darkblotched rockfish	Large zooplankton (78%)	
A	Greenstriped rockfish	Large zooplankton (72%)	Hicks et al. (2009) state that greenstripe diet includes fish, krill, shrimps, copepods, amphipods, and squid, but does not distinguish "major" prey items.
A	Pacific hake	Large zooplankton (78%) Small planktivores (19%)	Hamel and Stewart (2009) state that for larger hake, other fish (especially Pacific herring) become a more significant portion of their diet. Pacific hake feed on euphausiids, pandalid shrimp, and pelagic schooling fish (such as eulachon and Pacific herring) (Livingston and Bailey 1985).
A	Pacific ocean perch	Large zooplankton (65%)	
A	Pygmy rockfish	Large zooplankton (92%)	
A	Redstripe rockfish	Large zooplankton (100%)	
A	Sharpchin rockfish	Large zooplankton (45%) Deep vertical migrators (36%)	
A	Spiny dogfish	Large zooplankton (53%)	
A	Splitnose rockfish	Large zooplankton (94%)	
B	Black rockfish	Small planktivores (51%)	
B	Blue rockfish	Gelatinous zooplankton (55%) Small planktivores (35%)	
D	Dover sole	Benthic carnivores (43%) Deep macrozoobenthos (36%)	
D	English sole	Deposit feeders (70%) Benthic carnivores (16%)	
D	Rex sole	Benthic carnivores (67%) Deposit feeders (32%)	
E	Big skate	Shrimp (59%) Megazoobenthos (22%)	
E	Longnose skate	Shrimp (21%)	
E	Pacific sanddab	Shrimp (42%) Benthic herbivorous grazers (25%) Deposit feeders (24%)	
E	Petrale sole	Small flatfish (62%) Shrimp (25%)	Pearsall and Fargo (2007) found the composition in Hecate Strait consisted primarily of fishes, esp. Pacific herring. This contrasts with other studies showing greater reliance on decapods crustaceans. Allen et al. (2006) noted that petrale become increasingly piscivorous at larger sizes.

Guild (from Dufault et al. 2009)	Species	Prey species (approx % of diet; includes prey comprising ~>15% of diet)* from Dufault et al. 2009	Additional Sources/Notes
F	Pacific grenadier (Pacific rattail)	Cephalopods (35%) Deposit feeders (24%) Deep misc. fishes (23%)	
G	Rosethorn rockfish	Deposit feeders (46%) Benthic herbivorous grazers (35%)	
G	Rougheye rockfish	Benthic herbivorous grazers (49%)	
G	Widow rockfish	Gelatinous zooplankton (48%) Large zooplankton (34%)	
G	Yellowtail rockfish	Large zooplankton (40%) Gelatinous zooplankton (22%)	
H	Arrowtooth flounder	Pacific hake (46%) Small planktivores (16%)	Various studies suggest that arrowtooth flounder adults are preferably piscivores, feeding opportunistically on available fishes. Juveniles ingest a greater proportion of macrobenthos, euphausiids, and shrimp. (See Appendix G, Species Summaries)
H	Lingcod	Shallow small rockfish (21%) Miscellaneous nearshore fish (20%)	
H	Longspine thornyhead	Deposit feeders (24%) Megazoobenthos (20%) Small planktivores (14%)	
H	Sablefish	Deep small rockfish (34%)	
H	Shortspine thornyhead	Megazoobenthos (32%)	
H	Yelloweye rockfish	Small planktivores (33%) Deposit feeders (19%)	
	Other FMP Groundfish Species	**Diet**	**Notes/Source**
	Aurora rockfish		
	Bank rockfish		
	Black-and-yellow rockfish		
	Blackgill rockfish		
	Bocaccio	Primarily piscivorous	Field, John C., E.J. Dick, D. Pearson, A MacCall. Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monetery and Eureka INPFC areas for 2009.
	Bronzespotted rockfish		N/A
	Brown rockfish		FMP includes prey information
	Butter sole		FMP includes prey information
	Cabezon		FMP includes prey information
	Calico rockfish		FMP includes prey information
	California scorpionfish		FMP includes prey information
	California skate		FMP includes prey information

Guild (from Dufault et al. 2009)	Species	Prey species (approx % of diet; includes prey comprising ~>15% of diet)* from Dufault et al. 2009	Additional Sources/Notes
	Chameleon rockfish		N/A
	Chilipepper		FMP includes prey information
	China rockfish		FMP includes prey information
	Cowcod		FMP includes prey information
	Curlfin sole		FMP includes prey information
	Dusky rockfish		N/A
	Dwarf-red rockfish		N/A
	Flag rockfish		FMP includes prey information
	Flathead sole		FMP includes prey information
	Freckled rockfish		N/A
	Gopher rockfish		FMP includes prey information
	Grass rockfish		FMP includes prey information
	Greenblotched rockfish		FMP includes prey information
	Greenspotted rockfish		FMP includes prey information
	Halfbanded rockfish		N/A
	Harlequin rockfish		N/A
	Honeycomb rockfish		N/A
	Kelp greenling		FMP includes prey information
	Kelp rockfish		FMP includes prey information
	Leopard shark		FMP includes prey information
	Mexican rockfish		N/A
	Olive rockfish		FMP includes prey information
	Pacific cod		FMP includes prey information
	Pacific flatnose		N/A
	Pink rockfish		N/A
	Pinkrose rockfish		N/A
	Puget Sound rockfish		N/A
	Quillback rockfish		FMP includes prey information
	Redbanded rockfish		N/A
	Rock sole		FMP includes prey information
	Rosy rockfish		FMP includes prey information
	Sand sole		FMP includes prey information
	Semaphore rockfish		N/A
	Shortbelly rockfish		FMP includes prey information
	Shortraker rockfish		FMP includes prey information
	Silvergray rockfish		N/A
	Speckled rockfish		FMP includes prey information

Guild (from Dufault et al. 2009)	Species	Prey species (approx % of diet; includes prey comprising ~>15% of diet)* from Dufault et al. 2009	Additional Sources/Notes
	Spotted ratfish		FMP includes prey information
	Squarespot rockfish		FMP includes prey information
	Starry flounder		FMP includes prey information
	Starry rockfish		FMP includes prey information
	Stripetail rockfish		FMP includes prey information
	Swordspine rockfish		N/A
	Tiger rockfish		FMP includes prey information
	Tope		N/A
	Treefish		FMP includes prey information
	Vermilion rockfish		FMP includes prey information
	Yellowmouth rockfish		N/A

*Prey component groups:

- Large zooplankton: euphausiids, chaetognaths, pelagic shrimp, pelagic polychaetes, etc.
- Small planktivores: northern anchovy, Pacific sardine, Pacific herring
- Large planktivores: Pacific mackerel, jack mackerel
- Deposit feeders: small crustacean (isopods, amphipods, etc)
- Benthic carnivores: polychaetes, burrowing crustacean, peanut worms, and flatworms
- Benthic herbivorous grazers: gastropods, sea urchins, and herbivorous decapods shrimps
- Gelatinous zooplankton: salps, jellyfish, ctenophores, and comb jellies
- Megazoobenthos: *Cancer* and tanner crabs, and lobsters
- Miscellaneous nearshore fish: croakers, wrymouths, sculpins

An objective threshold for the proportion of a diet warranting identification of a “major” prey species does not exist in the EFH guidance or scientific literature; however, as an initial attempt to distinguish “major prey” for groundfish species with quantitative data on diet composition, a threshold of 13% was chosen for illustrative purposes, as that seemed to represent a relevant break in the data across species. Howeever, there may be cases where different threshold could arguably be more appropriate. Based on this threshold, the following Groundfish FMP species consume >14% of other FMP or state-managed species in their adult life stages:

- Arrowtooth flounder: Pacific hake (46%) and small planktivores (16%)
- Black rockfish: small planktivores (51%)
- Blue rockfish: small planktivores (35%)
- Big skate: shrimp (59%), small flatfish (15%)
- Lingcod: shallow small rockfish (21%), miscellaneous nearshore fish (20%)
- Longnose skate: shrimp (21%), miscellaneous nearshore fish (20%)
- Longspine thornyhead: small planktivores (14%)
- Pacific hake: small planktivores (19%)
- Pacific sanddab: shrimp (42%)
- Petrale sole: small flatfish (62%), shrimp (25%)
- Sablefish: deep small rockfish (34%), Pacific hake (13%)
- Yelloweye rockfish: small planktivores (32%)
- Yellow tail rockfish: juvenile. Pacific hake (15%)

6.3 Potential Fishing Activity Impacts to Groundfish Prey Species

While it can be challenging to quantify impacts to prey species from fishing or non-fishing activities, the EFH regulatory guidance states that FMPs “must describe each fishing activity, review and discuss all available relevant information” regarding intensity, extent, and frequency of any adverse effects in EFH. Each FMP must also minimize to the extent practicable adverse effects on EFH from Magnuson Act fishing activities (600.815(a)(2)(ii)).

The diets of several groundfish FMP species consist of significant percentages of Federal or state-managed species. This warrants consideration because targeted fishing could potentially adversely affect EFH if it reduces the availability of major prey species. In the case of state-managed stocks that are subject to directed fisheries and are also prey items for FMP species, the Council and NMFS may make conservation recommendations to minimize adverse affects.

Periodic reviews of EFH should describe new information that may inform determinations regarding adverse effects, but new minimization measures would be considered only after the Council and NMFS determine that sufficient new information exists to warrant revisions to EFH elements.

The groundfish FMP (PFMC 2011a) includes management measures intended to minimize effects on EFH, bycatch, and other purposes. Some non-EFH related minimization measures collaterally provide protections to EFH. The three general categories of management measures implemented to protect EFH are gear modification, area closures, and reduction of fishing effort. Areas closed to bottom trawling (or other bottom contact gear, in some cases) include all areas deeper than the 700 fathom line, as well as many reefs, seamounts, and other areas of high habitat value that the Council and NMFS determined should be closed to certain types of bottom contact gear. These management measures were aimed at protecting physical and biogenic habitats, and not at preventing harm to EFH via harvest of prey species.

6.3.1 Assessing Adverse Impacts due to Fishing Effects

The EFH regulatory guidance states that "actions that reduce the availability of a major prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat that are known to cause a reduction in the population of the prey species, may be considered adverse effects on EFH if such actions reduce the quality of EFH." For managed prey species that have stock assessments, it is possible to examine population trends. A low or biomass or decreasing population trend could indicate decreased availability of prey items for groundfish species. However, inferring whether a depleted stock results in reduced prey availability is more difficult to determine, particularly for generalist groundfish species that have the ability to switch among alternative prey sources. As described above, many piscivores are opportunistic feeders. Knowing that many small prey items (e.g., zooplankton and small planktivores) are subject to natural major population and biomass fluctuations, it is challenging to determine whether fishing activities have a significant effect against the backdrop of natural population fluctuation. A further challenge is that for some prey categories, the literature does not generally distinguish prey items down to the species level.

Nonetheless, it makes sense to examine possible methods for assessing fishing impacts to prey populations. One way to do that would be to explore the relative impacts of fishing pressure on prey populations and biomass. Small planktivores (i.e., anchovy, herring, and sardine) could provide a case study because they are subject to direct fishing, and one (Pacific sardine) has a large volume of data on population and biomass. The Dufault et al. (2009) prey categories include several functional groups containing multiple species rather than individual species. Therefore, identifying the major prey species is difficult, which in turn makes it difficult to assess the effects of fishing on groundfish prey, as fisheries information and management (e.g., landings, ACLs, etc.) are species-specific.

The bullet list above highlights several groundfish species for which a single species group comprises the majority of its diet. These include arrowtooth flounder (Pacific hake); black, blue, and yelloweye rockfish (small planktivores); big skate and Pacific sanddab (shrimp); petrale sole (small flatfish); and sablefish (deep small rockfish).

The following summaries provide information on specific groundfish prey species that are fished and/or federally managed on the U.S. Pacific Coast. These summaries are intended to provide an objective reporting of relevant recent information and statistics that might be part of a process for assessing potential adverse impacts to groundfish prey species caused by fishing. However, these summaries are not intended to provide recommendations or conclusions regarding whether adverse impacts are occurring. In particular, the status of one particular prey item in isolation may not be indicative of overall prey depletion, as many groundfish may switch prey as the relative availability. For example, it may be more appropriate to look at overall prey guilds as a whole rather than trends in individual species. Furthermore, trends in biomass may not be indicative of fishing impacts, as other factors such as recruitment or oceanic conditions also affect biomass trends. Therefore the challenges in reviewing this information include assessing whether overall prey abundance for each groundfish is depleted, and the extent to which fishing pressure has contributed to such depletion.

6.3.1.1 Krill (Euphausiids)

Large zooplankton comprise a significant portion of the diet of many groundfish species (e.g., yellowtail rockfish, widow rockfish, canary rockfish, darkblotched rockfish, greednstripe rockfish, Pacific ocean perch, redstripe rockfish, Pygmy rockfish, sharpchin rockfish, Pacific hake, splitnose rockfish, spiny dogfish). This category includes euphausiids, chaetognaths, pelagic shrimps, pelagic polychaetes, and pasiphaeids (Dufault et al. 2009). Krill has received significant attention in the management context as there is a significant global market for krill and there are major fisheries on krill globally, in particular in Antarctic waters. Two species of krill, *Euphausia pacifica* and *Thysanoessa spinifera*, form large aggregations near the surface, while *Nematocelis difficilis* is highly abundant in deeper waters. Other krill species off the Pacific Coast include *T. gregaria*, *E. recurva*, *E. gibboides*, and *E. eximia*. Recognizing the importance of krill in the Pacific Coast marine ecosystem, NMFS adopted a prohibition on krill harvest throughout the West Coast EEZ in July 2009 through Amendment 12 to the Coastal Pelagic Species FMP (PFMC 2011b), containing no provisions for future fisheries. In addition, state laws prohibit krill landings by state-licensed fishing vessels into California, Oregon, and Washington. Therefore, there are no directed fisheries in Council-managed waters.

6.3.1.2 Pacific Herring (Clupea pallasi)

Pacific herring are schooling pelagic fish serving as prey for at least 14 groundfish species (McCain et al. 2005), including Pacific hake (Livingston and Bailey 1985) and Petrale sole. They are part of the "small planktivore" functional group in Dufault et al. 2009 and are part of the Clupeid group identified in the FMP. While managed primarily by the three West Coast states, Pacific herring was added to the Coastal Pelagic Species FMP in Amendment 13 as an "Ecosystem Component" species due to incidental take in CPS fisheries. Less than half (47%) of Washington herring stocks are considered healthy or moderately healthy (Stick and Lindquist 2009). The Northwest San Juan Island herring population is considered to have disappeared and the Strait of Juan de Fuca herring population is in critical condition. The only current commercial herring fishery in Washington is in Puget Sound, landing an average of 387 mt in recent years (Stick and Lindquist 2009). Pacific herring is not heavily targeted in Oregon, as the only major commercial roe-herring fishery in Yaquina Bay has opened twice since 1999 due to low herring returns, and the other fisheries are small-scale for recreation and bait. Historically, Pacific herring was targeted in ocean waters off California, however, the only remaining major fishery takes place in San Francisco Bay, with an average biomass since 1978 of 49,327 short tons (2011 biomass estimated at 57,082 short tons) (Figure 27). Fishing rates have declined in recent years and the fishery was closed in 2009 as the population fell to a historic low. Since then, the population appears to be recovering and recent harvest rates remain below 5 percent; however, there remain concerns that there are relatively few older herring in the population (CDFG 2011).

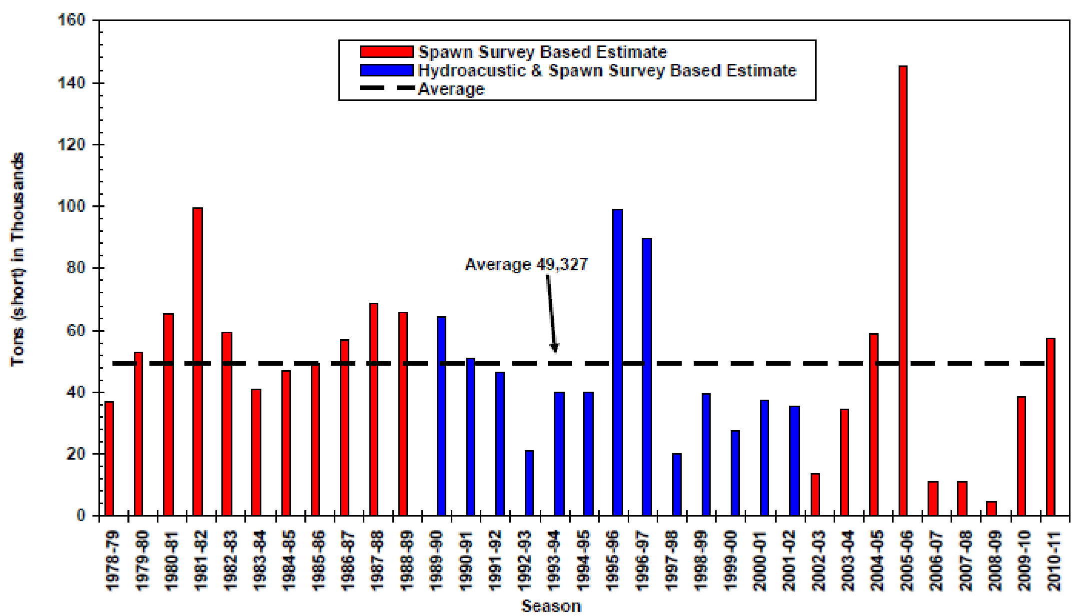

Figure 2.2 San Francisco Bay Pacific Herring Spawning Biomass Estimates for Seasons 1978 to 2011

Figure 27. San Francisco Bay Pacific herring spawning biomass estimates for season 1978-2011. From CDFG (2011), p. 2-8

6.3.1.3 Northern Anchovy (*Engraulis mordax*)

Northern anchovy abundance is highly variable; they have been identified in the diets of 18 groundfish species (McCain et al. 2005). The most recent complete assessment for northern anchovy was described in Jacobsen et al. (1995). Historically, northern anchovy was the subject of a major commercial fishery in the 1960s and 1970s, with peak landings of 143,799 mt in 1975. From 1983 to 1999, landings did not exceed 6,000 mt per year. Since 2000, U.S. landings have been variable, but have remained below 20,000 mt. The overfishing limit (OFL) values are based on past estimates of biomass and the ABC is reduced by 75 percent to account for uncertainty in the estimate of the OFL. An annual catch target for the northern subpopulation of northern anchovy was established at 1,500 mt.

6.3.1.4 Market Squid (*Doryteuthis opalescens*)

Market squid have been identified as a prey item for several groundfish species, including Pacific hake, lingcod, dogfish, scorpionfish, and many species of rockfish (California Market Squid FMP 2005; Table 2-1). The "Cephalopods" functional group from Dufault et al. (2009) includes market squid. Market squid have short lifespans (less than 10 months) and abundance is thought to fluctuate widely, as evidenced by high variance in catch levels (Figure 28). However, there are no estimates of the population size, as stock assessments are not conducted on this species. This species is the subject of a major commercial fishery, which in recent years has been the largest and most valuable commercial fishery in California. The market squid fishery has a catch limit of 118,000 short tons established by the State of California, and is managed through a suite of effort controls including a weekend closure to allow for uninterrupted spawning. Market squid adults and eggs serve as groundfish prey.

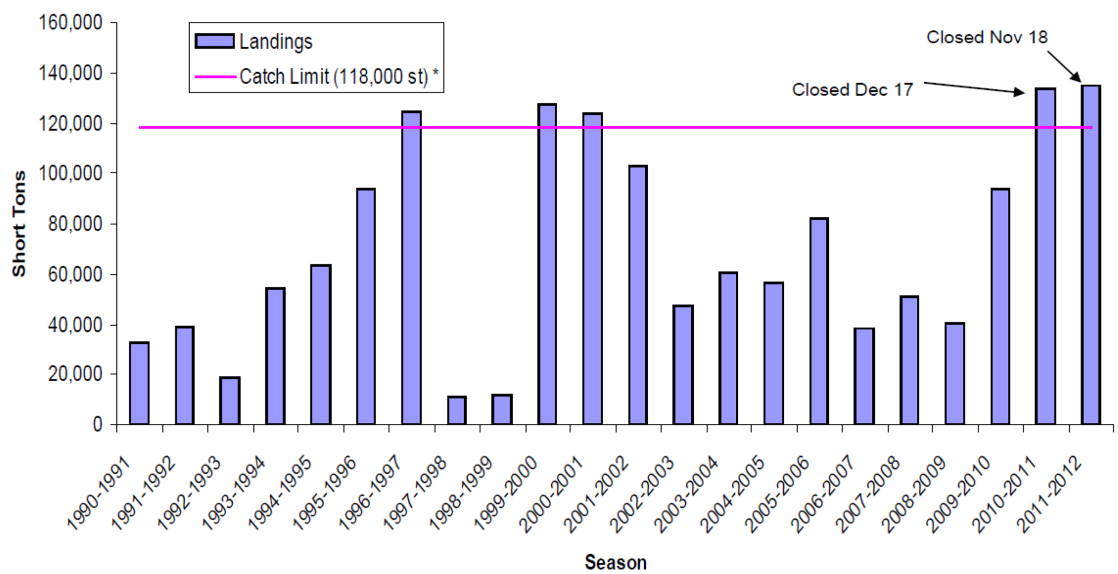

Figure 28. Market squid landings in California by season. The State of California estiblishedCatch limit was implemented beginning in the 2005-2006 season. Source: CDFG.

6.3.1.5 Pacific Hake (*Merluccius productus*)

Pacific hake is a semi-pelagic schooling species that serves as a prey item for multiple groundfish species including lingcod (Stewart et al. 2011), and in particular, represents the largest single component in the diet of arrowtooth flounder (Dufault et al. 2009). The coastal stock of Pacific hake ranges from the waters off southern California to Queen Charlotte Sound, British Columbia. Pacific hake is managed under the Pacific Coast Groundfish FMP and through an international treaty with Canada. The combined catches from the U.S. and Canada have ranged from 177,000 mt to 363,000 mt, making it the largest fishery by volume in the California Current System (Figure 30). Pacific hake is currently the most abundant groundfish population in the California Current System. The most recent stock assessment used two models, both indicating that the Pacific hake stock is increasing. Spawning biomass estimates (with 95% confidence intervals) produced by the two models are 91% (35%-203%) and 175% (75%-409%) of unfished levels respectively (Figure 29).

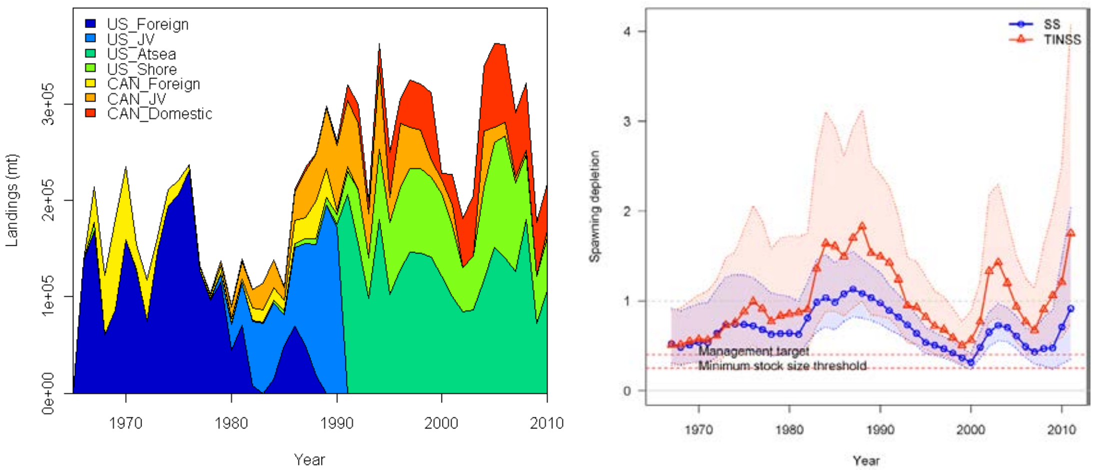

Figure 29. Left: Total Pacific hake landings by sector (including tribal catches). Right: Time series of estimated relative Pacific hake spawning depletion through 2011 using two models with 95% posterior credibility intervals. From Stewart et al. 2011.

6.3.1.6 Deposit Feeders and Benthic Carnivores

This group of prey species (including epibenthic and burrowing polychaetes, crustacea, mollusks, peanut worms, flatworms,and brittlestars) is consumed in the diets of several species in the Groundfish FMP, and are of mojor importance in the diet of a number of flatfishes. These prey species are not the subject of directed fisheries, however, may be impacted by mobile bottom tending gear managed under the groundfish FMP. Further exploration of this group should include a more detailed identification of the key prey species for groundfish and documented impacts to those species from trawl fishing.

6.3.1.7 Other Unmanaged Prey Species

Several groundfish prey items (e.g., myctophids or "deep vertical migrators") are not currently the subject of directed fisheries, and are currently not managed by the Council or individual states, but could potentially be targeted by fisheries in the future (PFMC 2011c). The Council has established a management objective "to prohibit the development of new directed fisheries on forage species that are not currently managed by our Council, or the States, until we have an adequate opportunity to assess the science relating to the fishery and any potential impacts to our existing fisheries and communities". The Council is currently considering modifications to its list of allowable fisheries and adding these prey species into a Federal FMP.

6.4 Potential Non-Fishing Activity Impacts to Groundfish Prey Species

Generally, groundfish prey species would be suceptable to the same non-fishing impacts as those affecting groundfish. Section 5 summarizes non-fishing activities that may affect groundfish EFH.

Pollution and oil spills from petroleum development can have catastrophic effects on prey species, through developmental effects and acute toxicity (Peterson et al. 2003). The *Exxon Valdez* oil spill caused the collapse of Prince William Sound herring populations, which has still not recovered over twenty years later and this has also likely affected the recovery of seabirds that feed on herring (Paine et al. 1996; EVOSTC 2009). In 2007, the container ship Cosco Busan released 54,000 gallons of bunker fuel oil into San Francisco Bay, causing unexpectedly high mortality in Pacific herring embryos and contributing to recent population declines (Incardona 2012).

7.0 INFORMATION AND RESEARCH NEEDS

The following information and research are recommended in order to improve the designation, monitoring, and effectiveness of groundfish EFH:

1. Recommendations to analyze the new information gathered in the EFHRC groundfish EFH Phase 1 Report, in order to inform decisions to modify the 2006 groundfish EFH regulations.

   a. Evaluate the boundaries of the 2005 EFH closures, relevant to the distribution of seafloor habitats in the newly developed 2011 maps.
   b. Evaluate associations of vulnerable groundfish species and benthic habitats, relevant to the 2011 maps of distribution of seafloor habitats, to identify new areas where additional habitat protection should be considered.
   c. Evaluate changes in the distribution of fishing effort, using the new 2005 and 2011 maps of effort for the bottom-contact fisheries, and determine if changes to current area management measures and gear restrictions from 2006 groundfish EFH regulations may be warranted.
   d. Evaluate the 2005 mobile-fishing-gear risk assessment model relevant to new data.
   e. Run the habitat suitability probability models for all west coast groundfish species, using the new maps of habitat distributions and other relevant data.
   f. Evaluate corals and sponges as essential habitat for groundfishes, especially relevant to 2006 groundfish EFH regulations.
   g. Evaluate new information on non-fishing-gear impacts to EFH (including environmental/oceanographic trends), especially relevant to 2006 groundfish EFH regulations.
   h. Evaluate new information on EFH relative to Level 1-4 and compare to information level available in establishing the 2006 groundfish EFH regulations.

2. Recommendation to conduct visual, no-take surveys of fishes and habitats inside and outside current EFH closures in order to evaluate the effectiveness of these conservations areas.

3. Recommendation to conduct high-resolution seafloor mapping (bathymetry, back-scatter, and associated interpreted substrata types), particularly on the shelf and slope associated with groundfish EFH conservation areas. Numerous studies and workshops have documented large gaps in the availability of spatial data for coastal and marine habitats, and information on the dynamic nature of benthic habitats is almost non-existent (e.g., recent seafloor mapping workshops conducted separately for the states of California, Oregon and Washington and a 2010 Pacific coast-wide report by the West Coast Govenors Alliance Seafloor Mapping Action Coordination Team). Detailed characterization of the seafloor is particularly needed in untrawlable rocky habitats of high relief. Such mapping efforts are needed to improve the scientific basis for designating and monitoring EFH conservation areas (for future EFH reviews), as well as to improve some groundfish stock assessments and habitat assessments for a diverse array of other spatial management issues.

4. Recommendation to improve the Habitat Use Database (HUD):

   a. implement a maintenance plan, including an oversight committee of HUD users (NOAA, EHFRC, OSU) and a schedule for regular HUD updates

b. develop tools and protocols to aid in data entry and to address specific architectural problems
c. address potential biases associated with inclusion of species from the Oregon Nearshore Strategy
d. update associations and distribution of groundfish habitat (including prey), using new information reported in the EFHRC report. Add descriptions for other species groups similar to those provided for Flatfish group.
e. develop crosswalk with other seafloor habitat classification schemes (i.e., Greene et al., 1999, FGDC CMECS, 2012)
f. update HUD definitions, documentation, and standards (e.g. clarify 'preferred depth'; consider young of year (YOY); verify species range and habitat preference using fishery dependent and independent survey data; develop standards for recording database amendments and expert opinion).

5. Recommendation to improve our understanding of habitat condition, including adverse effects of fishing gear to EFH, across the geographic range of groundfish,

6. Recommendation to advance our understanding of the affects of a changing climate on West Coast groundfishes.

7. Recommendation to evaluate potential adverse effects from fishing and non-fishing activities on the major prey species in the diets of west coast groundfish.
a. develop criteria for defining major prey species for groundfish species and lifestages
b. compile lists of major prey species for the all stocks and lifestages in the groundfish FMP.

8.0 REFERENCES

Abookire, A.A., Duffy–Anderson, J.T. and Jump, C.M. 2007. Habitat associations and diet of young–of–the–year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150: 713–726.

Agostini, V.N., Francis, R.C., Hollowed, A.B., Pierce, S.D., Wilson, C. and Hendrix, A.N. 2006. The relationship between Pacific hake (*Merluccius productus*) distribution and poleward subsurface flow in the California Current System. Canadian Journal of Fisheries and Aquatic Sciences 63: 2648–2659.

Aydin, K. and Mueter, F. 2007. The Bering Sea – a dynamic food web perspective. 2007. Deep Sea Research II 54: 2501–2525.

Anderson, T.J., Syms, C., Roberts, D.A., and Howard, D.F. 2009. Multi–scale fish–habitat associations and the use of habitat surrogates to predict the organization and abundance of deep–water fish assemblages. Journal of Experimental Marine Biology and Ecology 379: 34–42. Allen, L.G., D.J. Pondella II, and M.H. Horn (eds). 2006. The ecology of marine fishes: California and adjacent waters. University of California Press, Los Angeles. 660 pp.

Baer, A., A. Donaldson, and J. Carolsfeld. 2010. Impacts of Longline and Gillnet Fisheries on Aquatic Biodiversity and Vulnerable Marine Ecosystems. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/012 vii + 78.

Bailey, D.M., Ruhl, H.A. and Smith, K.L. 2006. Long–term change in benthopelagic fish abundance in the abyssal northeast Pacific Ocean. Ecology 87: 549–555.

Baldwin, D.H., J.F. Sandahl, J.S. Labenia, and N.L. Scholz. 2003. Sublethal effects of copper on coho salmon: Impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. Environmental Toxicology and Chemistry 22:2266-2274.

Ban N.C., and A.C.J. Vincent. 2009. Beyond Marine Reserves: Exploring the Approach of Selecting Areas where Fishing Is Permitted, Rather than Prohibited. PLoS ONE 4(7): e6258. doi:10.1371/journal.pone.0006258

Beaudreau, A.H. and Essington, T.E. 2007. Spatial, temporal, and ontogenetic patterns of predation on rockfishes by lingcod. Transactions of the American Fisheries Society 136: 1438–1452.

Bernardi, G., Findley, L., and Rocha–Olivares, A. 2003. Vicariance and dispersal across Baja California in disjunct marine fish populations. Evolution 57: 1599–1609.

Bianchi, C. 2011. Abundance and distribution of megafaunal invertebrates in NE Pacific submarine canyons and their ecological Association with fishes. M.S., thesis. Washington State University, Vancouver, WA.

Blood, D.M., Matarese, A.C. and Busby, M.S. 2007. Spawning, egg development, and early life history dynamics of arrowtooth flounder (*Atheresthes stomias*) in the Gulf of Alaska. NOAA Professional Paper NMFS 7, 28 p.

Boehlert, G.W. and A.B. Gill. 2010. Environmental and ecological effects of ocean renewable energy development: a current synthesis. Oceanography 23(2) 68-81.

Brand, E.J., I. C. Kaplan, C.J. Harvey, P.S. Levin, E.A. Fulton, AlJ. Hermann, and J.C. Field. 2007. A spatially explicit ecosystem model of the California Current's food web and oceanography. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-84.

Bright, J.L. 2007. Abundance and distribution of structure-forming invertebrates and their association with fishes at the Channel Islands "Footprint" Off the Southern Coast of California. M.S., thesis. Washington State Univ., Vancouver, WA.

Brown, E.J., Finney, B., Hills, S., and Dommisse, M., 2005. Effects of commercial otter trawling on benthic communities in the southeastern Bering Sea. Am. Fish. Soc. Symp. 41, 439–460.

Brown, J.A. 2006a. Classification of juvenile flatfishes to estuarine and coastal habitats based on the elemental composition of otoliths. Estuarine Coastal and Shelf Science 66: 594–611.

Brown, J.A. 2006b. Using the chemical composition of otoliths to evaluate the nursery role of estuaries for English sole *Pleuronectes vetulus* populations. Marine Ecology Progress Series 306: 269–291.

Bryan, T.L., and Metaxas, A. 2007. Predicting suitable habitat for deep–water gorgonian corals on the Atlantic and Pacific continental margins of North America. Marine Ecology Progress Series 330: 113–126.

California Department of Fish and Game (CDFG). 2008. Review of California halibut trawl fishery in the California halibut trawl grounds. Report to the California Fish and Game Commission. California Department of Fish and Game Marine Region State Fisheries Evaluation Project. June 2008.

CDFG. 2011. Final Supplemental Environmental Document. Pacific Herring Commercial Fishing Regulations.

California Market Squid FMP. 2005.

Carter, L., D. Burnett, S. Drew, G. Marle, L. Hagadorn, D. Bartlett-McNeil, and N. Irvine. 2009. Submarine cables and the oceans-connecting the world. The United Nations Environment Programme World Conservation Monitoring Centre (UNEP_WCMC) Biodiversity Series No. 31. 64p.

Casillas, E., L. Crockett, Y. deReynier, J. Glock, M. Helvey, B. Meyer, C. Schmitt, M. Yoklavich, A. Bailey, B. Chao, B. Johnson and T. Pepperell. 1998. Essential Fish Habitat West Coast Groundfish Appendix, National Marine Fisheries Service, 778 pp.Don, C., D. Fox, A. Merems, M. Sommer, H. Weeks, and B. Wiedoff. 2006. *The Oregon Nearshore Strategy*. Oregon Department of Fish and Wildlife. Newport, OR, 253 pp.Clark, M.R., Tittensor, D., Rogers, A.D., Brewin, P., Schlacher, T., Rowden, A., Stocks, K., and Consalvey, M. 2006. Seamounts, deep–sea corals and fisheries: vulnerability of deep–sea corals to fishing on seamounts beyond areas of national jurisdiction. UNEP–WCMC. Cambridge, UK.

Chiappone, M., H. Dienes, D.W. Swanson, and S.L. Miller. 2005. Impacts of lost fishing gear on coral reef sessile invertebrates in the Florida Keys National Marine Sanctuary. Biological Conservation 121, 221–230.

Chittaro, P.M., Finley, R.J. and Levin, P.S. 2009. Spatial and temporal patterns in the contribution of fish from their nursery habitats. Oecologia 160: 49–61.

Choromanski, E.M., Fargo, J., Workman, G.D. and Mathias, K. 2004. Multispecies trawl survey of Hecate Strait, F/V Viking Storm, June 10 – 28, 2002. Canadian Data Report of Fisheries and Aquatic Sciences 1124, 81 p.

Choromanski, E.M., Workman, G.D. and Fargo, J. 2005. Hecate Strait multi–species bottom trawl survey, CCGS WE Ricker, May 19 to June 7, 2003. Canadian Data Report of Fisheries and Aquatic Sciences 1169, 85 p.

Climate Impacts Group. 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest. University of Washington. Seattle, WA.

Copps, S.L., M.M. Yoklavich, G.B. Parkes, W.W. Wakefield, A. Bailey, H.G. Greene, C. Goldfinger, and R.W. Burn. 2007. Applying Marine Habitat Data to Fishery Management on the US West Coast: Initiating a Policy-Science Feedback Loop. In Mapping the Seafloor for Habitat Characterization, ed. Brian J. Todd and H. Gary Greene, 451-462. Special Paper 47. http://137.110.142.7/publications/FED/00606.pdf.

CSIRO. 2011. Atlantis – Ecosystem Model. http://atlantis.cmar.csiro.au/

de Marignac J., Hyland, J. Lindholm, A. DeVogelaere, W.L. Balthis, and D. Kline. 2008. A comparison of seafloor habitats and associated benthic fauna in areas open and closed to bottom trawling along the central californiaCalifornia continental shelf. Marine Sanctuaries Conservation Series ONMS-09-02, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries., Silver Spring, MD. 44 pp.

Devitt, 2. 2011. Pacific hake midwatertrawl fishery EEZ West Coast USA/ EEZ Canada: surveillance report 2. Intertek Moody Marine Ltd. Nova Scotia, Canada. 39 pp

Dufault, Aaron M., K. Marshall, and I. Kaplan. 2009. A Synthesis of diets and trophic overlap of marine species in the California current. NOAA Technical Memorandum NMFS-NWFSC-103. National Marine Fisheries Service, Seattle, WA.

Don, C., D. Fox, A. Merems, M. Sommer, H. Weeks, and B. Wiedoff. 2006. The Oregon Nearshore Strategy. Oregon Department of Fish and Wildlife. Newport, OR.

Ebert, D.A., White, W.T., Goldman, K.J., Compagno, L.J.V., Daly–Engel, T.S. and Ward, R.D. 2010. Resurrection and redescription of Squalus suckleyi (Girard, 1854) from the North Pacific, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae). Zootaxa: 22–40.

Emmett, R.L., P.J. Bentley, and G.K. Krutzikowsky. 2001. Ecology of marine predatory and prey fishes off the Columbia River, 1998 and 1999. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-51, 108 p.

Emmett, R.L., et al. 2005. Pacific sardine (*sardinops sagax*) abundance, distribution, and ecological relationships in the Pacific Northwest. CalCOFI Rep., Vol. 46, 2005.

Eschmeyer, W.N., and Fricke, R., eds. 2011. Catalog of fishes. http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp, version (November 30, 2011).

Etherington, L.L., van der Leeden, P., Graiff, K., Roberts, D., and Nickel, B. 2011. Summary of deep sea coral patterns and habitat modeling results from Cordell Bank, CA. Technical Report. NOAA–Cordell Bank Marine Sanctuary. Olema, CA.

Exxon Valdez Oil Spill Trustee Council (EVOSTC). 2009. Status Report: Legacy of an Oil Spill. 20 Years After Exxon Valdez.

FERC. 2010. Biological assessment and essential fish habitat assessment for the Oregon LNG terminal and pipeline project. October, 2010. Office of Energy Projects, Washington, DC.

FGDC (Federal Geographic Data Committee). January, 2012. Coastal and Marine Ecological Classification Standard, Version 4.0, Federal Geographic Data Committee, Standards Working Group, 329 pp.

Field, J.C. 2004. Application of ecosystem–based fishery management approaches in the northern California Current. Ph.D. Dissertation. University of Washington. School of Aquatic and Fishery Sciences.

Field, John C., E.J. Dick, D. Pearson, A MacCall. 2009. Status of bocaccio, Sebastes paucispinis, in the Conception, Monetery and Eureka INPFC areas for 2009.

Frid, A. and Marliave, J. 2010. Predatory fishes affect trophic cascades and apparent competition in temperate reefs. Biology Letters 6: 533–536.

Froese, R., and Pauly, D, eds. 2011. FishBase. www.fishbase.org, version (December, 2011).

Fujioka, J. T., 2006. A model for evaluating fishing impacts on habitat and comparing fishing closure strategies. Canadian Journal of Fisheries and Aquatic Sciences 63:(10) 2330-2342.

Fulton, E.A., Smith, A.D.M, and Johnson, C.R. 2004. Effects of spatial resolution on the performance and interpretation of marine ecosystem models. Ecological Modeling 176: 27–42.

Gaichas, S.K. and Francis, R.C. 2008. Network models for ecosystem–based fishery analysis: a review of concepts and application to the Gulf of Alaska marine food web. Canadian Journal of Fisheries and Aquatic Sciences 65: 1965–1982.

Gaichas, S.K., Aydin, K.Y. and Francis, R.C. 2010. Using food web model results to inform stock assessment estimates of mortality and production for ecosystem–based fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 67: 1490–1506.

Gill, A.B. 2005. Offshore renewable energy: ecological implications of generating electricity in the coastal zone. Journal of Applied Ecology 42: 605-615

Graham, M.H., Kinlan, B.P., and Grosberg, R.K. 2010. Post–glacial redistribution and shifts in productivity of giant kelp forests. Proceedings of the Royal Society of B 277: 399–406.

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea Jr., and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Oceanologica Acta. Vol 22: 6. pp. 663-678.

Gotshall, Daniel W. Guide to Marine Invertebrates: Alaska to Baja California. Monterey, CA: Sea Challengers, 1994.

Guinotte, J.M. and A.J. Davies. 2012. Predicted deep-sea coral habitat suitability for the U.S. West Coast. Report to NOAA-NMFS. 85 pp.

Hamel, Owen and I. Stewart. 2009. Stock Assessment of Pacific Hake, Merluccius productus, (a.k.a. Whiting) in U.S. and Canadian Waters in 2009. National Marine Fisheries Service, Seattle, WA.

Hannah, R.H., S.A. Jones, W. Miller, and J.S. Knight. 2010. Effects of trawling for ocean shrimp (Pandalus jordani) on macroinvertebrate abundance and diversity at four sites near Nehalem Bank, Oregon. Fishery Bulletin 108:30–38.Hart, J. 1973. Pacific Fishes of Canada, Vol Bulletin 180. Fisheries Research Board of Canada, Ottawa Jensen GC (1995) Pacific Coast Crabs and Shrimps. Sea Challengers, Monterey, California.

Harvey, C.J., Bartz, K.K., Davies, J., Francis, T.B., Good, T.P., Guerry, A.D., Hanson, B., Holsman, K.K., Miller, J., Plummer, M.L., Reum, J.C.P., Rhodes, L.D., Rice, C.A., Samhouri, J.F., Williams, G.D., Yoder, N., Levin, P., and Ruckelshaus, M.H. 2010. A mass–balance model for evaluating food web structure and community–scale indicators in the central basin of Puget Sound. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–106.

Hicks, Allan C., M. Haltuch, and C. Wetzel. 2009. Status of greenstriped rockfish (Sebastes longatus) along the outer coast of California, Oregon, and Washington. National Marine Fisheries Service, Seattle, WA.

Hightower, M.M., L. Gritzo, A. Luketa-Hanlin, J. Covan, S. Tieszen, G. Wellman, M. Irwin, M. Kaneshige, B. Melof, and C. Morrow. 2004. Guidance on risk analysis and safety Implications of a large liquefied natural gas (LNG) spill over water. SAND2004-6258. Sandia National Laboratories, Albuquerque, NM. December 2004.

Hill, K.T., P. Crone, N. Lo, B. Macewicz, E. Dorval, J. McDaniel, and Y. Gu. Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-487.

Hixon, M.A and B.N. Tissot. 2007. Comparison of trawled vs. untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. J. Exp. Mar. Biol. Ecol. 344: 23-34.

Hoff, G.R. 2006. Biodiversity as an index of regime shift in the eastern Bering Sea. Fishery Bulletin 104: 226–237.

Hoff, G. and Britt, L. 2005. Results of the 2004 Eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–156, 276 p.

Horne, P.J., Kaplan, I.C., Marshall, K.N., Levin, P.S., Harvey, C.J., Hermann, A.J., and Fulton, E.A. 2010. Design and parameterization of a spatially explicit ecosystem model of the Central California Current. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–104.

Iampietro, P.J., Kvitek, R.G., and Morris, E. 2005. Recent advances in automated genus–specific marine habitat mapping enabled by high–resolution multibeam bathymetry. Marine Technology Society Series 39(3): 83–93.

Iampietro, P.J., Young, M.A., and Kvitek, R.G. 2008. Multivariate prediction of rockfish habitat suitability in Cordell Bank National Marine Sanctuary and Del Monte Shalebeds, California, USA. Marine Geodesy 31: 359–371. Incardona, J.P., Vines CA, Anulacion BF, Baldwin DH, Day HL, French BL, Labenia JS, Linbo TL, Myers MS, Olson OP, Sloan CA, Sol S, Griffin FJ, Menard K, Morgan SG, West JE, Collier TK, Ylitalo GM, Cherr GN, Scholz NL.et al. 2012. Unexpectedly high mortaliy in Pacific herring embryos exponsed to the 2007 Cosco Busan oil spill in San Francisco Bay. Proceedings of the National Academy of Sciences 109(2)E51-E58.

Iverson, S., Springer, A. and Kitaysky, A. 2007. Seabirds as indicators of food web structure and ecosystem variability: qualitative and quantitative diet analyses using fatty acids. Marine Ecology Progress Series 352: 235–244.

Johnson, S.W., Murphy, M.L., and Csepp, D.J. 2003. Distribution, habitat, and behavior of rockfishes, Sebastes spp., in nearshore waters of southeastern Alaska: observations from a remotely operated vehicle. Environmental Biology of Fishes 66: 259–270.

Keller, A.A., Wick, T.L., Fruh, E.L., Bosley, K.L., Kamikawa, D.J., Wallace, J.R. and Horness, B.H. 2005. The 2000 U.S. west coast upper continental slope trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–70, 163 p.

Keller, A.A., Horness, B.H., Simon, V.H., Tuttle, V.J., Wallace, J.R., Fruh, E.L., Bosley, K.L., Kamikawa, D.J. and Buchanan, J.C. 2007. The 2004 U.S. west coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–87, 134 p.

Keller, A.A, Horness, B.H., Fruh, E.L., Simon, V.H., Tuttle, V.J., Bosley, K.L., Buchanan, J.C., Kamikawa, D.J. and Wallace, J.R. 2008. The 2005 U.S. west coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–93, 136 p.

Keller, A.A., E.L. Fruh, M. Johnson, V. Simon, C. McGourty. 2010. Distribution and abundance of anthropogenic marine debris along the shelf and slope of the U.S. West Coast. Mar. Pollut. Bull. 60: 672-700

Knoth, B.A. and Foy, R.J. 2008. Temporal variability in the food habits of arrowtooth flounder (*Atheresthes stomias*) in the Western Gulf of Alaska. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–184, 30 p.

Kramer, S., M. Previsic, P. Nelson, and S. Woo. 2010. Re Vision DE-003: Deployment effects of marine renewable energy technologies-framework for identifying key environmental concerns in marine renewable energy projects. U.S. Department of Energy, Advanced Waterpower Program. 93p.Langford, T.E., N.J. Utting, R.H.A. Holmes. 1978. Factors affecting the impingement of fishes on power station cooling-water intake screens. Pages 281-288 in D.S. McLusky, Berry, A.J., editors. Physiology and Behaviour of Marine Organisms. Pergamon Press. New York, NY.

Krigsman, L.M., Yoklavich, M.M., Dick, E.J., and Cochrane, G.R. 2012. Models and maps: predicting the distribution of corals and other benthic macro–invertebrates in shelf habitats. Ecosphere 3(article3):1-16.

Lamb, Andy and Bernard P. Hanby. Marine Life of the Pacific Northwest: A Photographic Encyclopedia of Invertebrates, Seaweeds and Selected Fishes. Madeira Park, BC: Harbour Publishing, 2005.

Lambert, Philip. Sea cucumbers of British Columbia, Southeast Alaska and Puget Sound. Vancouver, BC: Royal British Columbia Museum, 1997.

Lambert, Philip and William C. Austin. Brittle Stars, Sea Urchins and Feather Stars of British Columbia, Southeast Alaska and Puget Sound. Victoria, BC: Royal British Columbia Museum, 2007.

Lattemann, S. and T. Hoepner. (2008). Environmental impact and impact assessment of seawater desalination. Desalination 220: 1-15.

Lauth, R.R., Wakefield, W.W. and Smith, K. 2004. Estimating the density of thornyheads, *Sebastolobus* spp., using a towed video camera sled. Fisheries Research 70: 39–48.

Lindholm, J., M. Kelly, D. Kline, and J. deMarignac. 2008. Patterns in the local distribution of the sea Whipwhip, *Halipteris willemrnoesi*, in an area Iimpacted by mobile fishing gear. Marine Technology Society Journal 42: 64-68.

Livingston, P.A. and K.M. Bailey. 1985. Trophic role of the Pacific whiting, *Merluccius productus*. Mar. Fish. Rev. 47(2):16-22-34.

Logerwell, E.A., Aydin, K., Barbeaux, S., Brown, E., Conners, M.E., Lowe, S., Orr, J.W., Ortiz, I., Reuter, R. and Spencer, P. 2005. Geographic patterns in the demersal ichthyofauna of the Aleutian Islands. Fisheries Oceanography 14: 93–112.

Love, M.S. 1991. Probably more than you wanted to know about the fishes of the Pacific Coast. Really Big Press, Santa Barbara.

Love, M.S., Yoklavich, M., and Thorsteinson, L. 2002. The rockfishes of the Northeast Pacific. University of California Press. Berkeley, CA.

Love, M.S. and York, A. 2005. A comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, southern California bight. Bulletin of Marine Science 77: 101–117.

Luketa, A., M.M. Hightower, and S. Attaway. 2008. Breach and safety analysis of spills over waters from large liquefied natural gas carriers. SAND2008-3153. Sandia National Labortory, Albuquerque, NM. May 2008.

MacCall, A.D., Hill, K.T., Crone, P., and Emmett, R. 2012. Weak evidence for sardine collapse. Proceedings of the National Academy of Sciences 109(19):E1131

Marliave, J. and Challenger, W. 2009. Monitoring and evaluating rockfish conservation areas in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 66: 995–1006.

McCain, B.B., Miller, S.D., and Wakefield, W.W. 2005. Life history, geographical distribution, and habitat associations of 82 West Coast groundfish species: a literature review. National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle, WA.

McKenzie, J. and Wynne, K. 2008. Spatial and temporal variation in the diet of Steller sea lions in the Kodiak Archipelago, 1999 to 2005. Marine Ecology Progress Series 360: 265–283.

Miller, T.W., and R.D. Brodeur. 2007. Diets of and trophic relationships among dominant marine nekton within the northern California Current ecosystem. Fish. Bull. 105(4):548-559.

Montanio, p. 2006. Guidance to Refine the Description and Identification of Essential Fish Habitat. National Marine Fisheries Service, Memorandun, 7 pp.

Monterey Bay Aquarium.Website Accessed: 5 January 2010. http://www.montereybayaquarium.org/animals/AnimalList.aspx?a=Invertebrates.

Morris, R.H., D.P. Abbott, and E.C. Haderlie. 1980. Intertidal Invertebrates of California. Stanford University Press, Stanford, California.

Mote, P.W. and E.P. Salathé , Jr. 2009. Future climate in the Pacific Northwest. P. 21-43. In: The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. Climate Impacts Group, University of Washington, Seattle.

MRAG Americas Inc., TerraLogic GIS Inc., NMFS Northwest Fisheries Science Center FRAM Division, and NMFS Northwest Region. 2004. Risk assessment for the Pacific Groundfish FMP. Pacific States Marine Fisheries Commission. Portland, OR.

MRAG Americas Inc., 2005. "Identification of Essential Fish Habitat for the Pacific Groundfish FMP: Supplementary Document EFH Software Guide". MRAG Americas Inc., Tampa, FL., 18pp.

NMFS (Natioanl Marine Fisheries Service) 2005. Pacific coast groundfish fishery management plan, Essential fish habitat designation and minimization of adverse impacts, Final environmental impact statement. NMFS, Northwest Region, Seattle, WA.

Nelson P.A., D. Behrens, J. Castle, G. Crawford, R.N. Gaddam, S.C. Hackett, J. Largier, D.P. Lohse, K.L. Mills, P.T. Raimondi, M. Robart, W.J. Sydeman, S.A. Thompson, and S. Woo. 2008. Developing Wave Energy In Coastal California: Potential Socio-Economic And Environmental Effects. California Energy Commission, PIER Energy-Related Environmental Research Program & California Ocean Protection Council CEC-500-2008-083. 165 p.

NOAA Deep Sea Coral Research and Technology Program (2011). Deep-Sea Coral National Geographic Database, version 2.0. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD. Data Manager: Dan Dorfman (NOAA), Dan.Dorfman@noaa.gov, (301) 713-3028 x112.

NWFSC (Northwest Fisheries Center). 2009. Data report and summary analyses of the U.S. West Coast non-nearshore fixed gear groundfish fishery. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112.

NWSI (Northwest Straits Initiative). 2010. Northwest Straits Initiative derelict gear removal program. Online at: http://www.derelictgear.org/, and http://www.derelictgear.org/Progress/ARRA-Project.aspx.

Orr, J.W. and Blackburn, J.E. 2004. The dusky rockfishes (Teleostei: Scorpaeniformes) of the North Pacific Ocean: resurrection of *Sebastes variabilis* (Pallas, 1814) and a redescription of *Sebastes ciliatus* (Tilesius, 1813). Fishery Bulletin 102: 328–348.

Orr, J.C., V.J. Fabry, and O. Aumont. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437: 681-686.

Previsic, M. 2010. RE Vision DE-001: Deployment effects of marine renewable energy technologies. Wave energy scenarios. U.S. Department of Energy, Advanced Waterpower Program. 106p.

PFMC (Pacific Fishery Management Council). 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 19 (including Amendment 15). Pacific Fishery Management Council, Portland, OR.

PFMC. 2011a. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery as amended through December 2011. Pacific Fishery Management Council, Portland, OR.

PFMC. 2011b. Coastal Pelagic Species Fishery Management Plan as amended through Amendment 13. Pacific Fishery Management Council, Portland, OR.

PFMC. 2011c. Pacific Coast Fishery Ecosystem Plan for the U.S. portion of the California current large marine ecosystem; draft October 2011. Pacific Fishery Management Council, Portland, OR.

Paine RT, Ruesink JL, Sun A, Soulanille EL, Wonham MJ, Harley CDG, Brumbaugh DR, Secord DL. 1996. Trouble on Oiled Waters: Lessons from the Exxon Valdez Oil Spill. Annual Review of Ecology and Systematics 27: 197-235.

Pearsall and Fargo (2007) – need full referencePearsall I. A. and JJ Fargo. 2007. Diet composition and habitat fidelity for groundfish assemblages in Hecate Strait, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences, 2692.

Peterson CH, Rice SD, Short JW, Esler D, Bodkin JL, Ballachey BE, Irons DB (2003) Long-term ecosystem response to the Exxon Valdez Oil Spill. Science 302:2082-2086.

Pilati, DA. 1976. Cold shock: biological implications and a method for approximating transient environmental temperatures in the near-field region of a thermal discharge. Science of the Total Environment 6(3):227-37.

Pirtle, J.L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. M.S., thesis. Washington State Univ., Vancouver, WA.Shanks AL (ed) (2001) An Identification Guide to the Larval Marine Invertebrates of the Pacific Northwest. Oregon State University Press, Corvallis.

Riemer, S.D. and Mikus, R. 2006. Aging fish otoliths recovered from Pacific harbor seal (*Phoca vitulina*) fecal samples. Fishery Bulletin 104: 626–630.

Roberts, D.A., E.L. Johnston, and N.A. Knott. 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. Water Resources 44:5117-5128.

Rogers, CA. 1976. Effects of temperature and salinity on the survival of winter flounder embryos. Fisheries Bulletin 74(1):52-8.

Romsos, C.G. 2009. Habitat Use Database Review Meeting Report, unpublished report, Corvallis, Oregon, 10pp.

Rooper, C. 2008. Data report: 2006 Aleutian Islands bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–179, 239 p.

Rooper, C.N., Gunderson, D.R. and Armstrong, D.A. 2004. Application of the concentration hypothesis to English sole in nursery estuaries and potential contribution to coastal fisheries. Estuaries 27: 102–111.

Ruzicka, J.J., Brodeur, R.D., and Wainwright, T.C. 2007. Seasonal food web models for the Oregon inner–shelf ecosystem: investigating the role of large jellyfish. CalCOFI Reports. Volume 48.

Scheuerell, M.D. and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography 14(6):448-457.

Stewart, I.J., Forrest, R.E., et al. 2011. Status of the Pacific Hake (Whiting) stock in U.S. and Canadian Waters in 2011. Joint U.S. and Canadian Hake Technical Working Group. Final SAFE Document.

Stick, K.C., and Lindquist, A. 2009. 2008 Washington State Herring Stock Status Report. WDFW.

Stocks, K. 2009. SeamountsOnline: an online information system for seamount biology. Version 2009-1. World Wide Web electronic publication. http://seamounts.sdsc.edu

Terralogic GIS., S.L. Copps, 2005. Consolidated GIS Data, Vol. 1

Tittensor, D.P., Baco, A.R., Brewin, P.E., Clark, M.R., Consalvey, M., Hall–Spencer, J.H., Rowden, A.A., Schlacher, T., Stocks, K.I., and Rogers, A.D. 2009. Predicting global habitat suitability for stony corals and seamounts. Journal of Biogeography 36: 111–1128.

Tolimieri, N., and Levin, P.S. 2006. Assemblage structure of eastern Pacific groundfishes on the U.S. continental slope in relation to physical and environmental variables. Transactions of the American Fisheries Society 135: 317–332.

Toole, C.L., Brodeur, R.D., Donohoe, C.J., and Markle, D.F. 2011. Seasonal and interannual variability in the community structure of small demersal fishes off the central Oregon coast. Marine Ecology Progress Series 428: 201–217.

Trites, A.W. and Calkins, D.G. 2007. Diets of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, 1993−1999. Fishery Bulletin 105: 234–248.

U.S. DOE (U.S. Department of Energy). 2009. Report to Congress on the potential environmental effects of marine and hydrokinetic energy technologies. Prepared in response to the Energy Independence and Security Act of 2007, section 633(B). December, 2009. 143 p.

van Katwijk, M.M., G.H.W. Schmitz, A.P. Gasseling, and P.H. van Avesaanth. 1999. Effects of salinity and nutrient load and their interaction on Zostera marina. Marine Ecology Progress Series 190: 155-165.

von Szalay, P., Raring, N., Shaw, F., Wilkins, M. and Martin, M. 2010. Data report: 2009 Gulf of Alaska bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–208, 247 p.

Wada, T., Aritaki, M., Yamashita, Y. and Tanaka, M. 2007. Comparison of low–salinity adaptability and morphological development during the early life history of five pleuronectid flatfishes, and implications for migration and recruitment to their nurseries. Journal of Sea Research 58: 241–257.

Watters, D.L., M.M. Yoklavich, M.S Love, D.M. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Mar Pollut Bull., 60:131-138.

Whitmire, C.E. and Clarke, M.E. 2007. State of Deep Coral Ecosystems of the U.S. Pacific Coast: California to Washington. pp. 109-154. In: S.E. Lumsden, Hourigan T.F., Bruckner A.W. and Dorr G. (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum CRCP-3. Silver Spring MD. 365 pp.

Wilson, J.R., Broitman, B.R., Caselle, J.E. and Wendt, D.E. 2008. Recruitment of coastal fishes and oceanographic variability in central California. Estuarine Coastal and Shelf Science 79: 483–490.

Workman, G.D., Olsen, N., Fargo, J. and Stanley, R.D. 2008. West Coast Vancouver Island groundfish bottom trawl survey, R/V WE RICKER, May 23rd to June 19th, 2006. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2841, 83 p.

Yamanaka, K.L., Obradovichl, S.G., Cooke, K., Lackol, L.C. and Dykstra, C. 2008. Summary of non–halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 29 to July 22, 2006. Canadian Technical Report of Fisheries and Aquatic Sciences 2796, 58 p.

Yang, M.S., Dodd, K., Hibpshman, R. and Whitehouse, A. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–164, 199 p.

Young, M.A., Iampietro, P.J., Kvitek, R.G., and Garza, C.D. 2010. Multivariate bathymetry–derived generalized linear model accurately predicts rockfish distribution on Cordell Bank, California, USA. Marine Ecology Progress Series 415: 247–261.

Zador, S., Aydin, K., and Cope, J. 2011. Fine–scale analysis of arrowtooth flounder *Atherestes stomias* catch rates reveals spatial trends in abundance. Marine Ecology Progress Series 438: 229–239.

Zwolinski, J.P. and Demer, D.A. 2012. A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock. Proceedings of the National Academy of Sciences 109(11):4175-4180.

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APPENDIX A PERSONS CONSULTED AND CHRONOLOGY FOR THE PERIODIC REVIEW OF PACIFIC COAST GROUNDFISH ESSENTIAL FISH HABITAT

Table A-1 Members of the EFHRC[a/].

Name	Affiliation	Subcommittee	Alternate
Brad Pettinger, Chair	Oregon Trawl Commission	Data	Scott McMullen
Megan Mackey, Vice-Chair	Ecotrust	Data	
Ed Bowlby	NOAA Olympic Coast National Marine Sanctuary	Data	Karen Reyna
Bob Eder	Fixed gear fisheries		Bernie Bjork
Chris Goldfinger	Oregon State University		
Gary Greene	Moss Landing Marine Laboratories		
Dayna Matthews	NMFS Northwest Region, Office of Law enforcement		
Joe Schumacker	Quinault Indian Nation	Data	Jennifer Hagen
Geoff Shester	Oceana	Data	Ben Enticknap
John Stadler	NMFS Northwest Region, Habitat Conservation Division		
Waldo Wakefield	NMFS Northwest Fisheries Science Center	Data	
Mary Yoklavich	NMFS Southwest Fisheries Science Center	Data	

a/ Kerry Griffin and Chuck Tracy staffed the EFHRC for the Council.

Others who contributed:
Curt Whitmire, Marlene Bellman - NMFS NWFSC
Joe Bizzarro, Chris Romsos - NMFS Contractors
Kelly Corbett, Niels Leuthold, Bob Hannah, Maggie Sommer – ODFW
Lorna Wargo, Corey Niles - WDFW

Chronology

Table A-2. Meeting chronology and results of the EFHRC.

Timing/Due Date	Action
April 2011	Council approves the process, and solicits for information and data (deadline: July 1, 2011)
Summer 2011	NMFS Science Center (or contractor) compiles and synthesizes data and information, initiates review. EFHRC starts reviewing interim products
Dec 31, 2011	NMFS Science Center (or contractor) product due
April, 2012	EFHRC provides progress update to Council
Jan-August 2012	EFHRC drafts report summarizing new data and information; including how it compares with existing information, maps, etc.
September 2012	Council adopts interim report and consideres revised RFP
Sept 2012-Mar 2013	NMFS NWFSC synthesizes information in Phase 1 Report
April 2013	NMFS NWFSC presents synthesis report to Council; Council decides whether or not to issue an RFP for any changes to existing GF EFH, HAPCs, etc. (END PHASE I)

APPENDIX B RESULTS FROM THE NMFS 2011 GROUNDFISH ESSENTIAL FISH HABITAT DATA CALL

Thirty-nine sources of data relevant to groundfish EFH that had become available since 2006 were received through the NMFS data call (see Appendix B for details on each item). All of these data can be used to revise the descriptions of EFH and HAPC or to evaluate risk to EFH. Information associated with the NMFS data call comprised four general categories:

1. Four sources of new information on the distribution and extent of seafloor maps, seafloor data, and interpreted Pacific Coast groundfish habitat types were received. In addition to these responses to the NMFS data call, several other new and updated datasets related to seafloor bathymetry and interpreted habitats were identified and used in this EFH review (see section 3.2 of this report).
2. Eight sources of new and updated fishery-independent data were received on groundfish species and associated components of habitat. These datasets comprised: four trawl surveys, an integrated acoustic and trawl survey for hake (2005-present), two direct observation surveys (southern California SCUBA survey, 1974-present; central California submersible survey, 2007-2008), and the California Cooperative Oceanic Fisheries Investigations (CalCOFI) ichthyoplankton survey (2005-present). Associated habitat components that were collected during several of these surveys included water temperature, salinity, depth, dissolved oxygen, and specific habitat types (e.g., rocky banks, soft-bottom), among others.
3. Twenty sources of new and updated information or data were received on the distribution of habitats, including two coast-wide oceanographic datasets, 12 surveys of deepwater, structure-forming invertebrates (including corals and sponges) as biogenic components of habitat (i.e., visual surveys conducted with ROVs, manned submersibles, and AUV at various locations along the West Coast, and the NMFS West Coast bottom trawl survey), two models of deep coral distributions, an assessment of 146 West Coast estuaries conducted by The Nature Conservancy, an online data library and maps of California, and two visual surveys of fish and habitats off central California. Several of the visual surveys also included associations of fishes with corals and sponges. In addition to the two responses on modeling deep coral distributions, several other new modeling efforts related to biogenic habitats, trophodynamics, and habitat associations with groundfishes were reviewed in section 3.2 of this report.
4. Seven sources of new and updated information were received on existing and emerging threats to Pacific Coast groundfish EFH. These included five fishery-dependent datasets (i.e., NMFS bottom trawl logbook effort summaries in 10 x10 km and 500 x 500 m grid cells, 2002-2010; NMFS West Coast observed groundfish fixed-gear effort summaries, 2002-2010; NMFS observed hake commercial effort, 2002-2010; and NMFS groundfish trawl effort and coral/sponge locations). Much of these data have been analyzed, and the associated coastwide maps of the distribution of biogenic bycatch and fishing effort are presented in sections 3.2 and 3.3.1, respectively. and two sources of information on non-fishery threats were identified as responses to the NMFS data call: water sampling on Cordell Bank, central California (2010) and on Piggy Bank seamount, southern California (2010). Both studies were funded by the NOAA Deepsea Coral Program as baseline monitoring of ocean acidification.

1. SEAFLOOR MAPPING DATA

1.0.1 Item: SEAFLOOR MAPPING FOR CORAL SURVEYS

Source: NOAA Olympic Coast National Marine Sanctuary; NOAA Deepsea Coral Program

Time Frame: 2011

Spatial and Temporal Scale: inside Olympic Coast National Marine Sanctuary

Metric: side scan and multibeam (including backscatter) sonar data

Available Format: DVD; data; maps

URL: http://olympiccoast.noaa.gov/

Point(s) of Contact: N. Wright and C.E. Bowlby (NOAA Olympic Coast National Marine Sanctuary, Port Angeles, WA)

Key Reference(s):
Wright, N. 2011. Multibeam mapping of potential deep-sea coral habitats around Olympic II EFH. Report to NOAA Coral Reef Conservation Program. Olympic Coast National Marine Sanctuary Survey HMPR-128-2011-02. pp. 15.

Wright, N. 2011. Seafloor mapping in Olympic Coast National Marine Sanctuary: 2000-2011. A preliminary report to Pacific Fishery Management Council Essential Fish Habitat Review Committee, 7 p.

Comments: seafloor mapping in support of visual surveys of deep corals and sponges

1.0.2 Item: SEAFLOOR MAPPING FOR SPONGE REEF SURVEYS

Source: NOAA NMFS NWFSC; NOAA Deepsea Coral Program

Time Frame: 2010

Spatial and Temporal Scale: glass sponge reef area off Grays Harbor, WA

Metric: multibeam sonar data

Available Format: data; maps

URL: n/a

Point(s) of Contact: E. Clarke (NMFS NWFSC); C. Goldfinger (OSU)

Key Reference(s): n/a

Comments: seafloor mapping in support of visual surveys of deep sponge reefs

1.0.3 Item: SEAFLOOR MAPPING FOR CORAL AND SPONGE SURVEYS

Source: NOAA Cordell Bank National Marine Sanctuary; NOAA Deepsea Coral Program

Time Frame: 2011

Spatial and Temporal Scale: canyons and banks in vicinity of Cordell Bank National Marine Sanctuaries

Metric: multibeam sonar data; depth; slope; rugosity;aspect; substrate type

Available Format: data; maps

URL: n/a

Point(s) of Contact: D.F Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA); G. Cochrane (USGS)

Key Reference(s): n/a

Comments: seafloor mapping in support of visual surveys of deep sponge reefs; data in Cordell Bank collected from NOAA vessel *Okeanos Explorer*

1.0.4 Item: SEAFLOOR MAPPING OF RITTENBURG BANK, FARALLON ESCARPMENT AND AREA WEST OF FANNY SHOAL

Source: USGS

Time Frame: 2011

Spatial and Temporal Scale: canyons and banks within the boundaries of Gulf of Farallones National Marine Sanctuary

Metric: multibeam sonar data

Available Format: data; maps

URL: n/a

Point(s) of Contact: G. Cochrane (USGS) and

Key Reference(s): n/a

Comments: n/a

2. FISHERY-INDEPENDENT FISH DATA

2.1 *Trawl Surveys*

2.1.1 Item: NWFSC WEST COAST BOTTOM TRAWL SURVEY

Source: NOAA NMFS NWFSC

Time Frame: 2003 - present

Spatial and Temporal Scale: depths 55-1,280 m (30-700 fathoms), off Cape Flattery, Washington (lat 48° 10′ N) to the U.S.-Mexico border (lat 32° 30′ N)

Metric: size, age, abundance, biomass of benthic fishes and invertebrates

Available Format: database

URL: http://www.nwfsc.noaa.gov/research/divisions/fram/index.cfm

Point(s) of Contact: A.A. Keller (NOAA NWFSC, Seattle, WA)

Key Reference(s):

Keller, A.A., B.H. Horness, E.L. Fruh, V.H. Simon, V.J. Tuttle, K.L. Bosley, J.C. Buchanan, D.J. Kamikawa, J.R. Wallace. 2008. The 2005 U.S. West Coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: Estimates of distribution, abundance, and length composition. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-93, 136 p. (http://www.nwfsc.noaa.gov/assets/25/6802_08122008_165005_GroundfishSurveyTM93Final.pdf)

Comments: Additional west coast bottom trawl surveys were conducted from 1977-2002

2.1.2 Item: CITY OF LOS ANGELES TRAWL SURVEYS

Source: City of Los Angeles Environmental Monitoring Division

Time Frame: 1987-2011

Spatial and Temporal Scale: inner, middle, and outer shelf soft bottom in southern CA

Metric: size, abundance, biomass of benthic fishes and invertebrates

Availabile Format: *Access* database

URL: n/a

Point(s) of Contact: Curtis Cash (City of Los Angeles, Environmental Monitoring Division, Los Angeles, CA)

Key Reference(s): n/a

Comments: n/a

2.1.3 Item: CALIFORNIA HALIBUT TRAWL SURVEYS

Source: California Department of Fish and Game

Time Frame: 2007-2010

Spatial and Temporal Scale: annual data; southern and central California

Metric: length, weight, sex; species composition; tag-release

Available Format: reports and possible database

URL: http://www.dfg.ca.gov/marine/sfmp/halibut-studies.asp

Point(s) of Contact: Paul Reilly and Travis Tanaka (California Department of Fish and Game)

Key Reference(s): n/a

Comments: n/a

2.1.4 Item: TRAWL SURVEYS FOR JUVENILE ROCKFISHES AND PACIFIC HAKE

Source: NOAA NMFS SWFSC and NWFSC

Time Frame: annual surveys, ongoing

Spatial and Temporal Scale: California and Oregon

Metric: densities; associations with environmental factors

Available Format: database; reports

URL(S): n/a

Point(s) of Contact: John Field (NMFS SWFSC, Santa Cruz, CA); R. Brodeur (NMFS NWFSC Newport, OR)

Key Reference(s): n/a

Comments: mid-water trawls; CTD

2.2 ***Acoustic Surveys***

2.2.1 Item: NWFSC WEST COAST INTEGRATED ACOUSTIC AND TRAWL SURVEY OF PACIFIC HAKE

Source: NOAA NMFS NWFSC

Time Frame: 2005, 2007, 2009, 2011, and ongoing

Spatial and Temporal Scale: biannual; surveying a series of parallel line transects oriented east-west, spaced at a 10-nmi interval, and traversed sequentially in alternating directions; the survey typically begins just north of Point Piedras Blancas, California and extends north to the U.S/Canada border, continuing into Canada

Metric: acoustic estimates of hake biomass estimates, which are verified by trawl catches; data are recorded with a number of discrete narrow-band, split-beam acoustic echo sounders, typically at 18, 38, 120, and 200 kHz; CTD casts

Available format: database

URL: http://www.nwfsc.noaa.gov/research/divisions/fram/acoustics.cfm

Point(s) of Contact: Lawrence C. Hufnagle (NOAA NWFSC, Seattle, WA)

Key Reference(s):
Fleischer, G. W., K. D. Cooke, P. H. Ressler, R. E. Thomas, S. de Blois, L. C. Hufnagle Jr. 2008. The 2005 integrated acoustic and trawl survey of Pacific hake, Merluccius productus, in U.S. and Canadian waters off the Pacific coast. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-94, 41 p.

Comments: Additional acoustic surveys were conducted from 1977 to 2003

2.3 *Direct Observation Surveys*

2.3.1 Item: Vantuna Research Group visual SCUBA surveys

Source: Vantuna Research Group, Occidental College

Time Frame: Variable depending on project, with maximum duration for a single project from1974 - present

Spatial and Temporal Scale: Various rocky reef areas in Southern California Bight from ~2-30 m depth:

- Santa Monica Bay
- Rocky Point, Palos Verdes, and King Harbor, Redondo Beach (1974-present)
- Cabrillo Jetty and Breakwater, Angel's Gate (seaward side), Angel's Gate East (harbor side), the rocky perimeter of the shallow water habitat, Pier 400 Port of Los Angeles
- Southern California Bight (2008-2009) Regional Monitoring Project (Santa Barbara, Malibu coast, Palos Verdes Peninsula, King Harbor, Horseshoe Kelp near the Port of Los Angeles, inside Port of Los Angeles, Santa Barbara Island, San Nicolas Island [including Begg Rock], Santa Catalina Island, and San Clemente Island)
- Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) Program (88 reefs from Santa Cruz to the Mexico Border including southern California islands)

Metric: fish size/abundance, invertebrate abundance, biotic and abiotic habitat characteristics

Available Format: database

URL: http://college.oxy.edu/vrg/; http://www.dfg.ca.gov/marine/fir/crane.asp

Point(s) of Contact: Jeremy Claisse (claisse@oxy.edu)

Key Reference(s): n/a

Comments: similar protocol to PISCO surveys

2.3.2 Item: CALIFORNIA MARINE LIFE PROTECTION ACT VISUAL SURVEYS

Source: California Department of Fish and Game

Time Frame: 2007-2008

Spatial and Temporal Scale: inside/out of eight MPAs off central California; 20-365 m depth; 700 quantitative transects conducted from manned submersible

Metric: size, abundance, biomass of benthic fishes and invertebrates, habitat types

Available Format: *Access* database

URL: http://www.dfg.ca.gov/mlpa/

Point(s) of Contact: M.M. Yoklavich (NOAA SWFSC Santa Cruz, CA)

Key Reference(s):
Starr, R. and M. Yoklavich. 2008. Monitoring MPAs in deep water off central California: 2007 IMPACT submersible baseline survey. CA Sea Grant College Program Publ. No. T-067: 1-22.

Yoklavich, M. *et al*. (2010) Monitoring MPAs in Deep Water off Central California: 2007-2008 IMPACT Submersible Baseline Survey. Final report to CA Ocean Protection Council.

Comments: baseline monitoring of MPAs off south-central California coast, as associated with Marine Life Protection Act

2.4 *Ichthyoplankton Surveys*

2.4.1 Item: CalCOFI SURVEYS

Source: California Cooperative Oceanic Fisheries Investigations

Time Frame: 2005 – 2011, and ongoing; time series extending back to 1949

Spatial and Temporal Scale: standard survey: 4-5 cruises per year (winter, spring, summer, fall); 75-station pattern from San Diego to Pt. Conception, CA along 6 sampling lines

Metric: temperature, salinity, oxygen, phosphate, silicate, nitrate and nitrite, chlorophyll, transmissometer, PAR, C14 primary productivity, phytoplankton biodiversity, zooplankton biomass, and zooplankton biodiversity; ancillary data collected include continuous underway sea surface & meterological measurements; Acoustic Doppler Current Profiler data; the Continuous Underway Fish Egg Sampler (winter & spring); trace metals; sediments; MOCNESS net sampling; bio-optics; PCO2 air-sea interface, and atmospheric measurements; marine mammal and sea bird visual surveys

Available Format: database

URL(S): http://calcofi.org/

Point(s) of Contact: Tony Koslow (Scripps Institution of Oceanography, La Jolla, CA)

Key Reference(s): http://calcofi.org/pubs.html

Comment: CalCOFI is a partnership of the California Department of Fish and Game, NOAA Fisheries, and Scripps Institution of Oceanography

3. HABITAT INFORMATION

3.1 *Oceanographic*

3.1.1 Item: OCEANOGRAPHIC DATASETS FOR THE WASHINGTON AND OREGON COASTS

Source: Oregon State University, College of Earth, Ocean, and Atmospheric Sciences

Time Frame: The climatologies are formed from the earliest time available (depending on the variable and time of the year) to the year 2004

Spatial and Temporal Scale: Monthly climatologies from northern California Current System from the Strait of Juan de Fuca in northern Washington (49 degrees N) to northern California (41 degrees N) and extended from the coastline to 127 degrees W. The oceanographic data products were computed at depths of 0, 50, 100, 500, 1000 m and near the bottom.

Metric: temperature, salinity, chlorophyll-a and current velocity

Available Format: MS Thesis; database

URL(S): http://ir.library.oregonstate.edu/xmlui/handle/1957/1693

Point(s) of Contact: John Barth (College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR)

Key Reference(s):
Juan-Jorda´, M.J. (2006) Integration of oceanographic information off the Washington and Oregon coasts into the ecology of groundfish and their management. MS thesis, Oregon State University, Corvallis, Oregon, pp. 290.

Juan Jordá, M.J., J.A. Barth, M.E. Clarke and W.W. Wakefield. 2009. Groundfish species associations with distinct oceanographic habitats off the Pacific Northwest Coast. Fisheries Oceanography 8:1-19.

Comment: main sources of data used in this study were remotely sensed from satellites and high-frequency land-based coastal radars, and from in situ instruments, such as conductivity-temperature-depth, bottle samples, and data from an acoustic Doppler current profiler.

3.1.2 Item: OCEANOGRAPHIC DATA of the PACIFIC COAST

Source: International Pacific Halibut Commission

Time Frame: 2007-2010

Spatial and Temporal Scale: surface to depth (50-500 m) along part or all of the Pacific Coast

Metric: temperature/salinity/depth profiles

Available Format: database

URL(S): http://www.nodc.noaa.gov/; http://www.iphc.int/;
http://www.ecofoci.noaa.gov/efoci_sitemap.shtml

Point(s) of Contact: Lauri Sadorus (International Pacific Halibut Commission, Seattle, WA)

Key Reference(s): n/a

Comments: ongoing surveys

3.2 *Structure-Forming Invertebrates*

3.2.1 Item: BENTHIC INVERTEBRATES AS HABITAT IN SUBMARINE CANYONS

Source: Washington State University Vancouver

Time Frame: 1994, 2001

Spatial and Temporal Scale: 1 year each at Ascension, Carmel, Astoria Canyons

Metric: quantitative visual surveys; nearest neighbor analyses; distance of fish to deep corals

Available Format: MS Thesis; *Access* database

URL(S): n/a

Point(s) of Contact: B.N. Tissot (Washington State University Vancouver)

Key Reference(s):

Bianchi, C. 2011. Abundance and distribution of megafaunal invertebrates in NE Pacific submarine canyons and their ecological associations with demersal fishes. MS Thesis, Washington State University Vancouver.

Comments: includes fish associations with corals and sponges, 90-1400 m depth

3.2.2 Item: BENTHIC INVERTEBRATES AS HABITAT ON FOOTPRINT BANK, SOUTHERN CALIFORNIA BORDERLANDS

Source: Washington State University, Vanvouver

Time Frame: 1995-2004

Spatial and Temporal Scale: 28 dives on top of bank

Metric: quantitative visual surveys; nearest neighbor analyses; distance of fish to deep corals

Available Format: MS Thesis; database

URL(S):
https://research.vancouver.wsu.edu/sites/research.vancouver.wsu.edu/files/Bright_Thesis_2007.pdf

Point(s) of Contact: M.S. Love (University of California Santa Barbara), B.N. Tissot (Washington State University Vanvouver)

Key Reference(s):
Bright, J.L. 2007. Abundance and distribution of structure-forming invertebrates and their association with fishes at the Channel Islands “Footprint” off the southern coast of California. MS Thesis Washington State University Vancouver.

Comments: includes fish associations with corals and sponges at 97-314 m depth

3.2.3 Item: BENTHIC INVERTEBRATES AS HABITAT ON CORDELL BANK, CALIFORNIA

Source: Cordell Bank National Marine Sanctuary

Time Frame: 2002

Spatial and Temporal Scale: 27 quantitative dives

Metric: quantitative visual surveys; nearest neighbor analyses; distance of fish to deep corals

Available Format: MS Thesis; database

URL(S): http://cordellbank.noaa.gov/science/pirtle_invertfishhab_ms_thesis.pdf

Point(s) of Contact: D.F Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA); B.N. Tissot (Washington State University Vanvouver)

Key Reference(s):
Pirtle, J.L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. MS Thesis Washington State University Vancouver.

Comments: includes fish associations with corals and sponges at 55 – 250 m depth

3.2.4 Item: DEEP CORAL AND SPONGE VISUAL SURVEYS IN SOUTHERN CALIFORNIA (ROV AND HUMAN-OCCUPIED SUBMERSIBLE)

Source: NOAA NMFS SWFSC; NOAA Deepsea Coral Program

Time Frame: 2010

Spatial and Temporal Scale: cruise 1 (6 ROV dives from 280 to 900 m at Piggy Bank); cruise 2 (several dives with human-occupied submersible in 200-300 m depth on rocky banks in Southern California Borderlands)

Metric: quantitative visual surveys of corals, sponges, fishes, habitats; association of fish to deep corals and sponges

Available Format: database and report

URL(S): n/a

Point(s) of Contact: M.M. Yoklavich (NMFS SWFSC Santa Cruz, CA)

Key Reference(s):
Yoklavich, M., et al. 2011. A characterization of the coral and sponge community on Piggy Bank seamount in southern California from a survey using a remotely operated vehicle. Final report to NOAA Deepsea Coral Research and Technology Program. 63 p.

Comments: n/a

3.2.5 Item: QUANTITATIVE VISUAL SURVEYS of DENSITIES OF CORALS, SPONGES, AND FISHES, and ASSOCIATION OF FISH TO DEEP CORALS – CORDELL BANK

Source: Cordell Bank National Marine Sanctuary; NOAA Deepsea Coral Program

Time Frame: 2010 (ROV); 2001-2005 (human-occupied submersible); 2004, 2007 (towed camera)

Spatial and Temporal Scale: Cordell Bank

Metric: quantitative visual surveys; densities of corals, sponges, fishes, association of fish to deep corals

Available Format: database, reports, published papers

URL(S): n/a

Point(s) of Contact: D.F Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA)

Key Reference(s):
Graiff, K., D. Roberts, D. Howard, P. Etnoyer, G. Cochrane, J. Hyland, and J. Roletto. 2011. A characterization of deep-sea coral and sponge communities on the continental slope west of Cordell Bank, northern California using a remotely operated vehicle. Final Report to NOAA Deep-sea Coral Research and Technology Program, 21 p.

Comments: n/a

3.2.6 Item: ROV SURVEYS of DEEP CORALS AND SPONGES OFF WASHINGTON

Source: NOAA Olympic Coast National Marine Sanctuary; NOAA Deepsea Coral Program

Time Frame: 2005, 2006; 2008; 2010; 2011

Spatial and Temporal Scale: Olympic Coast National Marine Sanctuary

Metric: quantitative visual surveys; densities of corals, sponges, fishes, habitats, association of fish to deep corals

Available Format: database and reports

URL(S): n/a

Point(s) of Contact: C.E. Bowlby (NOAA Olympic Coast National Marine Sanctuary, Port Angeles, WA)

Key Reference(s):
Bowlby, C.E, M.S. Brancato, J. Bright, K. Brenkman, and J. Hyland. 2011. A characterization of deep-sea coral and sponge communities on the continental shelf of northern Washington, Olympic Coast National Marine Sanctuary, using a remotely operated vehicle in 2006. A preliminary report to Pacific Fishery Management Council Essential Fish Habitat Review Committee, 76 p.

Bowlby, C.E, M.S. Brancato, J. Bright, K. Brenkman, and J. Boutillier. 2011. A characterization of deep-sea coral and sponge communities on the continental shelf of northern Washington, Olympic Coast National Marine Sanctuary, using a remotely operated vehicle in 2008. A preliminary report to Pacific Fishery Management Council Essential Fish Habitat Review Committee, 56 p.

Bowlby, C.E, J. Bright, K. Brenkman, P. Etnoyer, S. Rooney, and C. Brady. 2011. A characterization of deep-sea coral and sponge communities on the continental shelf of northern Washington, Olympic Coast National Marine Sanctuary, using a remotely operated vehicle in June 2010. A report to NOAA Deep-sea Coral Research and Technology Program, 21 p.

Brancato, M.S., C.E. Bowlby, J. Hyland, S.S. Intelmann, and K. Brenkman. 2007. Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary, Washington. Cruise Report: NOAA Ship McArthur II Cruise AR06-06/07. Marine Sanctuaries Conservation Series NMSP-07-03. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. 48 pp. http://sanctuaries.noaa.gov/science/conservation/bowlby.html

Brancato, M.S. and C.E. Bowlby. 2005. Survey of fishing gear and fiber optic cable impacts to benthic habitats in the Olympic Coast National Marine Sanctuary. Pages 629-630 in P.W. Barnes and J.P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

Hyland, J., C. Cooksey, E. Bowlby, M.S. Brancato, and S. Intelmann. 2005. A Pilot Survey of Deepwater Coral/Sponge Assemblages and their Susceptibility to Fishing/Harvest Impacts at the Olympic Coast National Marine Sanctuary (OCNMS). Cruise Report for NOAA Ship McARTHUR II Cruise AR-04-04: Leg 2. NOAA Technical Memorandum NOS NCCOS 15. NOAA/NOS Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. 13 p. http://www.coastalscience.noaa.gov/documents/ar0404leg2.pdf

Comments: n/a

3.2.7 Item: AUV SURVEYS OF DEEP SPONGES and ASSOCIATION TO FISH

Source: NOAA NMFS NWFSC; NOAA Deepsea Coral Program

Time Frame: 2010

Spatial and Temporal Scale: 2 dives Olympic Coast National Marine Sanctuary [report/images not provided], WA; 6 dives Grays Harbor, WA glass sponge reef; 8 dives Piggy Bank southern California Borderlands

Metric: quantitative visual surveys; densities of sponges, corals, and association with fishes

Available Format: digital still images

URL(S): n/a

Point(s) of Contact: M.E. Clarke (NOAA NMFS NWFSC Seattle, WA)

Key Reference(s):
Clarke, M.E. and E. Fruh. 2011. A characterization of the sponge community in the region of Grays Canyon, WA from a survey using an autonomus underwater vehicle October 2010. A Report to NOAA Deep-Sea Coral Research and Technology Program, 62p.

Comments: n/a

3.2.8 Item: CLOUD SPONGES AS NURSERY HABITAT FOR FISHES IN BRITISH COLUMBIA

Source: Vancouver Aquarium

Time Frame: 2009

Spatial and Temporal Scale: Strait of Georgia, British Columbia; multiple years

Metric: scuba surveys of young-of-the-year yelloweye and quillback rockfishes

Available Format: poster presentation, dataset

URL(S): n/a

Point(s) of Contact: J.B. Marliave (Vancouver Aquarium, Vancouver, BC)

Key Reference(s): n/a

Comments: includes impacts from spot prawn traps

3.2.9 Item: ROV SURVEYS OF FISH, INVERTEBRATES AND HABITAT IN MONTEREY BAY AND SOUTHERN OREGON

Source: Oceana

Time Frame: 2010-2011

Spatial and Temporal Scale: ROV dives at 18 sites in Monterey Bay; 17 sites in southern Oregon

Metric: visual surveys

Available Format: raw video footage; summary

URL(S): n/a

Point(s) of Contact: G. Shester (gshester@oceana.org)

Key Reference(s): n/a

Comments: 24-188 m depth; former halibut trawl grounds; shale beds; in/out of EFH areas

3.2.10 Item: STRUCTURE-FORMING BENTHIC INVERTEBRATES ON THE CONTINENTAL MARGIN OF OREGON AND WASHINGTON

Source: Oregon State University

Time Frame: 1992-95

Spatial and Temporal Scale: nearshore and offshore regions at 66-370 m depth, from Cape Blanco, Oregon (ca. 43°50'N) to offshore of Gray's Harbor, Washington (ca. 47°05'N).

Metric: using a human-occupied submersible, quantitative inventory of structure-forming invertebrates; documentation of invertebrate associations with geological habitat types

Available Format: MS Thesis and database

URL(S):
http://oasis.oregonstate.edu/search~S13/?searchtype=a&searcharg=strom%2C+natalie&searchscope=13&SORT=D&extended=0&searchlimits=&searchorigarg=anatalie+reed;

Point(s) of Contact: C. Goldfinger (Oregon State University, Corvallis, OR)

Key Reference(s):
Strom, N.A. 2006. Structure-forming benthic invertebrates: habitat distributions on the continental margin of Oregon and Washington. MS Thesis, Oregon State University, Corvallis, OR.

Comments: n/a

3.2.11 Item: SURVEY OF CORAL AND SPONGE HABITATS OFF WEST COAST

Source: NOAA NMFS SWFSC; NOAA NOS NCCOS

Time Frame: November 1-5, 2010

Spatial and Temporal Scale: Five ROV transect surveys and CTD casts conducted between San Diego, CA and Seattle, WA at depths 110-400 m.

Metric: temperature, salinity, habitat type, relative abundance and density of corals, sponges, fishes

Available Format: Report

URL(S):

Point(s) of Contact: K. Stierhoff (kevin.stierhoff@noaa.gov); P. Etnoyer (peter.etnoyer@noaa.gov)

Key Reference(s):
Stierhoff, KL, PJ Etnoyer, DW Murfin, and JL Butler. 2011. A survey of deep-water coral and sponge habitats along the West Coast of the US using a remotely operated vehicle . NOAA Technical Memorandum NOS NCCOS, NOAA Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. 41 pp.

Comments: n/a

3.2.12 Item: DEEP CORAL MODELING

Source: Cordell Bank National Marine Sanctuary

Time Frame: n/a

Spatial and Temporal Scale: Cordell Bank

Metric: modeled habitat associations of deep corals

Available Format: data and report

URL(S): http://cordellbank.noaa.gov/science/research.html#coral

Point(s) of Contact: D.F Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA)

Key Reference(s):
Etherington, L.L., P. van der Leeden, K. Graiff, D. Roberts, and B. Nickel. 2011. Summary of deep sea coral patterns and habitat modeling results from Cordell Bank, CA. NOAA Cordell Bank National Marine Sanctuary, Olema, CA 94956.

Comments: n/a

3.2.13 Item: DEEP CORAL HABITAT SUITABILITY MODELING

Source: Marine Conservation Institute; NOAA Deepsea Coral Program

Time Frame: n/a

Spatial and Temporal Scale: U.S. West Coast

Metric: modeled habitat associations of deep corals

Available Format: data, model, and report

URL(S): n/a

Point(s) of Contact: J.M. Guinotte (John.Guinotte@marine-conservation.org)

Key Reference(s):
Guinotte, J.M. and A.J. Davies. 2012. Predicted deep-sea coral habitat suitability for the U.S. West Coast. Final Report to NOAA Deep-sea Coral Research and Technology Program, 85 pp.

Comments: n/a

3.2.14 Item: DEEP CORAL/SPONGE CPUE – NMFS NWFSC WEST COAST BOTTOM TRAWL SURVEY

Source: NOAA NMFS NWFSC

Time Frame: 2003-2010

Spatial and Temporal Scale: Pacific coast, 2003-05 and 2006-10 survey cycles

Metric: standardized CPUE

Available Format: data products via PaCOOS

Point(s) of Contact: Curt Whitmire (NOAA NMFS NWFSC, Newport, OR)

Comments: n/a

3.3 *Estuaries*

3.3.1 Item: CONSERVATION ASSESSMENT OF WEST COAST (USA) ESTUARIES

Source: The Nature Conservancy

Time Frame: n/a

Spatial and Temporal Scale: California, Oregon, Washington

Available Format: database and report

URL: http://conserveonline.org/workspaces/wcea/

Point(s) of Contact: Mary Gleason (The Nature Conservancy)

Key Reference(s):
Gleason MG, S Newkirk, MS Merrifield, J Howard, R Cox, M Webb, J Koepcke, B Stranko, B Taylor, MW Beck, R Fuller, P Dye, D Vander Schaaf, J. Carter. 2011. A Conservation Assessment of West Coast (USA) Estuaries. The Nature Conservancy, Arlington VA. 65pp.

Comments: Geographic information system (GIS) database containing spatial data for 146 estuaries and their associated catchments; includes 27 variables that characterize some key biophysical and human use parameters

3.4 *Other Habitat Information*

3.4.1 Item: HABITAT ASSOCIATIONS WITH FISHES

Source: Cordell Bank National Marine Sanctuary

Time Frame: n/a

Spatial and Temporal Scale: Cordell Bank

Metric: quantitative visual surveys of fishes and habitats

Available Format: data and published papers

URL(S): n/a

Point(s) of Contact: D.F Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA)

Key Reference(s):
Anderson, T.J., C. Syms, D.A. Roberts, D.F. Howard. 2009. Multi-scale fish-habitat associations and the use of habitat surrogates to predict the organization and abundance of deep-water fish assemblages. Journal of Experimental Marine Biology and Ecology 379:34-42.

Young, M.A., P. J. Iampietro, R.G. Kvitek, and C.D. Garza. 2010. Multivariate bathymetry-derived generalized linear model accurately predicts rockfish distribution on Cordell Bank, California, USA. Marine Ecology Progress Series 415:247-261.

Comments: n/a

3.4.2 Item: DATA LIBRARY and MARINE MAP - AN ONLINE MAPPING TOOL

Source: California Department of Fish and Game

Time Frame: n/a

Spatial and Temporal Scale: Coast of California

Metric: A geospatial data library viewable with MarineMap, which is an online mapping tool developed to assist in the design of marine protected areas (MPAs) in California.

Available Format: database and software

URL(S): http://marinemap.org/; http://northcoast.marinemap.org/; http://www.dfg.ca.gov/mlpa/northcoast.asp

Point(s) of Contact: Paulo Serpa (California Department Fish Game, Monterey, CA)

Key Reference(s): n/a

Comments: n/a

3.4.3 Item: VISUAL SURVEYS (ROV), SEDIMENT GRABS, MULTIBEAM MAPPING OF RIPPLED SCOUR DEPRESSIONS

Source: California State University Monterey Bay, Seafloor Mapping

Time Frame: 2009

Spatial and Temporal Scale: Monterey Bay; 15-50m depth

Metric: densities of scour depressions and associated fishes and invertebrates

Available Format: MS Thesis; database

URL(S): http://sep.csumb.edu/cwsp/theses/Hallenbeck_MSThesis_110327.pdf

Point(s) of Contact: R. Kvitek (California State University Monterey Bay, Seaside, CA)

Key Reference(s):
Hallenbeck, T.R. 2011. Rippled scour depressions add ecologically significant heterogeneity to soft sediment habitats on the continental shelf. MS Thesis, California State University Monterey Bay, Seaside, CA.

Comments: possible rockfish nursery habitat

4. EXISTING AND EMERGING THREATS

4.1 *Fishery-Dependent Threats*

4.1.1 Item: BOTTOM TRAWL LOGBOOK DATA SUMMARIES

Source: PacFIN (raw data); NMFS NWFSC (data products)

Time Frame: 2002-2010

Spatial and Temporal Scale: trawl towline model was used to allocate effort data in 10 x 10 km grid cells; annual representations

Metric: tow duration (h); groundfish catch (lbs); numbers of vessels and tows

Available Format: data products via PaCOOS

URL: http://pacoos.coas.oregonstate.edu/

Point(s) of Contact: Curt Whitmire (NOAA NMFS NWFSC, Newport, OR) and Marlene Bellman (NOAA NMFS NWFSC Seattle, WA)

Key Reference(s): n/a

Comments: To preserve confidentiality standards, data from grid cells with fewer than 3 vessels in any given year were excluded from that year's data product. In addition, bottom trawling is prohibited in Washington and California state waters, except within designated California Halibut Trawl Grounds; therefore data in cells that straddle the territorial sea boundaries of Washington and California were clipped to exclude those portions within state waters.

4.1.2 Item: BOTTOM TRAWL LOGBOOK DATA SUMMARIES

Source: PacFIN (raw data); NMFS NWFSC (data products)

Time Frame: 2002-2010

Spatial and Temporal Scale: 500 X 500 meter cells and composite convex hull of half degree latitude blocks; 5-year periods (2002–11 Jun 2006 and 12 Jun 2006 –2010)

Metric: distance fished (km) per km^2

Available Format: data products via PaCOOS

URL: http://pacoos.coas.oregonstate.edu/

Point(s) of Contact: Curt Whitmire (NOAA NMFS NWFSC, Newport, OR) and Marlene Bellman (NOAA NMFS NWFSC Seattle, WA)

Key Reference(s): n/a

Comments: To preserve confidentiality standards, data from grid cells with fewer than 3 vessels in any given time period were excluded from the data product. In addition, bottom trawling is prohibited in Washington and California state waters, except within designated California Halibut Trawl Grounds; therefore data in cells that straddle the territorial sea boundaries of Washington and California were clipped to exclude those portions within state waters.

4.1.3 Item: WEST COAST GROUNDFISH OBSERVER PROGRAM (WCGOP) FIXED GEAR DATA SUMMARIES

Source: NOAA NMFS NWFSC

Time Frame: 2002-2009

Spatial and Temporal Scale: fixed gear set and haul locations were used to allocate effort data to 20 x 20 km grid cells, combined 2002-2009 period; composite convex hull of half degree latitude blocks, 5-year periods (2002–11 Jun 2006 and 12 Jun 2006 –2010)
Metric: groundfish catch (lbs); number of hooks, pots, vessels, and sets or hauls

Available Format: data products via PaCOOS

URL: http://pacoos.coas.oregonstate.edu/

Point(s) of Contact: Marlene Bellman (NOAA NMFS NWFSC Seattle, WA)

Key Reference(s): n/a

Comments: To preserve confidentiality standards, data in grid cells with fewer than 3 vessels were excluded from the data product.

4.1.4 Item: OBSERVED PACIFIC HAKE COMMERCIAL EFFORT

Source: NOAA NMFS NWFSC

Time Frame: 2002-2010

Spatial and Temporal Scale: 500 X 500 meter cells and composite convex hull of half degree latitude blocks; 5-year periods (2002–11 Jun 2006 and 12 Jun 2006 –2010)

Metric: distance fished (km) per km^2

Available Format: data products via PaCOOS

Point(s) of Contact: Curt Whitmire (NOAA NMFS NWFSC, Newport, OR) and Marlene Bellman (NOAA NMFS NWFSC Seattle, WA)

Key Reference(s): n/a

Comments: Combined product from shore-side sector (PacFIN) and at-sea sector (At-Sea Hake Observer Program or A-SHOP). To preserve confidentiality standards, data in grid cells with fewer than 3 vessels were excluded from the data product.

4.1.5 Item: GROUNDFISH BOTTOM TRAWL FISHING EFFORT AND CORAL/SPONGE LOCATIONS

Source: NOAA NMFS SWFSC; NOAA Deepsea Coral Program

Time Frame: 1997 - 2009

Spatial and Temporal Scale: California coast; comparative maps of trawl effort between time periods 1997-1999 and 2006-2009; maps of coral/sponge presence 1980-2007

Metric: data from California trawl logbook data: hr towed per km^2 per year, aggregated over years and mapped in 1-minute latitude and longitude blocks; data from NMFS trawl surveys: presence of coral taxa

Available Format: maps and GIS layers

URL: n/a

Point(s) of Contact: J. Mason (NOAA NWFSC, Pacific Grove, CA)

Key Reference(s): n/a

Comments: To protect confidentiality, data were not used from 1-minute blocks with < 3 vessels for the aggregated years.

4.2 *Non-Fishing Threats*

4.2.1 Item: BASELINE WATER SAMPLING ON CORDELL BANK FOR STUDIES ON OCEAN ACIDIFICATION

Source: Cordell Bank National Marine Sanctuary

Time Frame: 2010

Spatial and Temporal Scale: Cordell Bank, California, shelf and slope

Metric: temperature, salinity, water chemistry

Available Format: dataset

URL(S): n/a

Point(s) of Contact: D. Howard (Cordell Bank National Marine Sanctuary, Point Reyes Station, CA)

Key Reference(s): n/a

Comments: baseline pilot study of ocean chemistry

4.2.2 Item: WATER SAMPLING ON PIGGY BANK SEAMOUNT IN SOUTHERN CALIFORNIA

Source: Channel Island National Marine Sanctuary; NOAA Deepsea Coral Program

Time Frame: June 27-1July 2010

Spatial and Temporal Scale: Piggy Bank, Southern California; surface to 815 m depth

Metric: temperature, salinity, pH, dissolved oxygen, phosphate, nitrite, nitrate, ammonium, dissolved inorganic carbon, total alkalinity, pCO2, aragonite

Available Format: dataset and report

URL(S): n/a

Point(s) of Contact: Danielle Lipski (danielle.lipski@noaa.gov)

Key Reference(s): n/a

Comments: baseline pilot study of ocean chemistry; 9 CTD casts and 68 water samples taken at surface, 50 m, 100 m, 150 m, 200 m, and near bottom (290-815 m)

APPENDIX C BATHYMETRY AND SEAFLOOR HABITAT MAPS

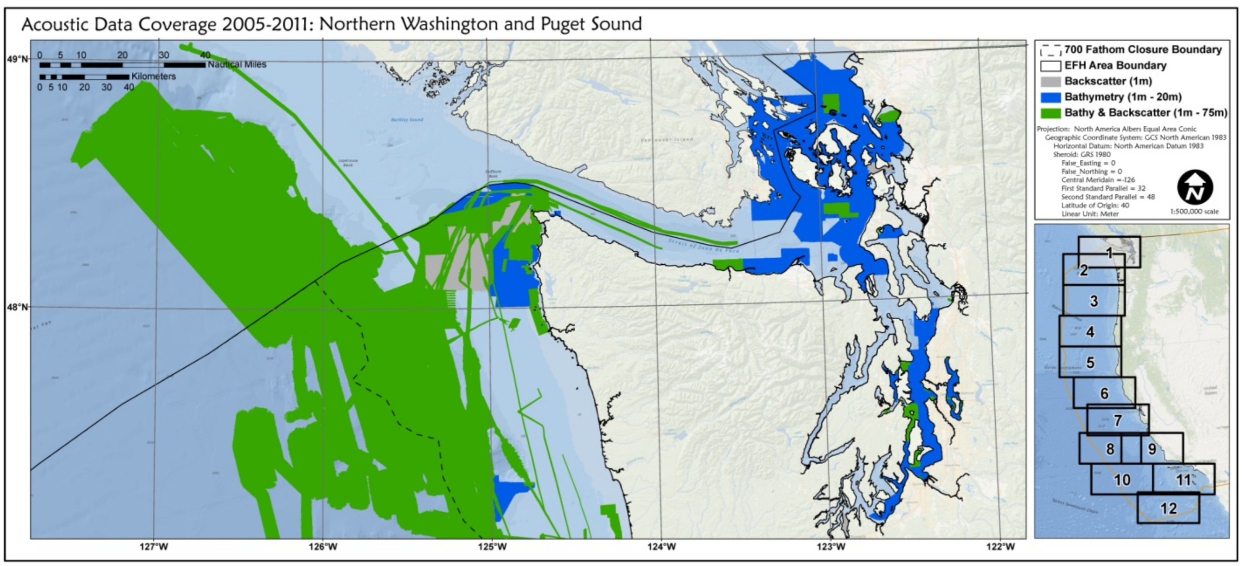
A set of 24 comparison map panel layouts were constructed at a scale of 1:500,000 and encompassed the EEZ of the southern U.S. Pacific Coast. Each comparison panel presents a geographic comparison of project components (Imagery; Appendix C-1, and Habitat; Appendix C-2) and over three time intervals: Pre 2005, 2005-2011, and Aggregate 2011 (combined overlay of pre-2005 and 2005-2011 data). Note that plates are meant to be printed at full size (44" wide by 60" tall). Shrinking a plate to fit on an 8.5" by 11" letter size page will change the map scale to approximately 1:2,588,235. . It will also result in a loss of resolution due to resampling and printing limitations.

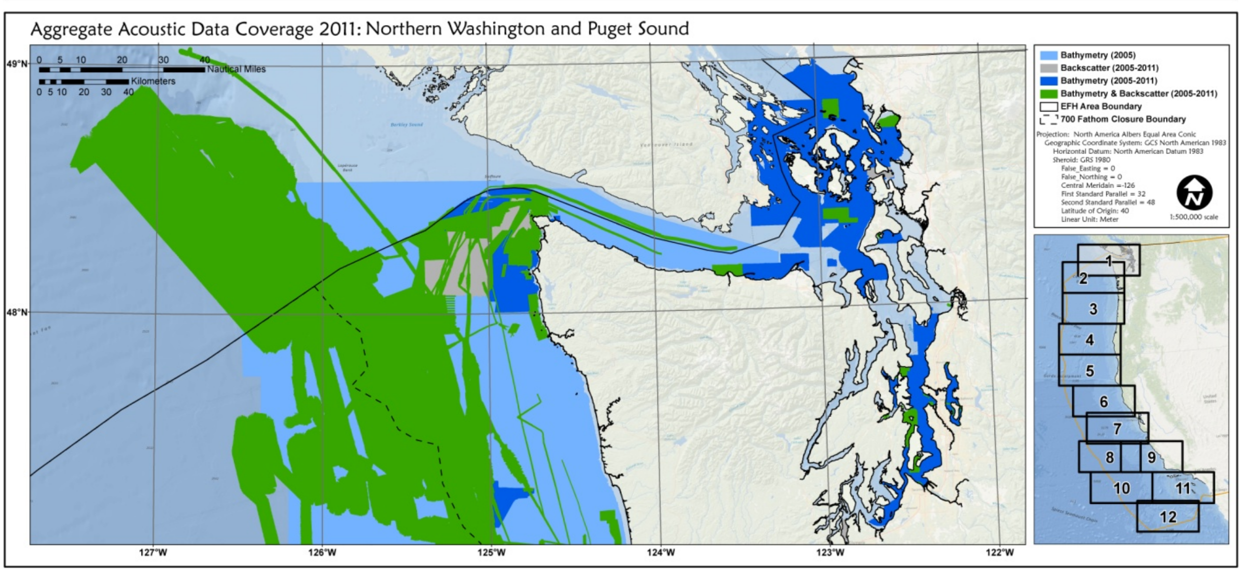
A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/.

Seafloor imagery and habitat types were color-coded so that the composition of the available data associated with each survey region could be easily distinguished. Survey regions were divided into three categories, those that contained only bathymetry data (blue), those that contained bathymetry and backscatter data (green), and those that contained only backscatter data (grey) (e.g., Figure 6). Habitat types were distinguished as probable soft sediment (yellow), probable rock (red), or a mixture of soft sediment and rock (brown) (e.g., Figure 7). Given that this effort compiled habitat maps from a variety of sources, it is essential to understand that mapping methods varied widely among sources and that it was our task to display the sources under some common scheme.

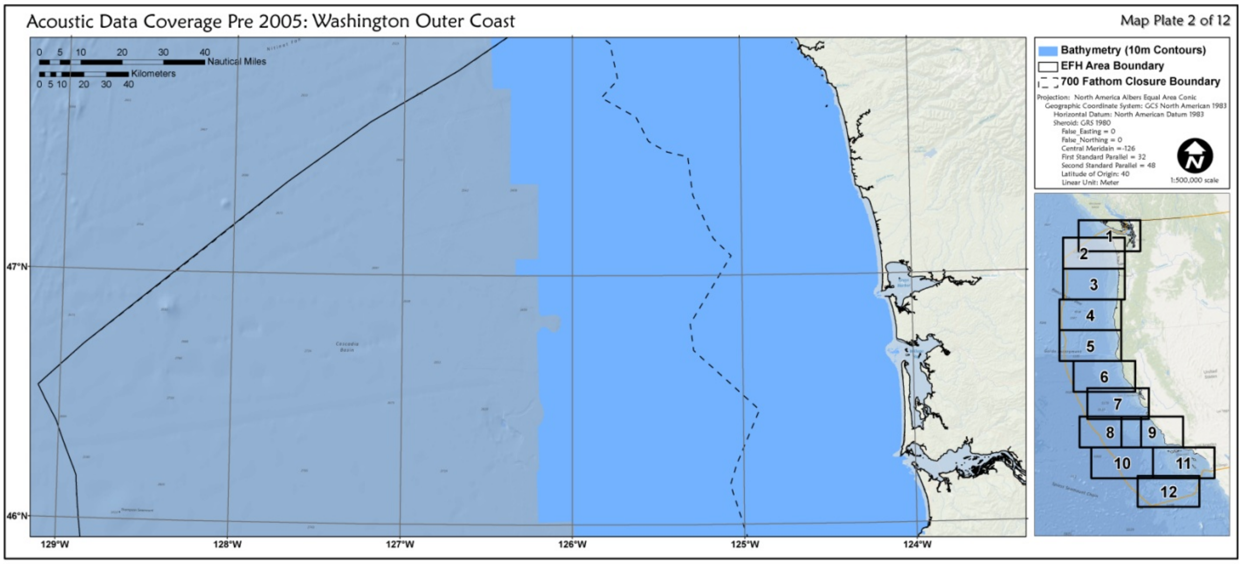
A special habitat type case exists for Oregon and Washington. During the 2002 mapping effort, seafloor below 150m water depth and of 10 degrees slope or greater were mapped as rock outcrop (red). This mapping was made based upon expert observation that steep slopes in this region do not hold unconsolidated sediments well and are often rocky. To call attention to the facts that: 1) similar mapping was not done for California, 2) the mapping technique only infers rock outcrop through a simple >10 degrees of slope angle rule, and 3) the rule when applied classifies a large quantity of seafloor as rocky, this habitat type was mapped as "Inferred Rock" using a light red color. The extent of inferred rock in the current pre-2005 map plates is identical to that depicted in the 2002 West Coast Oregon and Washington substrate map; however, it is colored differently in the current pre-2005 map plates so that it may be distinguished from rock that was determined based on geologic interpretations or more rigorous automated classification techniques (Figure 7).

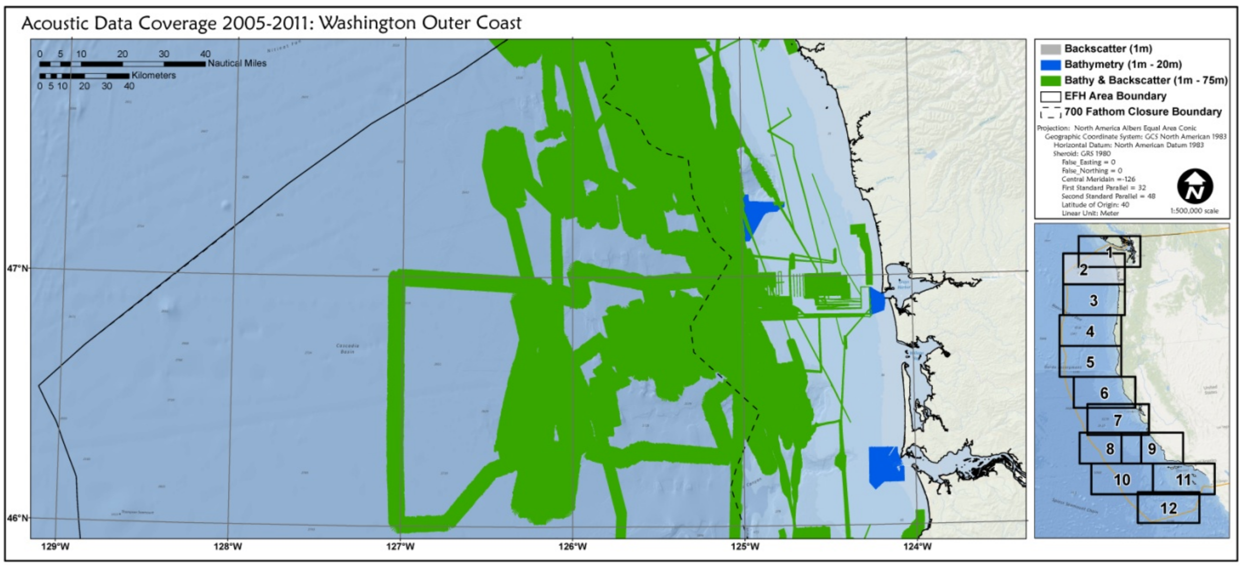
Appendix C-1: Imagery

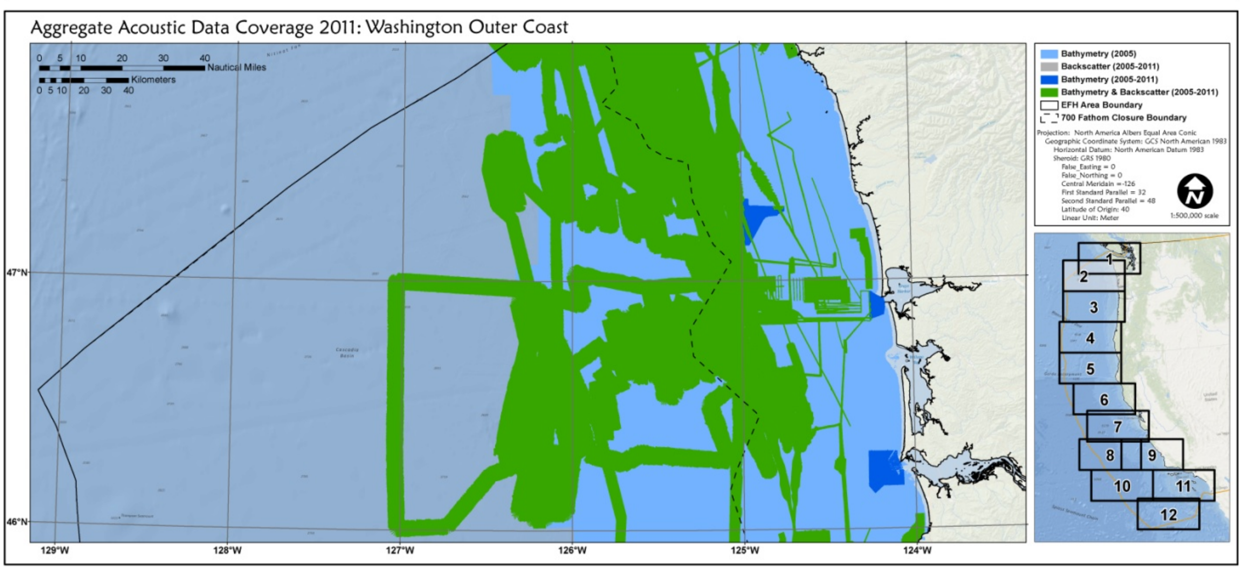




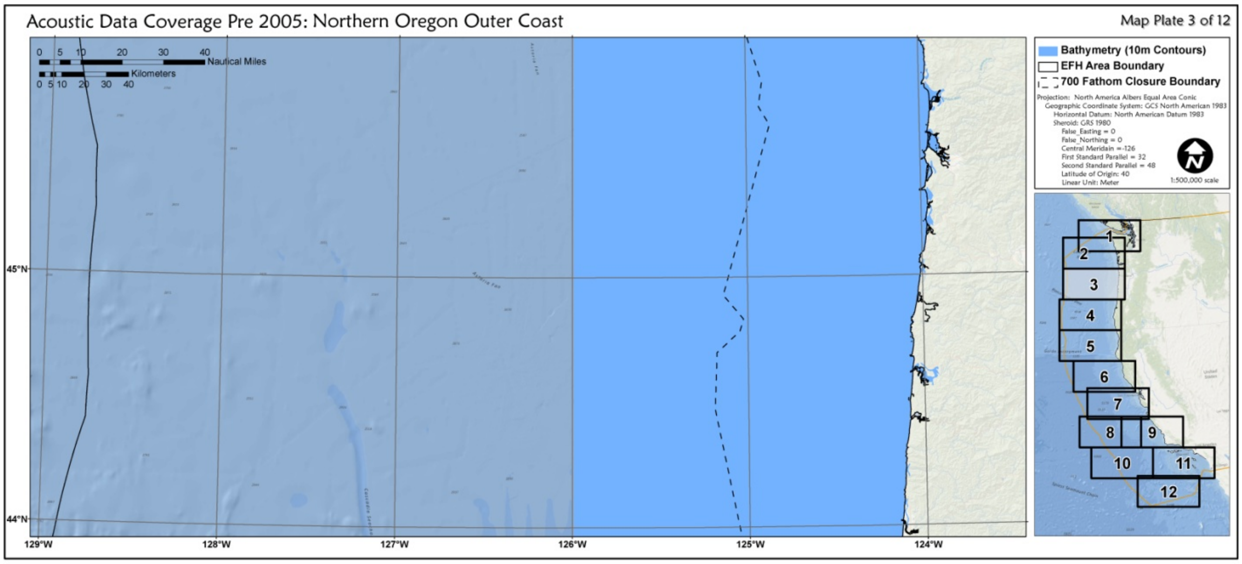
Appendix C-1: Imagery

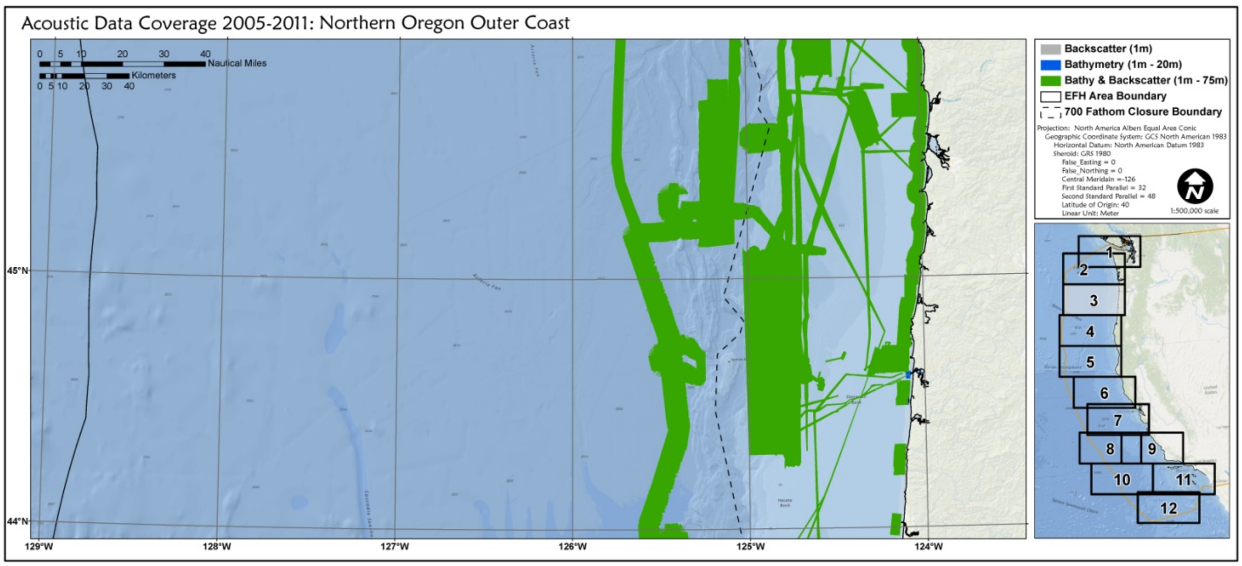


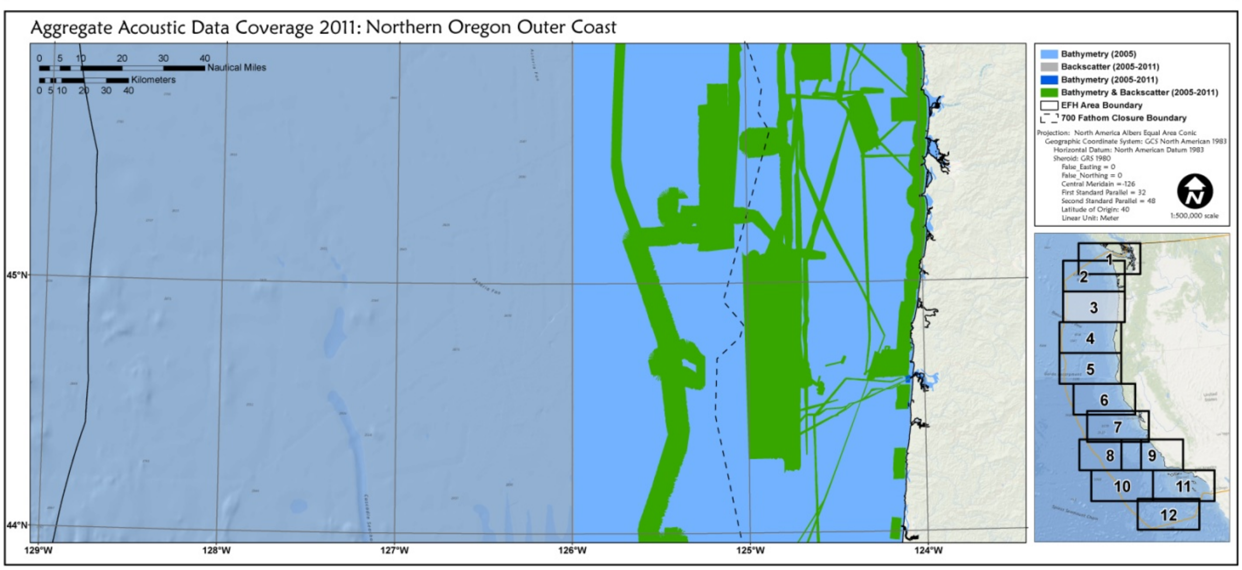




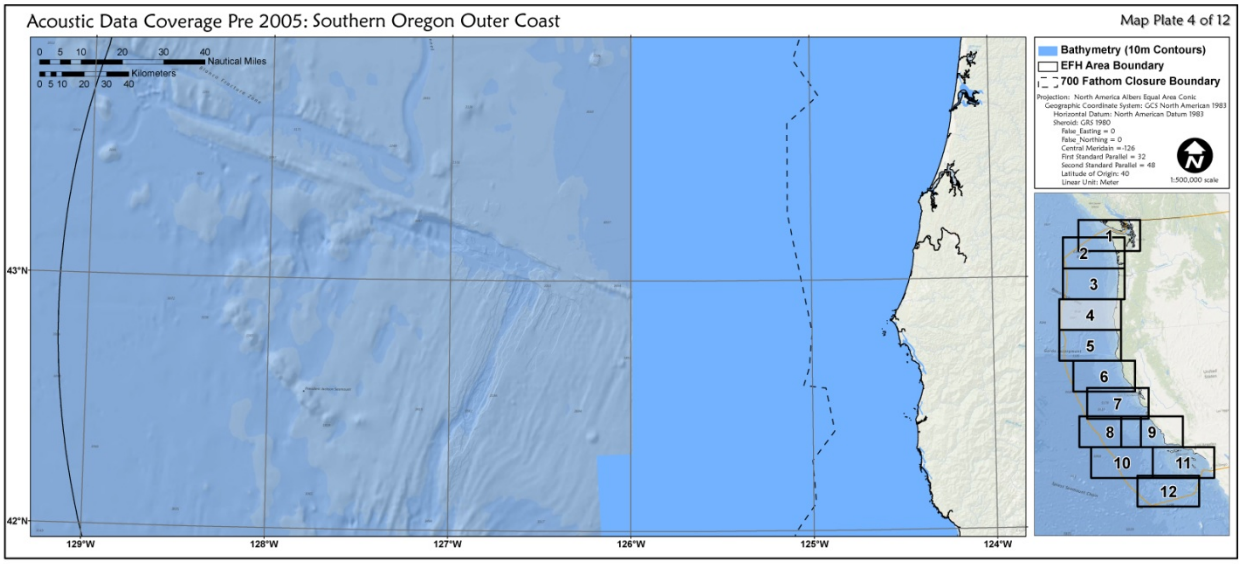
Appendix C-1: Imagery

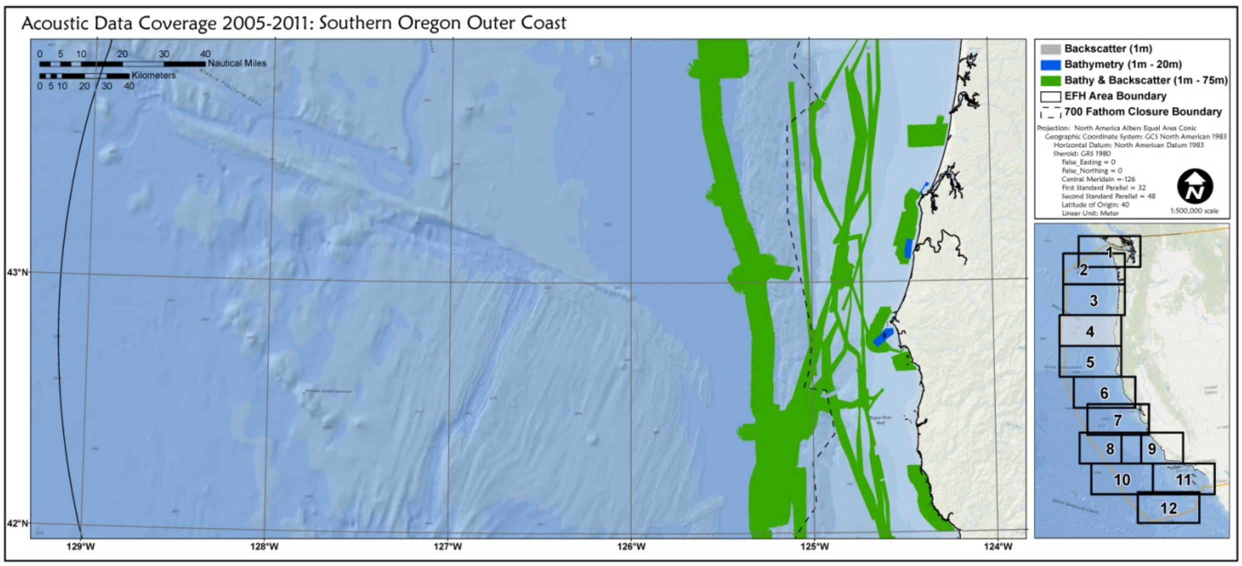


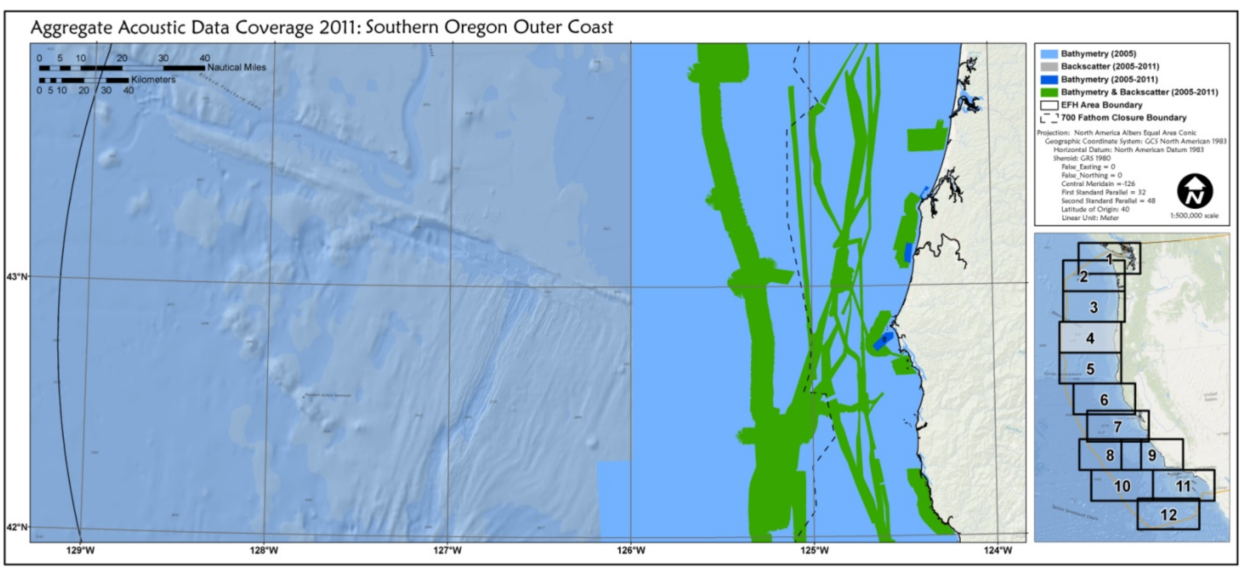




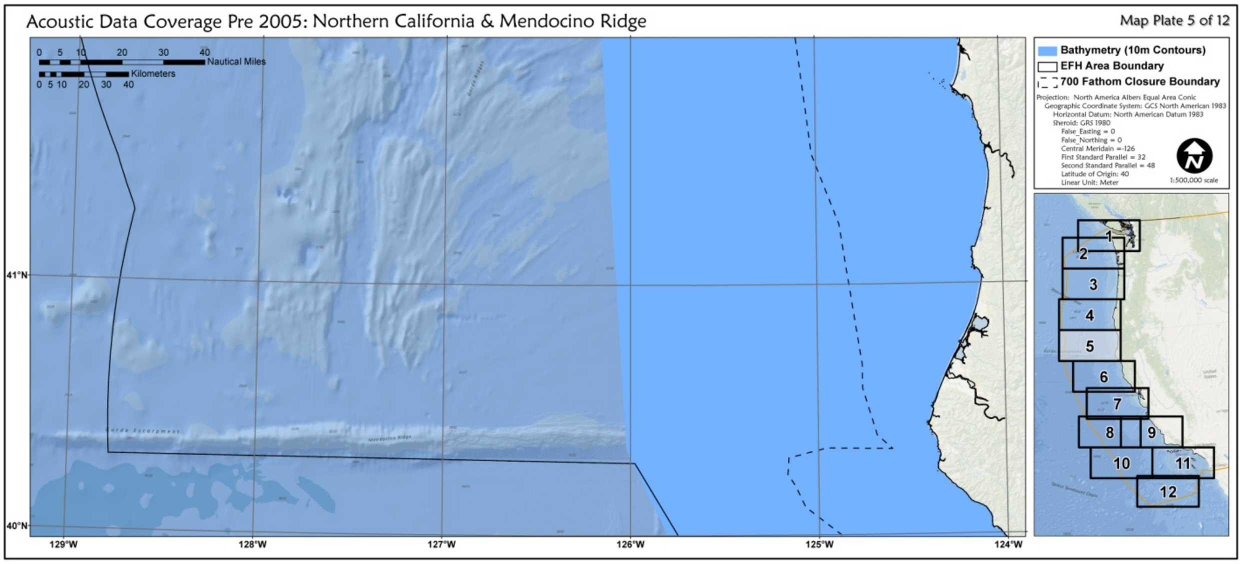
Appendix C-1: Imagery

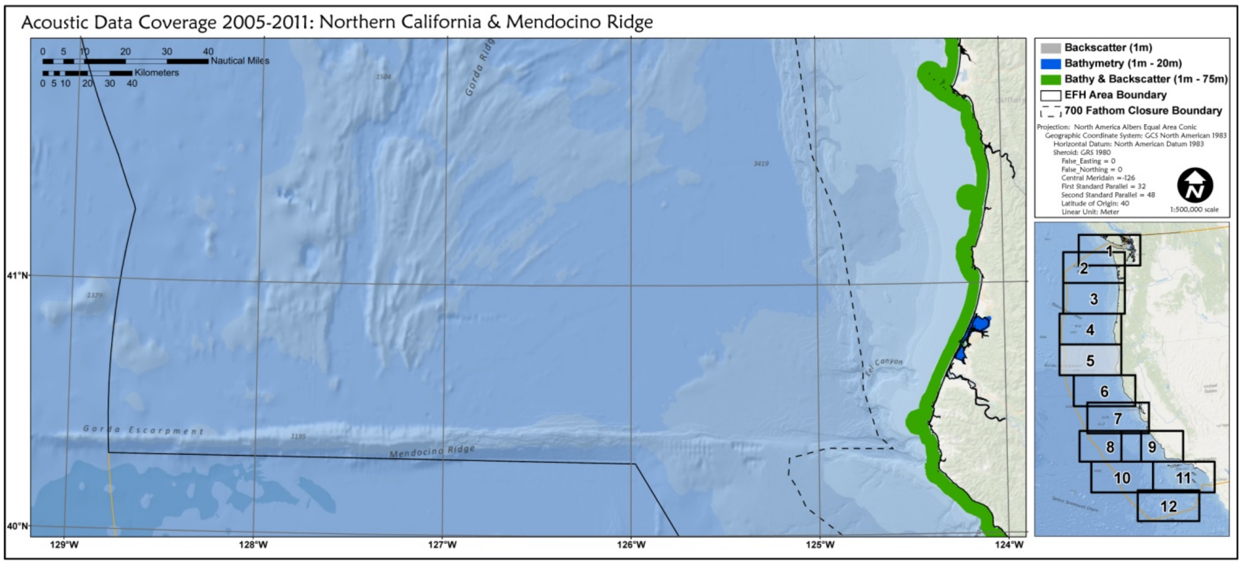


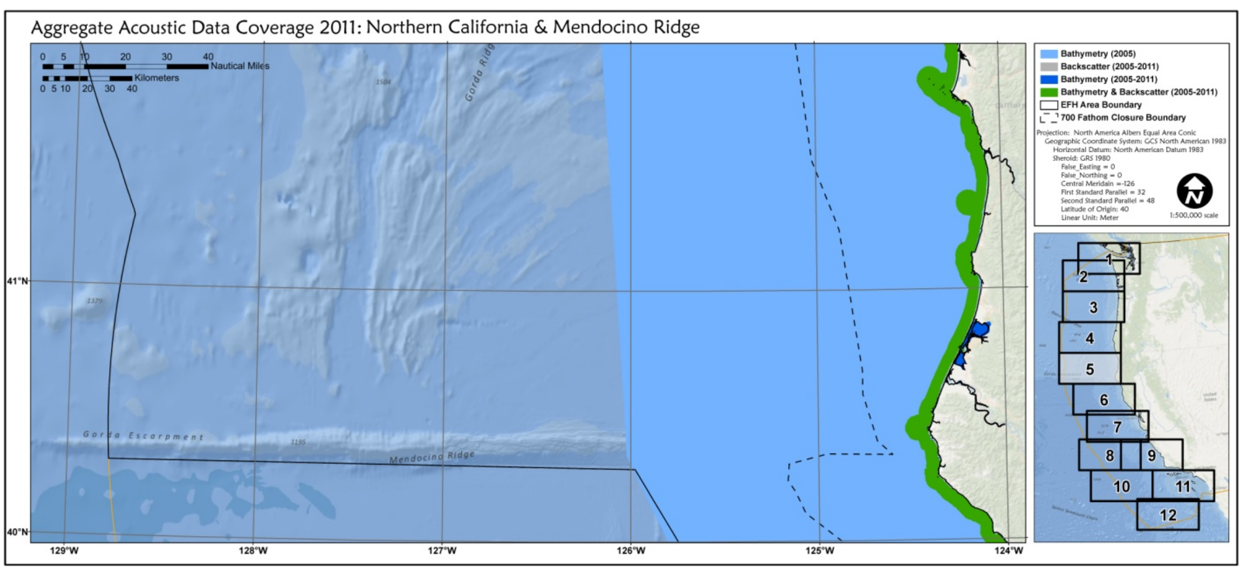




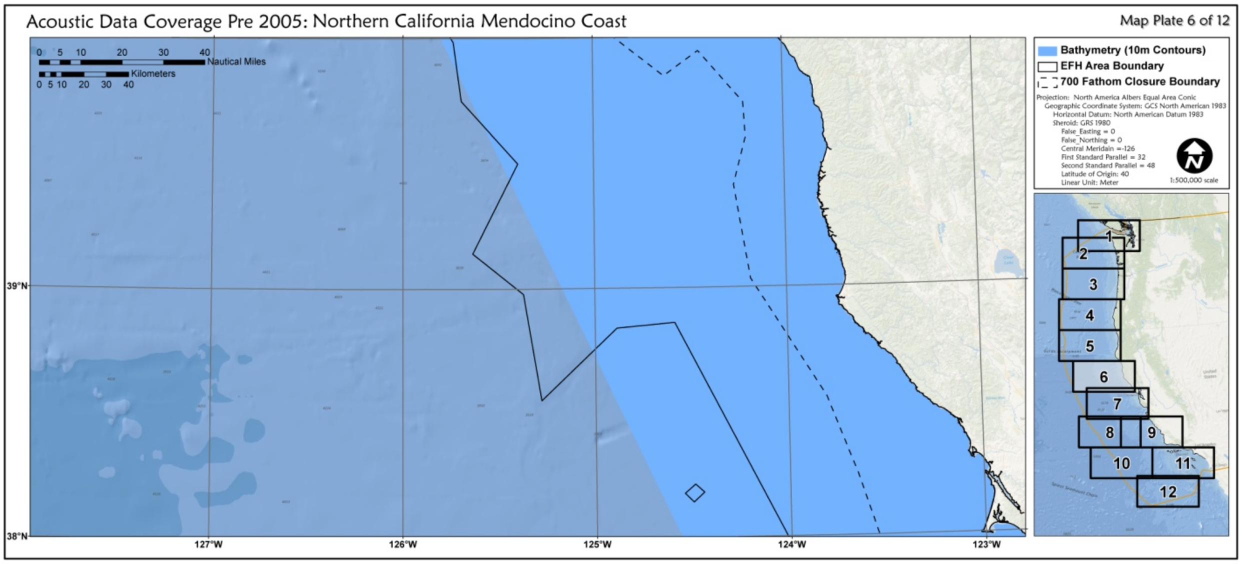
Appendix C-1: Imagery

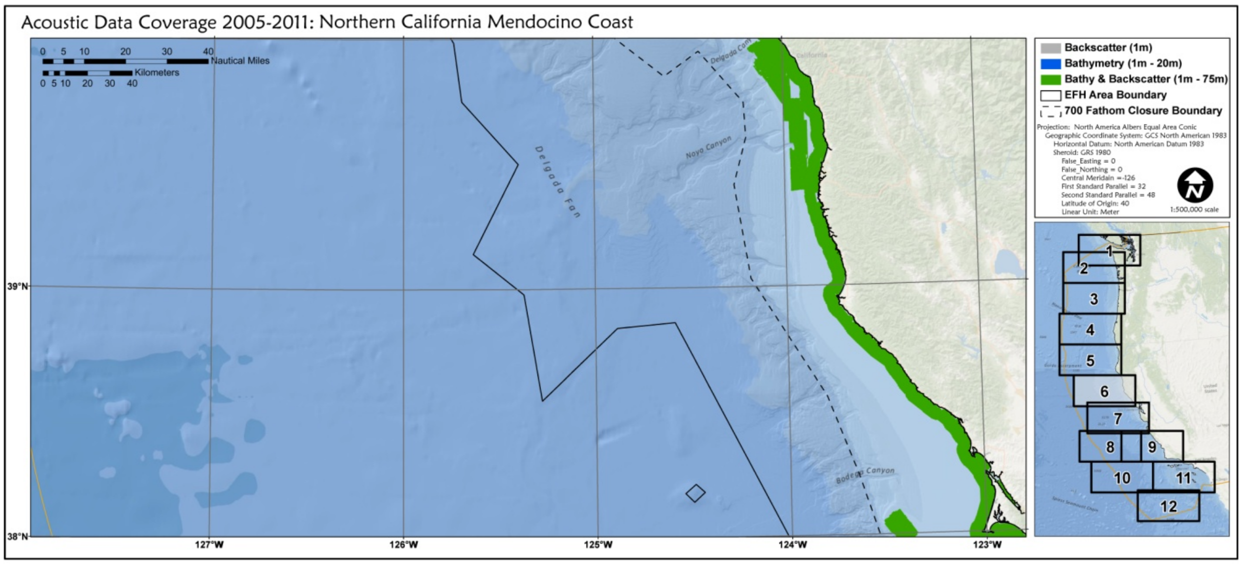


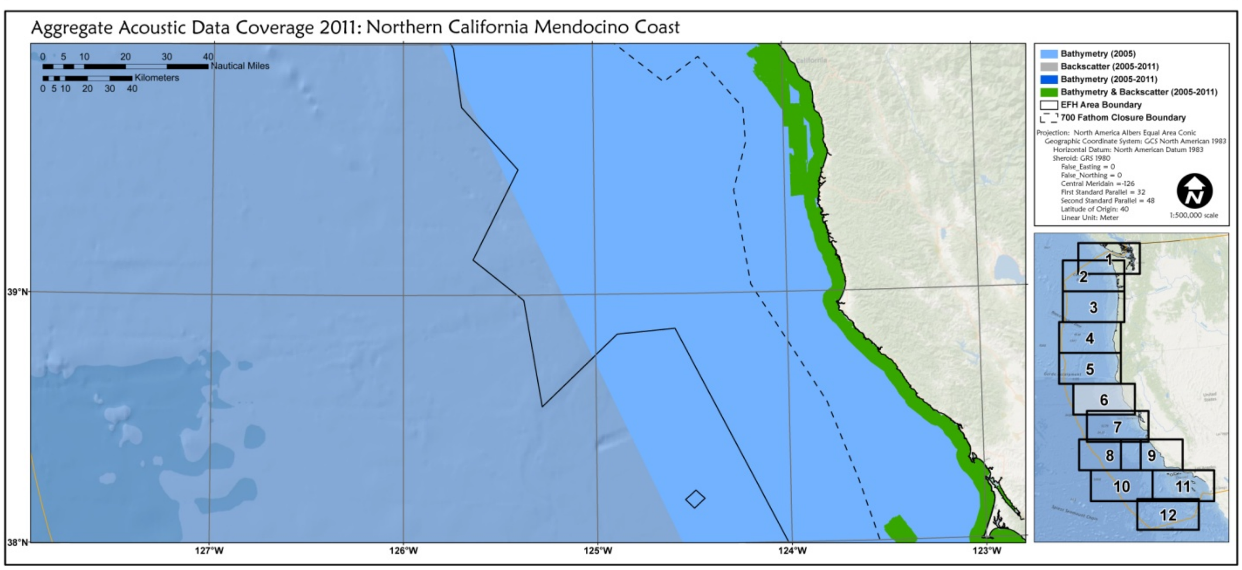




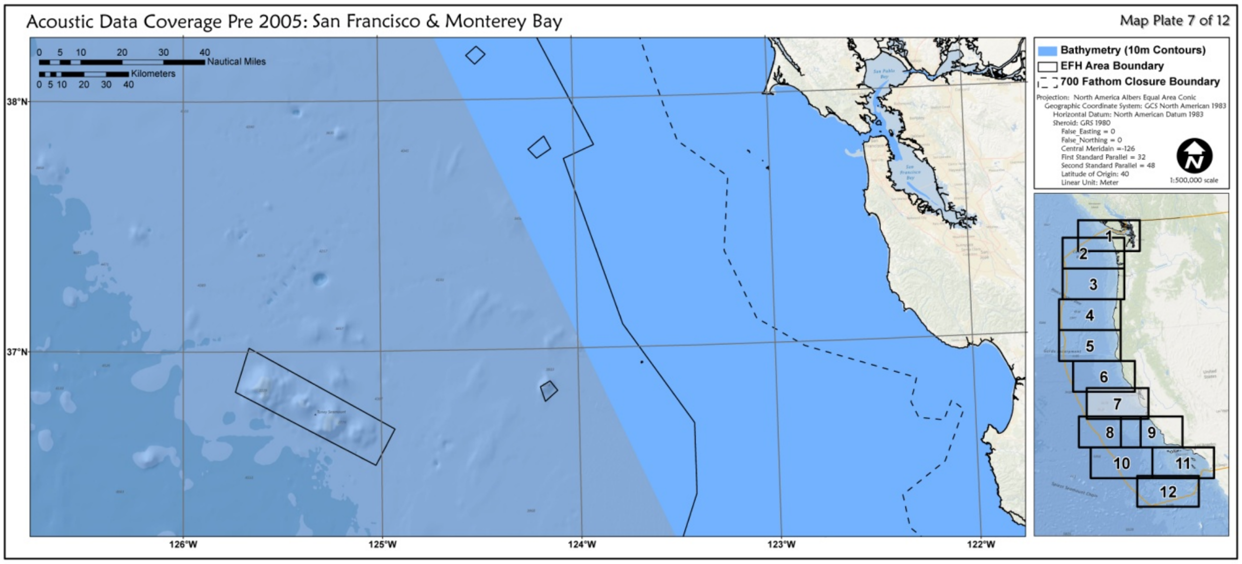
Appendix C-1: Imagery

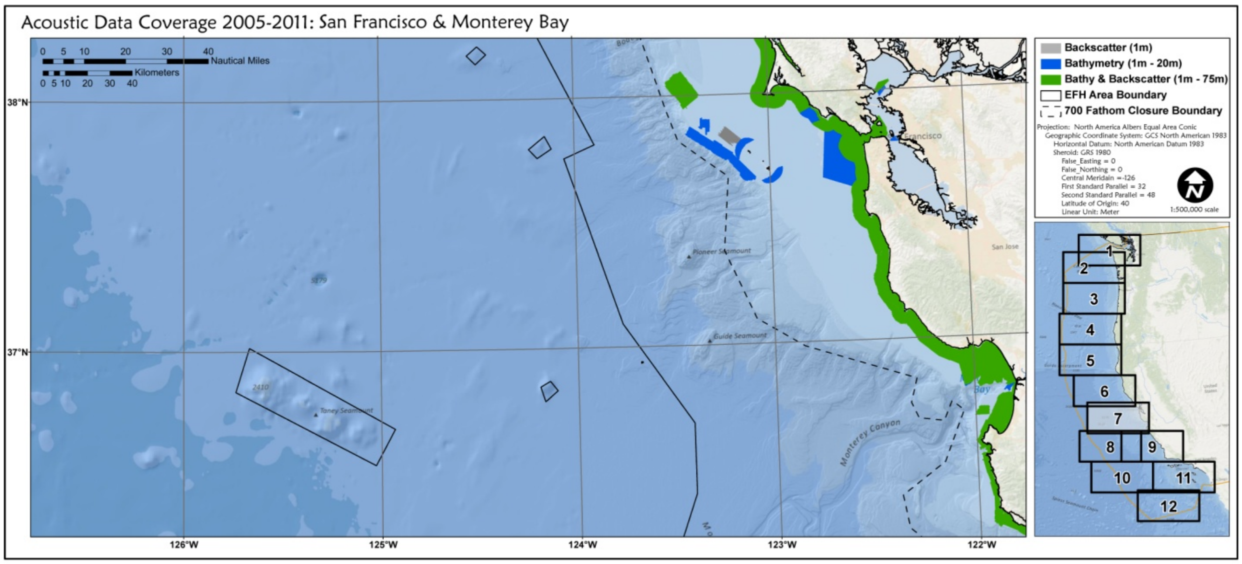


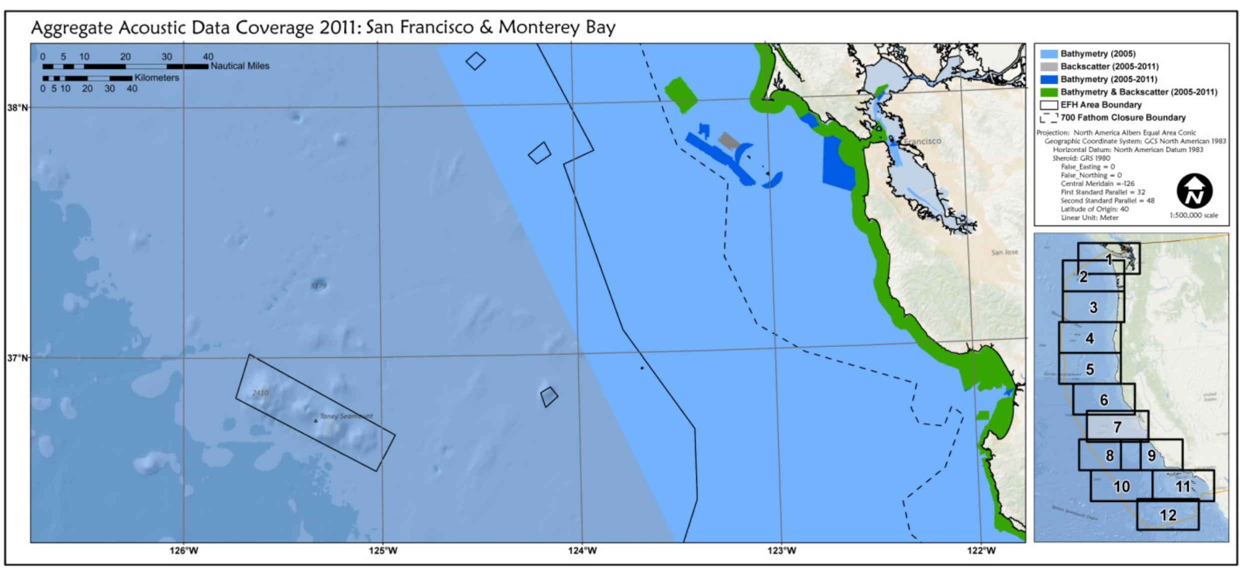




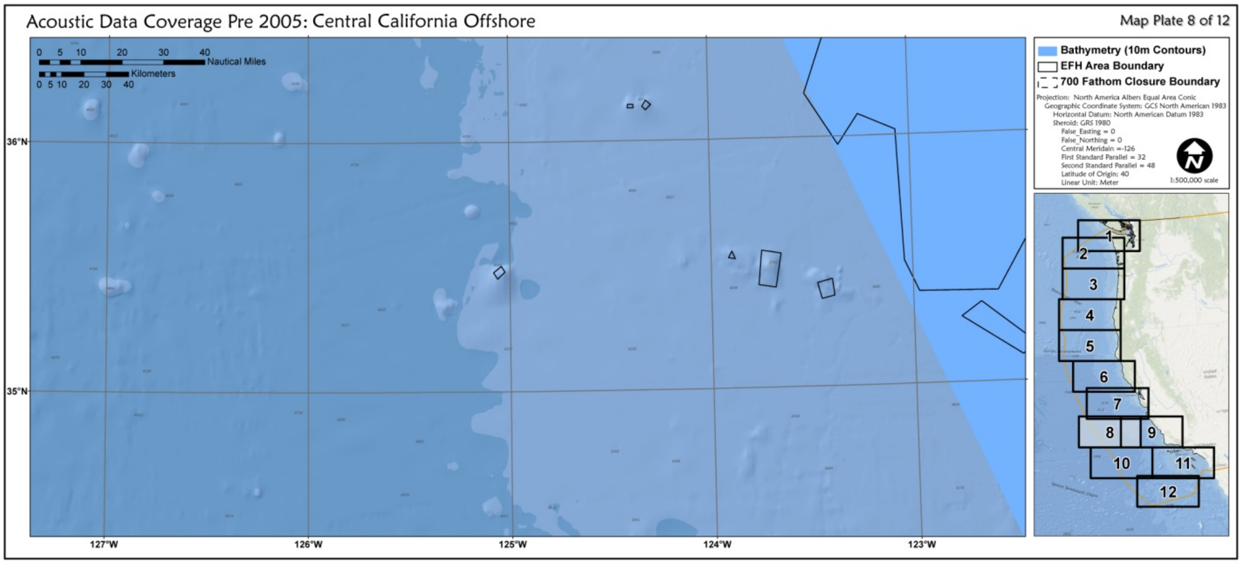
Appendix C-1: Imagery

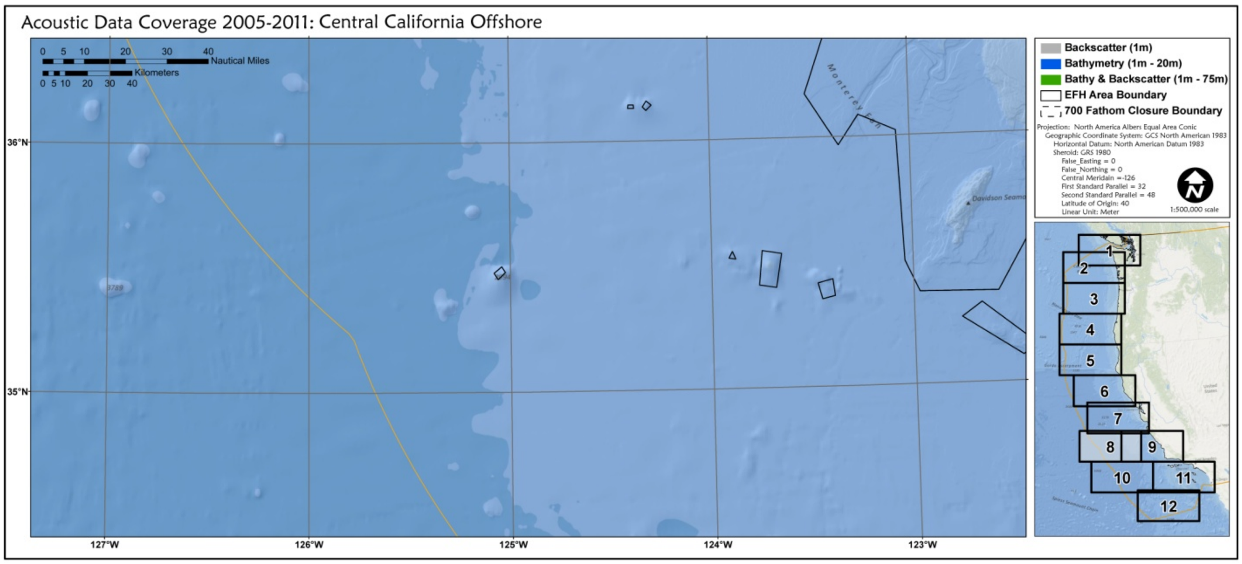


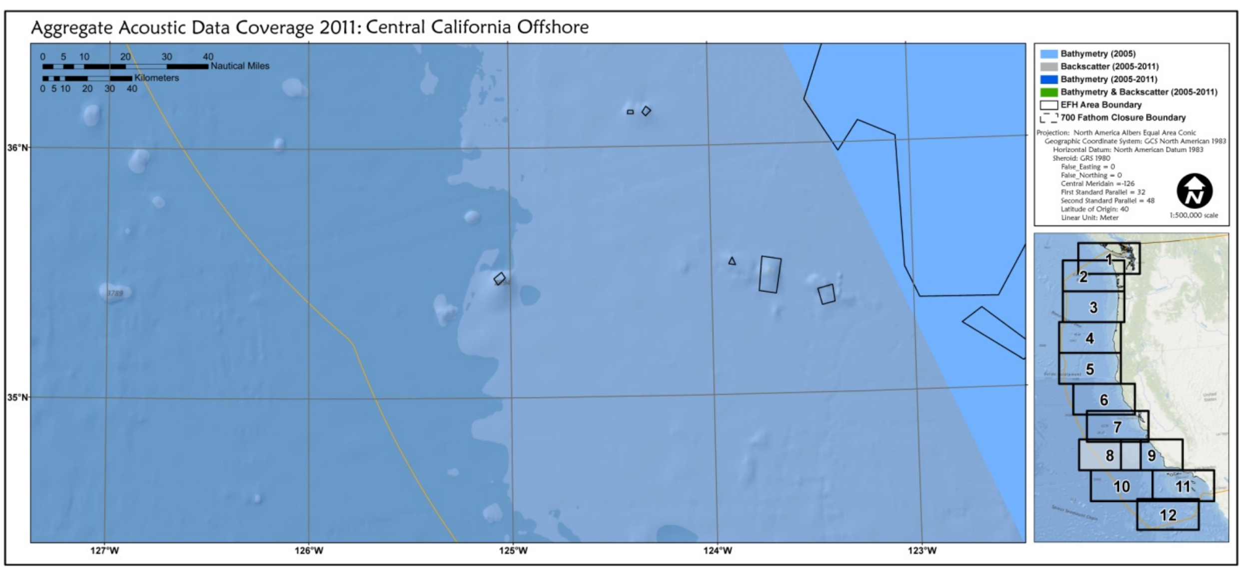




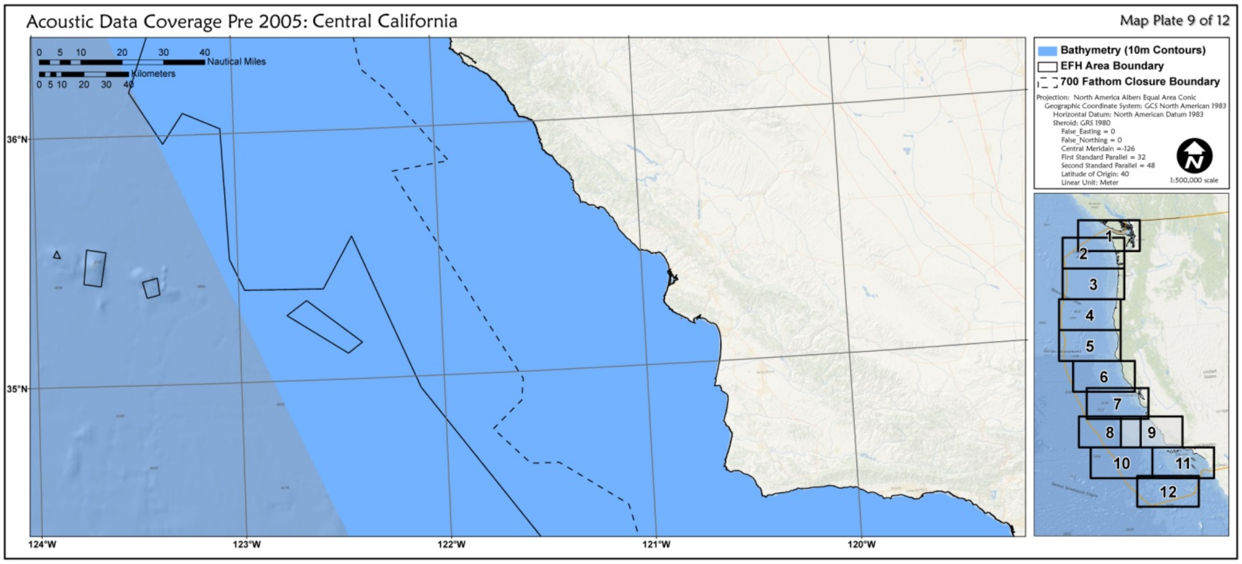
Appendix C-1: Imagery



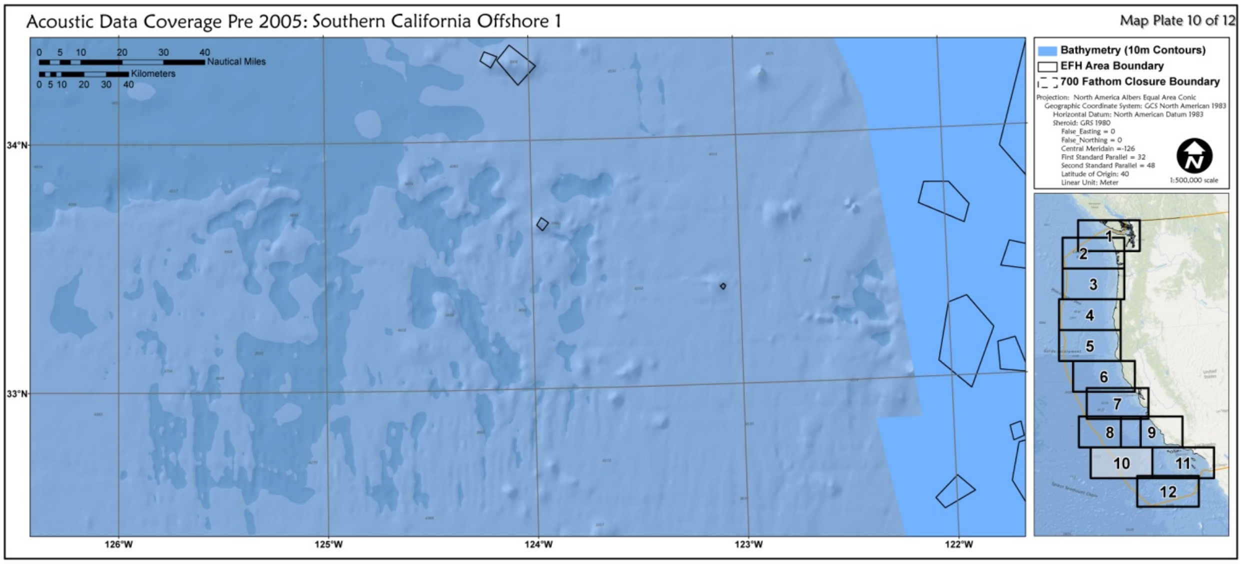


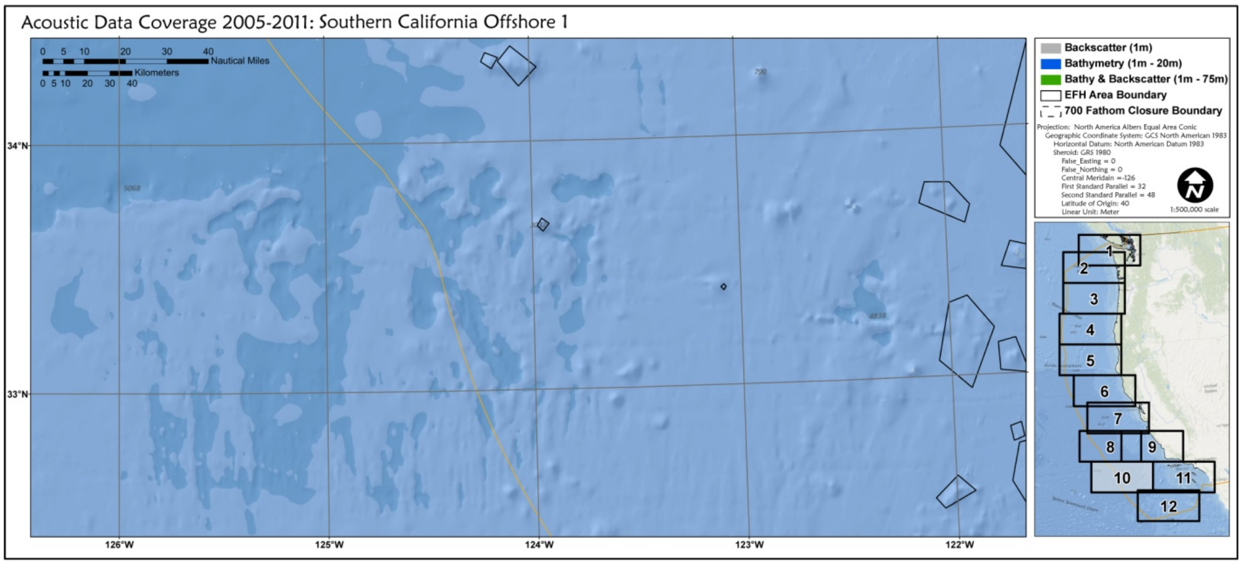


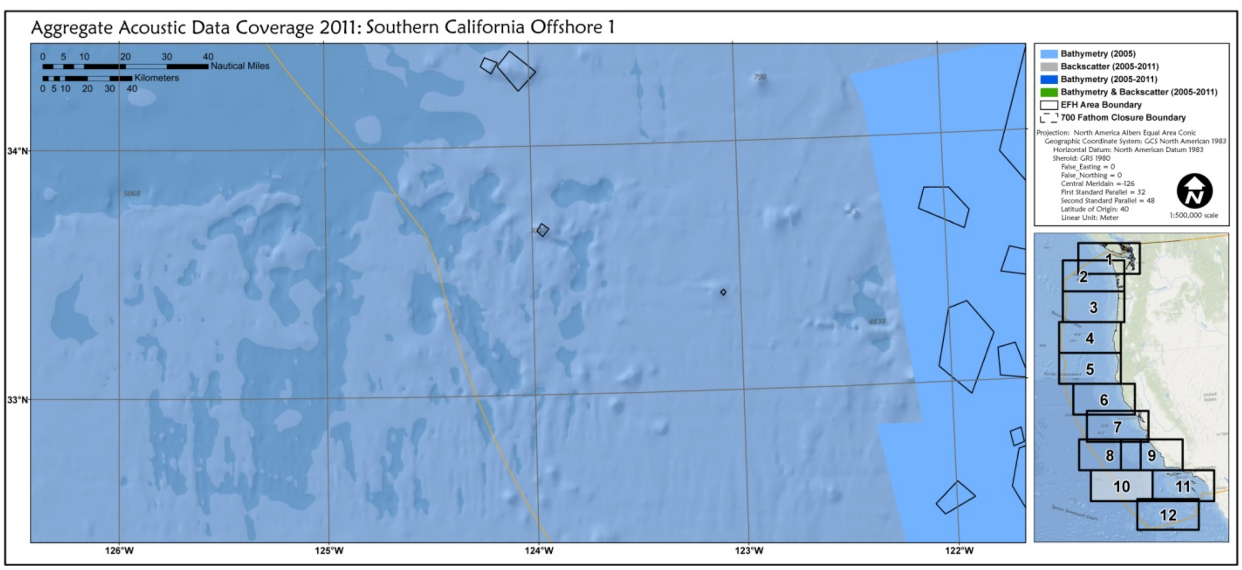
Appendix C-1: Imagery



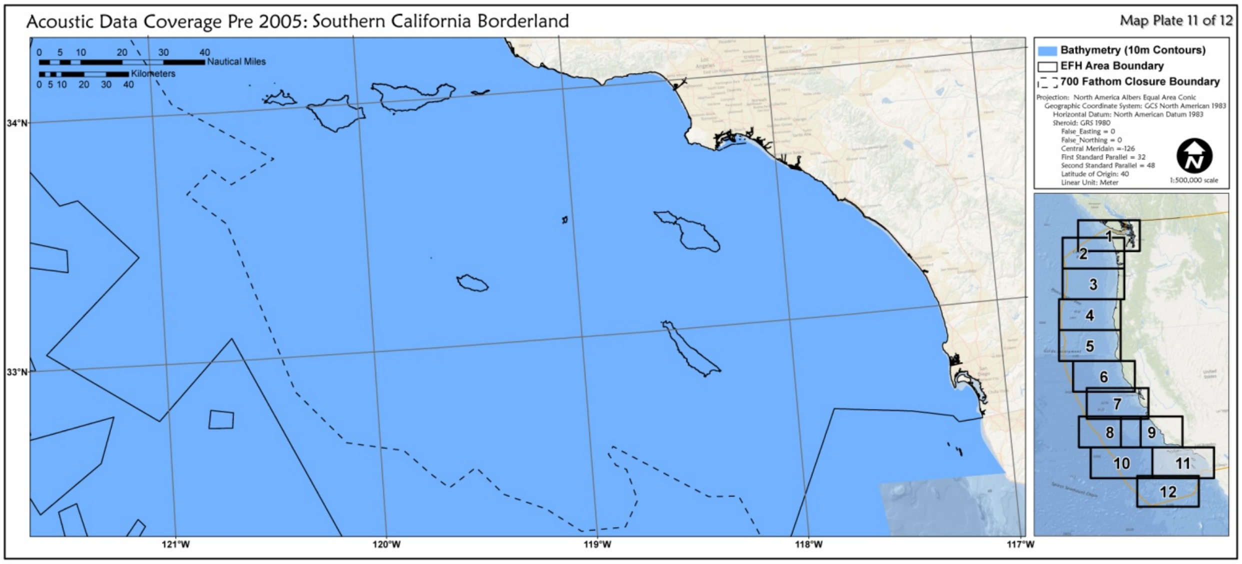
Appendix C-1: Imagery

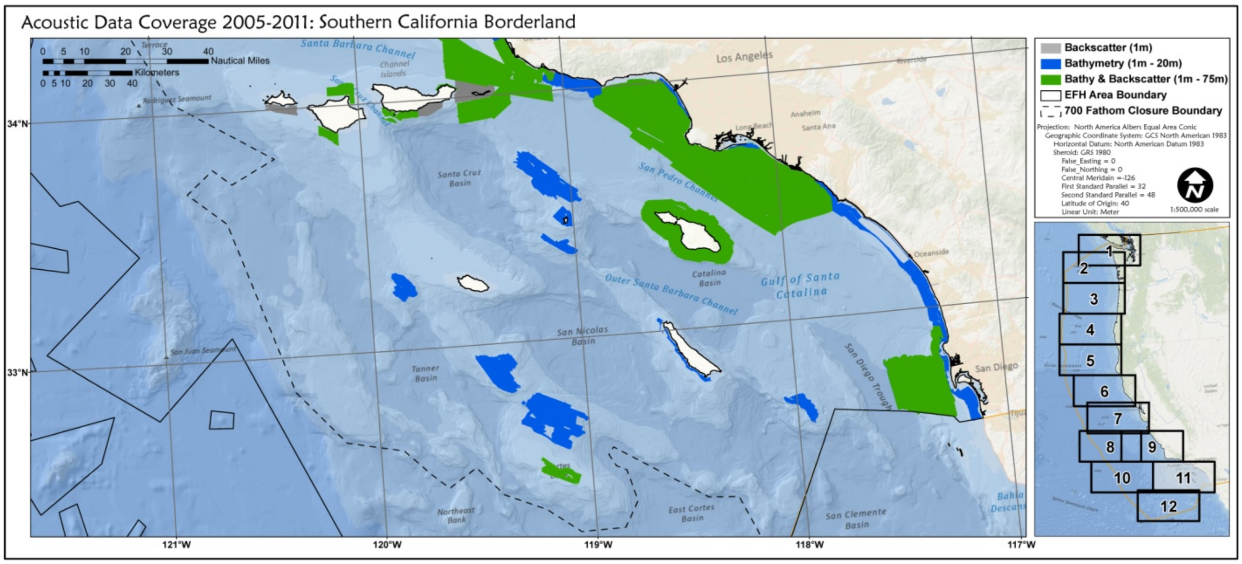


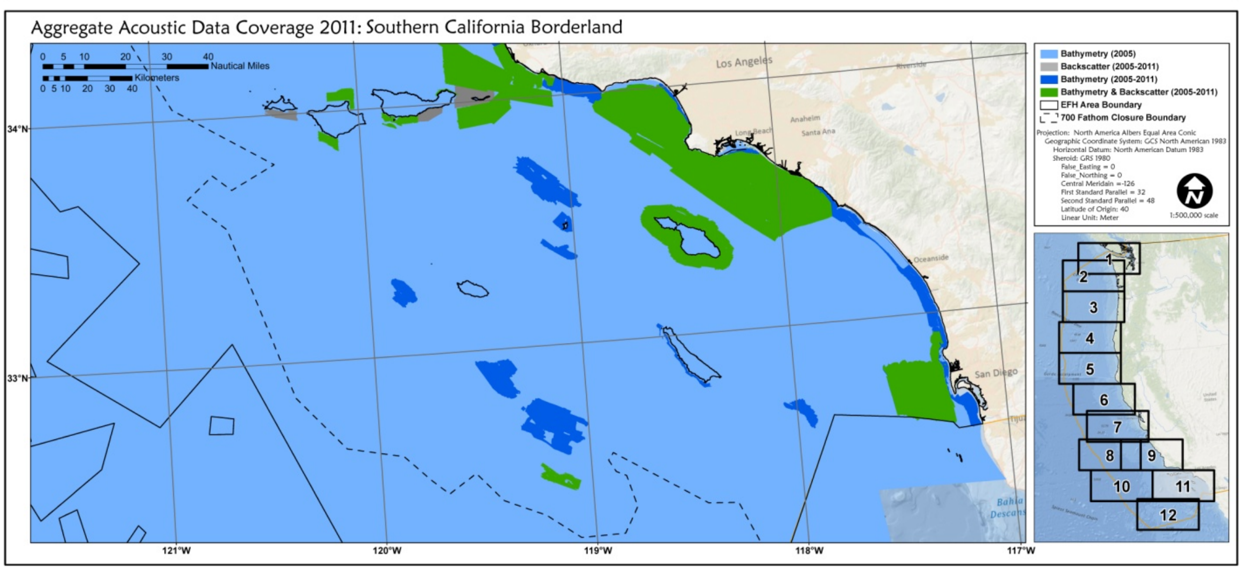




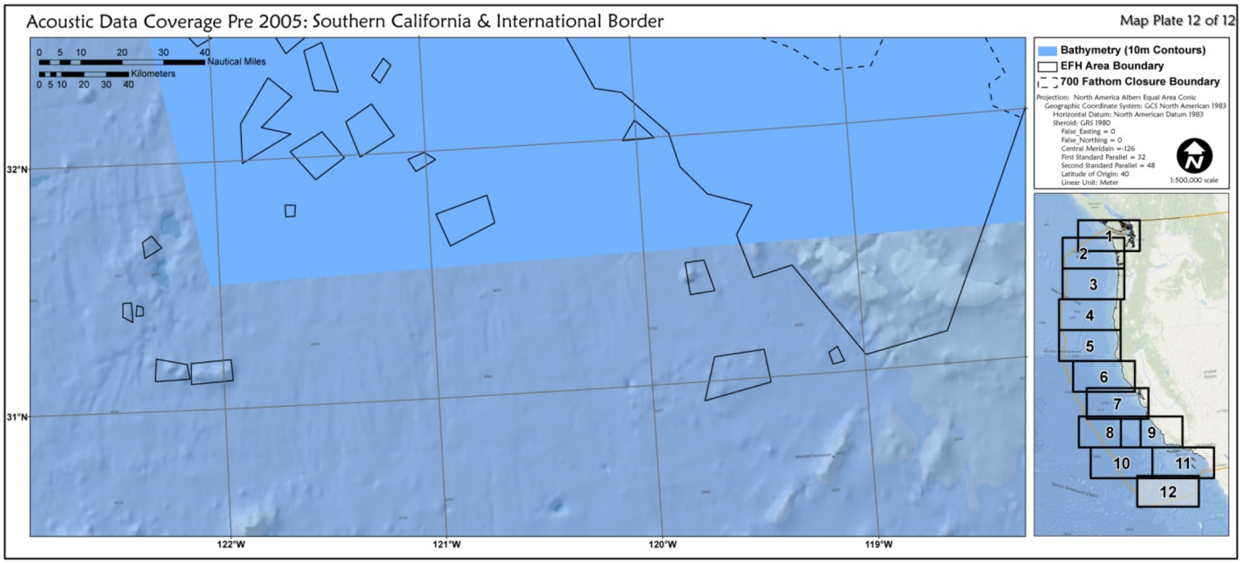
Appendix C-1: Imagery

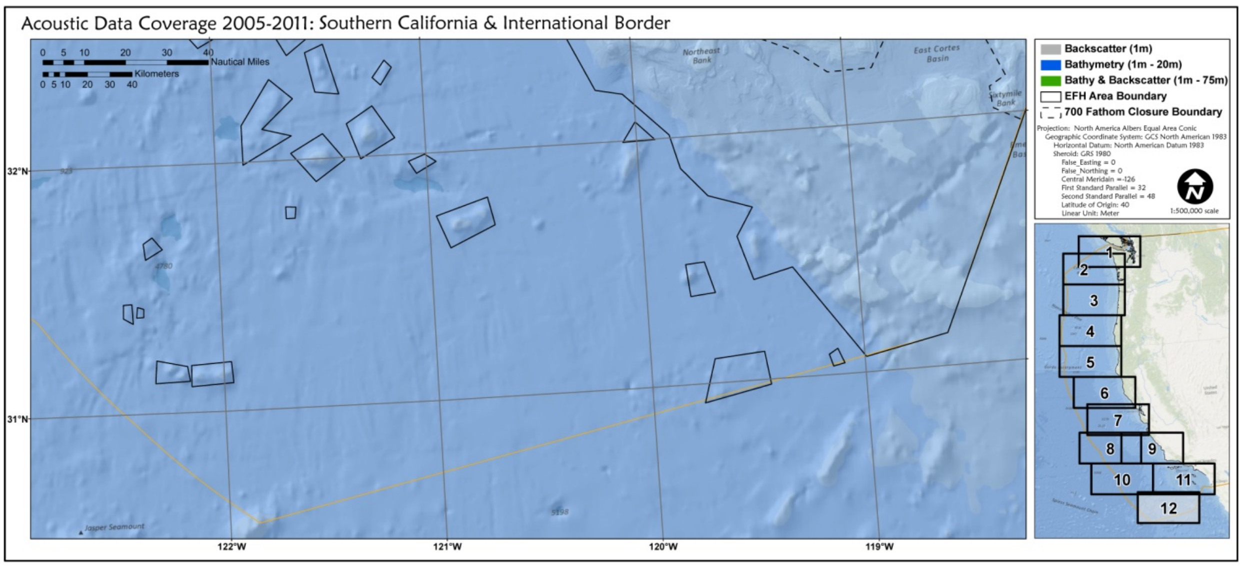


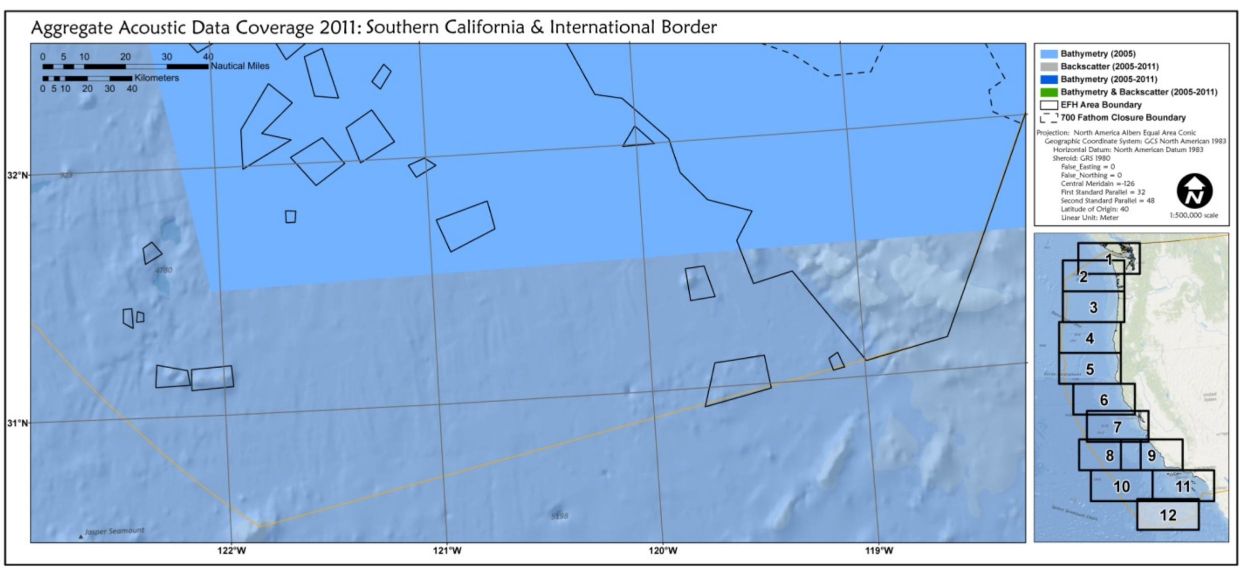




Appendix C-1: Imagery

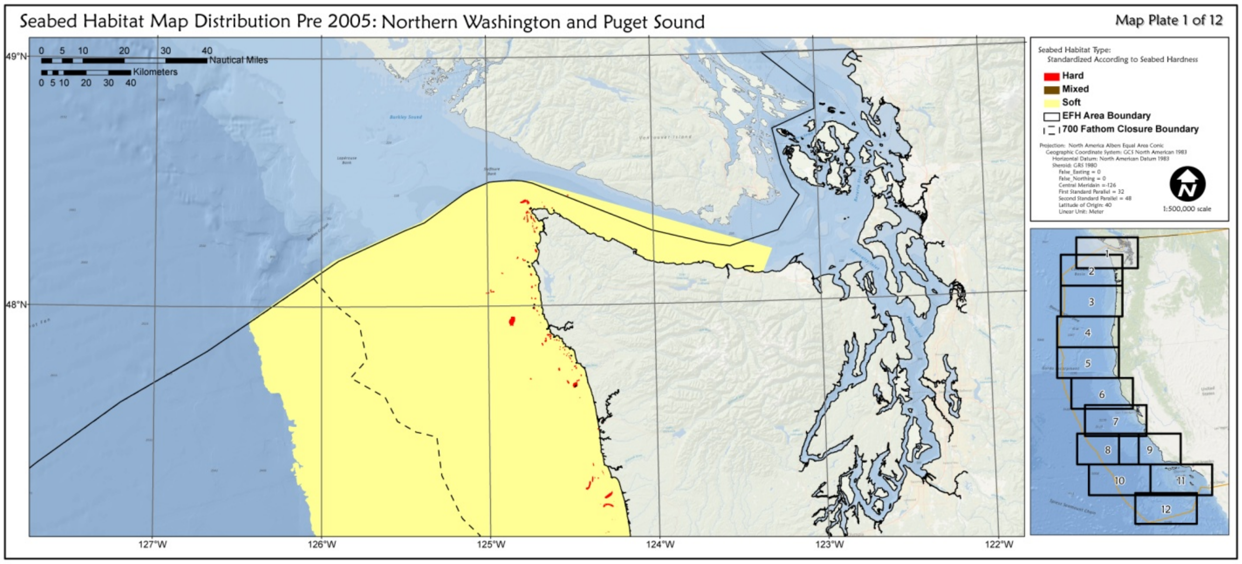


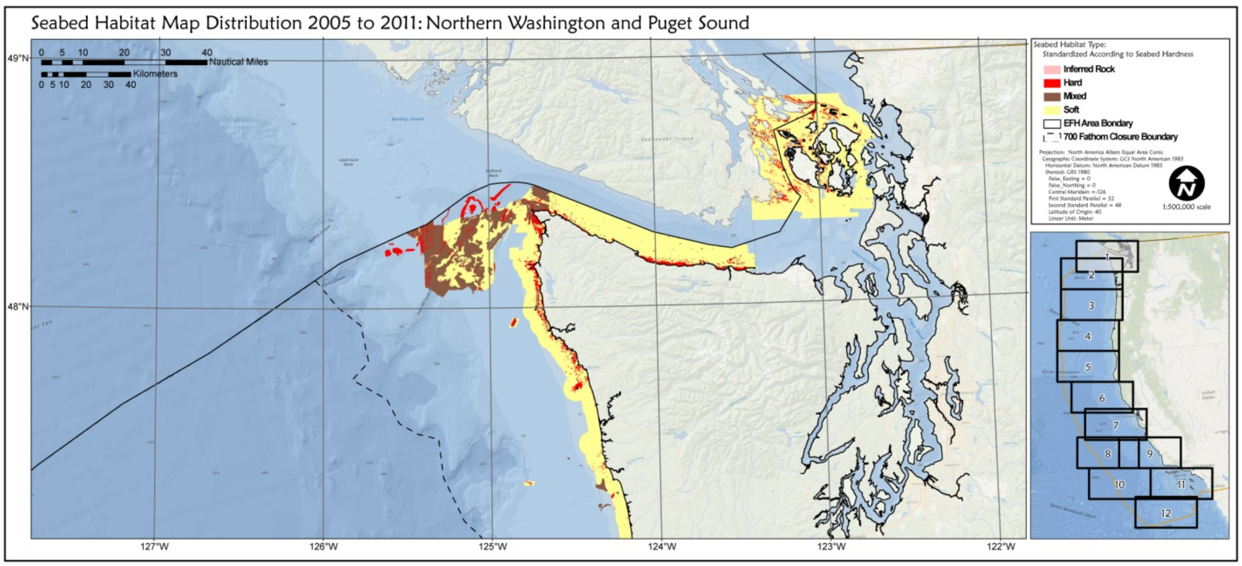


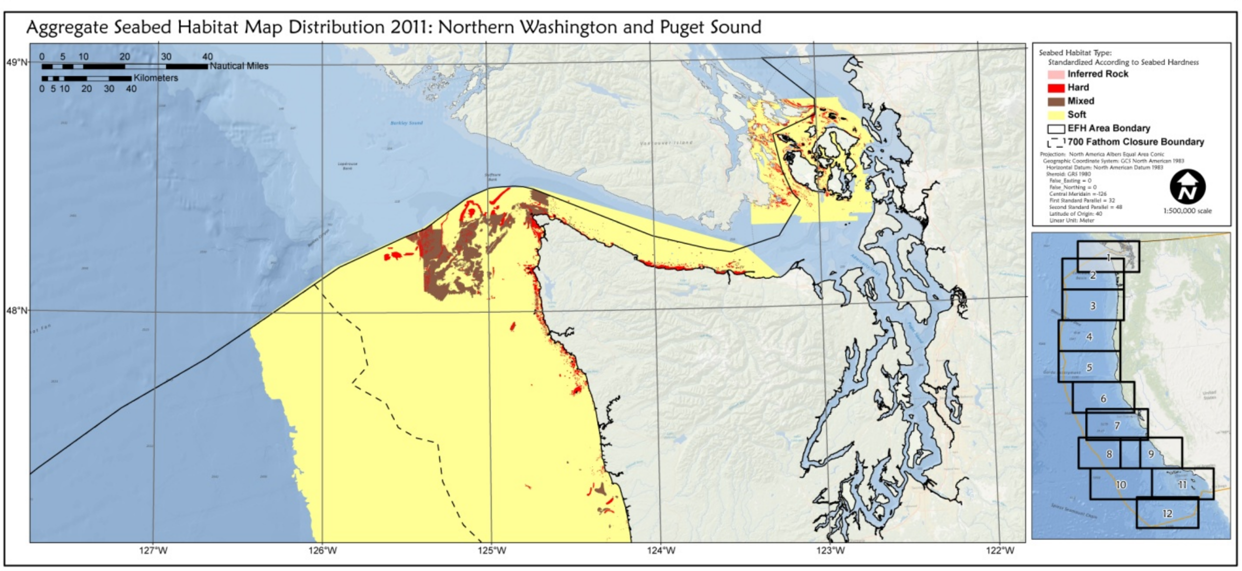


Apendix C-2: Substrate

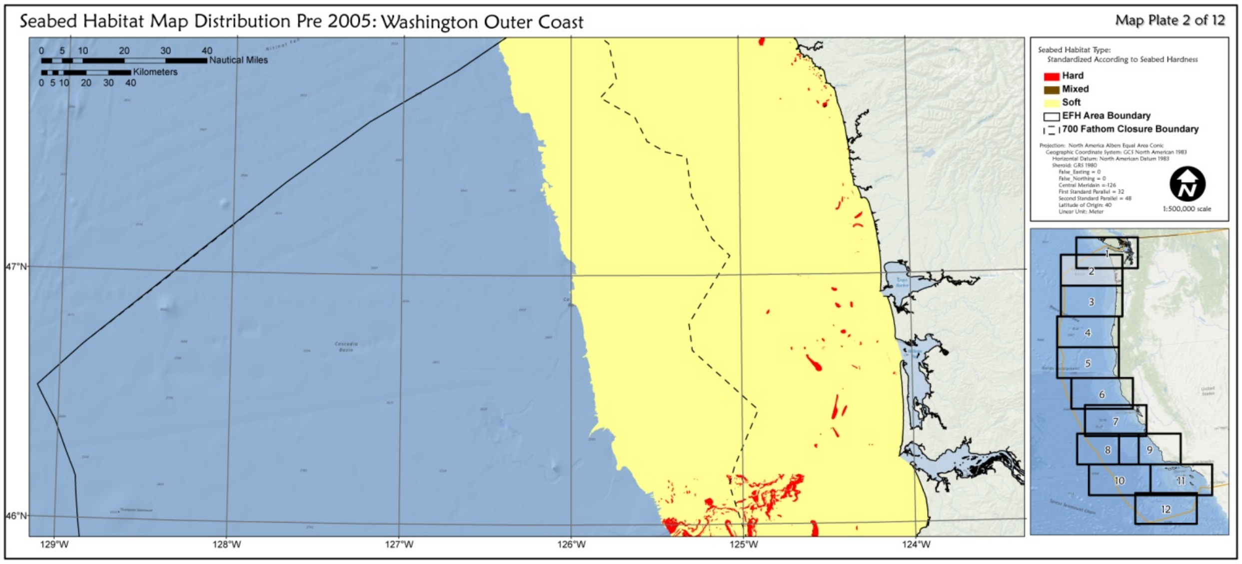
Apendix C-2: Substrate

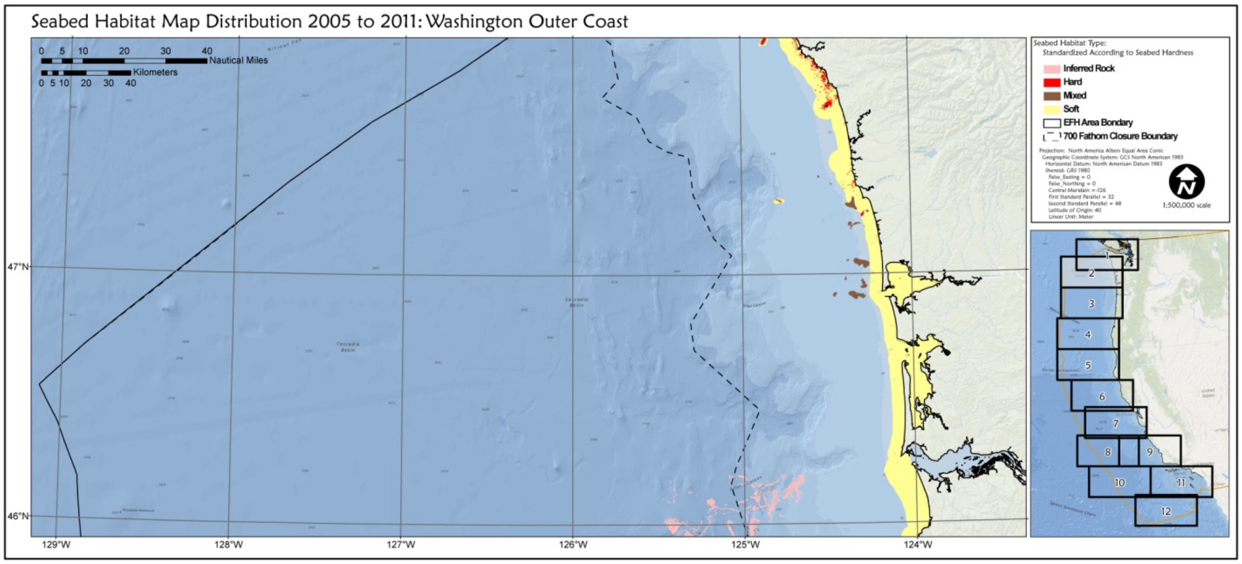


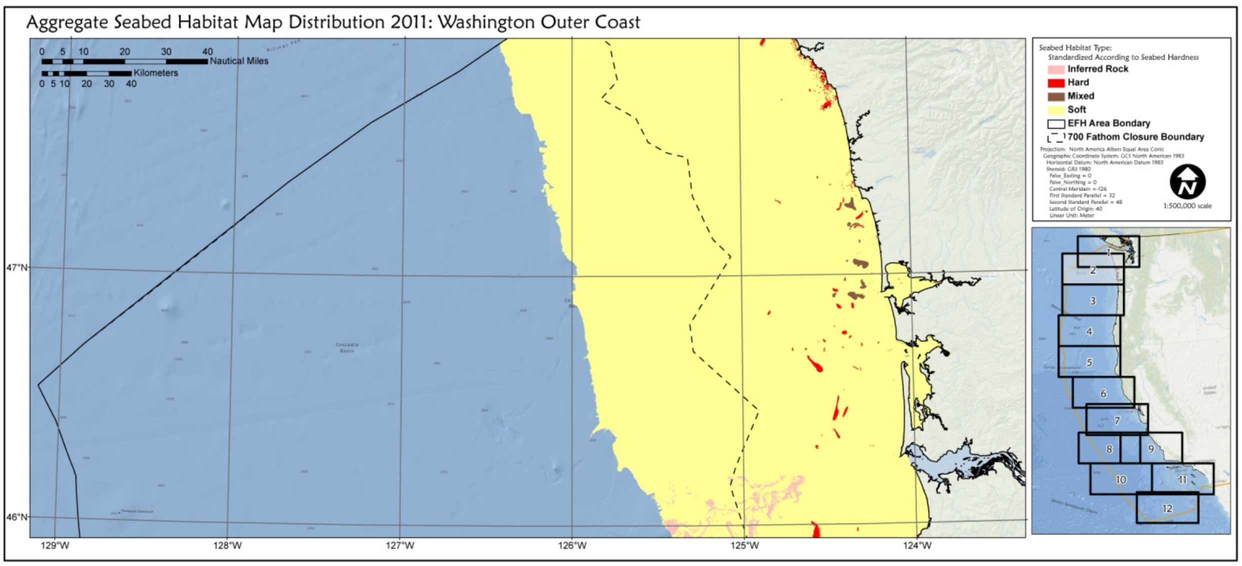




Apendix C-2: Substrate







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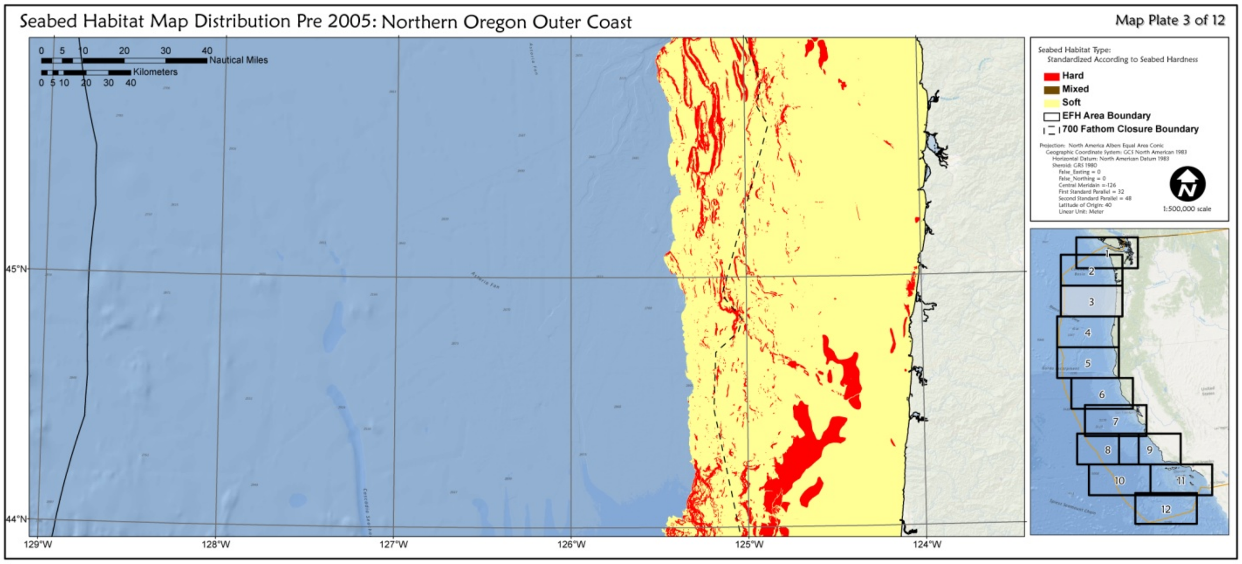

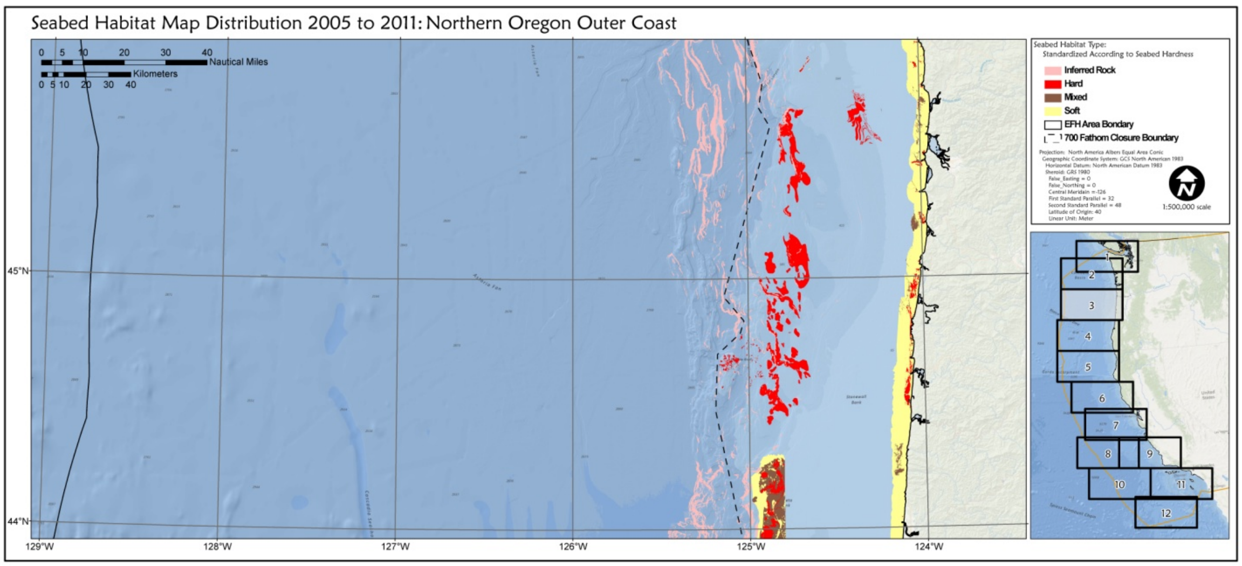

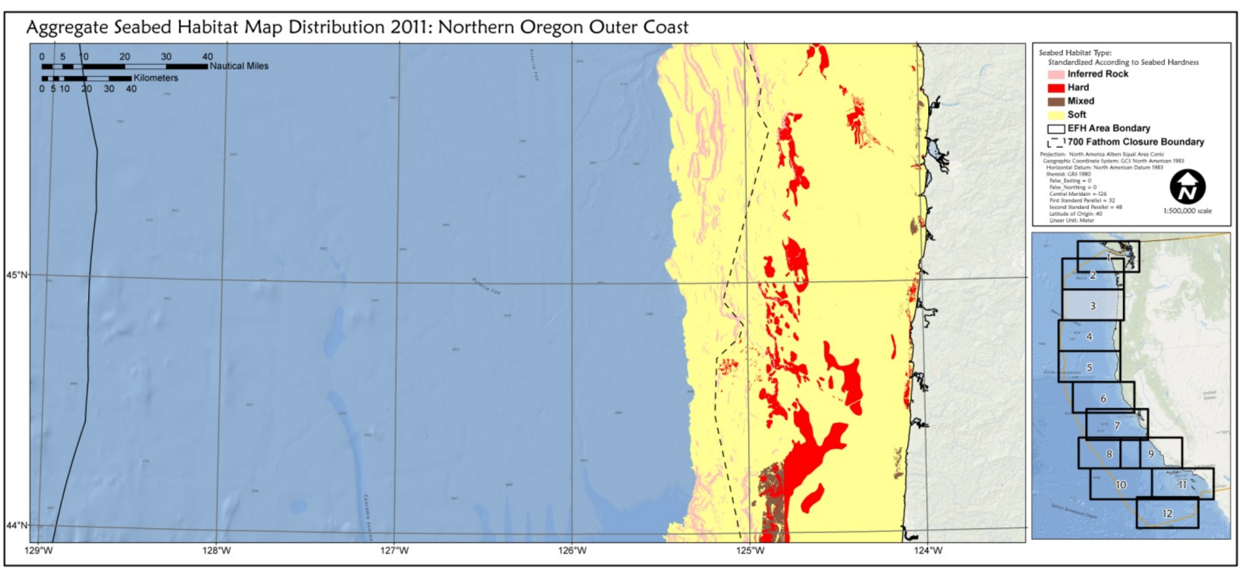

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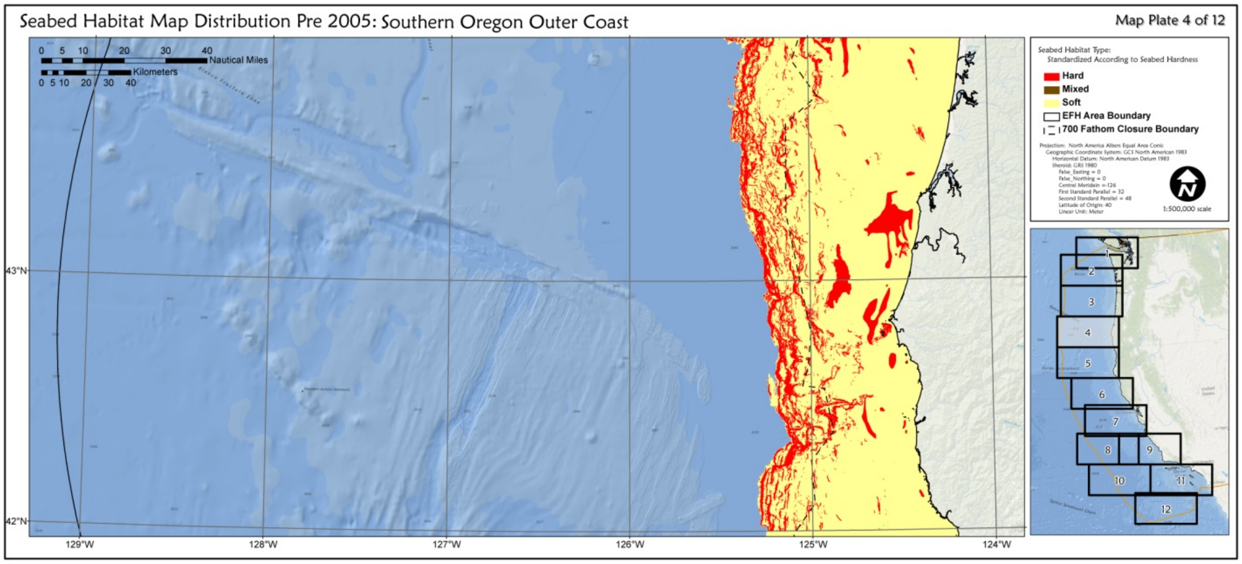

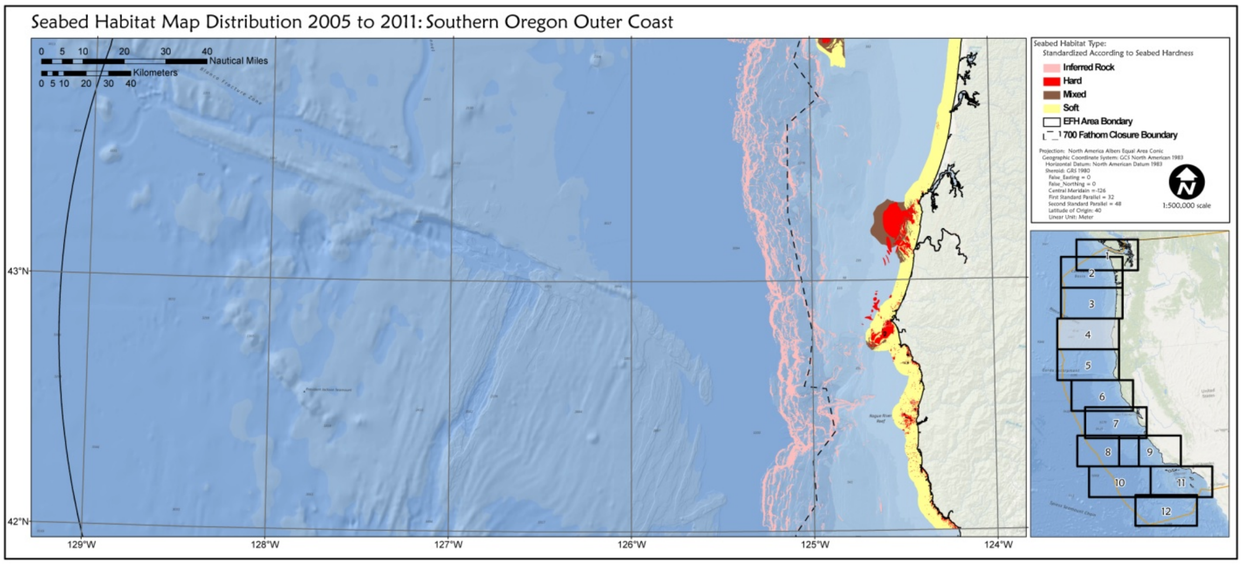

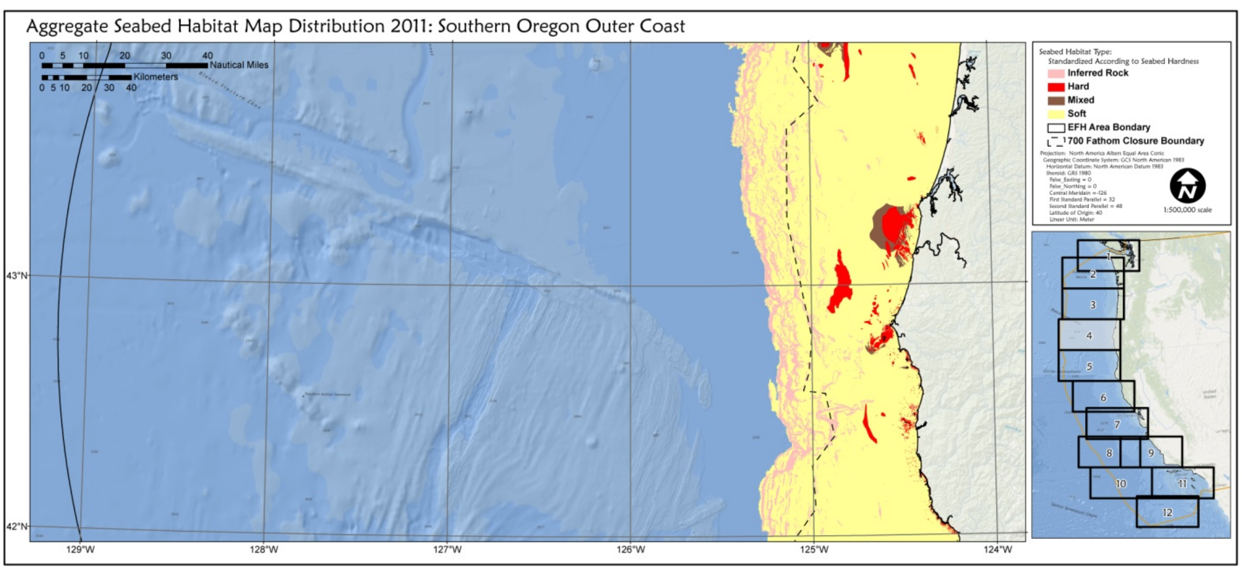

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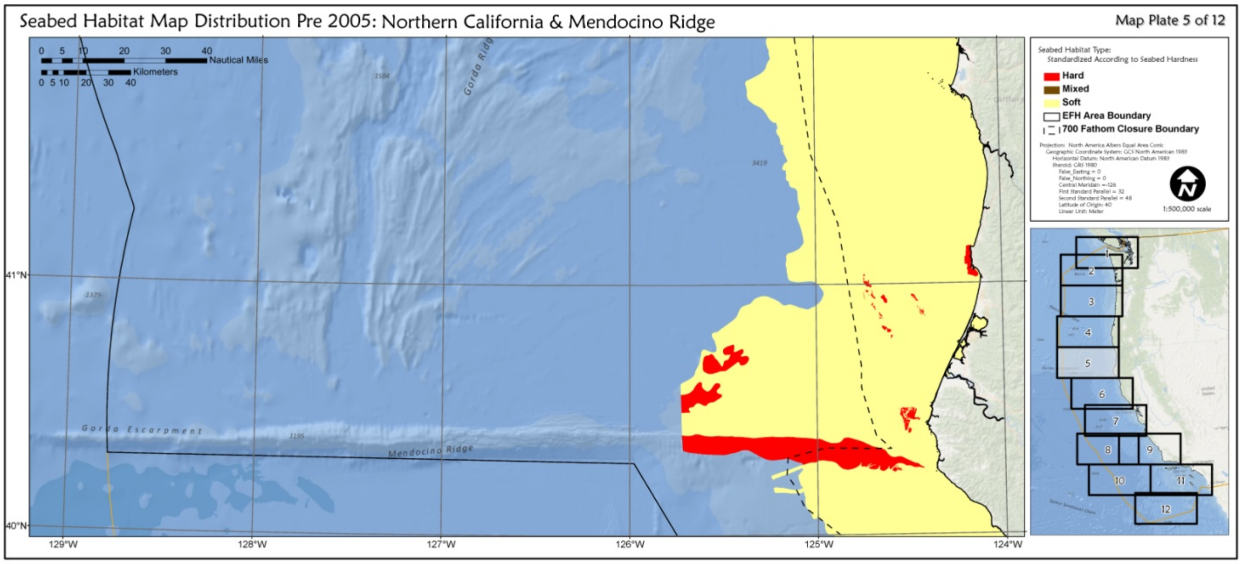
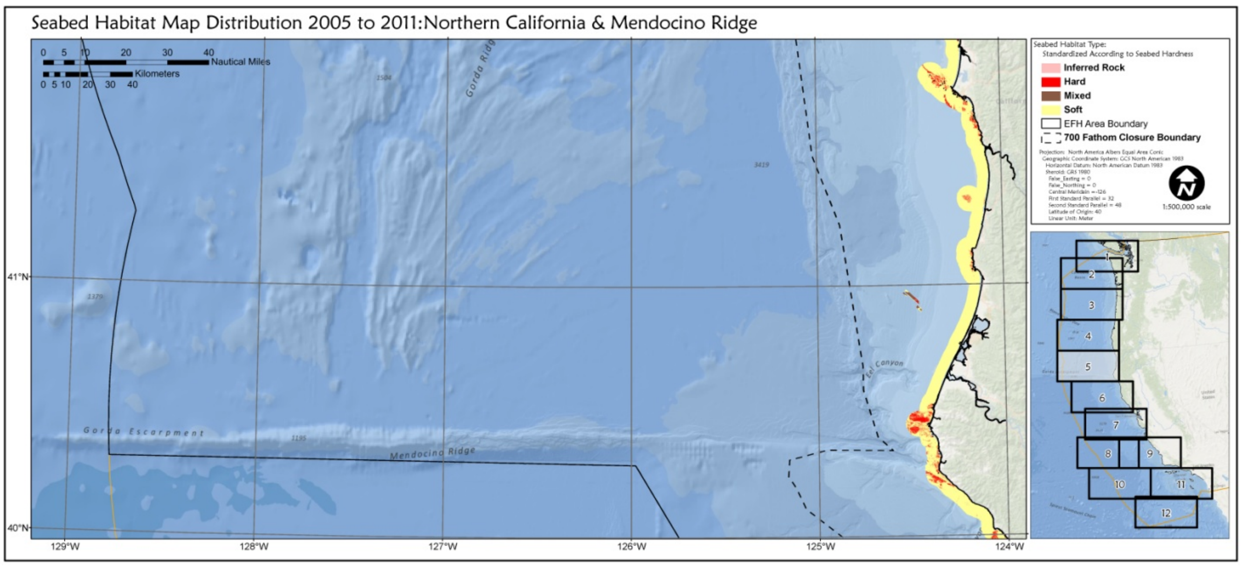
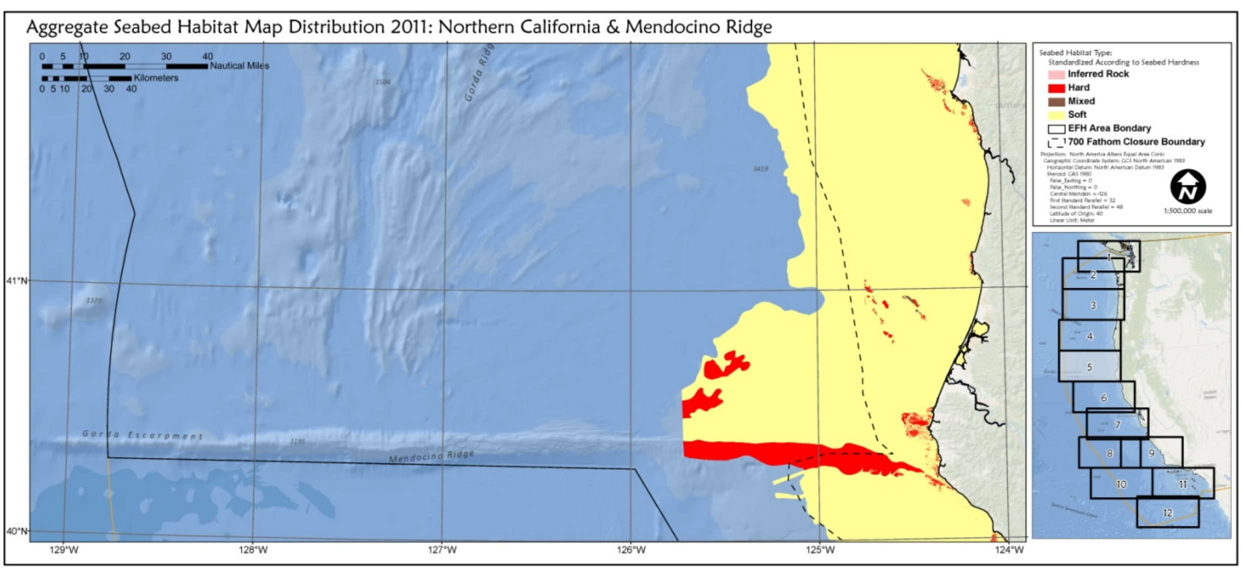
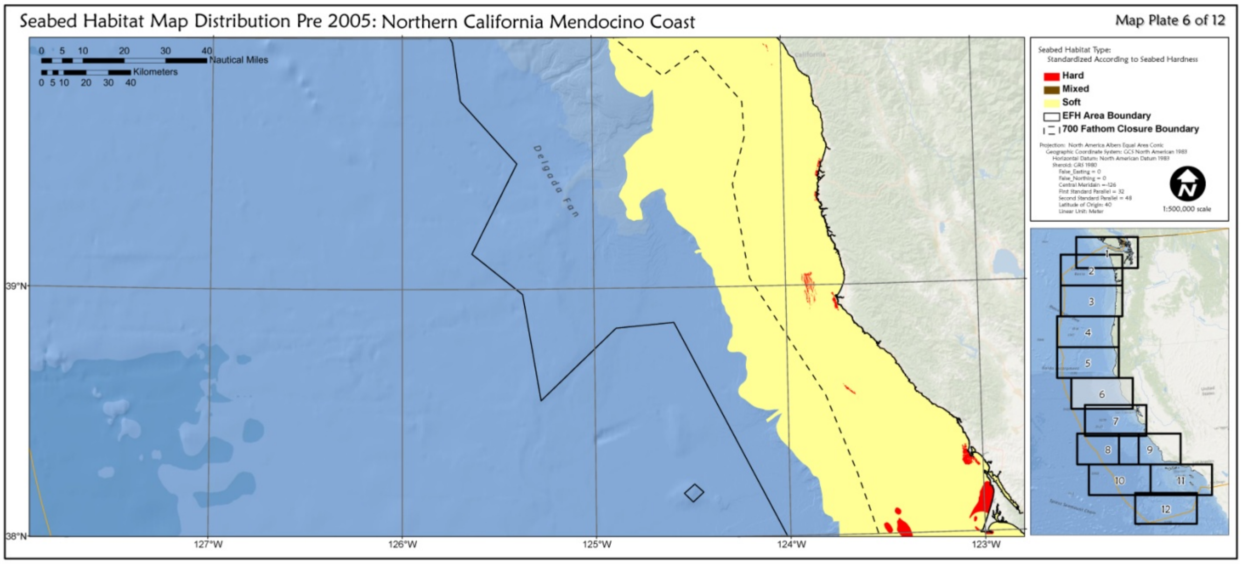
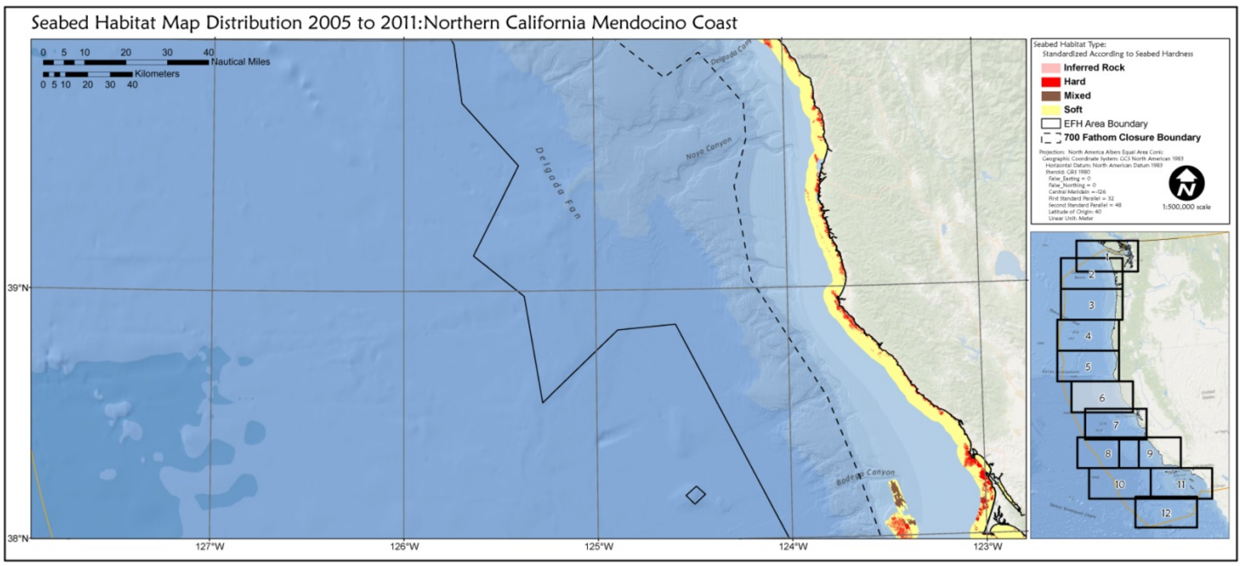


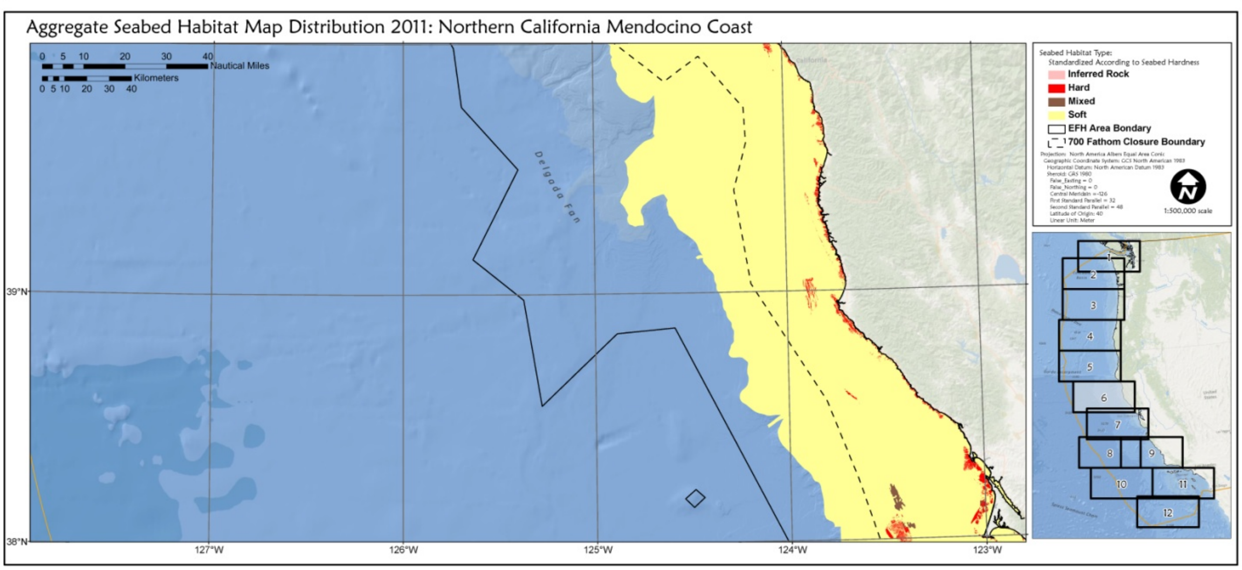




Apendix C-2: Substrate







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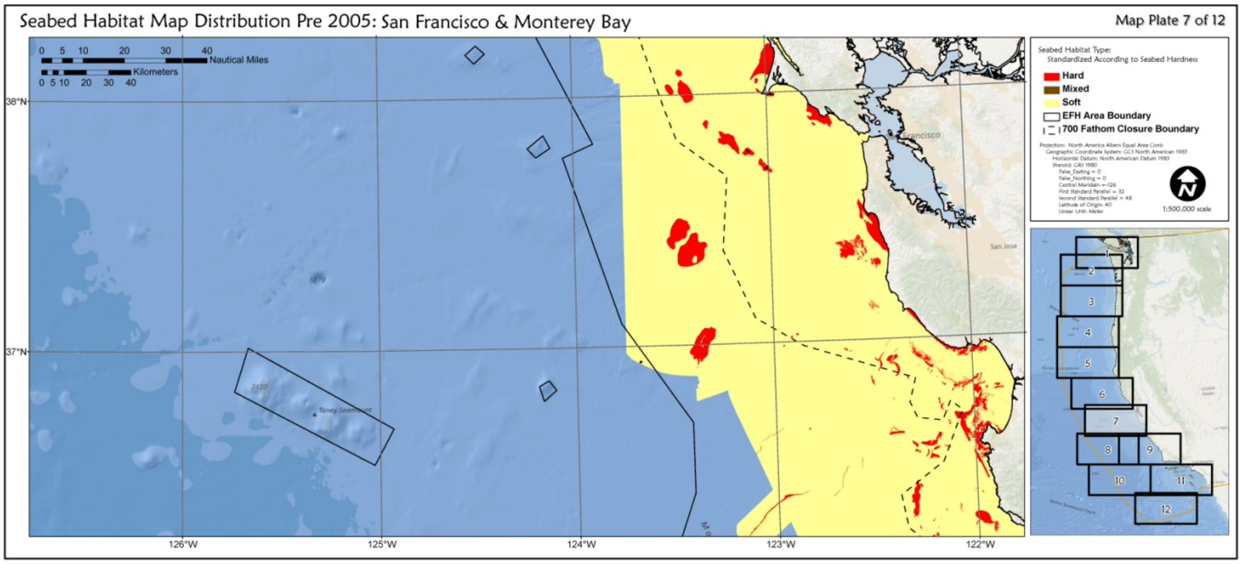

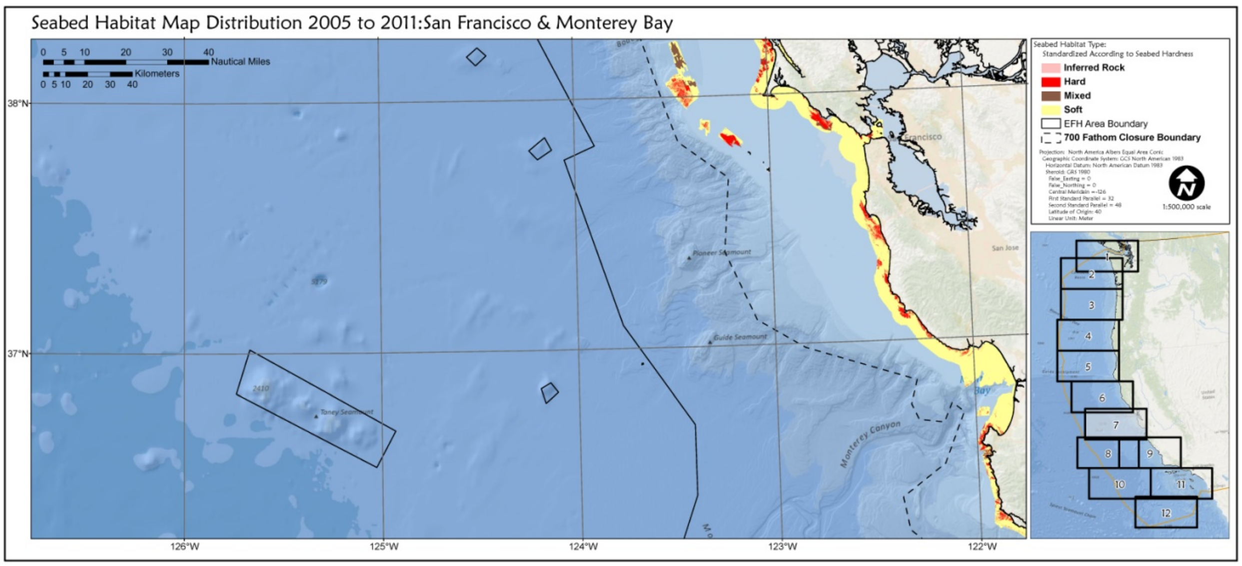

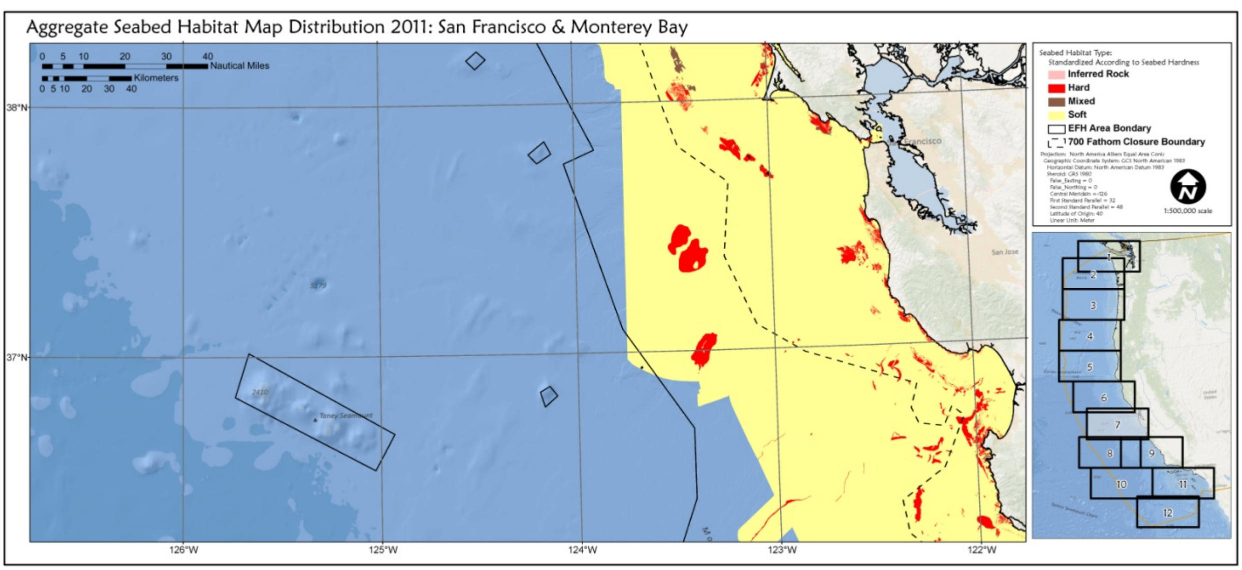

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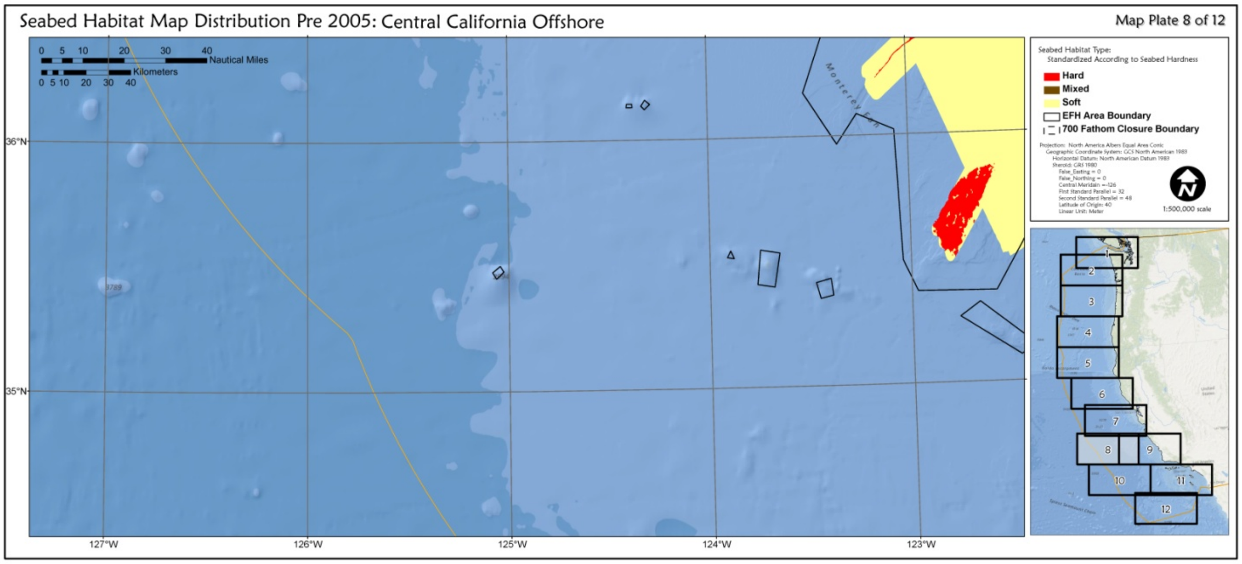

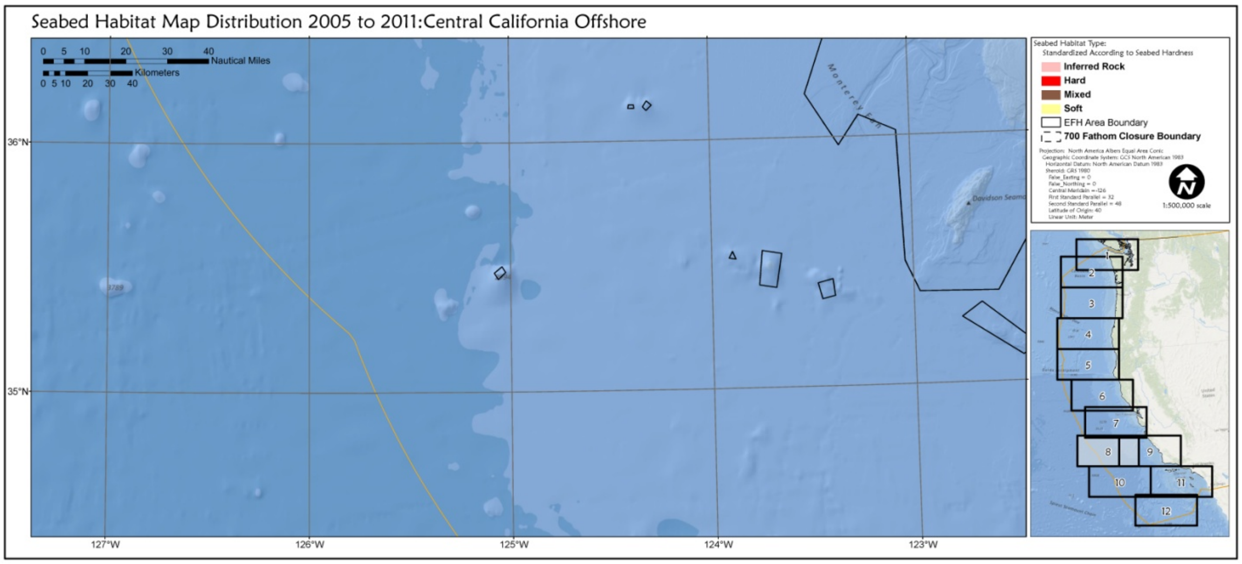

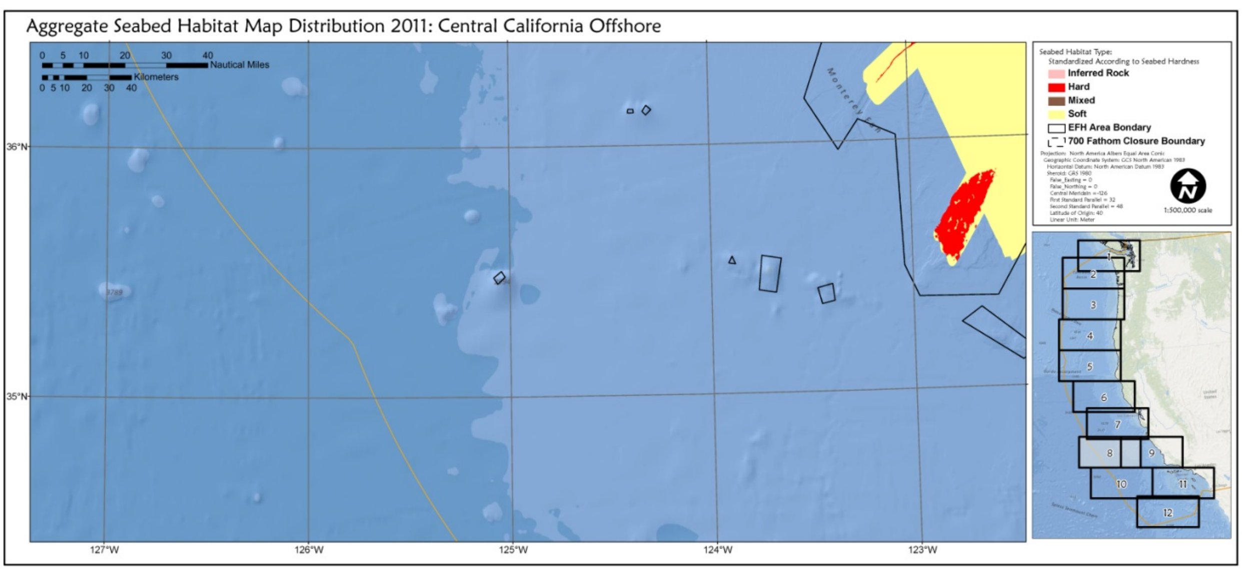

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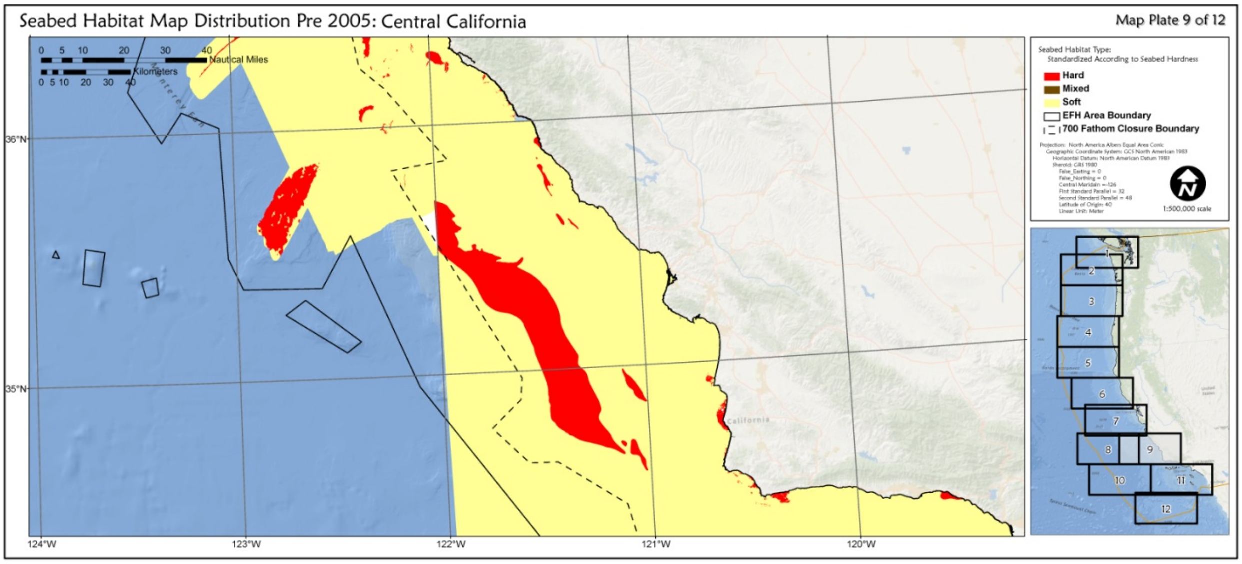

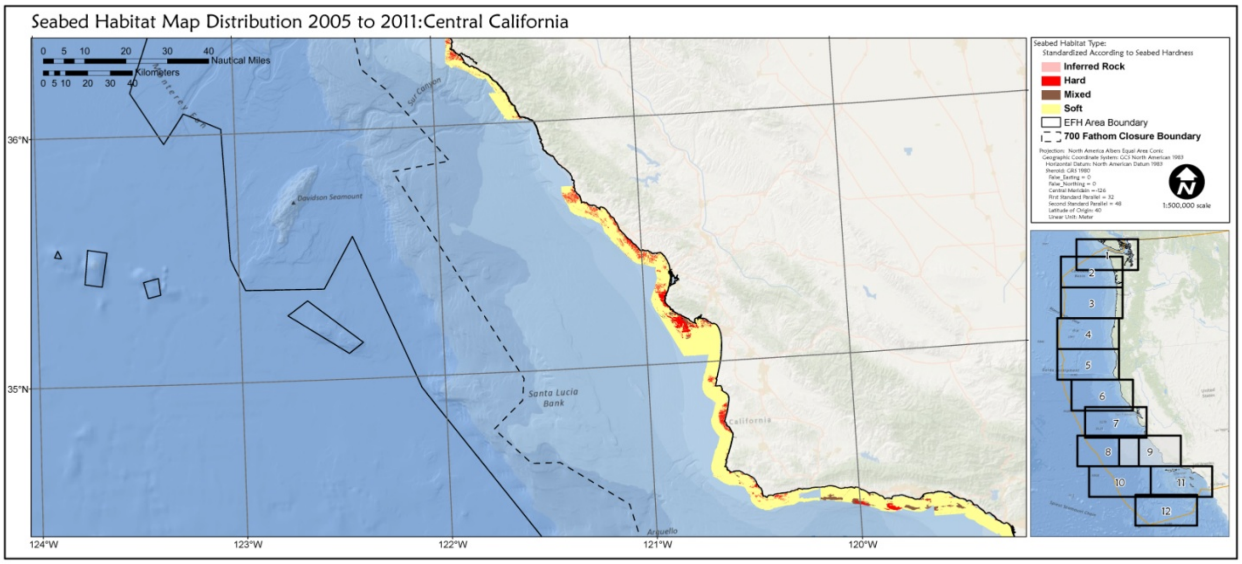

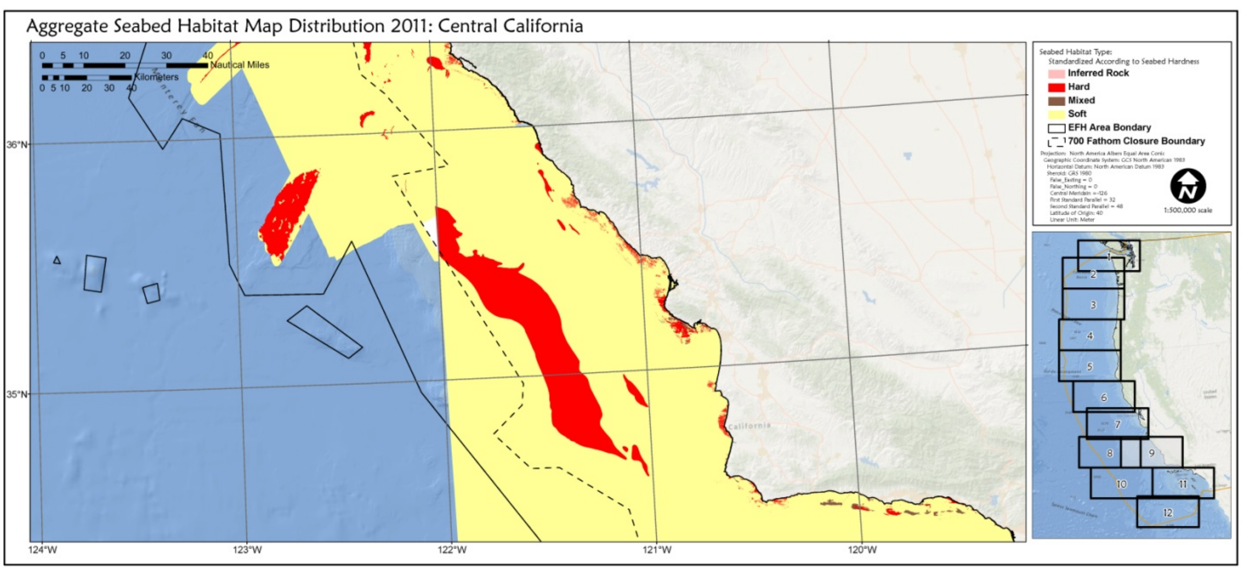

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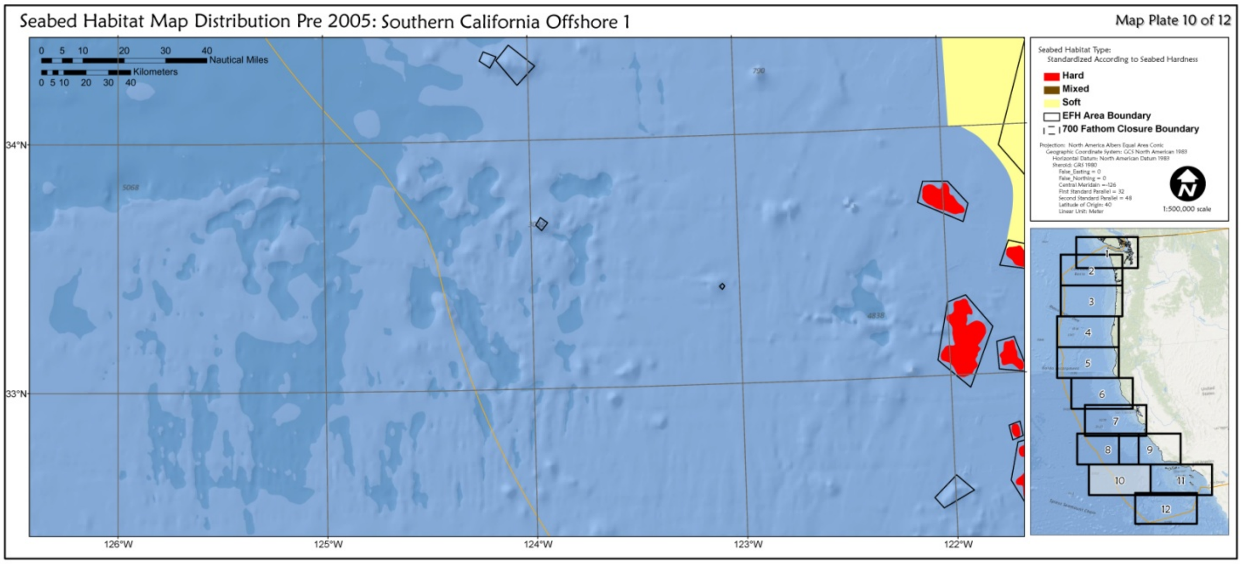

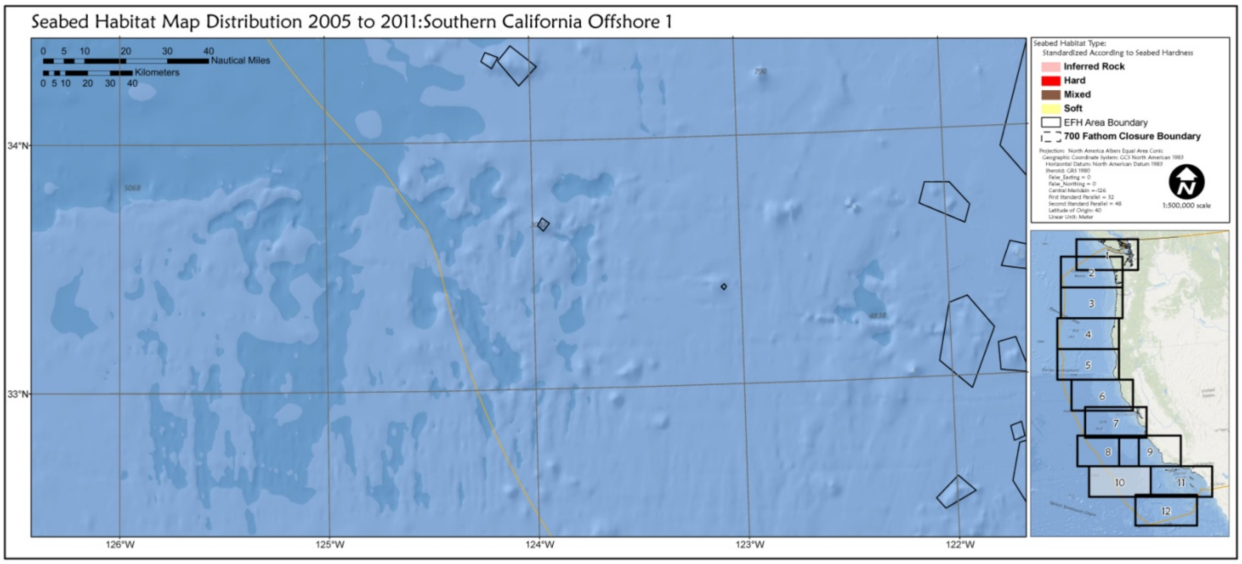

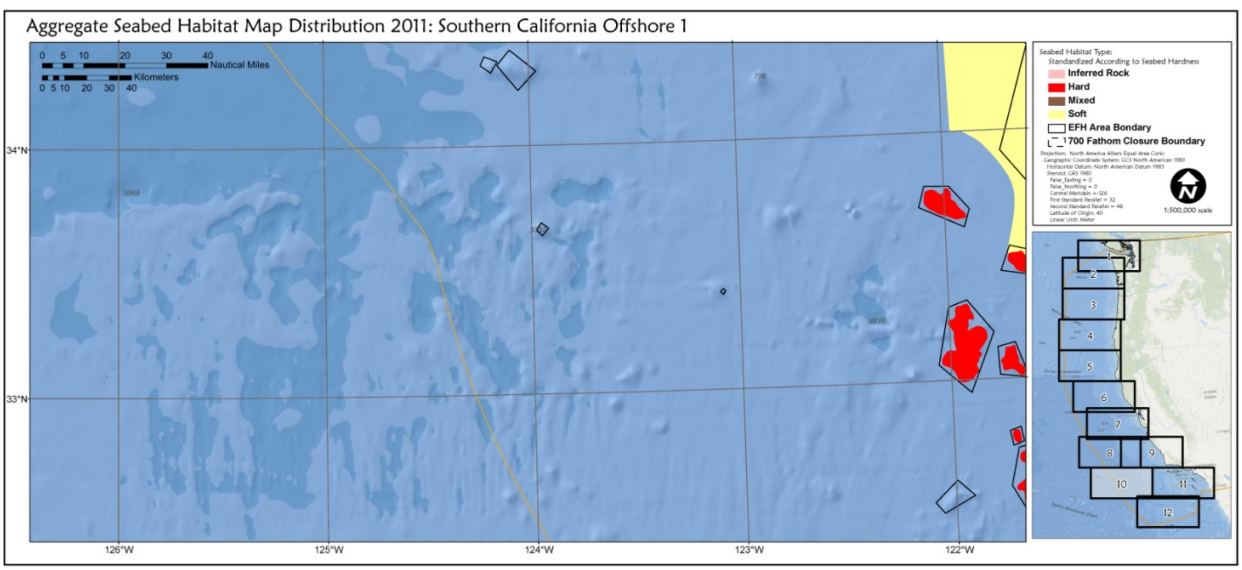

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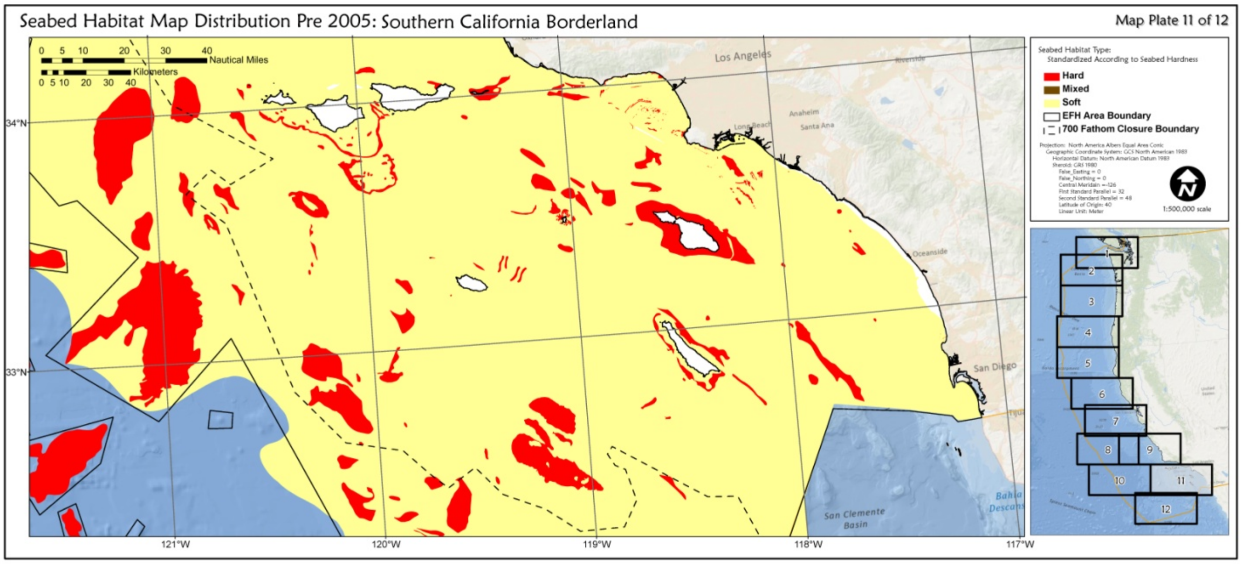

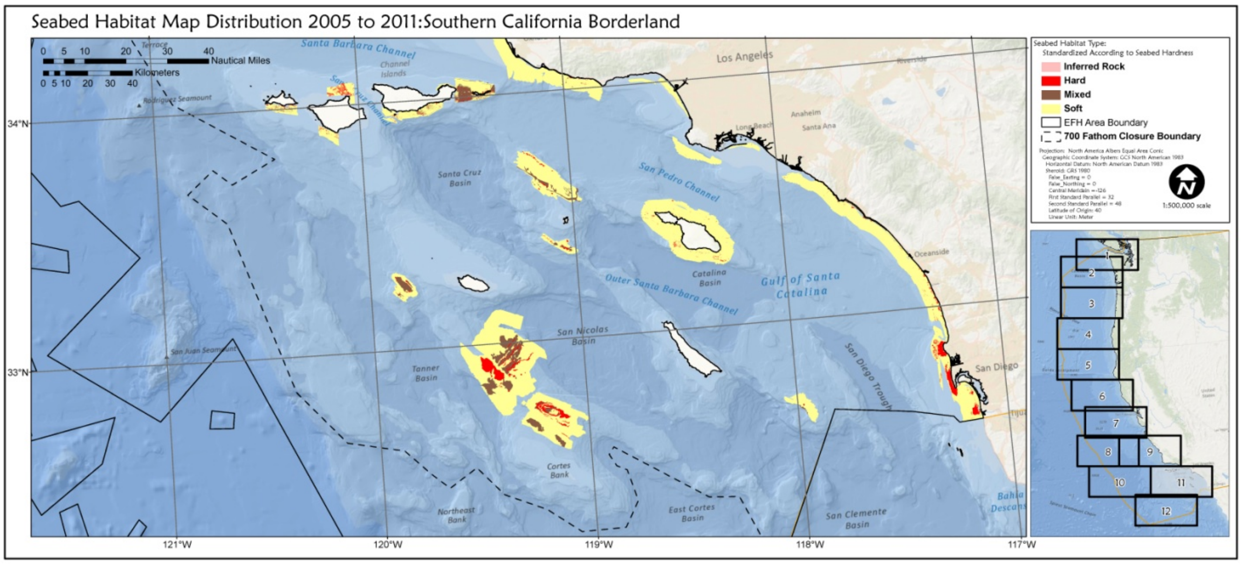

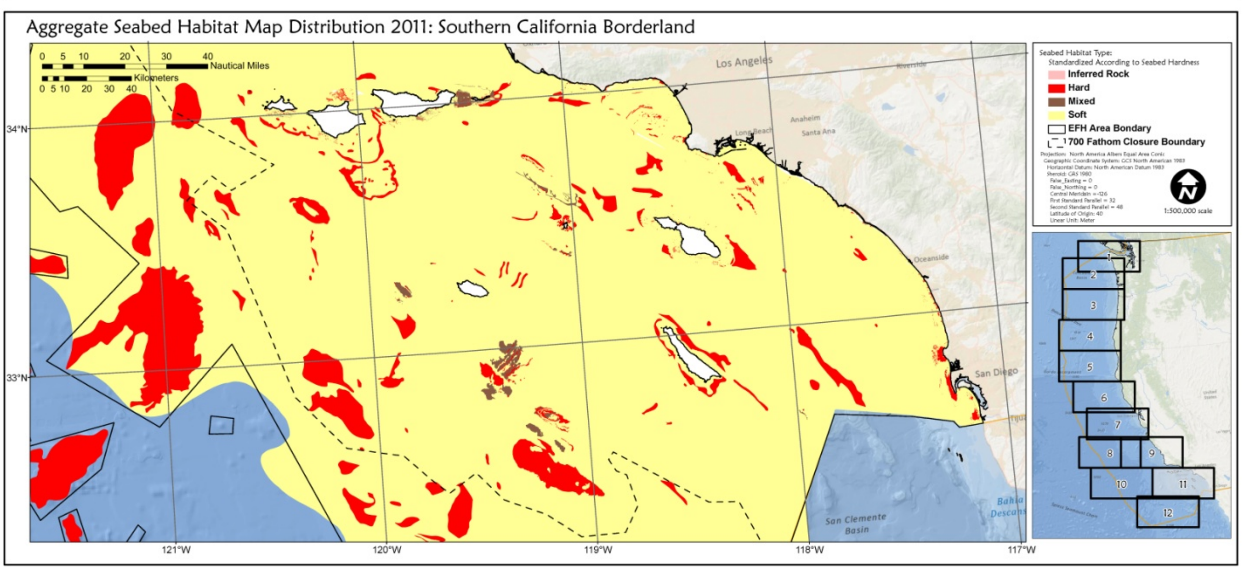

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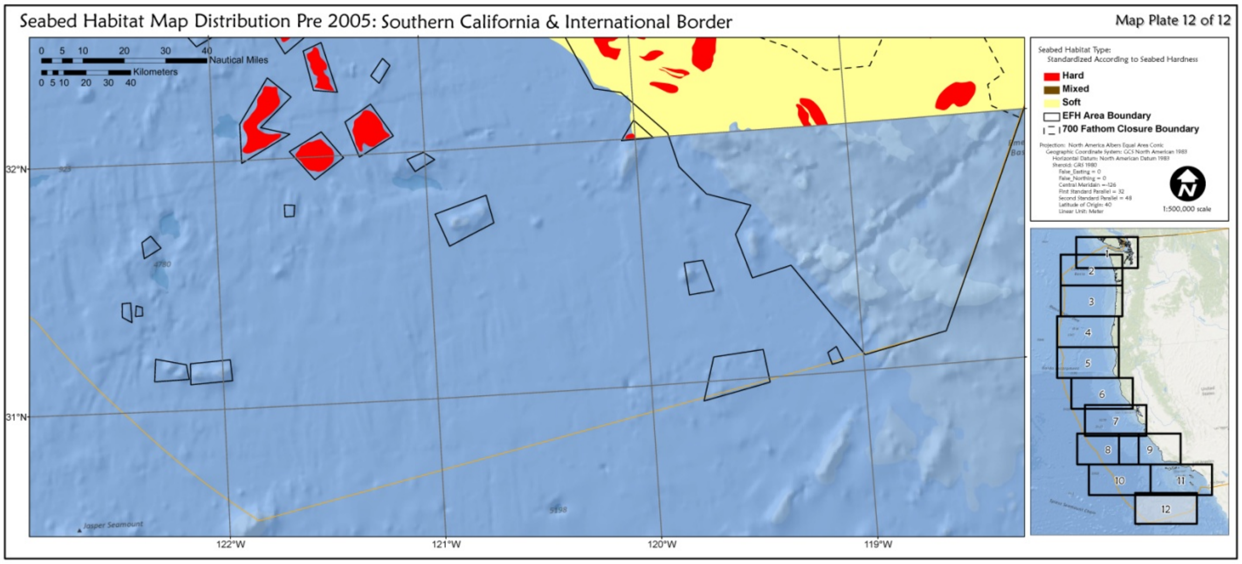
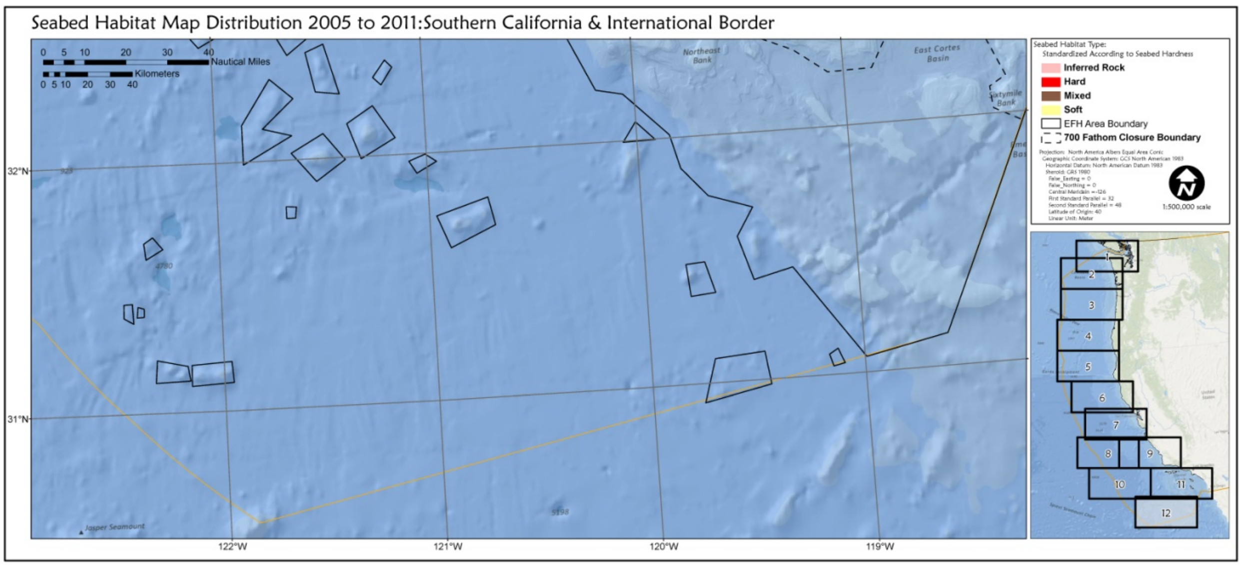
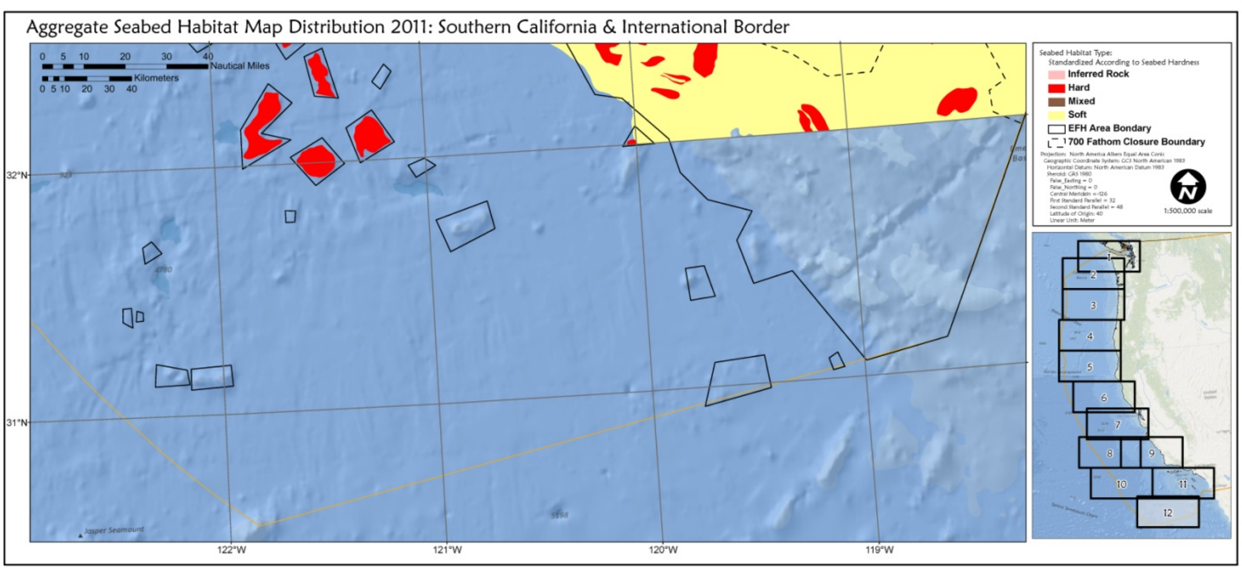
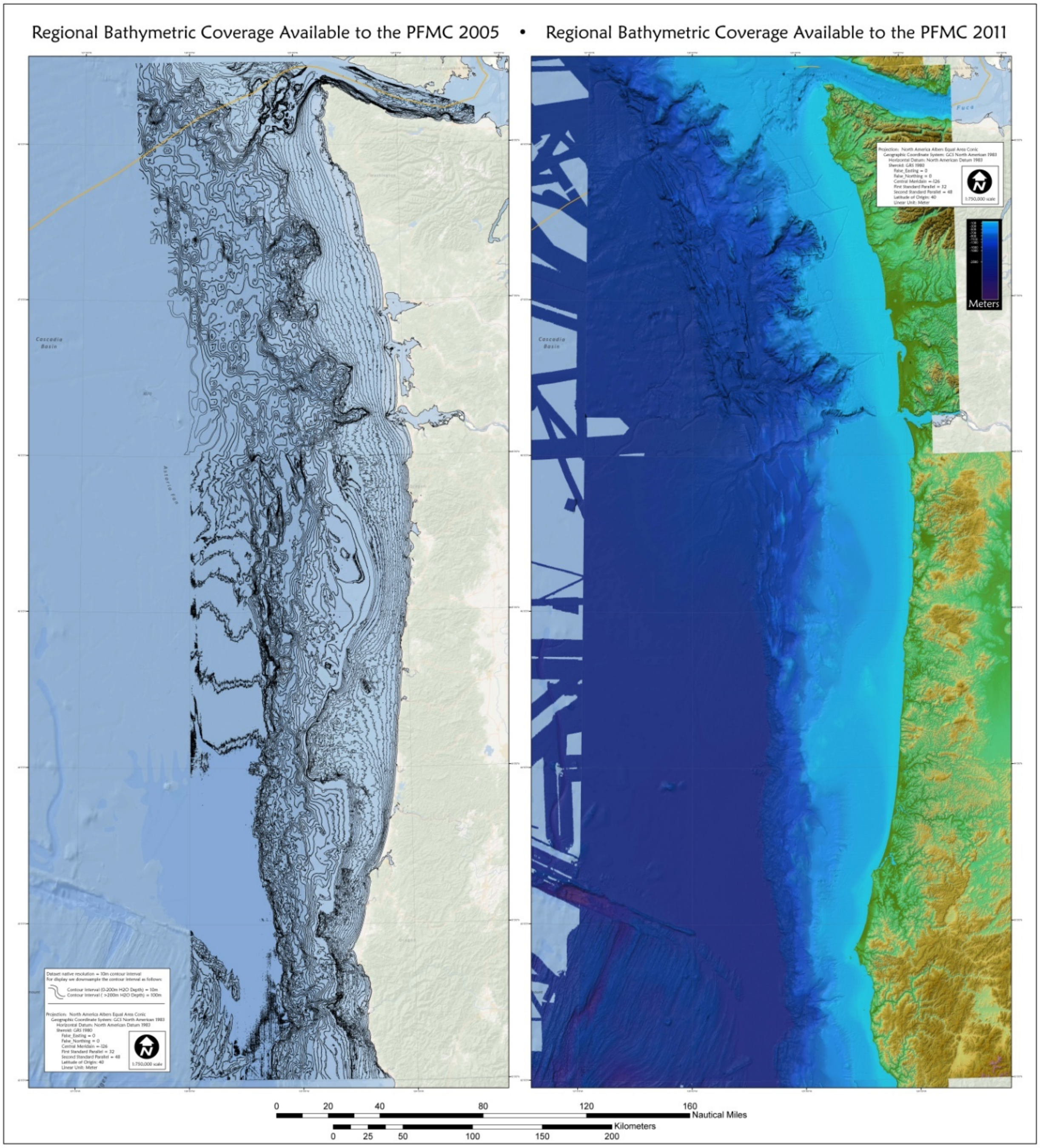


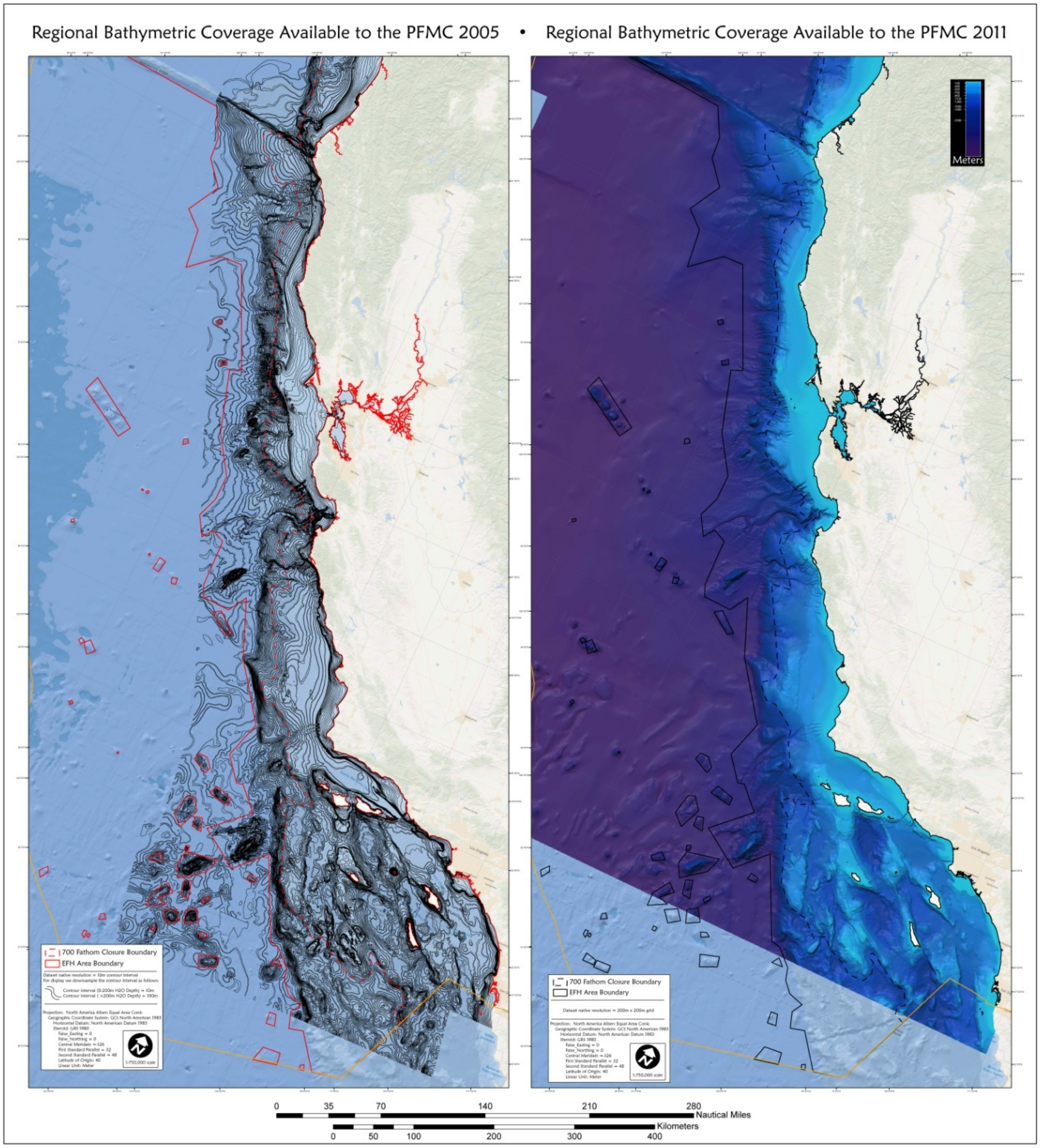




Apendix C-3: Regional Bathemetry



Apendix C-3: Regional Bathemetry



Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
1	1	X	X	X	Pacific Storm 2011, OCNMS North	OSU-AT&SML	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
2	1	X		X	San Juan Islands, WA	MLML-CHS	MLML-CHS	http://habitat.mlml.calstate.edu/pugetsound-georgiabasin/index.htm
3	1	X	X	X	Elwah River Delta West	USGS	USGS	http://pubs.usgs.gov/ds/320/index.html
4	1	X	X	X	Rainier 2001, Cape Flattery, OC-2 & OC-52	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
5	1	X	X	X	Rainier 2001, Cape Flattery, OC-3 & OC-56	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
6	1	X	X	X	Rainier 2001, Cape Flattery, OC-4 & OC-57	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
7	1	X	X	X	Rainier 2001, Anderson Pt, OC-5 & OC-58	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
8	1	X	X	X	Rainier 2002, Makah Bay, OC-6 & OC-65	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
9	1	X	X	X	Rainier 2002, Anderson Pt, OC-7 & OC-66	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
10	1	X	X	X	Rainier 2003, Makah Bay, OC-8 & OC-69	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
11	1	X	X	X	Rainier 2003, Makah Bay, OC-9 & OC-70	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
12	1	X	X	X	Rainier 2003, Anderson Pt, OC-10 & OC-71	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
13	1	X	X	X	Rainier 2003, Anderson Pt, OC-11 & OC-72	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
14	1	X	X	X	Rainier 2003, Anderson Pt, OC-12 &OC-73	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
15	1	X	X	X	Rainier 2003, Anderson Pt, OC-13 & OC-74	NOAA	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
16	1	X	X	X	OCNMS 2003, South of Cape Alava, OC-14 & OC-75	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
17	1	X	X	X	Rainier 2003, Neah Bay Region, OC-32 & OC-67	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
18	1		X	X	Mystery Bay 2002, Mystery Bay, offshore, OC-20	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
19	1		X		McArthur 2002, Anderson Pt, OC-23	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
20	1		X	X	McArthur 2004, Cape Alava, offshore, OC-27	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
21	1		X	X	McArthur 2004, West of Cape Flattery, OC-28	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
22	1		X	X	Tatoosh 2004, East of Neah Bay, OC-31	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
23	1		X	X	Tatoosh 2004, Cape Flattery, OC-33	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
24	1		X	X	McArthurII 2005, Cape Flattery, offshore, OC-34	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
25	1		X	X	McArthurII 2005, West of Cape Flattery, OC-35	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
26	1		X	X	McArthurII 2005, West of Cape Alava, OC-36	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
27	1		X	X	Tatoosh 2005, Cape Flattery, OC-37	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
28	1		X	X	Tatoosh 2005, East of Neah Bay, OC-38	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
29	1		X	X	Tatoosh 2005, Cape Flattery, offshore, OC-39	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
30	1		X	X	Tatoosh 2005, Cape Alava, offshore, OC-40	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
31	1		X	X	McArthurII 2006, Cape Flattery, OC-41	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
32	1		X	X	McArthurII 2006, West of Cape Alava, OC-42	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
33	1		X	X	McArthurII 2006, NA, OC-43	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
34	1		X	X	McArthurII 2006, NA, OC-44	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
35	1		X	X	Tatoosh 2006, NA, OC-47	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
36	1		X	X	Tatoosh 2006, NA, OC-48	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
37	1	X	X		EX0801	NOAA OE		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
38	1	X	X		TN175	NSF		Contact: R. McDuff (gmcduff@uw.edu)
39	1	X			Rainier 2001, Sheet F, OC-50	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
40	1	X			Rainier 2001, Sheet C, OC-52	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
41	1	X			Rainier 2001, Sheet D, OC-51	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
42	1	X			Rainier 2001, Sheet A, OC-54	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
43	1	X			Rainier 2001, Sheet T, OC-55	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
44	1	X			Quinault Canyon Auriga, Sheet A, OC-59	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
45	1	X	X		Prelay Fiber Optics Survey Tyco,OC-17 & OC-60	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
46	1	X	X		Postlay Fiber Optics Survey Fugro, OC-16 & OC-61	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
47	1	X			Rainier 2002, Sheet P, OC-62	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
48	1	X			Rainier 2002, Sheet P, OC-63	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
49	1	X			Rainier 2002, Sheet S, OC 64	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
50	1	X			Rainier 2002, Sheet T, OC 67	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html

Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
51	1	X			Rainier 2003, Sheet T, OC-68	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
52	1	X			Rainier 2004, Sheet F, OC-77	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
53	1	X			Rainier 2004, Sheet T, OC-78	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
54	2	X			Rainier 2004, Sheet T, OC-79	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
55	3	X			Rainier 2004, Sheet T, OC-80	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
56	4	X			Rainier 2004, Sheet T, OC-81	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
57	5	X			Rainier 2004, Sheet A, OC-82	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
58	1	X			Rainier 2004, Sheet A, OC-83	NOAA NOS		http://olympiccoast.noaa.gov/library/gisdata.html
59	1	X	X		Sinclair Inlet to Rich Passage (F00541)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/F00001-F02000/F00541/
60	1	X			Commencement Bay (F00589)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/F00001-F02000/F00589/
61	1	X	X		Elliot Bay West Anchorage (F00568)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/F00001-F02000/F00568/
62	1	X			Possession Sound (H11018)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11018
63	1	X			H11039	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11039
64	1	X			H11040	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11040
65	1	X			H11188	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11188
66	1	X			H11190	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11190
67	1	X			H11268	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11268
68	1	X			H11269	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11269
69	1	X			H11292	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11292
70	1	X			H11293	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11293
71	1	X			H11316	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11316
72	1	X			H11317	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11317
73	1		X		H11370	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11370
74	1	X			Vicinity of Smith Island (H11371)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11371
75	1	X			Northwest coast of Whidbey Island (H11375)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11375
76	1	X			H11376	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11376
77	1	X			H11377	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11377
78	1	X			Bellingham Bay Vendovi Island to Post Point (H11419)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11419
79	1	X	X		H11420	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11420
80	1				H11458	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11458
81	1	X	X		H11548	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11548
82	1	X	X		H11549	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11549
83	1	X			H11550	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11550
84	1	X	X		H11551	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11551
85	1	X			Hale Passage (H11552)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11552
86	1	X			South Portion of Bellingham Bay (H11553)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11553
87	1	X	X		H11556	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11556
88	1	X	X		H11605	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11605
89	1	X			Vicinity of Patos and Sucia Islands (H11631)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11631
90	1	X			H11632	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11632
91	1	X			H11646	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11646
92	3	X			Approaches to Coos Bay to Empire (H11744_1)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11744
93	3	X			Approaches to Coos Bay to Empire (H11744_2)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11744
94	3	X			Approaches to Coos Bay to Empire (H11744_3)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11744
95	1	X			Vicinity of Dungeness Bay (H11749)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11749
96	1	X			Green Point to Dungeness Bay (H11750)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11750
97	1	X			Port Angeles to Green Point(H11751)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11751
98	1	X			Oak Harbor to Saratoga Passage (H11801)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11801
99	1	X			H11826	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H11826
100	1	X			Cultus Bay (H12053)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12053

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Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
101	1	X			NW Offshore Portion of cape Flattery (H12220)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12220
102	1	X			Central Offshore Portion of Cape Flattery (H12222)	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12222
104	1	X			H12281	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12281
105	1	X			H12311	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12311
106	1	X			H12322	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12322
107	1	X			H12323	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12323
108	1	X			H12368	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12368
109	1	X			H12369	NOAA NOS		ftp://ftp.ngdc.noaa.gov/pub/coast/H10001-H12000/H12369
110	1		X		Cape Alava 1999 Kvitek, Cape Alava, OC-18	CSUMB-SML		http://olympiccoast.noaa.gov/library/gisdata.html
111	1		X		USGS97 Corliss, Sanctuary,Southeast, OC-19	USGS		http://olympiccoast.noaa.gov/library/gisdata.html
112	1		X		Tatoosh CapeAlava 2002, Cape Alava, OC-21	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
113	1		X		Tatoosh CapeAlava 2002, Cape Alava, OC-22	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
114	1		X		Tatoosh LaPush 2003, La Push, OC-24	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
115	1		X		McArthur 2004, West of Cape Flattery, OC-29	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
116	1		X		McArthur 2004, West of Cape Flattery, OC-30	OCNMS		http://olympiccoast.noaa.gov/library/gisdata.html
117	1		X		Agate Pass, NA, OC-45	UN		http://olympiccoast.noaa.gov/library/gisdata.html
118	1		X		Agate Pass, NA, OC-46	UN		http://olympiccoast.noaa.gov/library/gisdata.html
119	1,2,3,4	X	X	X	WA & OR Shelf and Slope	AT&SML	AT&SML	http://pacoos.coas.oregonstate.edu
120	1,2	X	X	X	Kvitek Cake Carrol, La Push, OC-1 & OC-49	CSUMB-SML	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
121	1,2		X	X	McArthur 2004, La Push, offshore, OC-26	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
122	1,2,3,4,5	X	X		TN240	NSF		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
123	1,2,3,4,5	X	X		TN265	NSF		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
124	2	X	X	X	Seadside	AT&SML	AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
125	2	X	X	X	OCNMS 2003, La Push, OC-15 & OC-76	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
126	2		X	X	McArthur 2004, OC-25	OCNMS	OCNMS	http://olympiccoast.noaa.gov/library/gisdata.html
127	2	X	X		BOEM Grays Harbor	AT&SML		http://activetectonics.coas.oregonstate.edu/state_waters.htm
128	2	X	X		NOAA Sponge Reef	AT&SML		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
129	2	X	X		OOI WA Inshore 2009	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
130	2	X	X		OOI WA Inshore 2010	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
131	2	X	X		OOI WA Inshore 2011	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
132	2	X	X		OOI WA Shelf 2009	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
133	2	X	X		OOI WA Shelf 2010	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
134	2	X	X		OOI WA Offshore	NSF-OOI		http://pacoos.coas.oregonstate.edu/OOI
135	2	X			Tillamook Head (H12122)	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
136	2	X	X		TN177	UW		http://pacoos.coas.oregonstate.edu/OOI
137	2	X	X		TN207	UW		http://pacoos.coas.oregonstate.edu/OOI
138	2	X	X		TN252	OSU-ATSML		http://pacoos.coas.oregonstate.edu/OOI
139	2	X			Approaches to Columbia River (H11723)	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
140	2	X			Approaches to Grays harbor (H11939)	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
141	2,3	X	X	X	H12122Plus	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
142	3	X	X	X	Cannon Beach to Arch Cape (H12123)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
143	3	X	X	X	Cape Falcon (H12124)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
144	3	X	X	X	Cape Lookout to Cascade Head (H12127)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
145	3	X	X	X	Cape Mears (H12126)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
146	3	X	X	X	Cape Perpetua (H12129)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
147	3	X	X	X	Cascade head to Siletz Bay (H12128)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
148	3	X	X	X	Depoe Bay Extension	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
149	3	X	X	X	Florence	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
150	3	X	X	X	Netarts	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
151	3	X	X	X	Newport	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm

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Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
152	3	X	X	X	Ocean Explorer Nehalem Bank	OSU-AT&SML	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
153	3	X	X	X	Siletz Reef North	ODFW	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
154	3	X	X	X	Siletz Reef South	ODFW	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
155	3	X	X	X	USGS Depoe Bay	USGS	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
156	3	X	X	X	Vacinity of Rockaway Beach (H12125)	NOAA NOS	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
157	3	X		X	ODFW Seal Rock	ODFW	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
158	3	X	X		BOEM Nehalem	OSU-AT&SML		http://activetectonics.coas.oregonstate.edu/state_waters.htm
159	3	X	X		BOEM Newport	OSU-AT&SML		http://activetectonics.coas.oregonstate.edu/state_waters.htm
160	3	X	X		Ocean Explorer Daisy Bank & Margin	NOAA OE		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
161	3	X	X		Ocean Explorer R2 TN173	NOAA PMEL		http://pacoos.coas.oregonstate.edu
162	3	X	X		OOI Newport	NSF OOI		http://pacoos.coas.oregonstate.edu/OOI
163	3	X			H11989	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
164	3,4	X	X	X	Heceta Bank	NOAA PMEL	NOAA NWFSC	Contact: W. Wakefield (waldo.wakefield@noaa.gov)
165	3,4,11	X	X	X	TN 174, NOAA ATC 2004	OSU-AT&SML	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
166	3,4,6	X	X		NOAA ATC/OSU 2005	OSU-AT&SML		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
167	4	X	X	X	Cape Arago	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
168	4	X	X	X	Cape Blanco	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
169	4	X	X	X	Humbug Mountain	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
170	4	X	X	X	Island Rock	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
171	4	X	X	X	Lakeside	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
172	4	X	X	X	Redfish Rocks	OSU-AT&SML	OSU-AT&SML	http://activetectonics.coas.oregonstate.edu/state_waters.htm
173	4	X		X	ODFW Bandon Reef	ODFW	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
174	4	X		X	ODFW Orford Reef	ODFW	OSU-AT&SML	http://pacoos.coas.oregonstate.edu
175	4	X	X		BOEM Lakeside	OSU-AT&SML		http://activetectonics.coas.oregonstate.edu/state_waters.htm
176	4	X			Cape Ferrolo to Winchuck River (H12131)	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
177	4	X			Crook Point to Cape Ferrelo (H12130)	NOAA NOS		http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html
178	4, 5	X	X	X	Pelican Bay (H11985)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
179	5	X	X	X	Saint George Reef (H11984)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
180	5	X	X	X	Point Saint George (H11983)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
181	5	X	X	X	Midway Point to Split Rock (H11982)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
182	5	X	X	X	Johnson Creek to Mussel Point (H11981)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
183	5	X	X	X	Conical Rock to Rocky Point (H11980)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
184	5	X	X	X	Trinidad (H11979)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
185	5	X	X	X	West of Arcata Bay (H11978)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
186	5	X	X	X	Humboldt (H11977)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
187	5	X	X	X	Eel River to Mussel Rock (H11976)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
188	5	X	X	X	Cape Mendocino (H11975)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
189	5	X	X	X	Mussel Rocks to Punta Gorda (H11974)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
190	5	X	X	X	Spanish Canyon (H11973)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
191	5			X	Eel River Basin		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
192	5	X	X		Humboldt Bay North	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
193	5	X	X		Humboldt Bay South	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
194	5	X			Humboldt Bay Data Fusion Project	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
195	5	X	X		Approach to Humboldt Bay to Arcata Bay (H11919)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
196	5	X	X		North of the Entrance Channel Humboldt Bay (F00579)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
197	5	X	X		Crescent City Harbor (F00562)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
198	5, 6	X	X	X	Point Delgada (H11972)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
199	6	X	X	X	North Central Coast Block A11	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
200	6	X	X	X	North Central Coast Block B01	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
201	6	X	X	X	North Central Coast Block B02	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm

Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
202	6	X	X	X	North Central Coast Block B03	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
203	6	X	X	X	North Central Coast Block B04	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
204	6	X	X	X	North Central Coast Block B05	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
205	6	X	X	X	North Central Coast Block B06	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
206	6	X	X	X	North Central Coast Block B07	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
207	6	X	X	X	North Central Coast Block B08	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
208	6	X	X	X	North Central Coast Block B09	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
209	6	X	X	X	North Central Coast Block B10	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
210	6	X	X	X	North Central Coast Block B11	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
211	6	X	X	X	North Central Coast Block B12	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
212	6	X	X	X	North Central Coast Block B13	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
213	6	X	X	X	Bear Landing (H11971)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
214	6	X	X	X	Big White Rock to Abalone Point (H11970)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
215	6	X	X	X	De Haven to Laguna Point (H11969)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
216	6	X	X	X	Fort Bragg to Little River (H11968)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
217	6	X	X	X	Still Well Point to Greenwood Cover (H11967)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
218	6	X	X	X	Punta Arena Lighthouse (H11966)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
219	6	X	X		Mackerricher State Reserve	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
220	6	X	X		Point Arena	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
221	6	X	X		Northern San Andreas Fault	OSU-AT&SML		Contact: C. Goldfinger (gold@coas.oregonstate.edu)
222	6, 7			X	Pt. Reyes		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
223	6, 7	X	X	X	Cordell Bank	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
224	6, 7	X	X	X	North Central Coast Block A03	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
225	6, 7	X	X	X	North Central Coast Block A04	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
226	6, 7	X	X	X	North Central Coast Block A05	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
227	6, 7	X	X	X	North Central Coast Block A06	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
228	6, 7	X	X	X	North Central Coast Block A07	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
229	6, 7	X	X	X	North Central Coast Block A08	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
230	6, 7	X	X	X	North Central Coast Block A09	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
231	6, 7	X	X	X	North Central Coast Block A10	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
232	6, 7			X	Bodega Basin (Inshore)		MLML-CHS	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
233	6, 7			X	Bodega Basin (Offshore)		MLML-CHS	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
234	6, 7	X			Northern California Coast (H11739)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
235	6, 7	X	X		Tomales Point (H11767)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
236	6, 7	X	X		Tomales Bay	USGS		http://pubs.er.usgs.gov/
237	7			X	Golden Gate National Recreational Area		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
238	7			X	Carmel Canyon		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
239	7	X	X	X	Yankee Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
240	7	X	X	X	Cypress Point to Point Pinos	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
241	7	X	X	X	Point Pinos to Shale Beds	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
242	7	X	X	X	Soquel Canyon West	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
243	7	X	X	X	Soquel Canyon East	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
244	7	X	X	X	Kasler Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
245	7	X	X	X	Point Lobos	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
246	7	X	X	X	Monastery to Cypress Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
247	7	X	X	X	Central Monterey Bay South	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
248	7	X	X	X	Central Monterey Bay North	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
249	7	X	X	X	Portuguese Ledge	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
250	7	X	X	X	Asilomar	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm

Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
251	7	X	X	X	Central Coast Block 00 (Stinson Beach)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
252	7	X	X	X	Central Coast Block 01	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
253	7	X	X	X	Central Coast Block 02	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
254	7	X	X	X	Central Coast Block 03	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
255	7	X	X	X	Central Coast Block 04 and 05	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
256	7				Central Coast Block 05	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
257	7	X	X	X	Central Coast Block 06	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
258	7	X	X	X	Central Coast Block 07	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
259	7	X	X	X	Central Coast Block 08	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
260	7	X	X	X	Central Coast Block 09	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
261	7	X	X	X	Central Coast Block 10	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
262	7	X	X	X	Central Coast Block 11	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
263	7	X	X	X	North Central Coast Block A01	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
264	7	X	X	X	North Central Coast Block A02	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
265	7	X	X	X	Soberanes Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
266	7	X	X	X	North Monterey Bay Block 1	USGS	CSUMB-SML	http://pubs.er.usgs.gov/; http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
267	7	X	X	X	North Monterey Bay Block 2	USGS	CSUMB-SML	http://pubs.er.usgs.gov/; http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
268	7	X		X	Rittenburg Bank	USGS	USGS	Contact: P. Etnoyer (peter.etnoyer@noaa.gov); G. Cochrane (gcochrane@usgs.gov)
269	7		X	X	Outer Continental Shelf, North-Central CA	USGS	USGS	http://pubs.er.usgs.gov/
270	7	X	X		San Pablo Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
271	7	X	X		Presidio Shoals	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
272	7	X	X		West San Francisco Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
273	7	X	X		South San Francisco Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
274	7	X	X		North San Francisco Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
275	7	X			Entrance San Francisco Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
276	7	X			Monterey Bay Canyon (Fall 2008)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
277	7	X			Monterey Bay Canyon (Spring 2008)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
278	7	X			Monterey Bay Canyon (Fall 2007)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
279	7	X			Monterey Bay Canyon (Spring 2007)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
280	7	X			Monterey Bay Canyon (Fall 2006)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
281	7	X			Monterey Bay Canyon (Winter 2006)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
282	7	X			Monterey Bay Canyon (Fall 2005)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
283	7	X			Monterey Bay Canyon (Winter 2005)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
284	7	X			Monterey Bay Canyon (Fall 2004)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
285	7	X			Monterey Bay Canyon (Fall 2003)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
286	7	X			Monterey Bay Canyon (Spring 2003)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
287	7	X			Monterey Bay Canyon (Fall 2002)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
288	7	X			Soquel Canyon (2006)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
289	7	X			Elkhorn Slough (2001)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
290	7	X			Elkhorn Slough (2003)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
291	7	X			Elkhorn Slough (2005)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
292	7	X			Offshore San Francisco Bay (H11965)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
293	7	X			San Pablo Point to 1.5 Miles West of Pinole Point (H117	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
294	7	X			San Francisco Bay (H11639)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
295	7	X			Gulf of Farallons (H12109)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
296	7	X			Gulf of Farallons (H12110)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
297	7	X			Gulf of Farallons (H12111)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
298	7	X			Gulf of Farallons (H12112)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
299	7	X			Gulf of Farallons (H12113)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
300	7	X	X		Monterrey Bay (Pt. Ano Nuevo to Moss Landing)	USGS		http://pubs.er.usgs.gov/

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Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
301	7	X	X		San Francisco	USGS		http://pubs.er.usgs.gov/
302	7	X			Farallon Escarpment	USGS		Contact: P. Etnoyer (peter.etnoyer@noaa.gov); G. Cochrane (gcochrane@usgs.gov)
303	7, 9	X	X	X	Grimes Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
304	7, 9	X	X	X	Point Sur	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
305	7, 9	X	X	X	Hurricane Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
306	7, 9	X	X	X	Cooper Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
307	9			X	California Seafloor Mapping Project (Block 54)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
308	9			X	California Seafloor Mapping Project (Block 55)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
309	9			X	California Seafloor Mapping Project (Block 62)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
310	9			X	California Seafloor Mapping Project (Block 63)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
311	9			X	California Seafloor Mapping Project (Block 64)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
312	9			X	California Seafloor Mapping Project (Block 65)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
313	9			X	California Seafloor Mapping Project (Block 66)		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
314	9	X	X	X	Santa Barbara Channel Block E	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
315	9	X	X	X	Santa Barbara Channel Block F	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
316	9	X	X	X	Santa Barbara Channel Block G	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
317	9	X	X	X	Santa Barbara Channel Block H	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
318	9	X		X	Coal Oil Point (H11950)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
319	9	X		X	Coal Oil Point (H11951)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
320	9	X		X	Point Conception (H11952)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
321	9	X	X	X	Point Arguello (H11953)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
322	9	X	X	X	South Central Coast Block 1	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
323	9	X	X	X	South Central Coast Block 2	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
324	9	X	X	X	South Central Coast Block 3	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
325	9	X	X	X	South Central Coast Block 4	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
326	9	X	X	X	South Central Coast Block 5	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
327	9	X	X	X	South Central Coast Block 6	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
328	9	X	X	X	South Central Coast Block 7	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
329	9	X	X	X	South Central Coast Block 8	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
330	9	X	X	X	South Central Coast Block 9	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
331	9	X	X	X	South Central Coast Block 10	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
332	9	X	X	X	South Central Coast Block 11	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
333	9	X	X	X	South Central Coast Block 12	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
334	9	X	X	X	South Central Coast Block 13	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
335	9	X	X	X	South Central Coast Block 14	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
336	9	X	X	X	South Central Coast Block 15	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
337	9	X	X	X	South Central Coast Block 16	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
338	9	X	X	X	South Central Coast Block 17	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
339	9	X	X	X	South Central Coast Block 18	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
340	9	X	X	X	South Central Coast Block 19	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
341	9	X	X	X	South Central Coast Block 20	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
342	9	X	X	X	South Central Coast Block 21	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
343	9	X	X	X	South Central Coast Block 22	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
344	9	X	X	X	South Central Coast Block 23	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
345	9	X	X	X	South Central Coast Block 24	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
346	9	X	X	X	South Central Coast Block 25	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
347	9	X	X	X	South Central Coast Block 26	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
348	9	X	X	X	South Central Coast Block 27	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
349	9	X	X	X	South Central Coast Block 28	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
350	9	X	X	X	South of Morro Bay - Avila Bay Block A1	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm

Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
351	9	X	X	X	South of Morro Bay - Avila Bay Block A2	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
352	9	X	X	X	South of Morro Bay - Avila Bay Block A3	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
353	9	X	X	X	South of Morro Bay - Avila Bay Block B	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
354	9	X	X	X	South of Morro Bay - Avila Bay Block C	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
355	9	X	X	X	South of Morro Bay - Avila Bay Block D	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
356	9	X	X	X	South of Morro Bay - Avila Bay Block E	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
357	9	X	X	X	South of Morro Bay - Avila Bay Block F	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
358	9	X	X	X	South of Morro Bay - Avila Bay Block G	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
359	9	X	X	X	South of Morro Bay - Avila Bay Block H	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
360	9	X	X	X	South of Morro Bay - Avila Bay Block I	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
361	9	X	X	X	South of Morro Bay - Avila Bay Block J	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
362	9	X	X	X	Point Buchon Control	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
363	9	X	X	X	Point Buchon MPA	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
364	9	X	X	X	Big Creek North	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
365	9	X	X	X	Big Creek South	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
366	9	X	X	X	Slate Rock	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
367	9	X	X	X	Lopez Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
368	9	X	X	X	Santa Barbara Channel (Northeastern)	USGS	USGS	http://pubs.er.usgs.gov/
369	9		X	X	South Vandenberg Reserve	USGS	USGS	http://pubs.er.usgs.gov/
370	9	X			Morro Bay Harbor	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
371	9	X	X		Morro Bay	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
372	9	X	X		Santa Barbara Channel (F00512)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
373	9	X	X		Gaviota	USGS		http://pubs.er.usgs.gov/
374	9	X	X		Northern Santa Barbara Channel	USGS		http://pubs.er.usgs.gov/
375	9	X			Coal Oil Point	USGS		http://pubs.er.usgs.gov/
376	9, 11			X	Hueneme		MLML-CHS	Contact: H.G. Greene (greene@mlml.calstate.edu)
377	9, 11	X	X	X	Santa Barbara Channel D	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
378	9, 11	X	X		Santa Barbara Channel (Coastal)	USGS		http://pubs.er.usgs.gov/
379	9, 11	X	X		Northeastern Channel Islands	USGS		http://pubs.er.usgs.gov/
380	11	X	X	X	Ocean Beach (H11875)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
381	11	X	X	X	Pacific Beach (H11876)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
382	11	X		X	San Elijo Lagoon (H11877)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
383	11	X		X	Santa Margarita River (H11878)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
384	11	X		X	Dana Point to Cupola (H11879)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
385	11	X		X	Newport Beach to Three Arch Bay (H11880)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
386	11	X		X	San Pedro Bay (H11881)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
387	11	X		X	San Pedro Escarpment (H11882)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
388	11	X	X	X	Santa Catalina Island Block 1	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
389	11	X	X	X	Santa Catalina Island Block 2	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
390	11	X	X	X	Santa Catalina Island Block 3	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
391	11	X	X	X	Santa Catalina Island Block 4	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
392	11	X	X	X	Santa Catalina Island Block 5	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
393	11	X	X	X	Santa Catalina Island Block 6	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
394	11	X	X	X	Santa Catalina Island Block 7	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
395	11	X	X	X	Santa Catalina Island Block 8	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
396	11	X	X	X	Santa Catalina Island Block 9	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
397	11	X	X	X	Santa Catalina Island Block 10	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
398	11	X	X	X	Santa Catalina Island Block 11	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
399	11	X	X	X	Santa Catalina Island Block 12	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
400	11	X		X	Santa Monica (H11883)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm

Appendix C: Data Sources

Table C-1. Source data (bathymetry, backscatter, habitat) included in high resolution acoustic data and seabed habitat map plates 1-12. Abbreviations are as follows: CSUMB-SML = California State Univeristy, Seafloor Mapping Lab; MLML_CHS = Moss Landing Marine Laboratories, Center for Habitat Studies; NOAA OCNMS = NOAA Olympic Coast National Marine Sanctuary; NOAA OE = NOAA Ocean Explorer; NOAA NOS = NOAA National Ocean Service; NOAA PMEL = Pacific Marine Environmental Laboratory; NSF = National Science Foundation; NSF OOI = NSF Ocean Observing Initiative; OSU_AT&SML = Oregon State University, Active Tectonics and Seafloor Mapping Lab; USGS = United States Geological Survey; USN = United States Navy

Ref#	Plate Number	Bathymetry	Backscater	Habitat	Site Name	Imagery Source	Habitat Source	Data Archive(s)
401	11	X		X	Malibu (H11891)	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
402	11	X	X	X	Santa Barbara Channel A	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
403	11	X	X	X	Santa Barbara Channel B	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
404	11	X	X	X	Santa Barbara Channel C	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
405	11	X	X	X	Scorpion Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
406	11	X	X	X	Gull Island	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
407	11	X	X	X	Carrington Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
408	11	X	X	X	South Point	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
409	11	X		X	San Clemente-Oceanside-San Diego	CSUMB-SML	CSUMB-SML	http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
410	11	X		X	43 Fathom Bank	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
411	11	X		X	Cherry Bank	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
412	11	X		X	Osborn Bank	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
413	11	X		X	Pilgrim/Kidney Banks	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
414	11	X		X	Potato Bank	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
415	11	X		X	Tanner Bank	OSU-AT&SML	OSU-AT&SML	Contact: C. Goldfinger (gold@coas.oregonstate.edu)
416	11		X	X	South San Miguel Island	USGS	USGS	http://pubs.er.usgs.gov/
417	11		X	X	Big Sycamore Reserve	USGS	USGS	http://pubs.er.usgs.gov/
418	11		X	X	Southern Anacapa Island	USGS	USGS	http://pubs.er.usgs.gov/
419	11		X	X	Southern Anacapa Passage	USGS	USGS	http://pubs.er.usgs.gov/
420	11		X	X	Santa Cruz Island	USGS	USGS	http://pubs.er.usgs.gov/
421	11		X	X	North Anacapa Island	USGS	USGS	http://pubs.er.usgs.gov/
422	11		X	X	Northern Anacapa Passage	USGS	USGS	http://pubs.er.usgs.gov/
423	11	X	X		Cortes Bank	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
424	11	X			Tanner Bank	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
425	11	X			San Clemente Island South	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
426	11	X			San Clemente Island North	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
427	11	X			Santa Barbara Island	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
428	11	X			San Clemente Island (Eel Point)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
429	11	X			San Clemente Island (Mail Point)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
430	11	X			San Clemente Island (Lost Point)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
431	11	X			San Clemente Island (Cove Point)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
432	11	X			San Clemente Island (China Point)	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
433	11	X			Farnsworth Bank	CSUMB-SML		http://seafloor.csumb.edu/SFMLwebDATA_SURVEYMAP.htm
434	11	X	X		Oxnard (H11501)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
435	11	X	X		San Pedro Bay (F00507)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
436	11	X	X		Los Angeles Harbor (H11471)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
437	11	X	X		San Diego (F00513)	NOAA NOS		http://ngdc.noaa.gov/nndc/struts/form?&t=101523&s=2&d=1&d-2
438	11	X	X		Los Angeles Margin (2004)	USGS		http://pubs.er.usgs.gov/
439	11	X			San Diego Margin	USGS		http://pubs.er.usgs.gov/
440	11	X	X		Los Angeles Margin (2002)	USGS		http://pubs.er.usgs.gov/
441	11	X	X		San Diego	USGS		http://pubs.er.usgs.gov/
442	11	X	X	X	Santa Monica	USGS	CSUMB-SML	http://pubs.er.usgs.gov/

APPENDIX D SELECTED OBSERVATIONS OF CORALS AND SPONGES

Appendix D maps depict the spatial distribution of selected observations of corals and sponges from visual surveys conducted by a number of agencies and institutions. Many of the locations of observations are included in a national database prepared under the auspices of NOAA's Deep-Sea Coral Research and Technology Program (NOAA 2011). Although there are a number of records of additional observations recorded at various research institutes, this database is currently the most comprehensive source of electronically available records of coral and, to a lesser extent, sponge observations in the region. Development of this database is ongoing and additional records of observations will be added as they become available. Appendix D plates also depict records from two other database query results: 1) selected observations of corals and sponges from submersible and remotely operated vehicle (ROV) surveys off southern California (NMFS SWFSC [M. Yoklavich]), and 2) a database maintained by Brian Tissot (Washington State University Vancouver) containing records of coral observations from submersibles and ROV surveys off Oregon and central and southern California (Bianchi, 2011; Bright, 2007; Pirtle, 2005). These additional records were added to the map figures because they were not yet included in the version of the national database. Compared to the 2006 groundfish EFH review, this database represents a major advancement in access and dissemination of records of coral and sponge presence in the region. Furthermore, this database was not available during the Amendment 19 process.

The Appendix D maps depict point locations of observations of corals and sponges recorded via a variety of collection methods. Records with the label "in situ observation" were made using direct count methods utilizing submersible, ROV, or camera sled platforms. The precision of these point locations varies between data sets, ranging from very precise estimates of vehicle position at the location of the individual coral or sponge specimen observed in situ, to more general representations of a vehicle dive transect. Almost all records of corals and sponges collected via "trawls" or "dredges" originate from surveys conducted by NMFS during the past three decades; however, numerous records from museum collections within the "various" category also originate from very early NMFS trawl surveys conducted over the last century. Trawl and dredge records exhibit less locational precision, because trawls often operate over 100's of meters to 10's of kilometers. It is very difficult to estimate over the course of a trawl or dredge track when and where a particular specimen was collected. As mentioned above, records termed "various" most often are part of museum collections, for which the original collection method varies between the other four general categories or is not specified. The final category, "ROV collection" refers to specimens that were physically extracted from their benthic habitat by an ROV. Often times, these specimens are accessed in a museum collection. Consequently, this database of observations may contain duplicate records. Due to the varying and often unrecorded precision of the location information, particularly from trawl samples, users of these data should exercise caution when conducting any fine scale spatial analysis.

These records of selected coral and sponge observations are presented in map view to highlight the geographic scope of the observations (see Appendix D figures). The spatial distribution of these locations of coral and sponge presence is largely driven by survey effort. The largest number of records originates from in situ observations (red) at discrete survey sites. Major areas of direct count *in situ* studies include sites in the Olympic Coast National Marine Sanctuary, numerous rocky banks off Oregon, central California (e.g., Cordell Bank National Marine Sanctuary) and in the southern California Bight, and submarine canyons off Oregon and central California, including a very large number of records from sites in and around Monterey Bay.

The second most numerous category of records comes from trawl surveys (blue), which were conducted mostly by the NMFS starting in the mid 1970's and continuing through 2010, at least for the current version of the database. These observations are limited to "trawlable" areas of the continental shelf and slope, while survey focus was often to make fishery-independent estimates of groundfish biomass. It is important to note that most trawl gear is not designed to sample sessile benthic invertebrates, nor is it designed to access the types of habitats in which these organisms typically reside. The exception is sea pens and sea whips, since they don't require hard substrate for attachment. For this reason, sea pens and sea whips are encountered much more frequently in the catch of trawl surveys than any other coral taxa (see Whitmire and Clarke, 2007).

Lastly, records in the "various" category (yellow) are less numerous and occur in areas off Washington and central and southern California. When they appear in dense clusters around a feature such as seamounts (e.g., Figure 8), they almost certainly originate from ROV or submersible surveys. Such records would have been members of the "*in situ* observation" had the data attributes indicated this. Often times, these records were provided as queries of museum specimen collections or online databases for which observations are compiled from a variety of sources.

In contrast to the existing databases of observations described above, the last review of groundfish EFH that concluded in 2006 utilized significantly fewer records of observations. A summary of data sources, total records reviews, and numbers of observations used during the last review is detailed in Appendix B of the Final Environmental Impact Statement (NMFS, 2005).

To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
To request a copy of the most current version of the national database, please contact Dan Dorman (NOAA), Dan.Dorfman@noaa.gov, (301) 713-3028 x112.

Literature Cited:

Bianchi, C. 2011. Abundance and distribution of megafaunal invertebrates in NE Pacific submarine canyons and their ecological associations with dermersal fishes. M.S. Thesis. Washington State Univ. Vancouver.

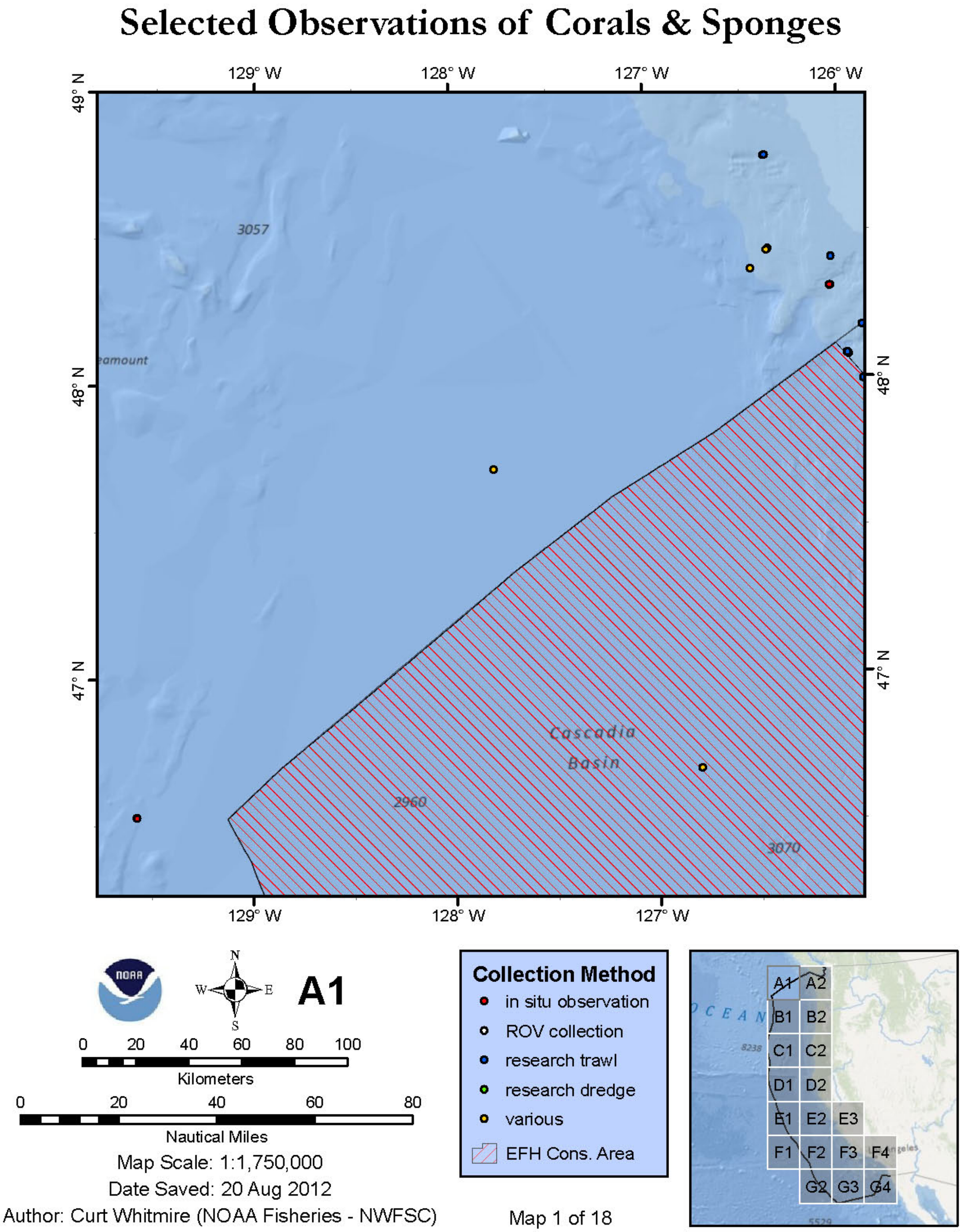
Bright, J.L. 2007. Abundance and distribution of structure-forming invertebrates and their associations with fishes at the Channel Islands "Footprint" off the southern coast of California. M.S. Thesis. Washington State Univ. Vancouver.

NOAA Deep Sea Coral Research and Technology Program. 2011. Deep-Sea Coral National Geographic Database, version 2.0. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD.
Data Manager: Dan Dorfman (NOAA), Dan.Dorfman@noaa.gov, (301) 713-3028 x112.

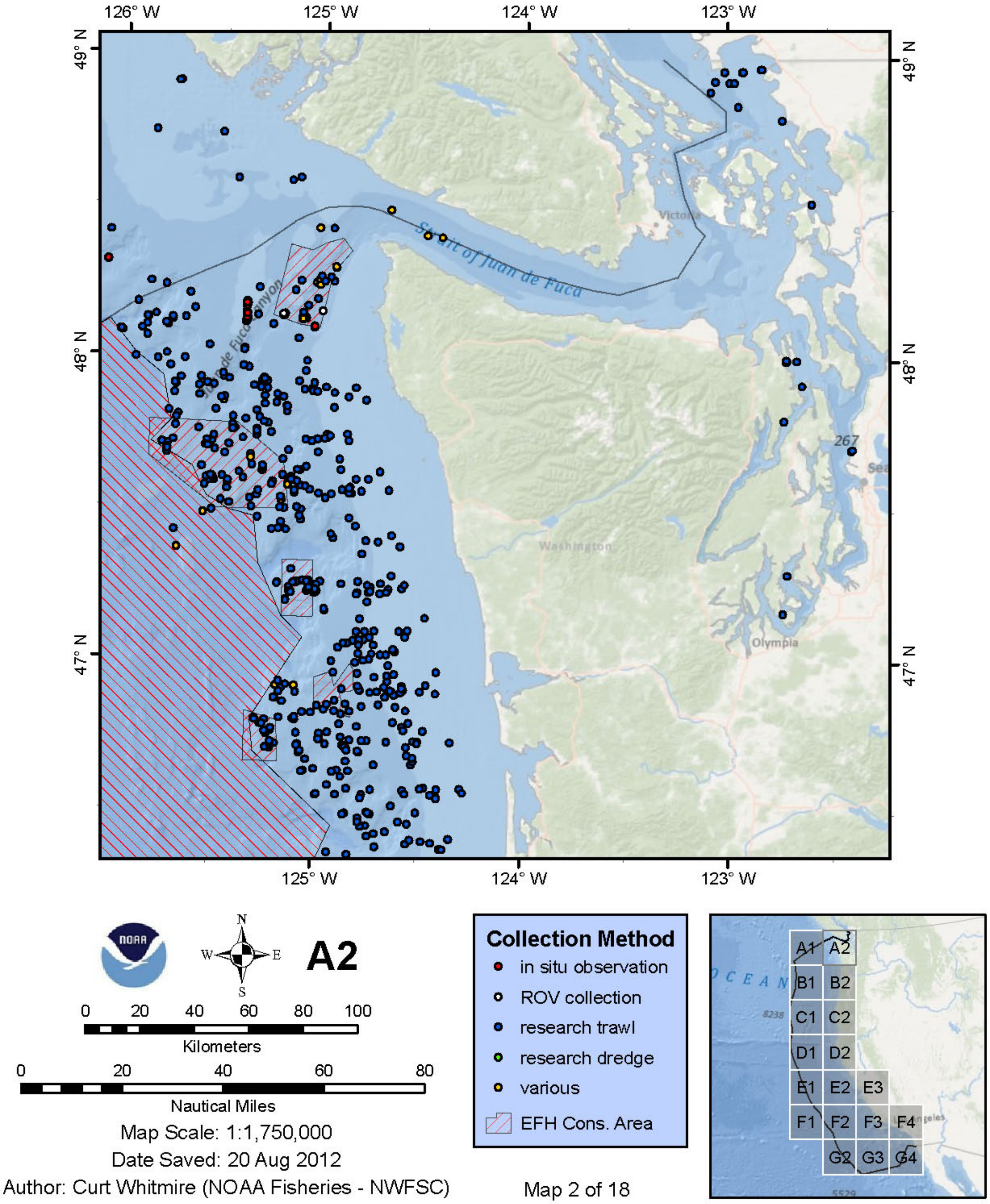
Pirtle, J.L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. M.S. Thesis. Washington State Univ. Vancouver.

Stocks, K. 2009. SeamountsOnline: an online information system for seamount biology. Version 2009-1. World Wide Web electronic publication. http://seamounts.sdsc.edu

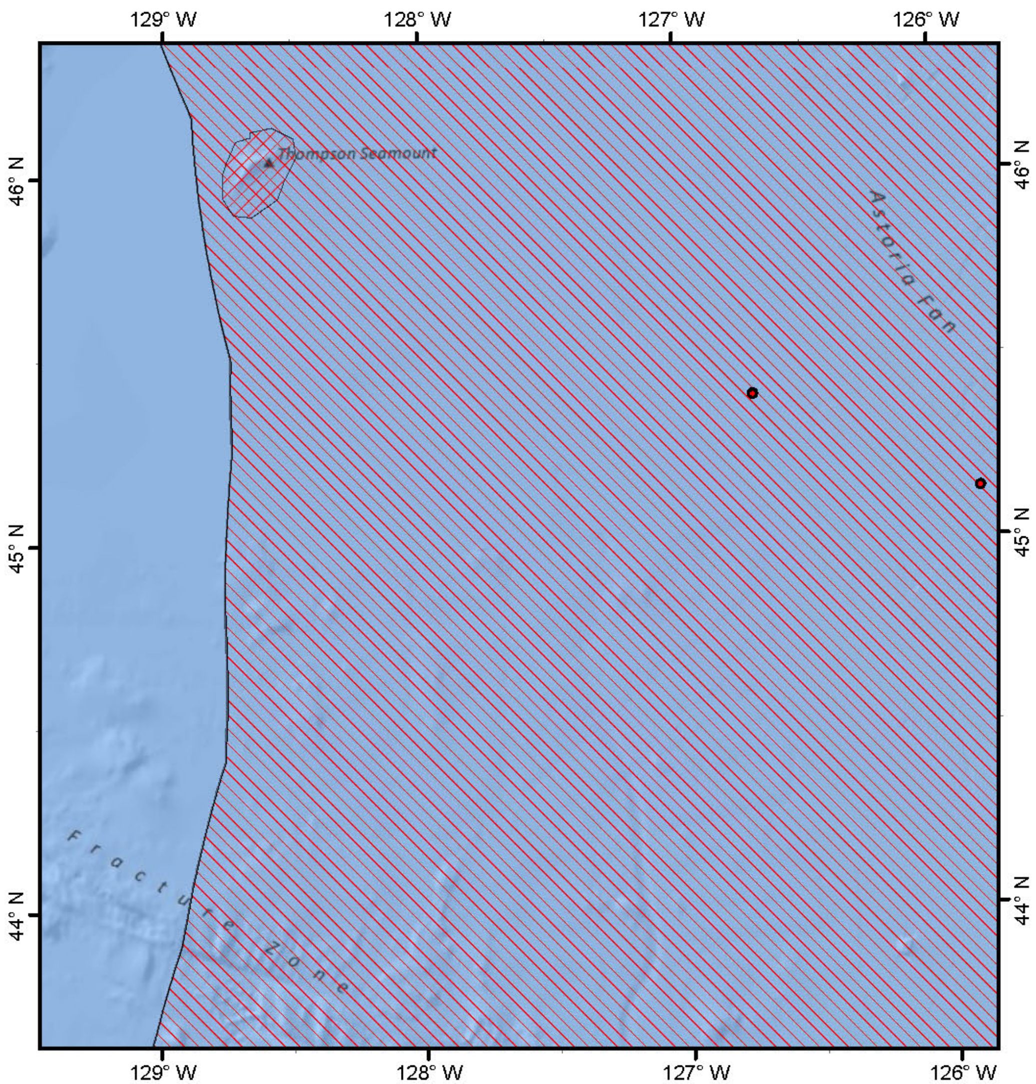
Whitmire, C.E. and Clarke, M.E. 2007. State of Deep Coral Ecosystems of the U.S. Pacific Coast: California to Washington. pp. 109-154. In: S.E. Lumsden, Hourigan T.F., Bruckner A.W. and Dorr G. (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum CRCP-3. Silver Spring MD. 365 pp.

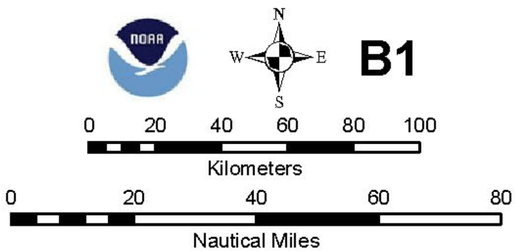

Selected Observations of Corals & Sponges
129° W
128° W
127° W
126° W
49° N
48° N
47° N
3057
eamount
Cascadia
Basin
2960
3070
A1
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
Collection Method
in situ observation
ROV collection
research trawl
research dredge
various
EFH Cons. Area
Map 1 of 18
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

Selected Observations of Corals & Sponges



Selected Observations of Corals & Sponges



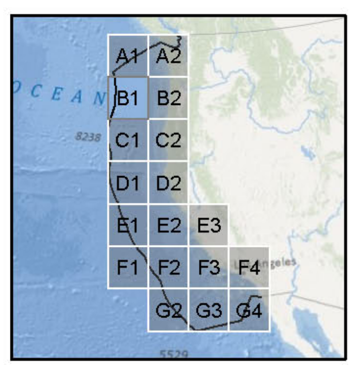


Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)

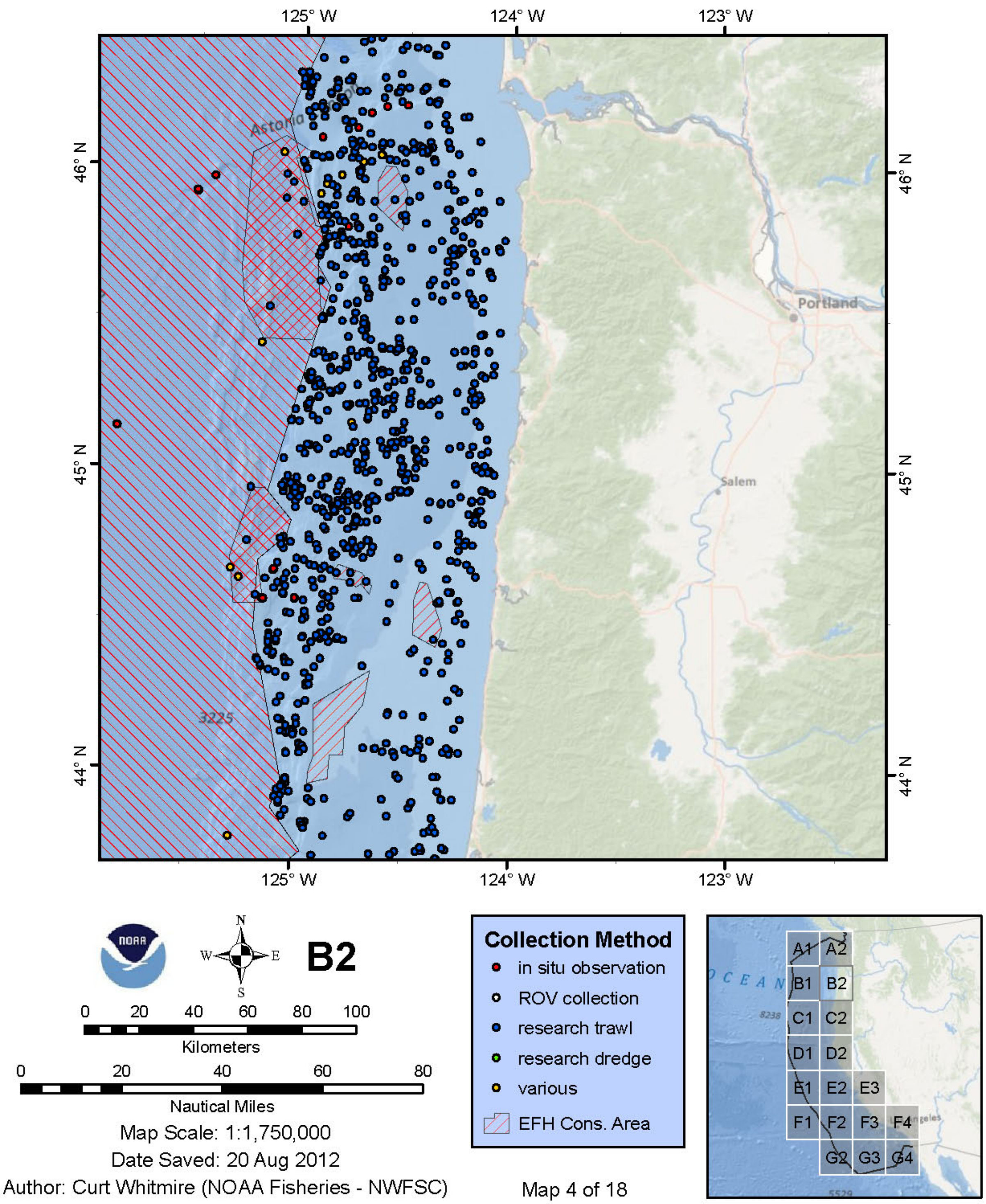
Collection Method

- in situ observation
- ROV collection
- research trawl
- research dredge
- various
- EFH Cons. Area

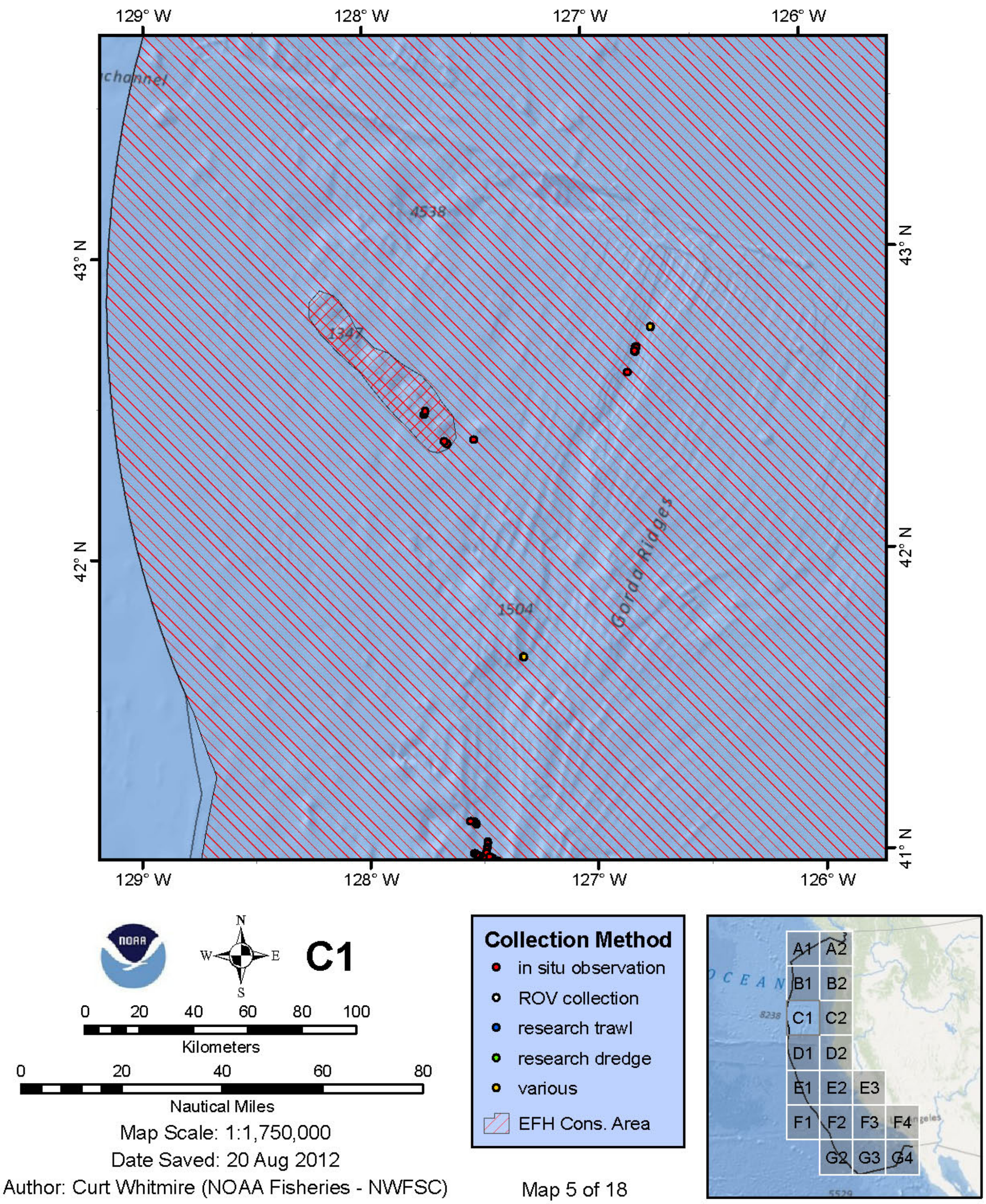
Map 3 of 18

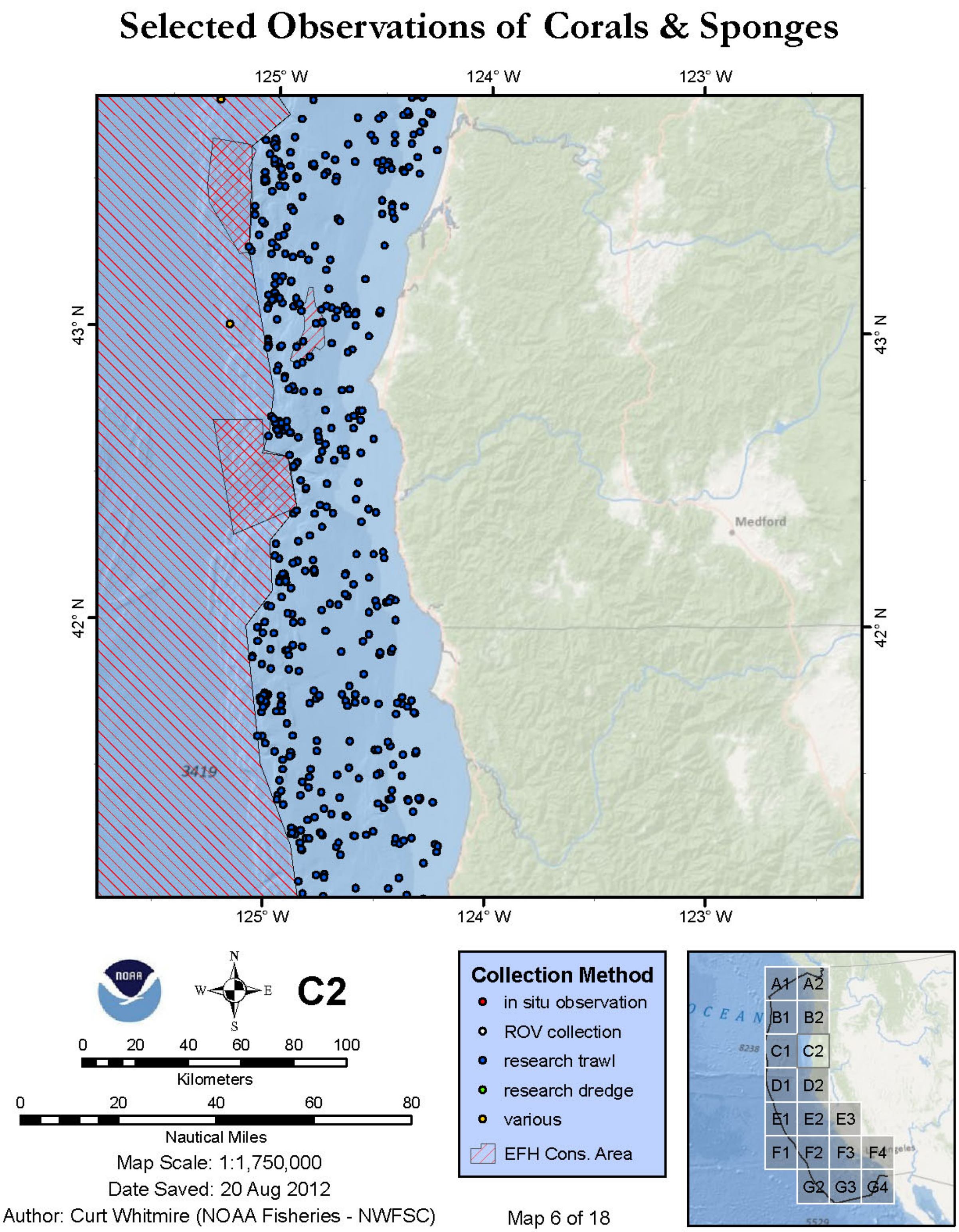


Selected Observations of Corals & Sponges

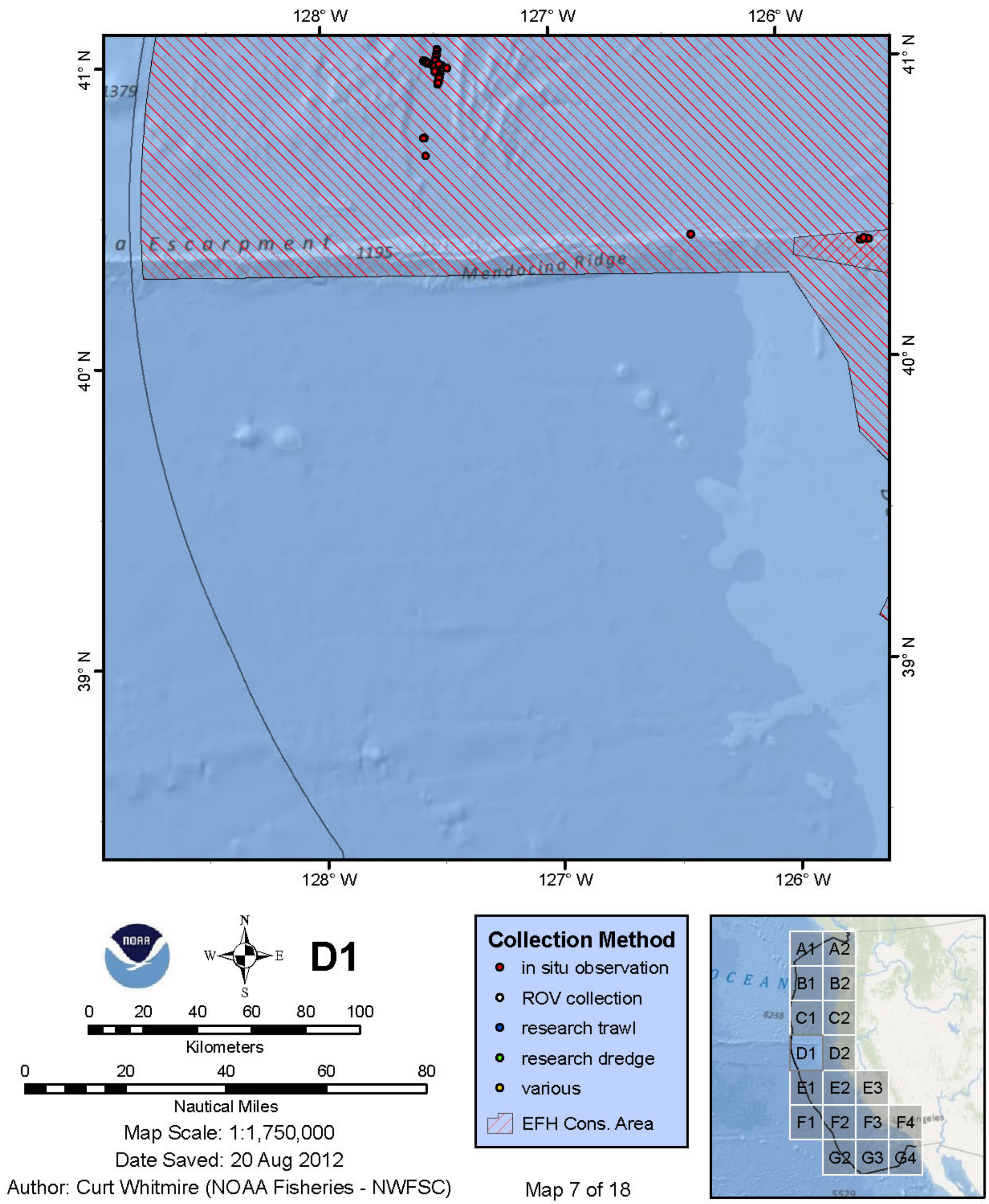


Selected Observations of Corals & Sponges

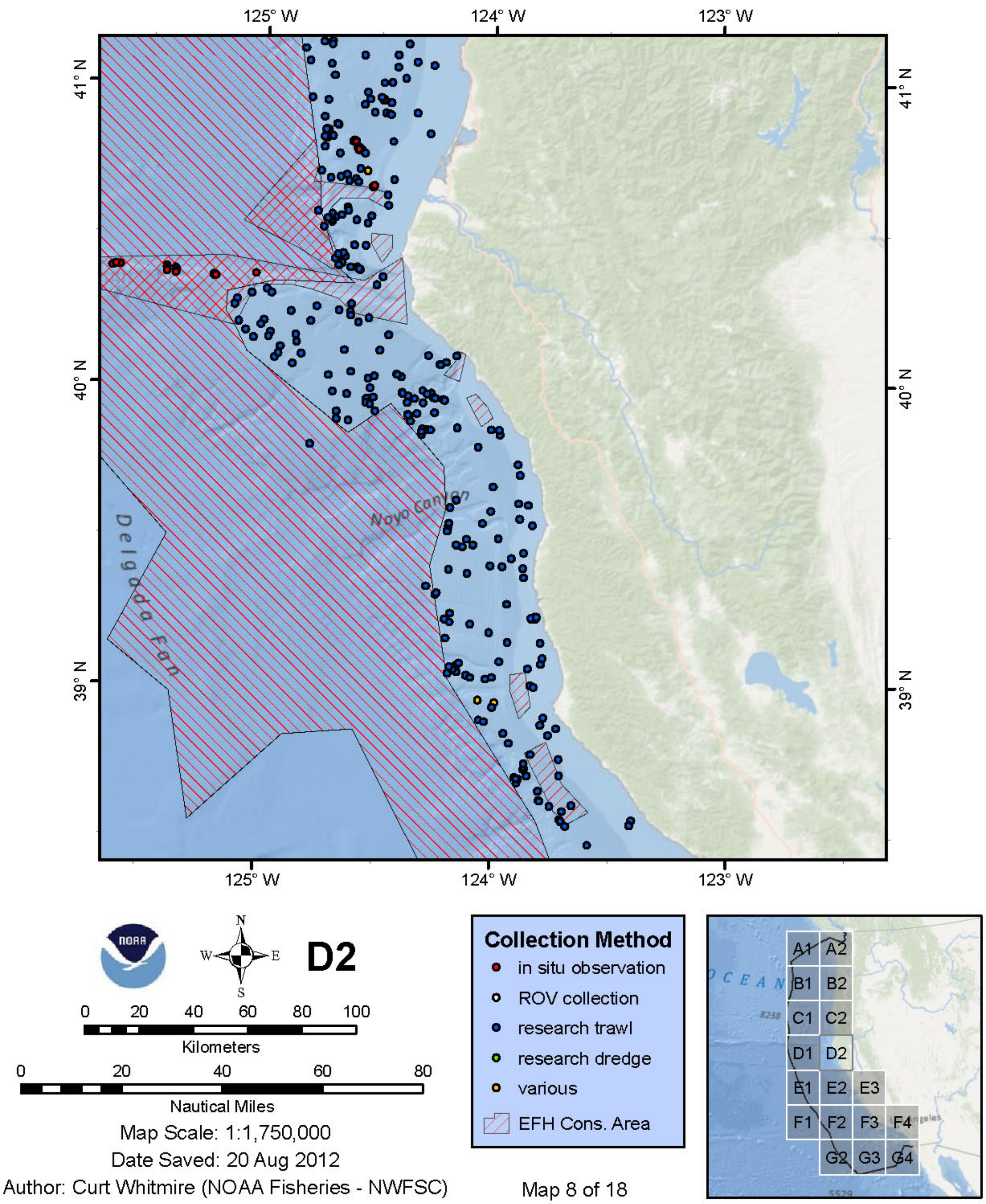



Selected Observations of Corals & Sponges
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
N
S
W
E
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
Collection Method
in situ observation
ROV collection
research trawl
research dredge
various
EFH Cons. Area
Map 6 of 18
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

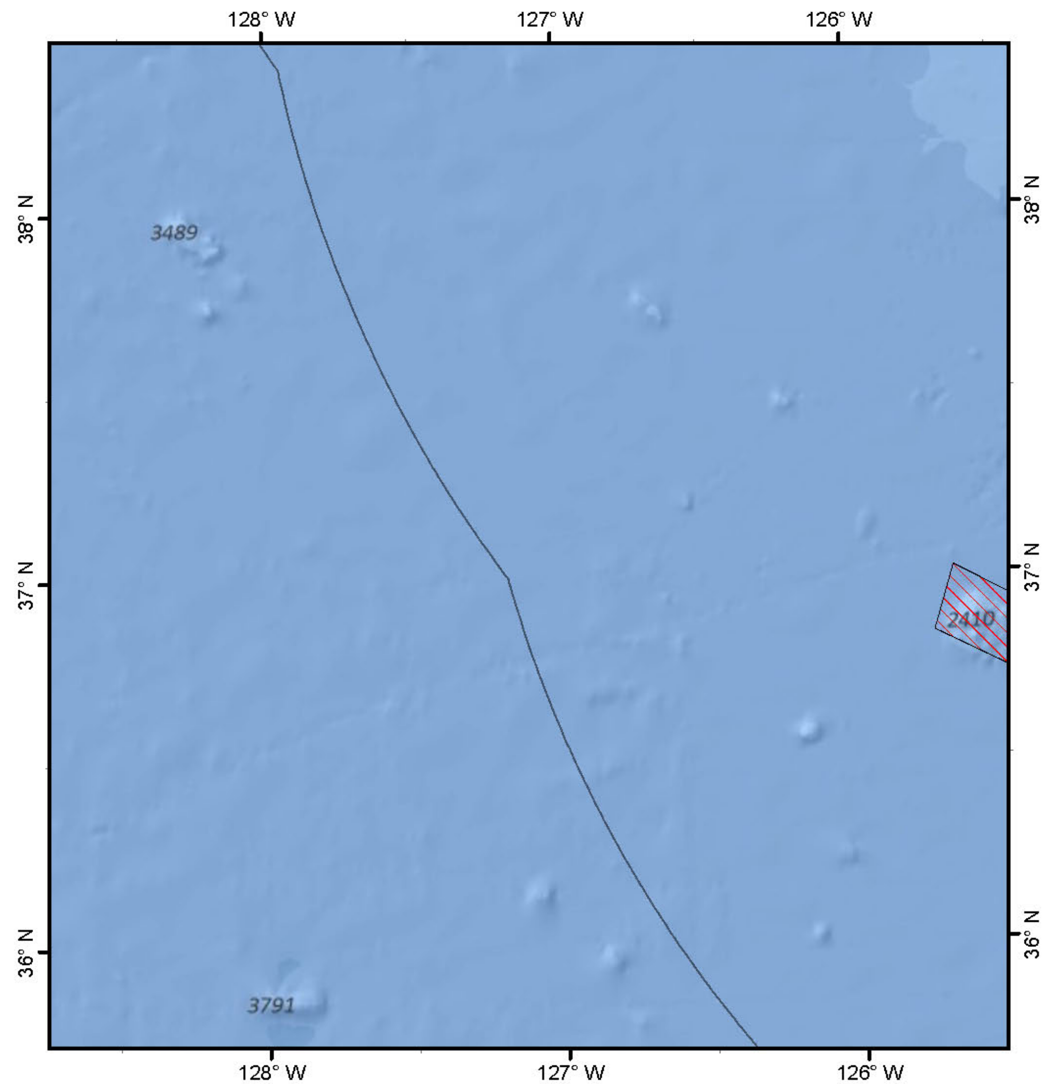
Selected Observations of Corals & Sponges



Selected Observations of Corals & Sponges



Selected Observations of Corals & Sponges



E1

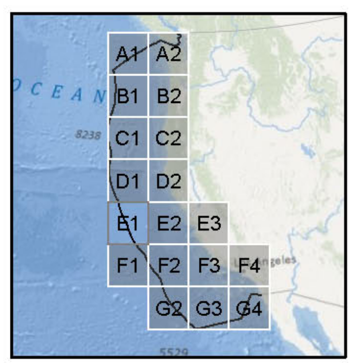
0 20 40 60 80 100
Kilometers

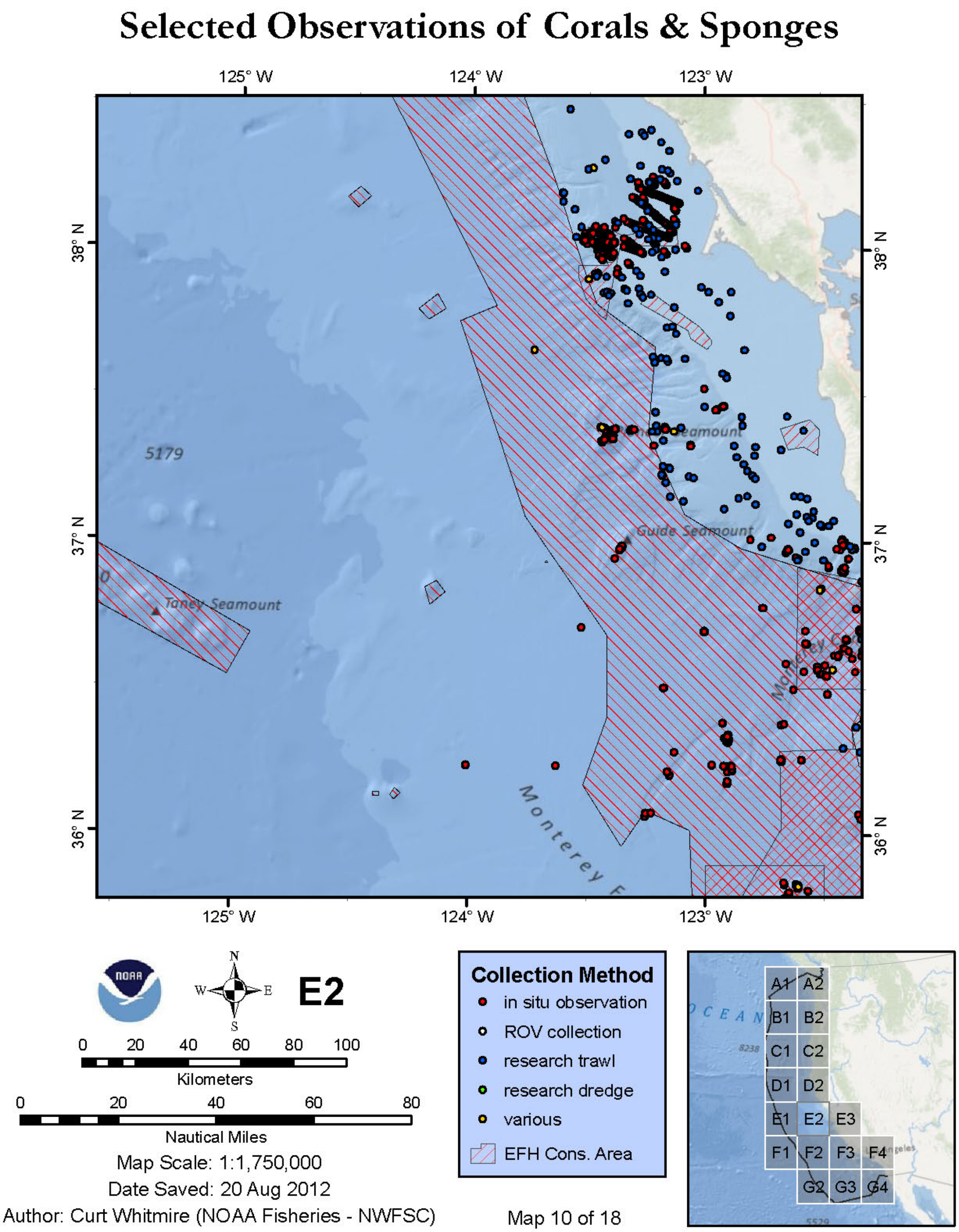
0 20 40 60 80
Nautical Miles

Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)

Collection Method
- in situ observation
- ROV collection
- research trawl
- research dredge
- various
- EFH Cons. Area

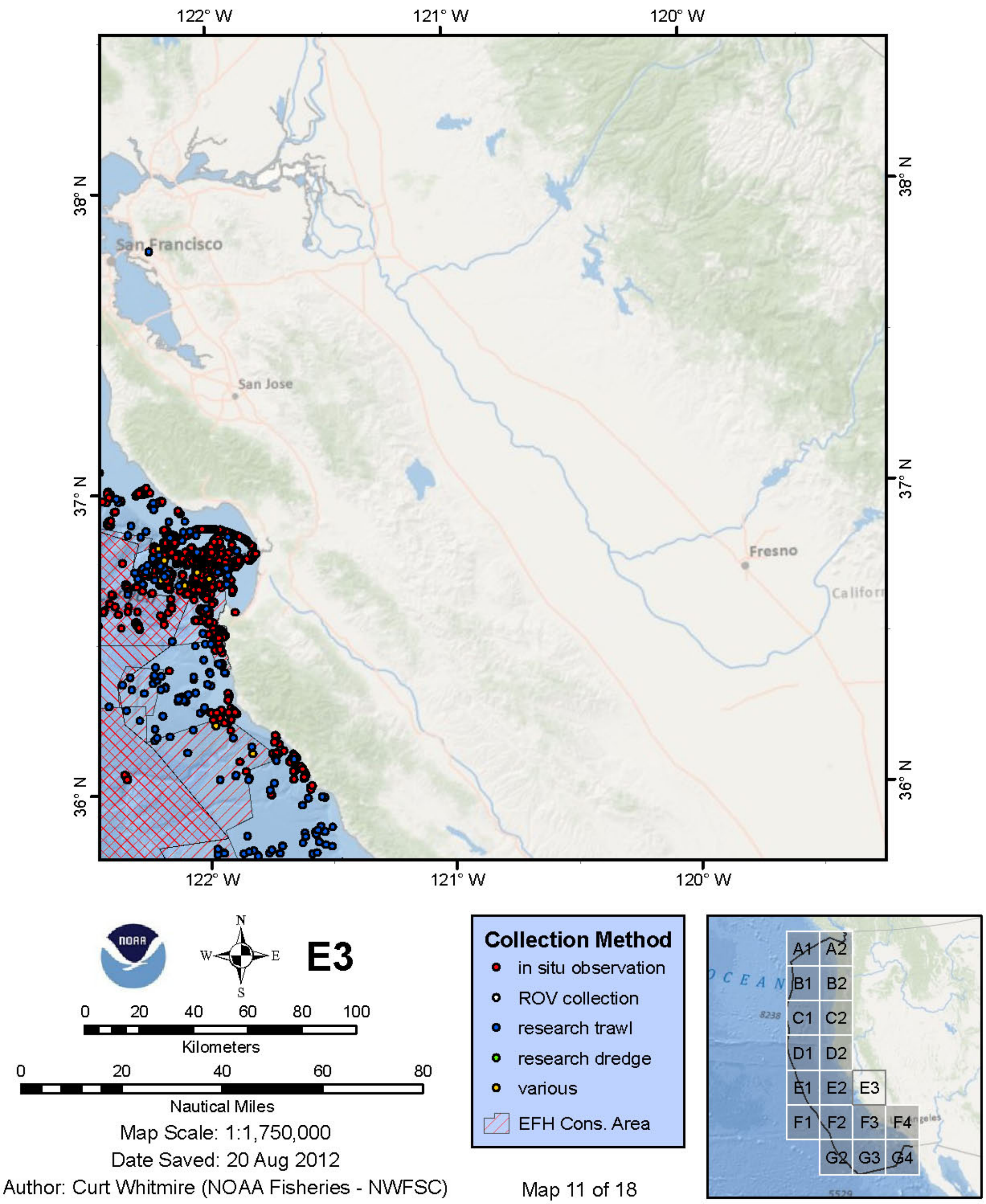
Map 9 of 18



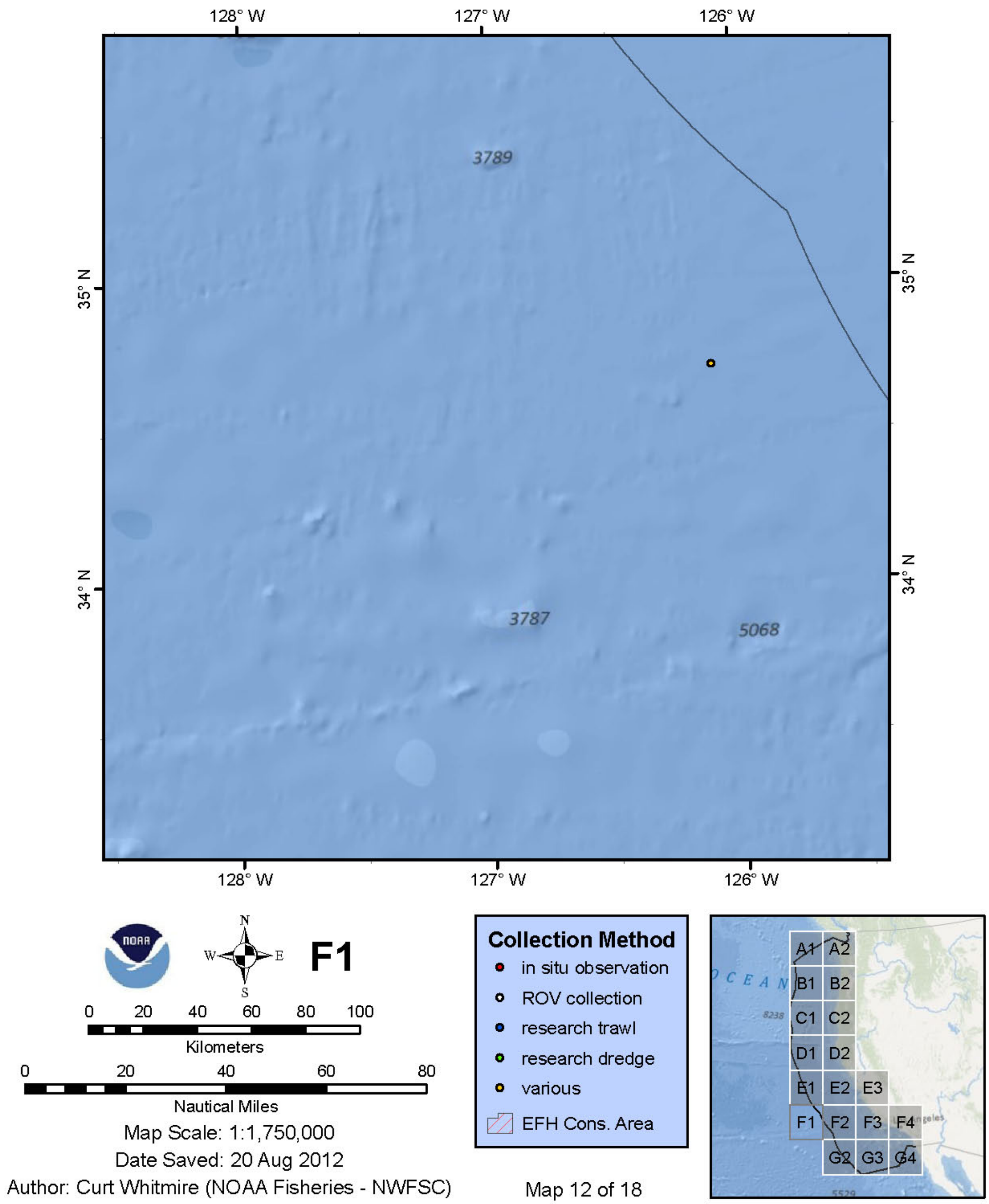


Selected Observations of Corals & Sponges
125° W
124° W
123° W
38° N
37° N
36° N
5179
Taney Seamount
Guide Seamount
Monterey
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
Collection Method
in situ observation
ROV collection
research trawl
research dredge
various
EFH Cons. Area
Map 10 of 18
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

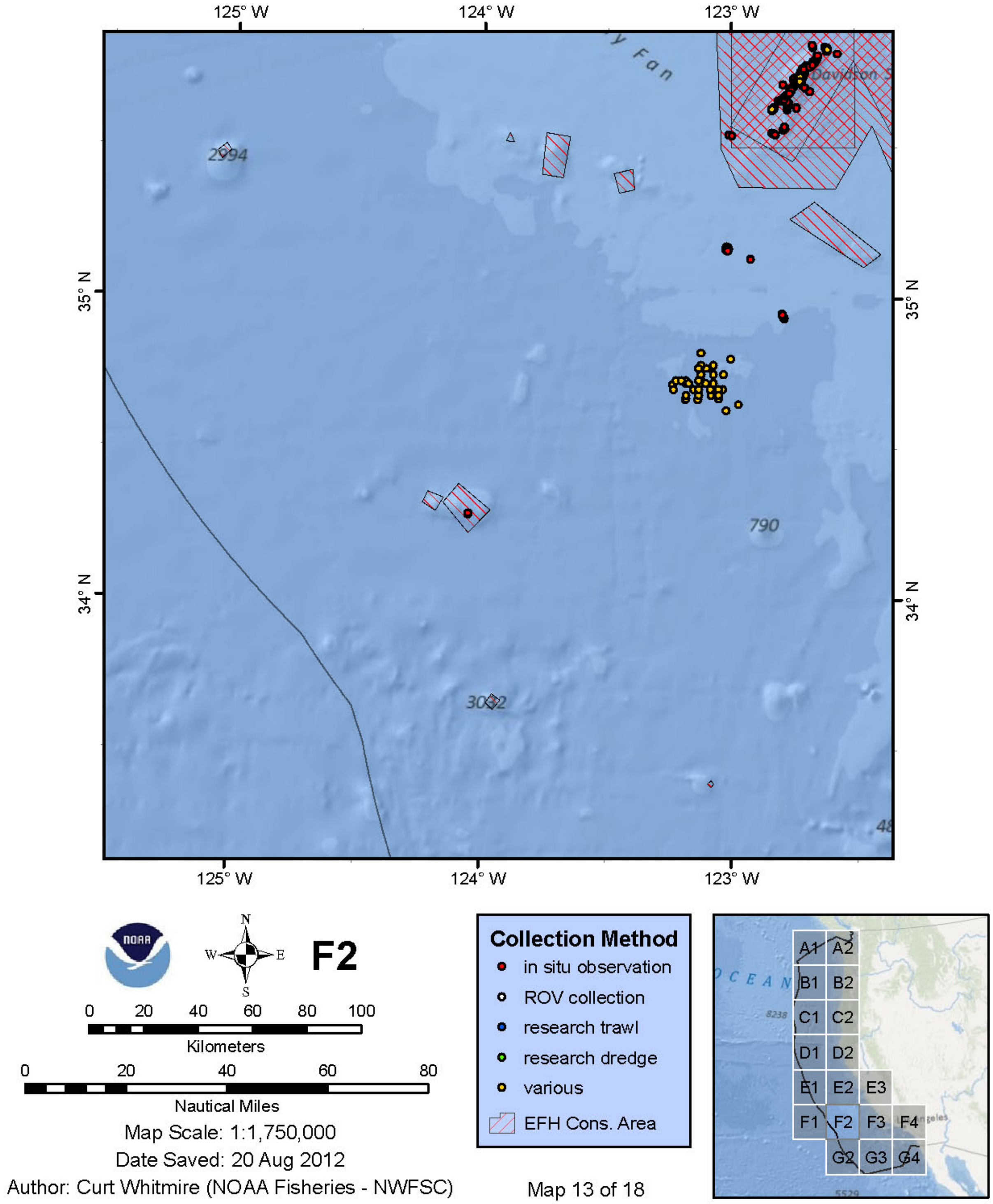
Selected Observations of Corals & Sponges

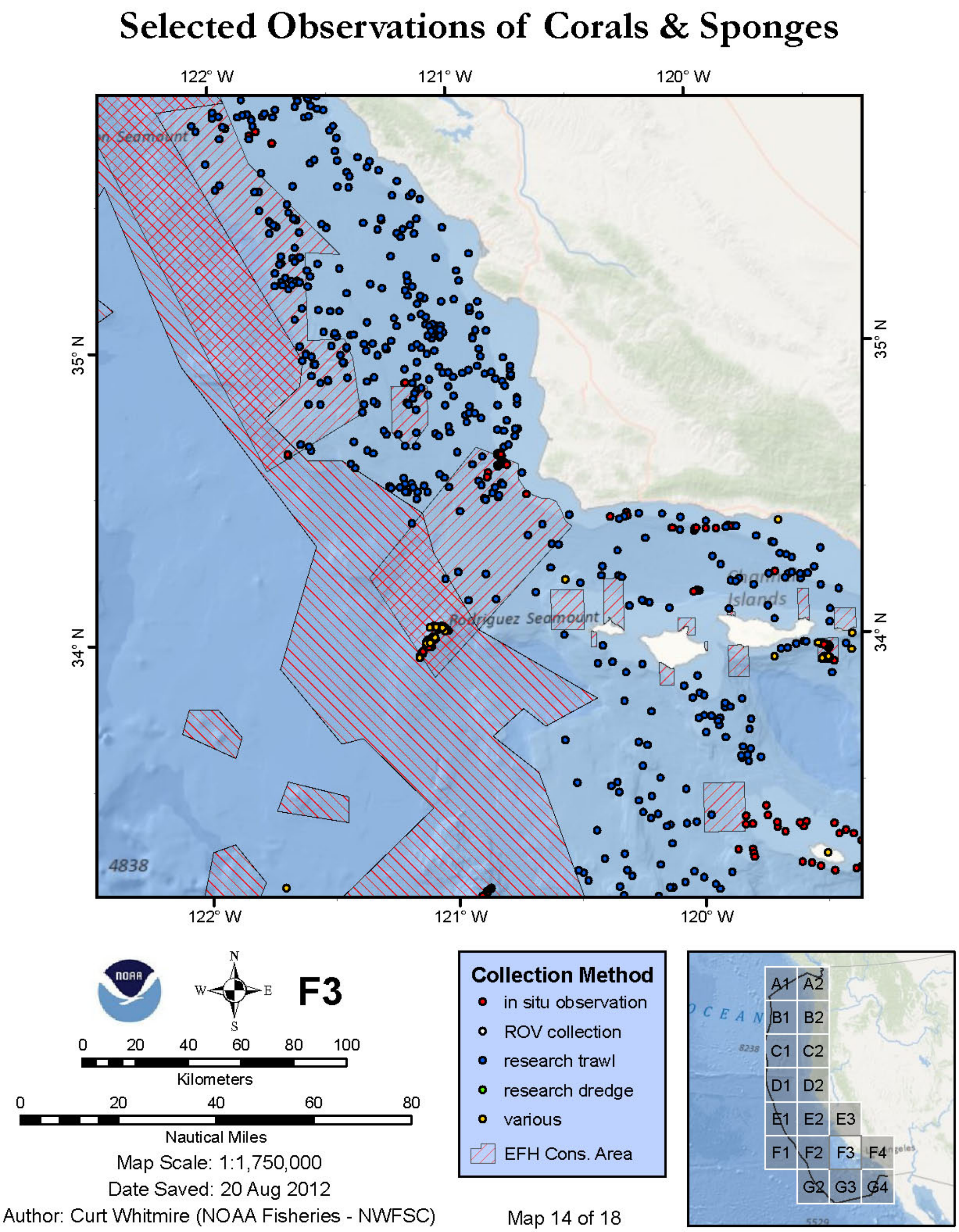


Selected Observations of Corals & Sponges

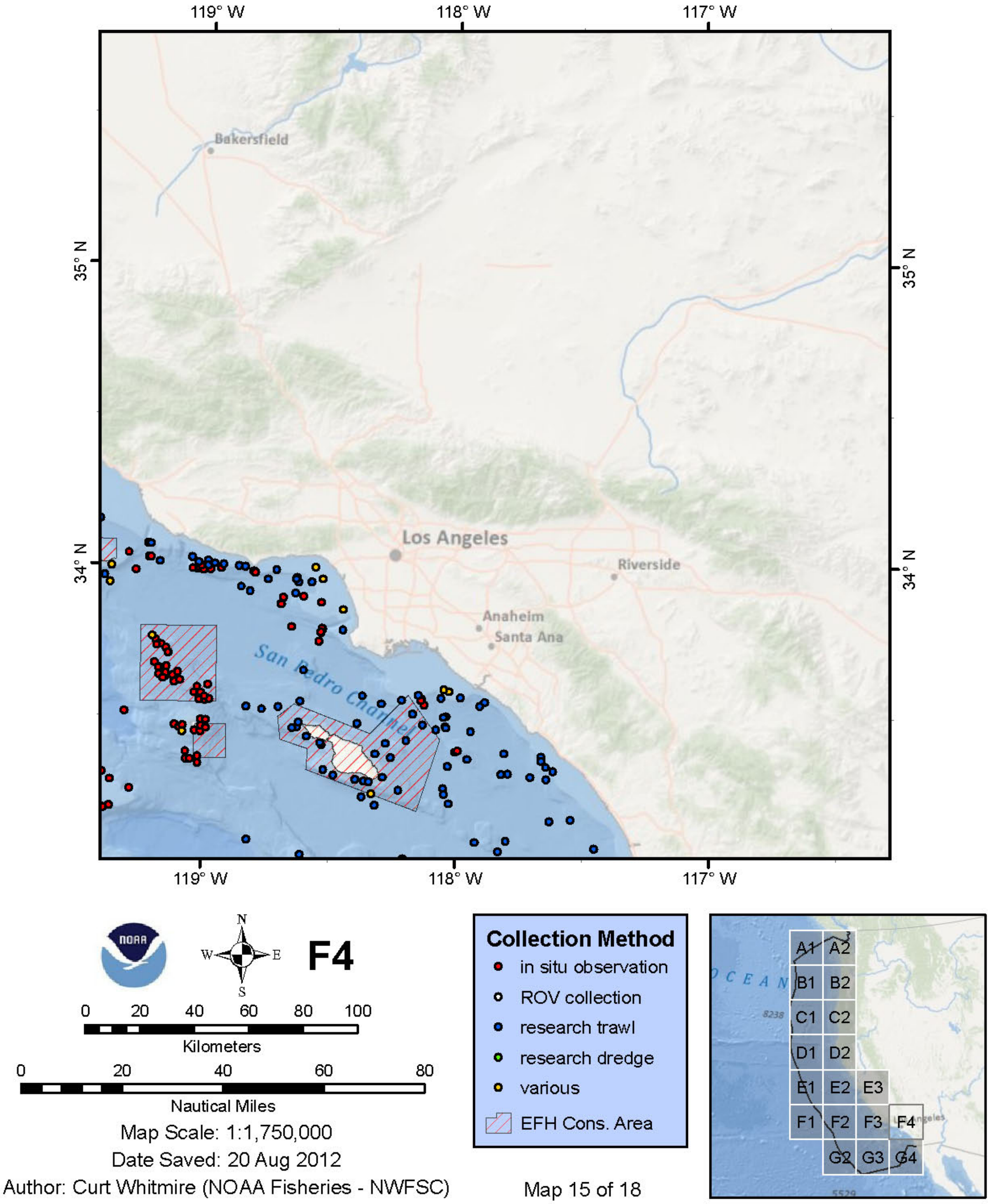


Selected Observations of Corals & Sponges

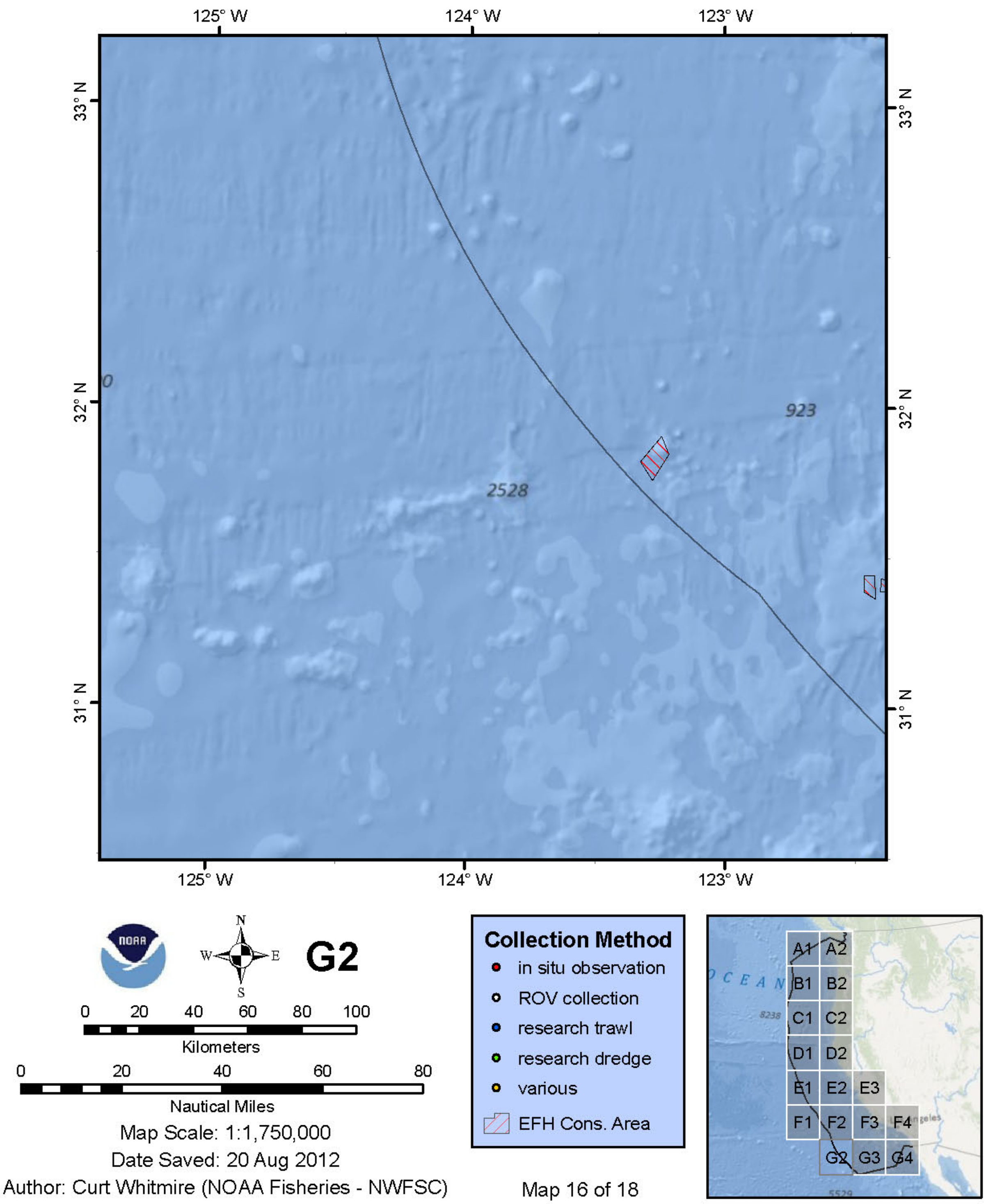



Selected Observations of Corals & Sponges
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
Channel Islands
4838
F3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
Collection Method
in situ observation
ROV collection
research trawl
research dredge
various
EFH Cons. Area
Map 14 of 18
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

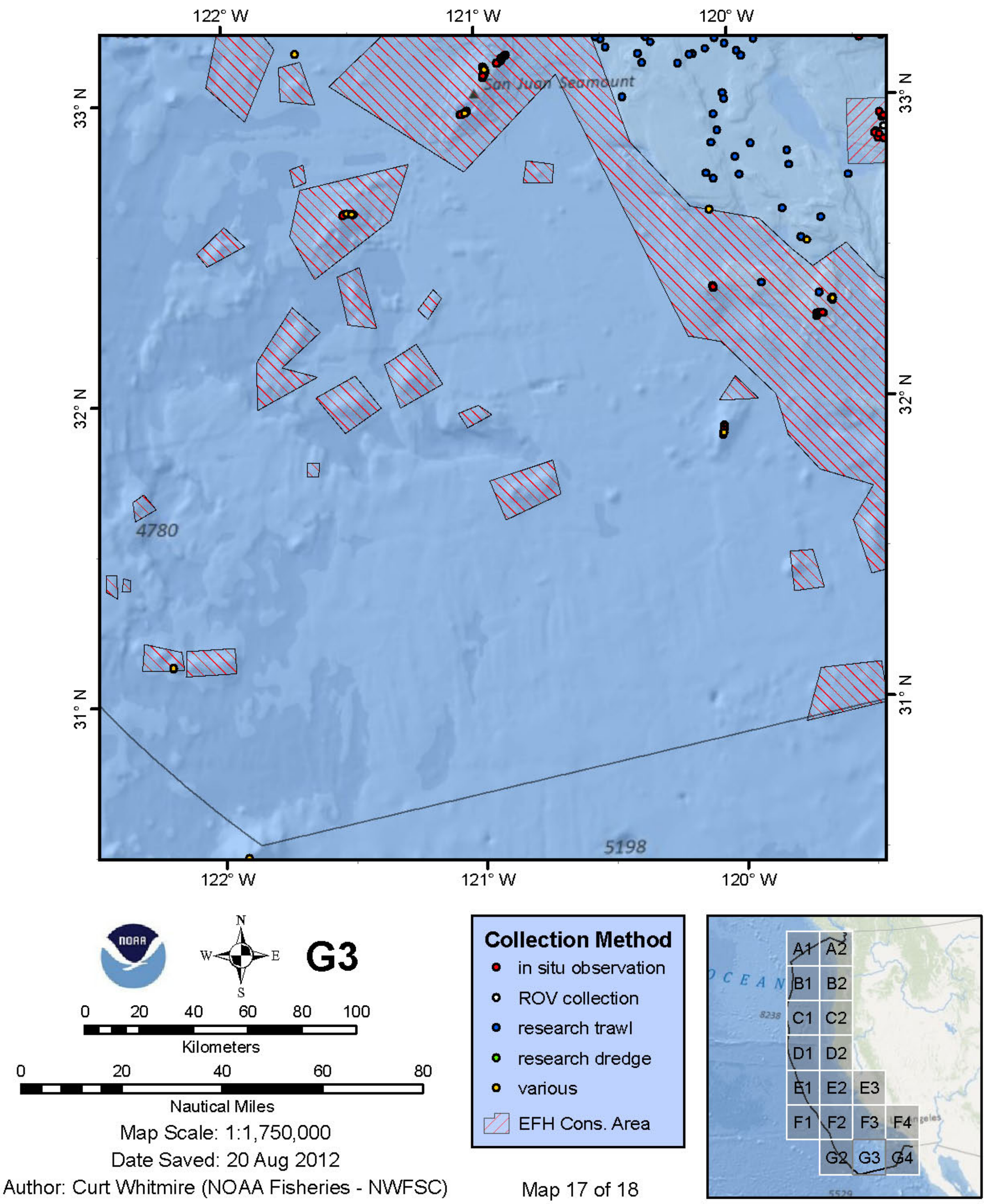
Selected Observations of Corals & Sponges

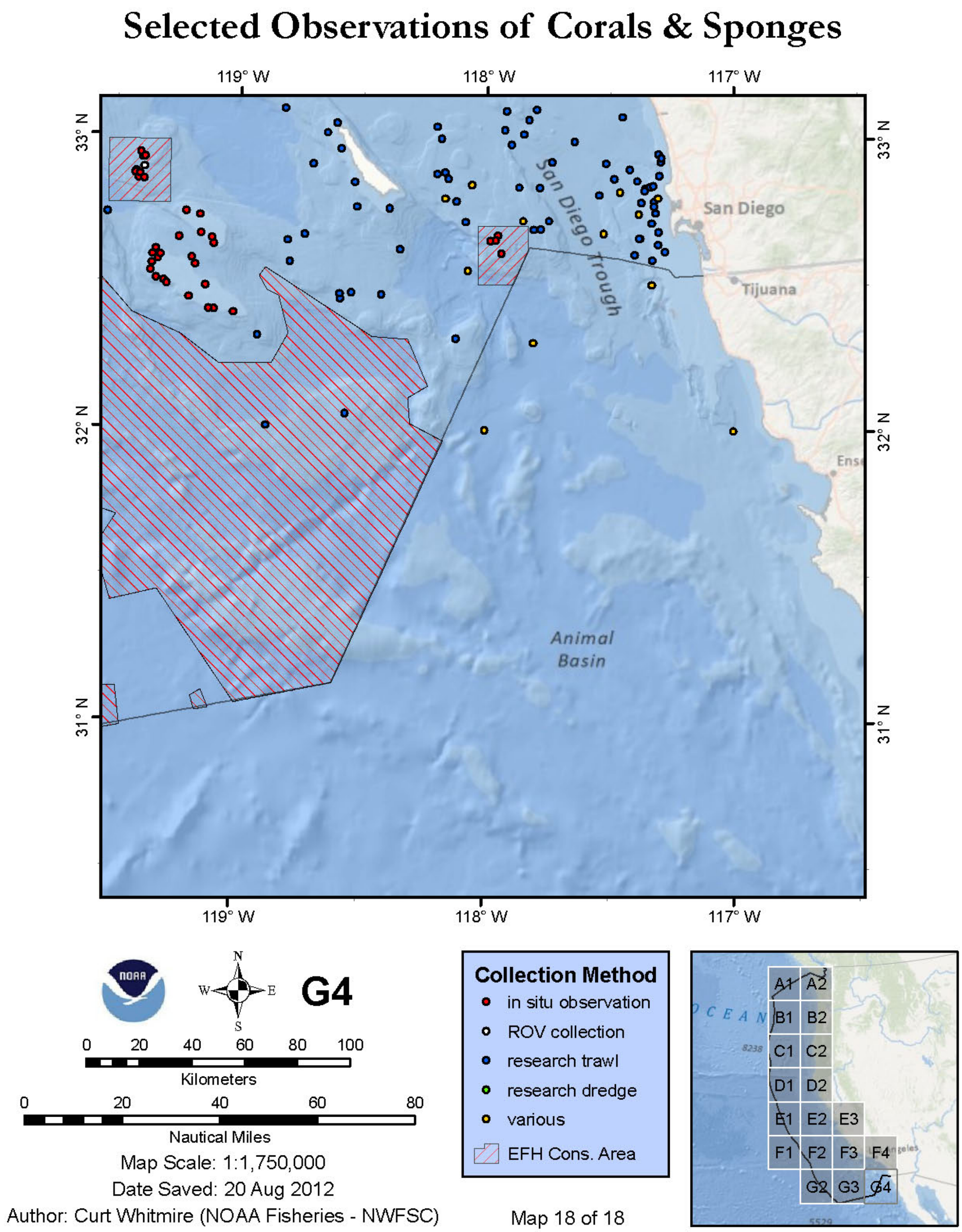


Selected Observations of Corals & Sponges



Selected Observations of Corals & Sponges




Selected Observations of Corals & Sponges
119° W
118° W
117° W
33° N
32° N
31° N
San Diego Trough
San Diego
Tijuana
Animal Basin
G4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:1,750,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
Collection Method
in situ observation
ROV collection
research trawl
research dredge
various
EFH Cons. Area
Map 18 of 18
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4

APPENDIX E DISTRIBUTION OF CORALS AND SPONGES FROM STANDARDIZED CATCH IN THE NMFS WEST COAST GROUNDFISH BOTTOM TRAWL SURVEY CONDUCTED BEFORE AND AFTER THE 2006 EFH REVIEW

Appendix E plates depict the spatial distribution of standardized survey catch of corals and sponges within two time periods: "Before" (2003-05 survey cycles) and "After" (2006-10 survey cycles) implementation of Amendment 19 regulations. The sole data source for the map layers is catch records from the WCGBTS. Since 2003, the WCGBTS has been a combined survey of demersal species residing in both continental shelf (i.e., 30-100 fm) and slope (i.e., 100-700 fm) habitats. Each year, the WCBGTS sampled about 750 stations during two passes (May-July, August-October) operating north to south from the Canadian to Mexican maritime borders. Tow durations were targeted at 15 minutes, with a mean tow distance of 1.4 km. Invertebrates in the catch were sorted, weighed and identified down to the lowest possible taxonomic level. Consequently, taxonomic resolution was dependent upon the expertise of onboard biologists. A full description of the survey design and protocols can be found in past cruise reports at: http://www.nwfsc.noaa.gov/research/divisions/fram/index.cfm.

Standardized catch was defined as the total weight of organisms (kg) per linear distance towed (km) witin a standard area and calculated for four taxonomic groupings of organisms: 1) corals (excluding sea pens and sea whips) and sponges, 2) corals (excluding sea pens and sea whips), 3) sponges, and 4) sea pens and seas whips (Appendix E-1 to E-4). The numerator (catch) was calculated using a kernel density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California). The kernel density algorithm distributes catch over a surface that is defined by a user-specified distance from the line, where the catch is highest on the line and dimishes proportionally with distance from the line. Each kernel surface encompasses the toal catch value for a given tow. The denominator (effort) was calculated using a line density algorithm that sums the total portions of lines intersecting a circular search area. Both density values are assigned to grid cells of user-specified dimensions. Cells with values greater than zero indicate areas of positive catch, while cells of zero value indicate areas where effort occurred but no corals and/or sponges were present in the catch. The density parameters used for calculating both catch and effort were a 6-km search radius and a 500x500 m cell size. By standardizing catch by effort, the resulting catch outputs were standardized over both space and time. Since density outputs are highly sensitive to the specified radius and cell size, the absolute values are less important than the relative nature of them. The benefit of this output over depicting towlines themselves is that the density output better identifies areas where catch is concentrated.

In order to evaluate how fishing effort has changed between the two time periods, the color ramps for the intensity layers are scaled to the same range of values in each panel (see Appendix E figures). Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. White areas repreent those where no catch occurred but where effort still existed. The value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

In the maps showing standardized catch of corals excluding sea pens/whips (Appendix E-2), areas of highest relative CPUE occurred off northern California in both time periods. Two areas off northern Washington show moderate CPUE, one within the Olympic 2 EFH conservation area in the recent time period (Figure 12).

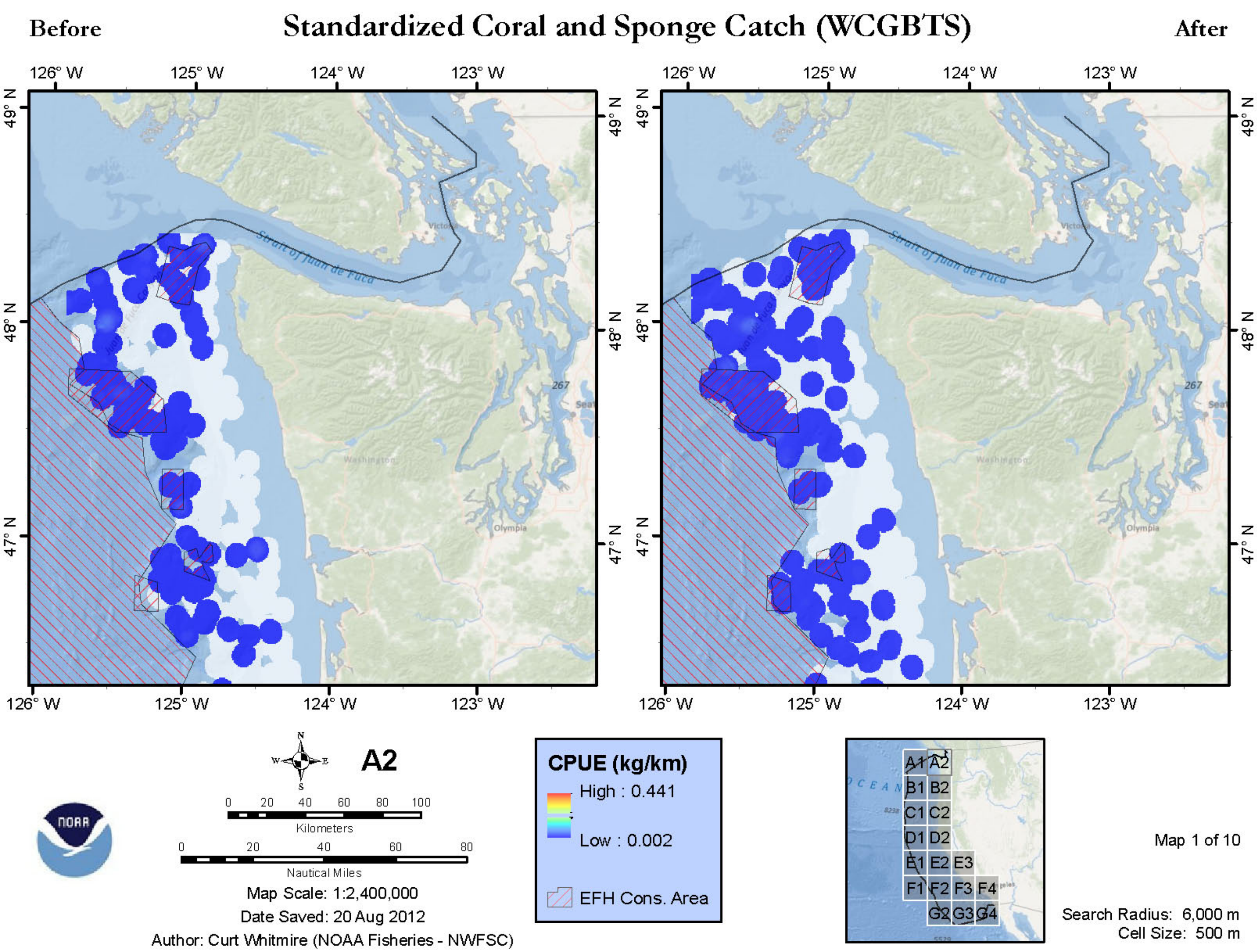
In the maps showing sponges only (Appendix E-3), the areas of highest relative CPUE occurred off southern California, two sites in the before period and one in the after (Plate F3). The one area of highest

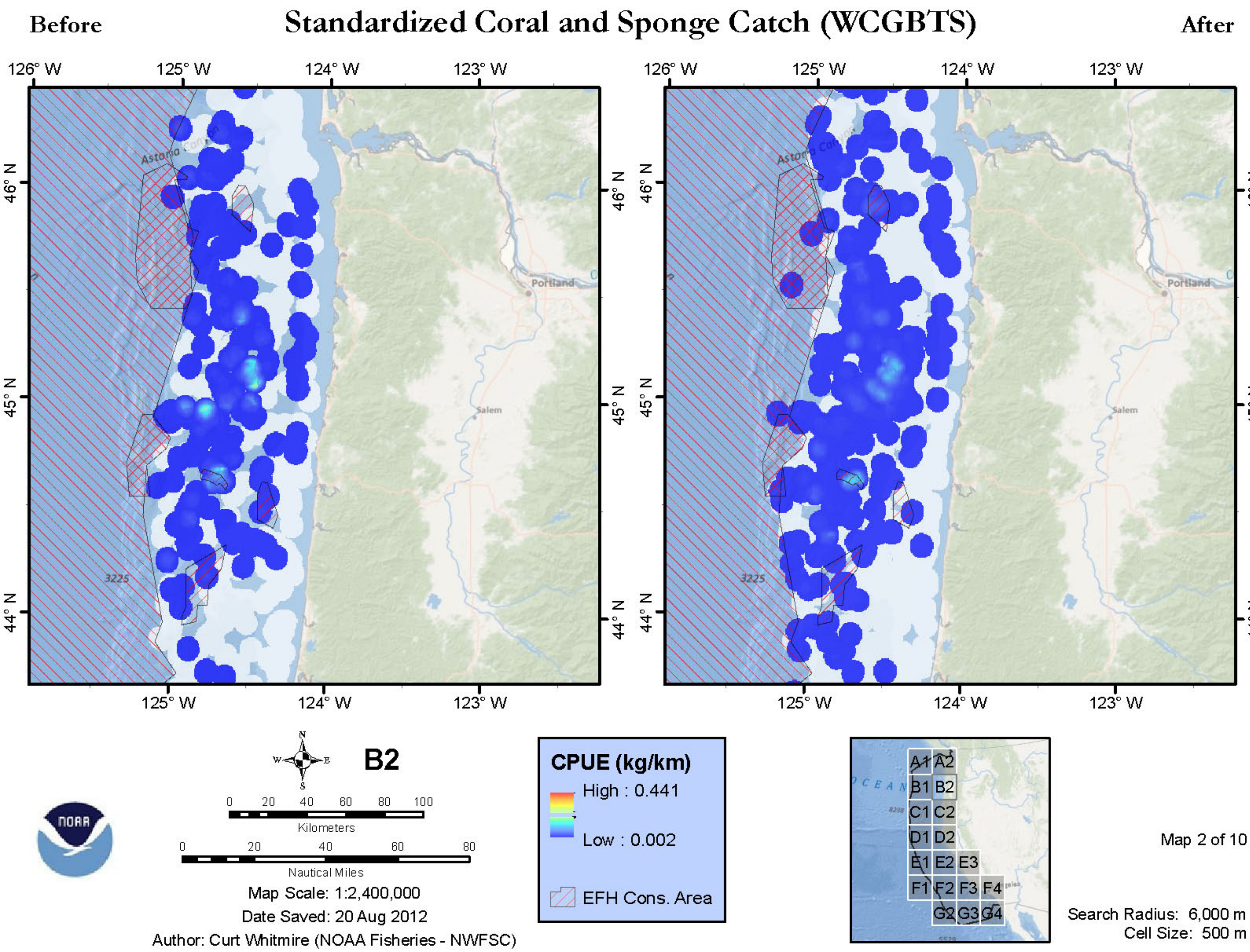
CPUE in the recent time period also showed relative moderate catches of sponges in the before period. Other areas of moderate catch of sponges occurred near the Eel River Canyon (Plate D2, before) and off central Oregon in both time periods (Plate B2).

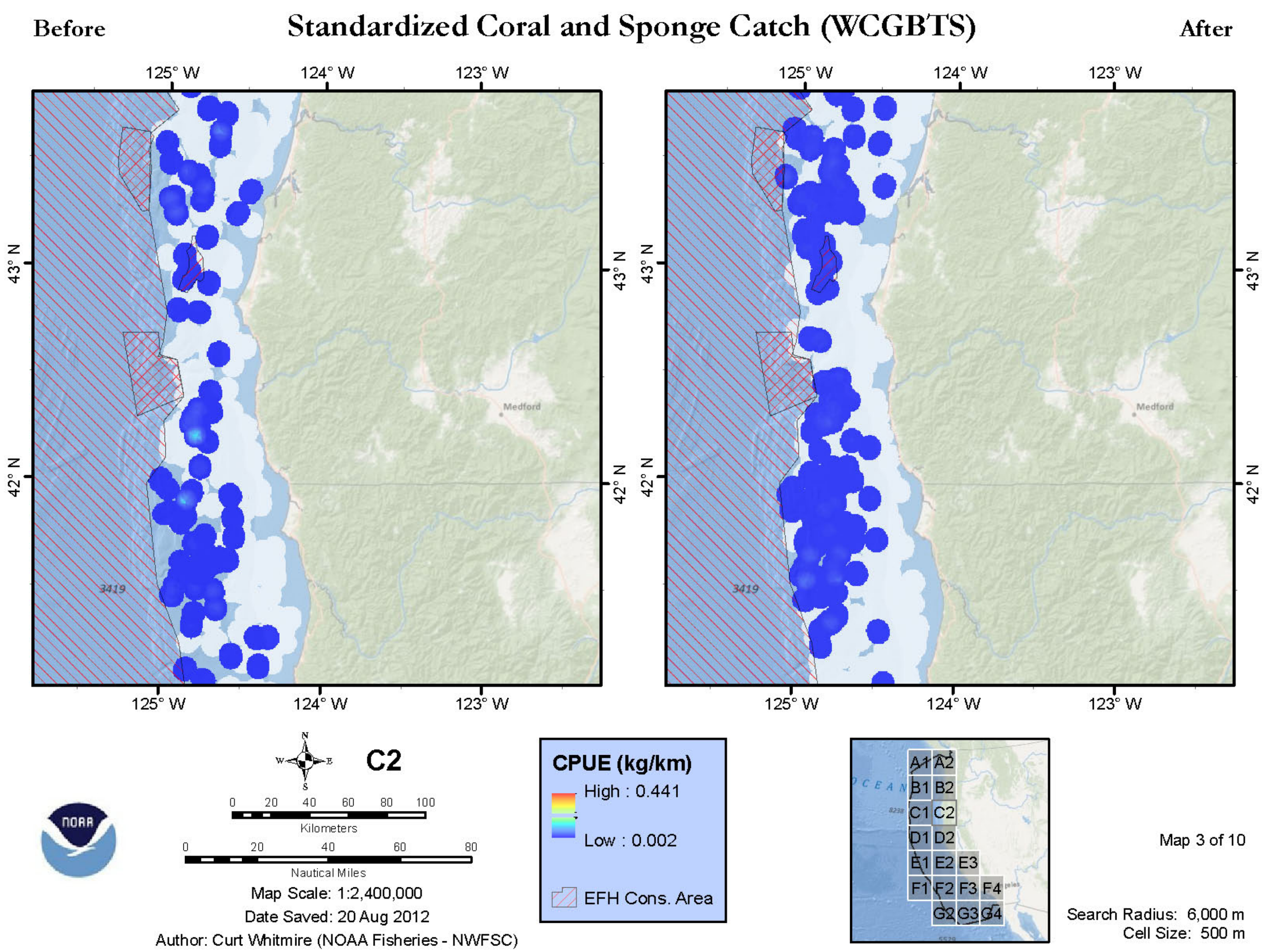
Areas of highest CPUE for sea pens/whips (Appendix E-4) occurred off northern and central Oregon (Plate B-2) and central California (Plate F3). Other areas of moderate CPUE are apparent off San Francisco in the recent time period (Plate E2) and central (Plate F3) and southern California (Plates F4 and F5).

One important consideration when evaluating catch records of invertebrates from trawl surveys is the sampling gear itself. Bottom trawl gear used in the WCGBTS is not designed to sample sessile invertebrates, nor is it designed to access many of the preferred habitats for coral and sponge settlement or habitats known to support corals and sponges. Regardless of the limitations of the gear, corals or sponges were recorded in almost half of all survey tows. The average length of survey tows is much shorter in duration than commercial tows, and vessel captains can often prosecute a tow in areas where they normally would not during commercial operations. This may in part account for the fact that corals and sponges are recorded more frequently in survey catches (see Section 3.2.2.3, Table 5).

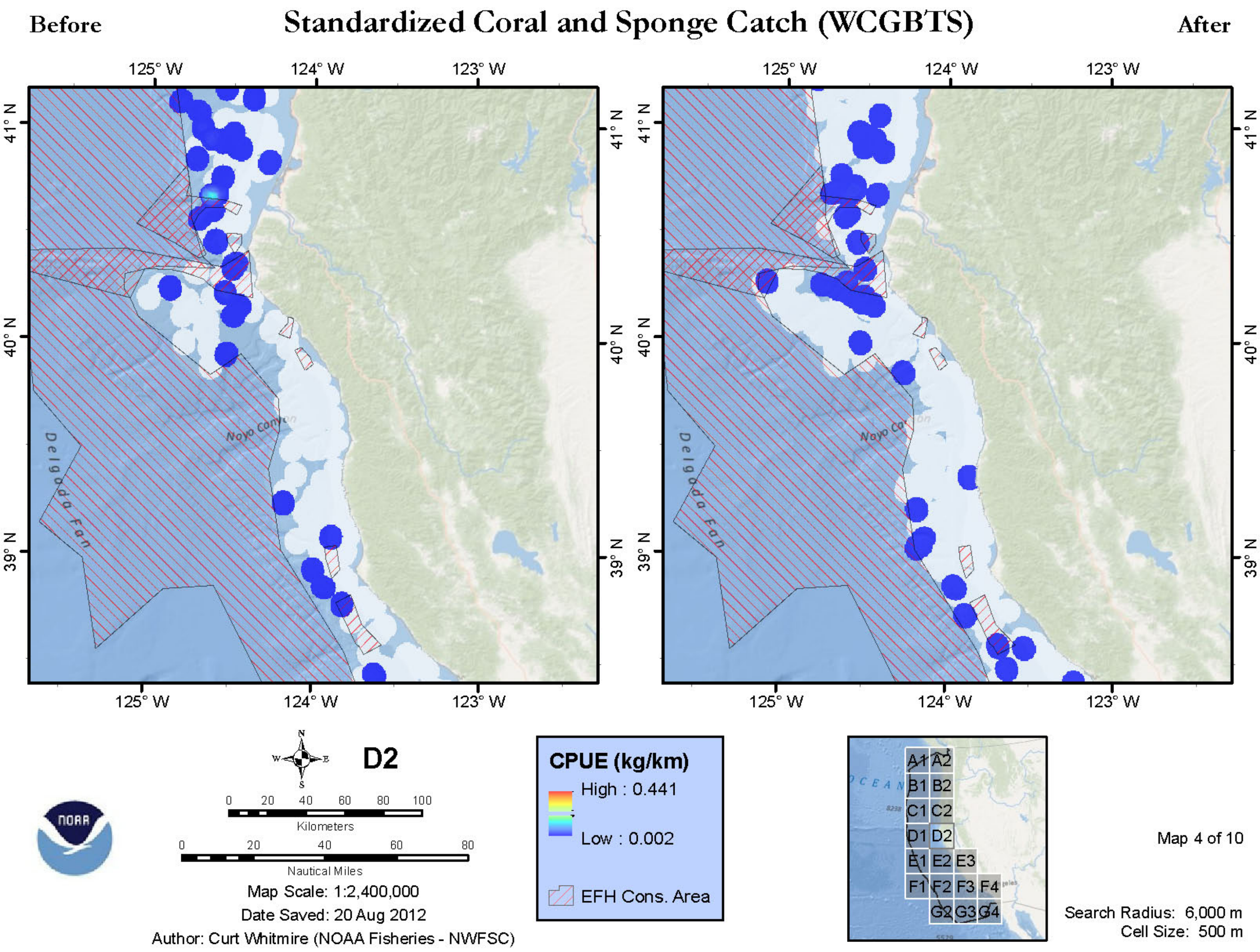
To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/.


Before
Standardized Coral and Sponge Catch (WCGBTS)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
Victoria
Washington
Olympia
267
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 10
Search Radius: 6,000 m
Cell Size: 500 m

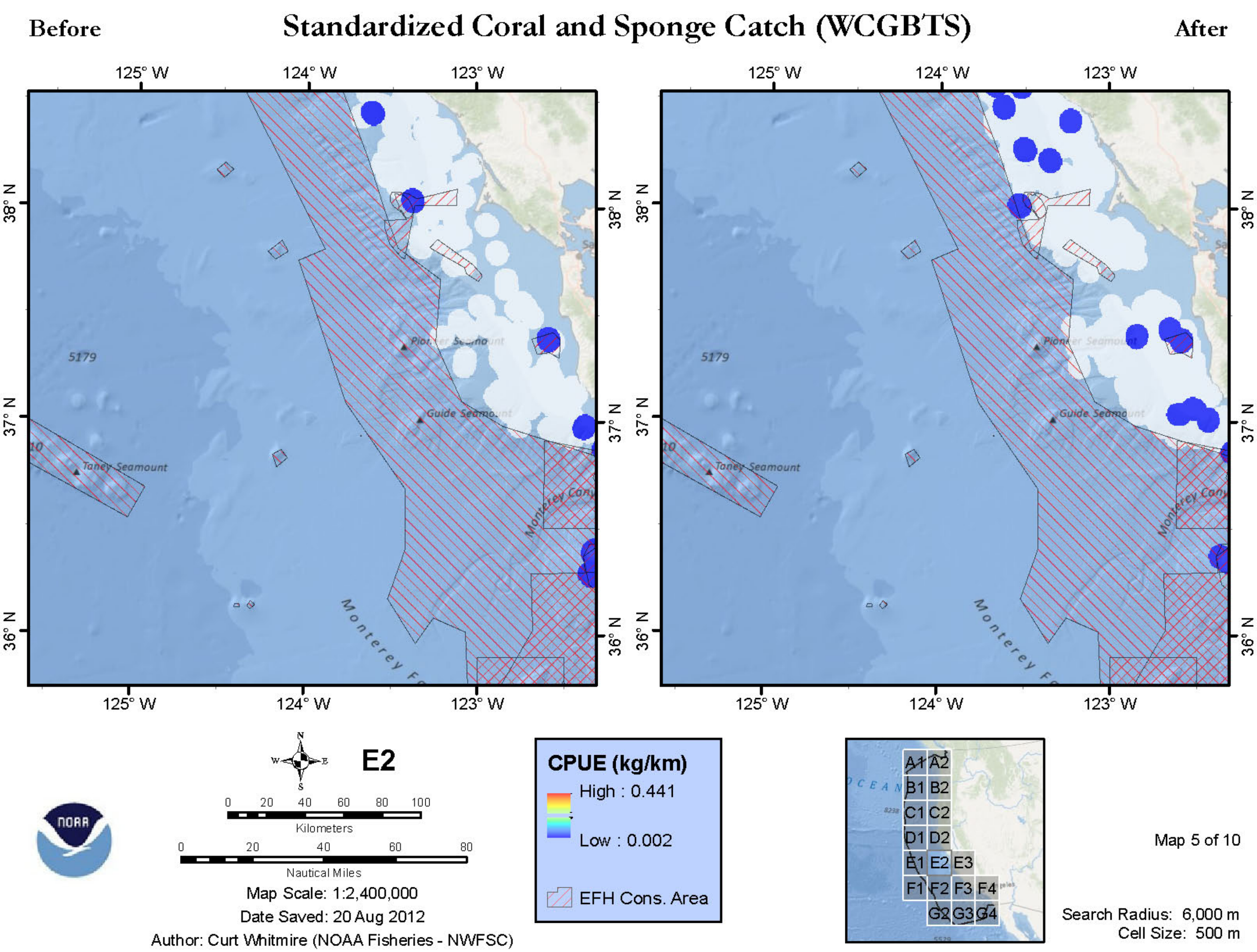

Before
Standardized Coral and Sponge Catch (WCGBTS)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria
Portland
Salem
3225
B2
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 10
Search Radius: 6,000 m
Cell Size: 500 m

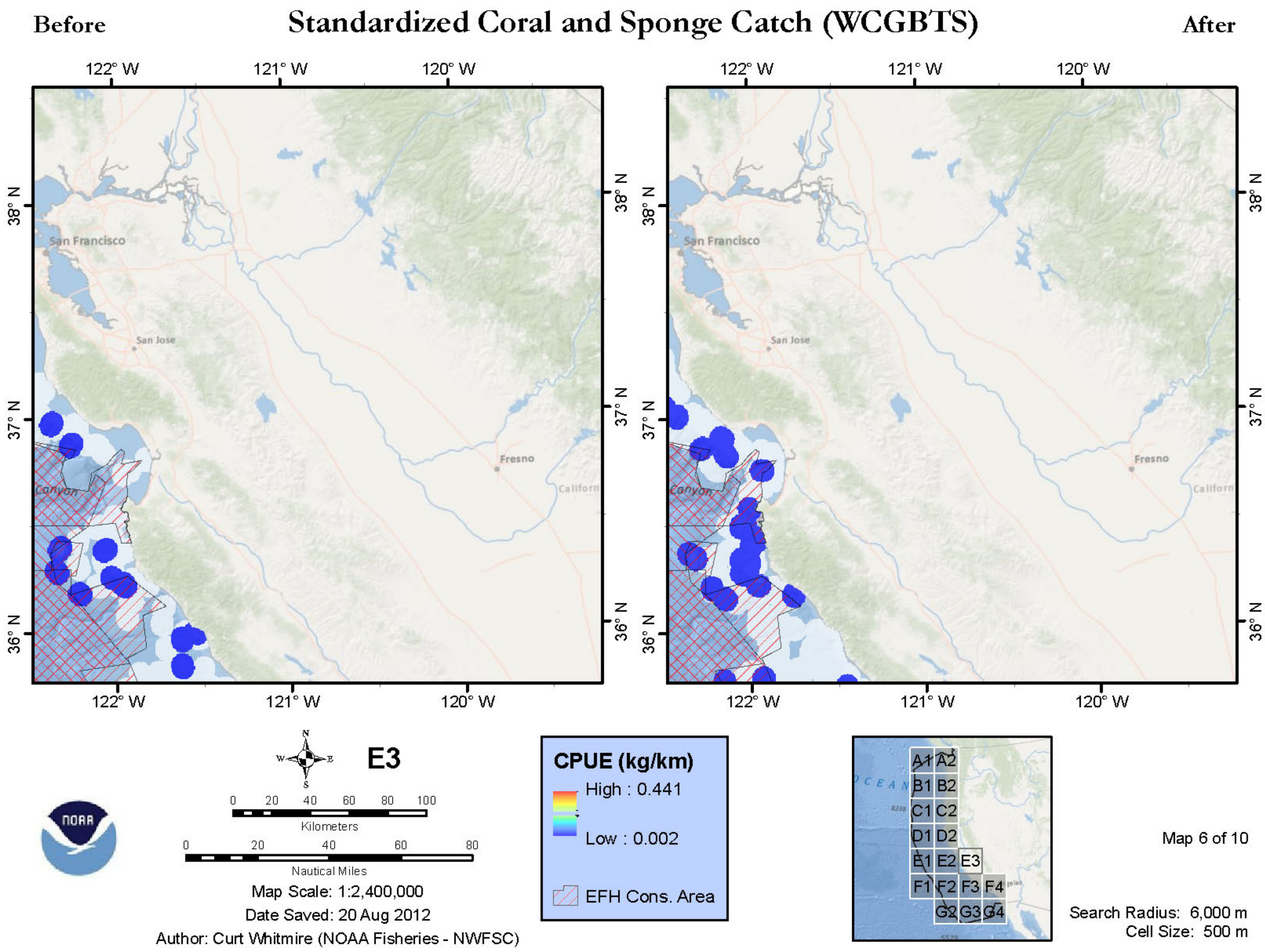


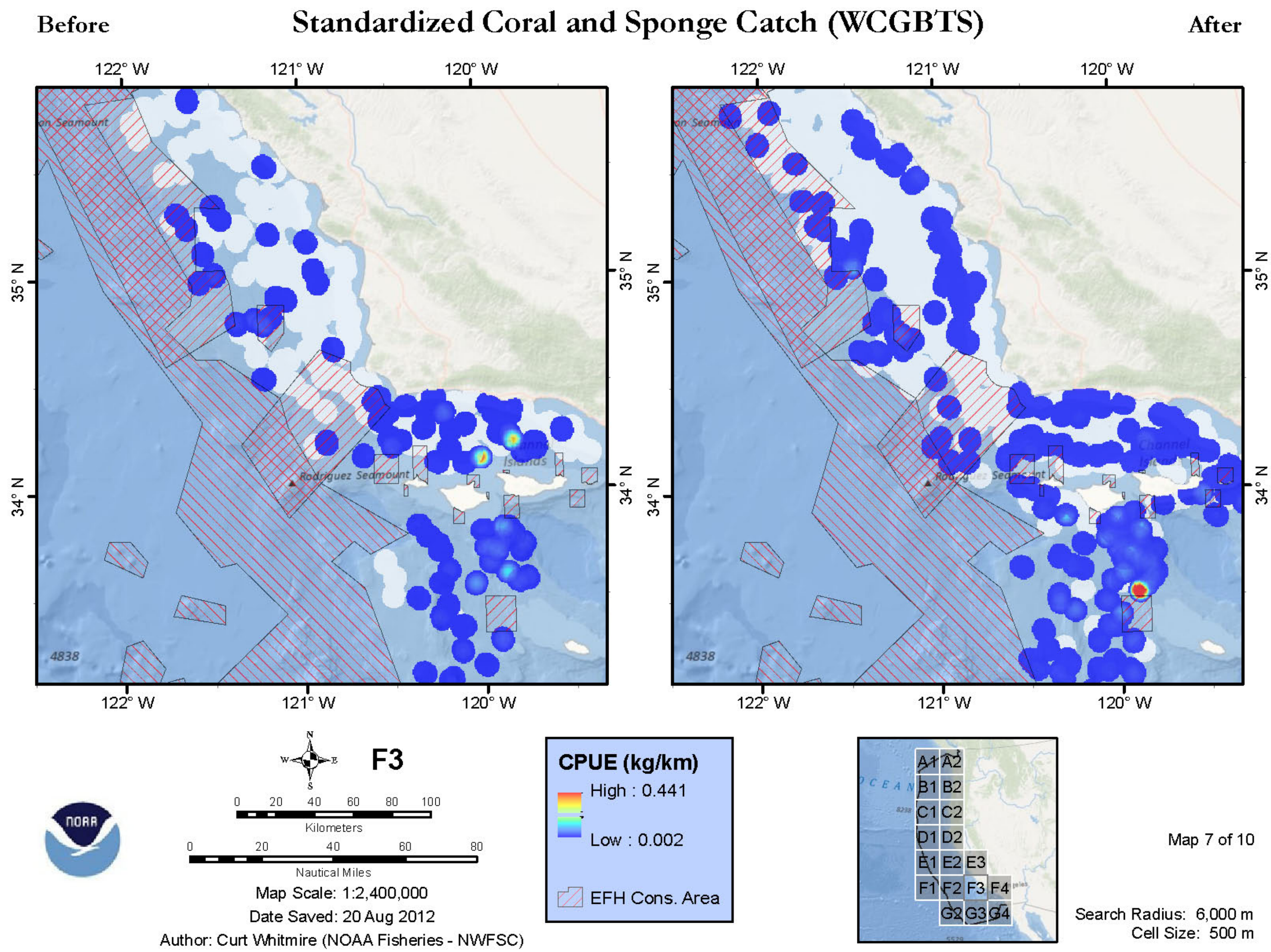
Before
Standardized Coral and Sponge Catch (WCGBTS)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 10
Search Radius: 6,000 m
Cell Size: 500 m

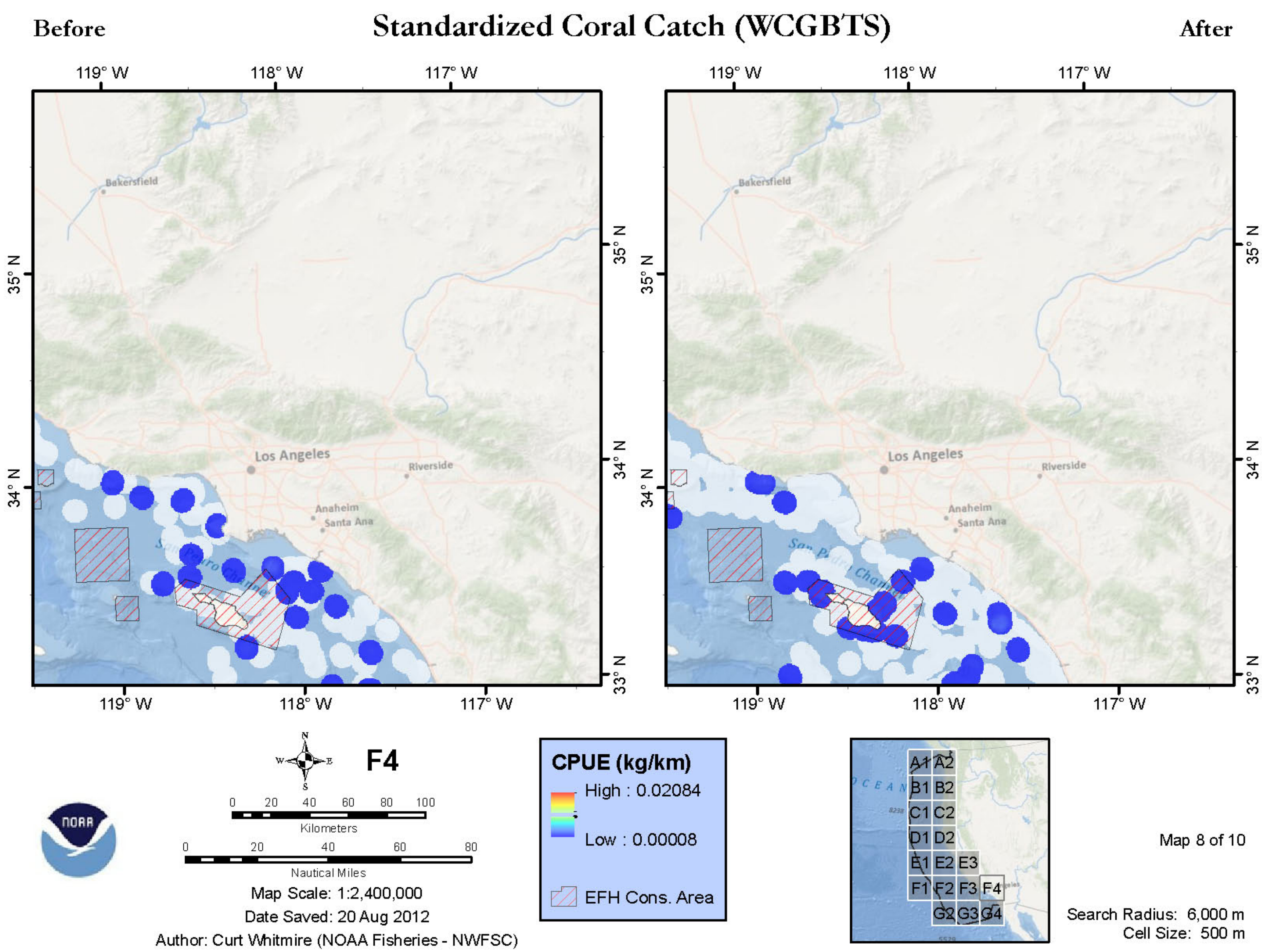


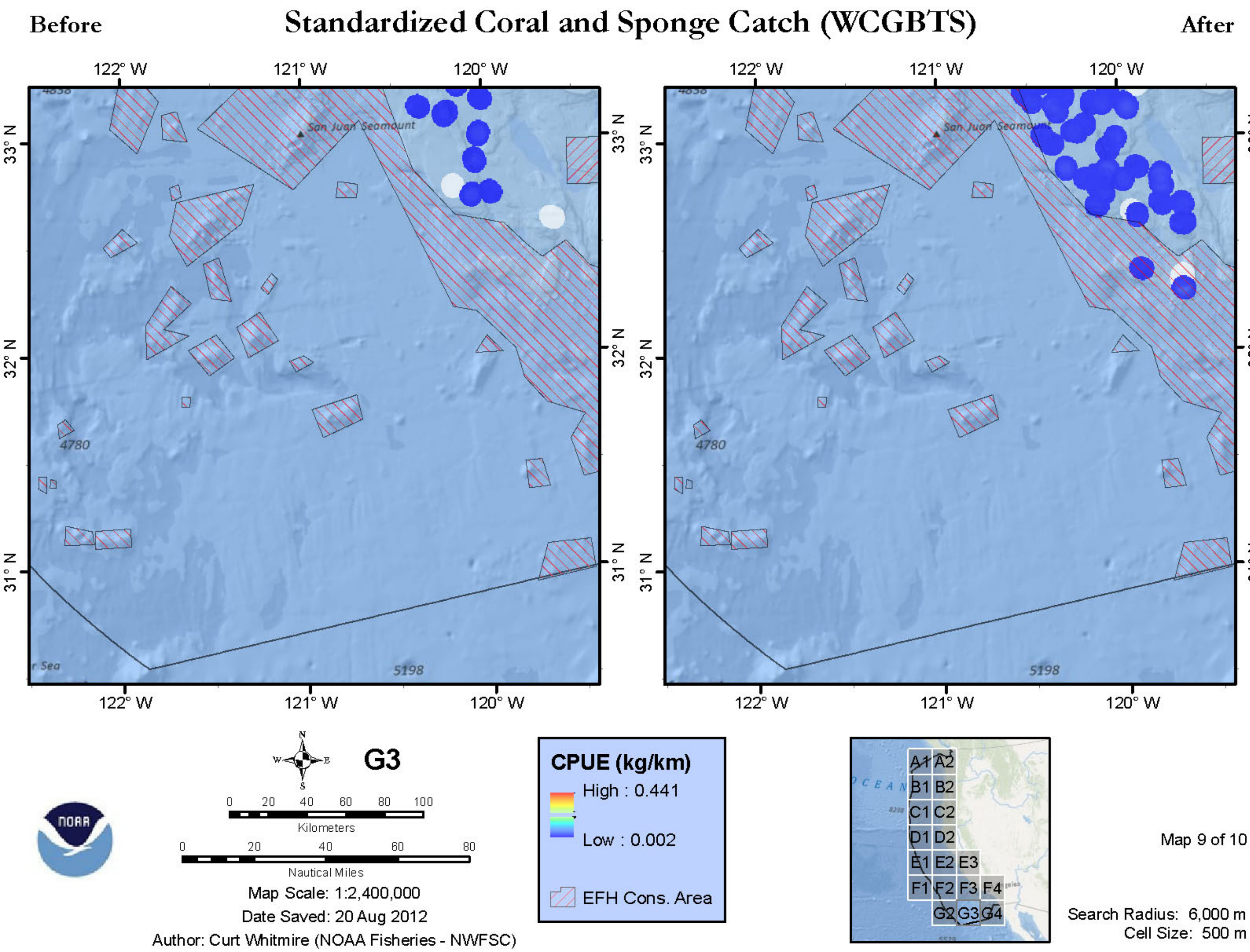
Before
Standardized Coral and Sponge Catch (WCGBTS)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 10
Search Radius: 6,000 m
Cell Size: 500 m

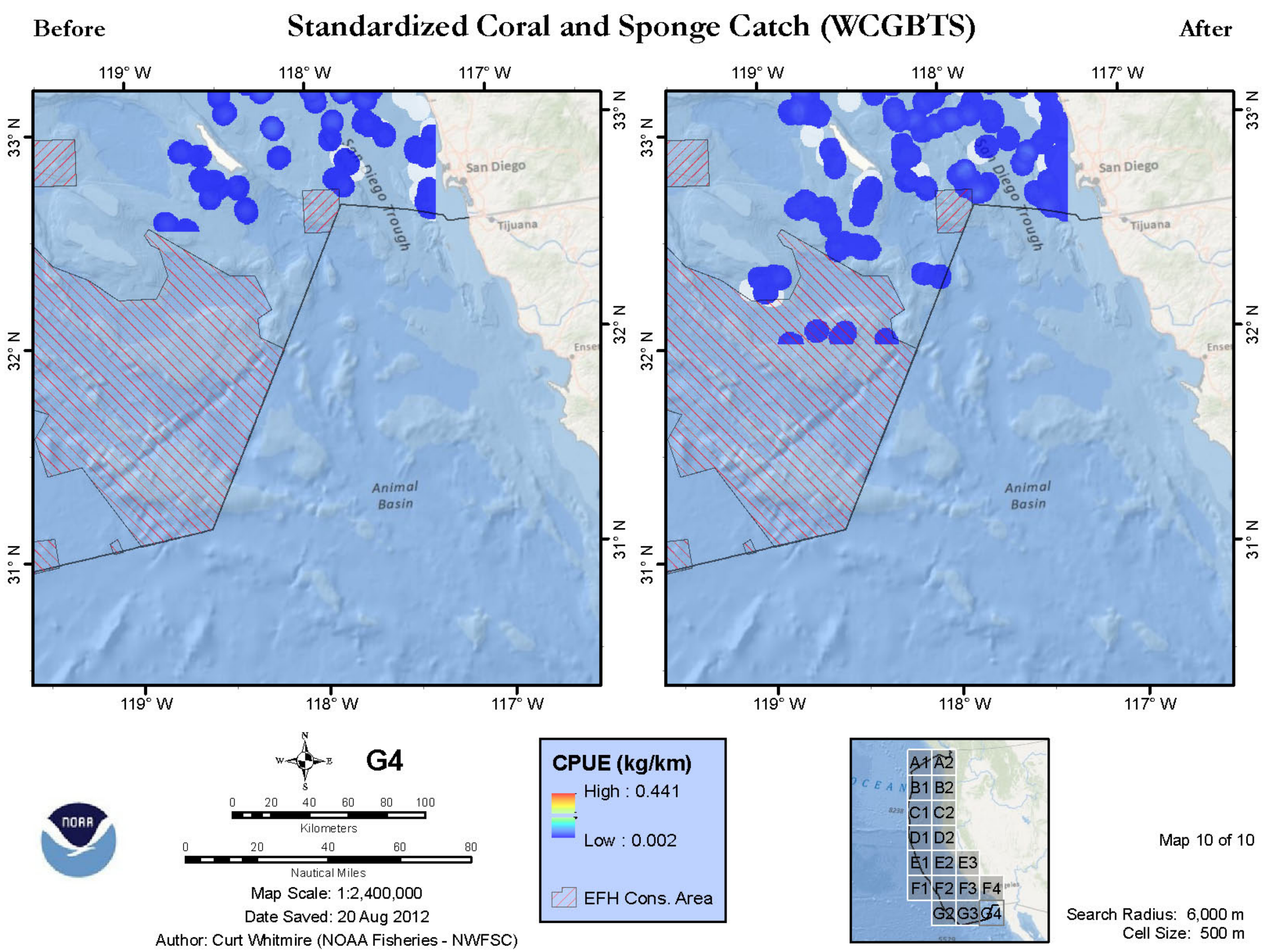

Before
Standardized Coral and Sponge Catch (WCGBTS)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral and Sponge Catch (WCGBTS)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 6 of 10
Search Radius: 6,000 m
Cell Size: 500 m

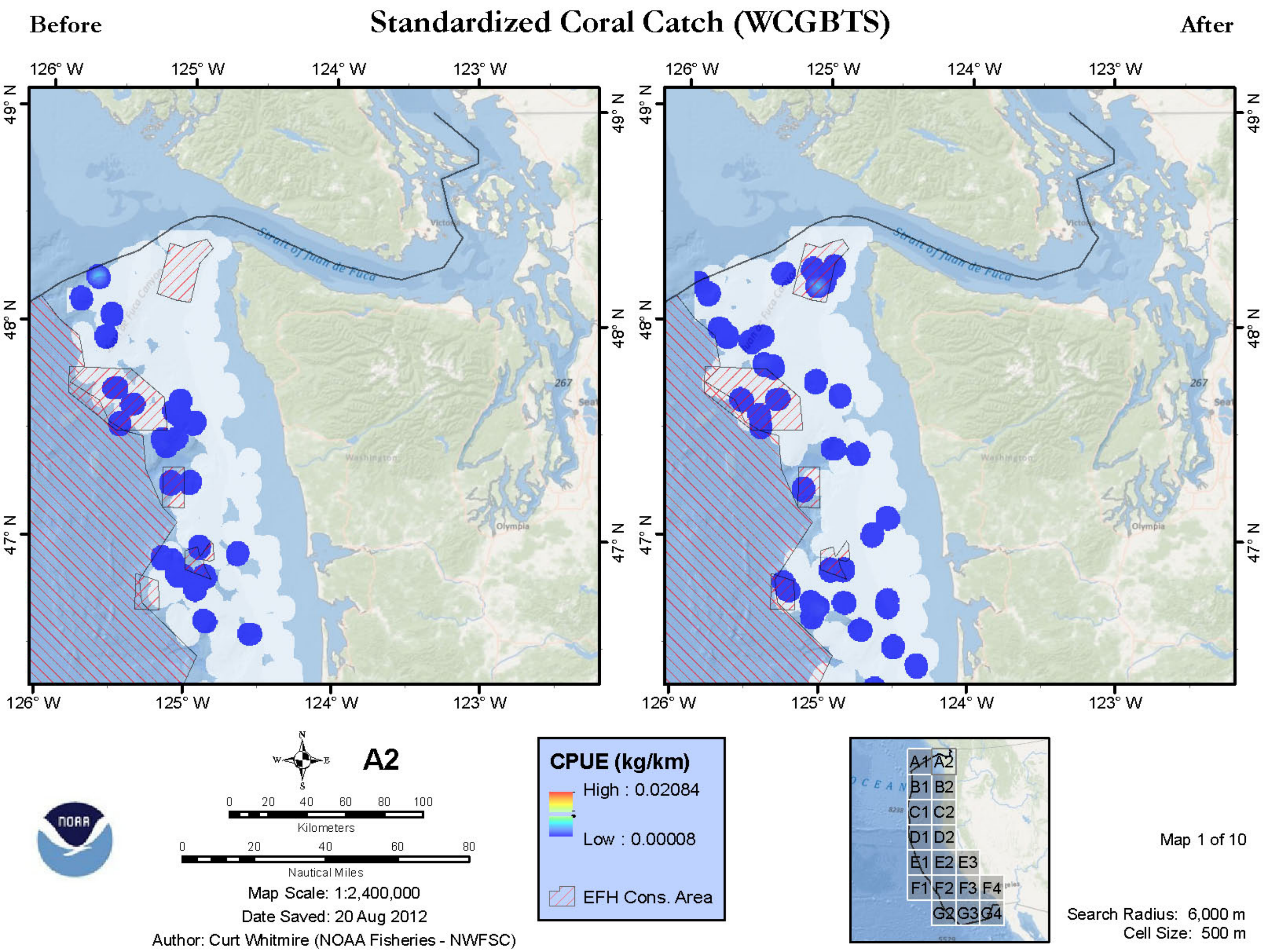

Before
Standardized Coral and Sponge Catch (WCGBTS)
After
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
4838
F3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral Catch (WCGBTS)
After
119° W
118° W
117° W
35° N
34° N
33° N
Bakersfield
Los Angeles
Riverside
Anaheim
Santa Ana
San Pedro Channel
F4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 8 of 10
Search Radius: 6,000 m
Cell Size: 500 m

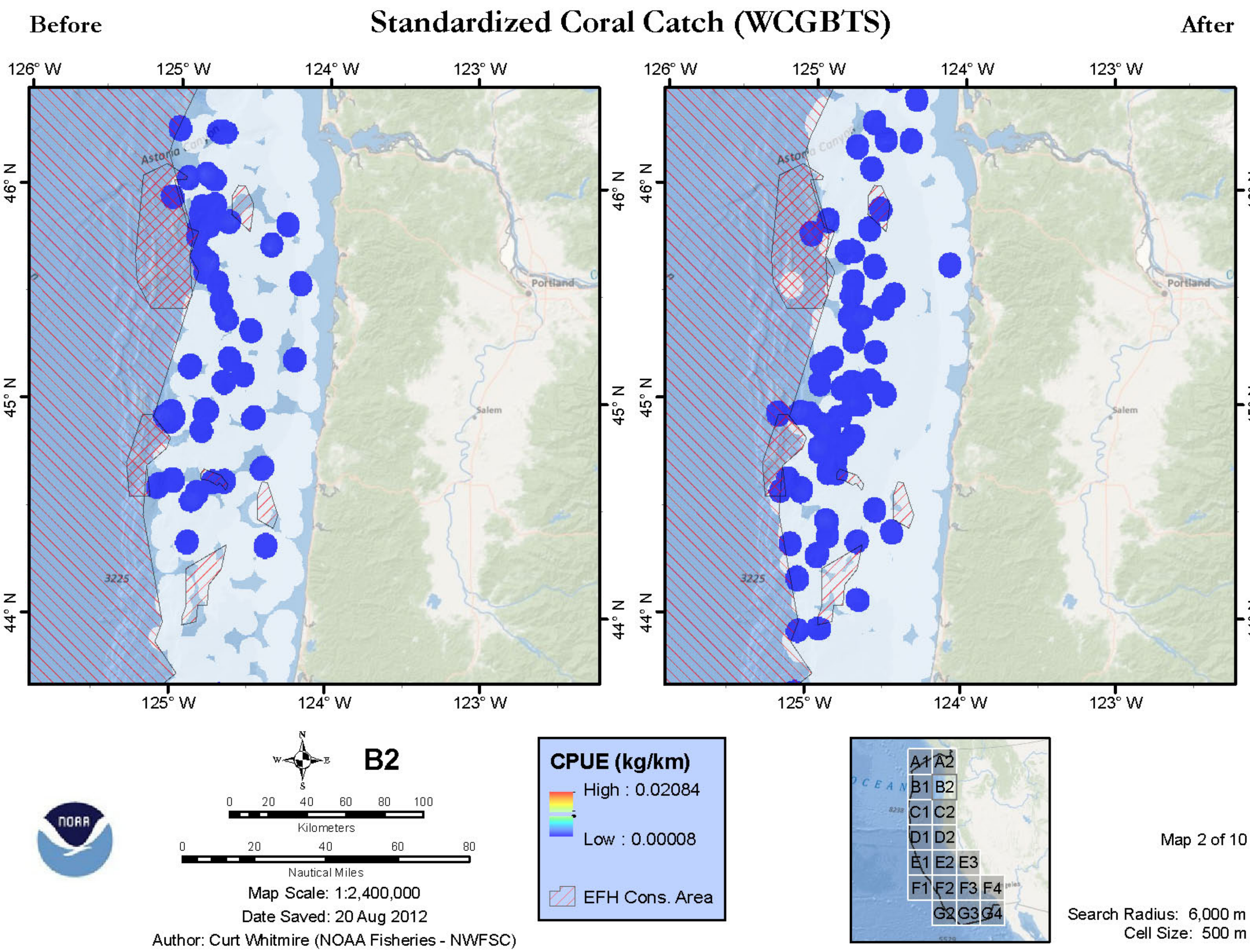

Before
Standardized Coral and Sponge Catch (WCGBTS)
After
122° W
121° W
120° W
33° N
32° N
31° N
San Juan Seamount
4780
5198
G3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 9 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral and Sponge Catch (WCGBTS)
After
119° W
118° W
117° W
33° N
32° N
31° N
San Diego
Tijuana
San Diego Trough
Animal Basin
G4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 10 of 10
Search Radius: 6,000 m
Cell Size: 500 m

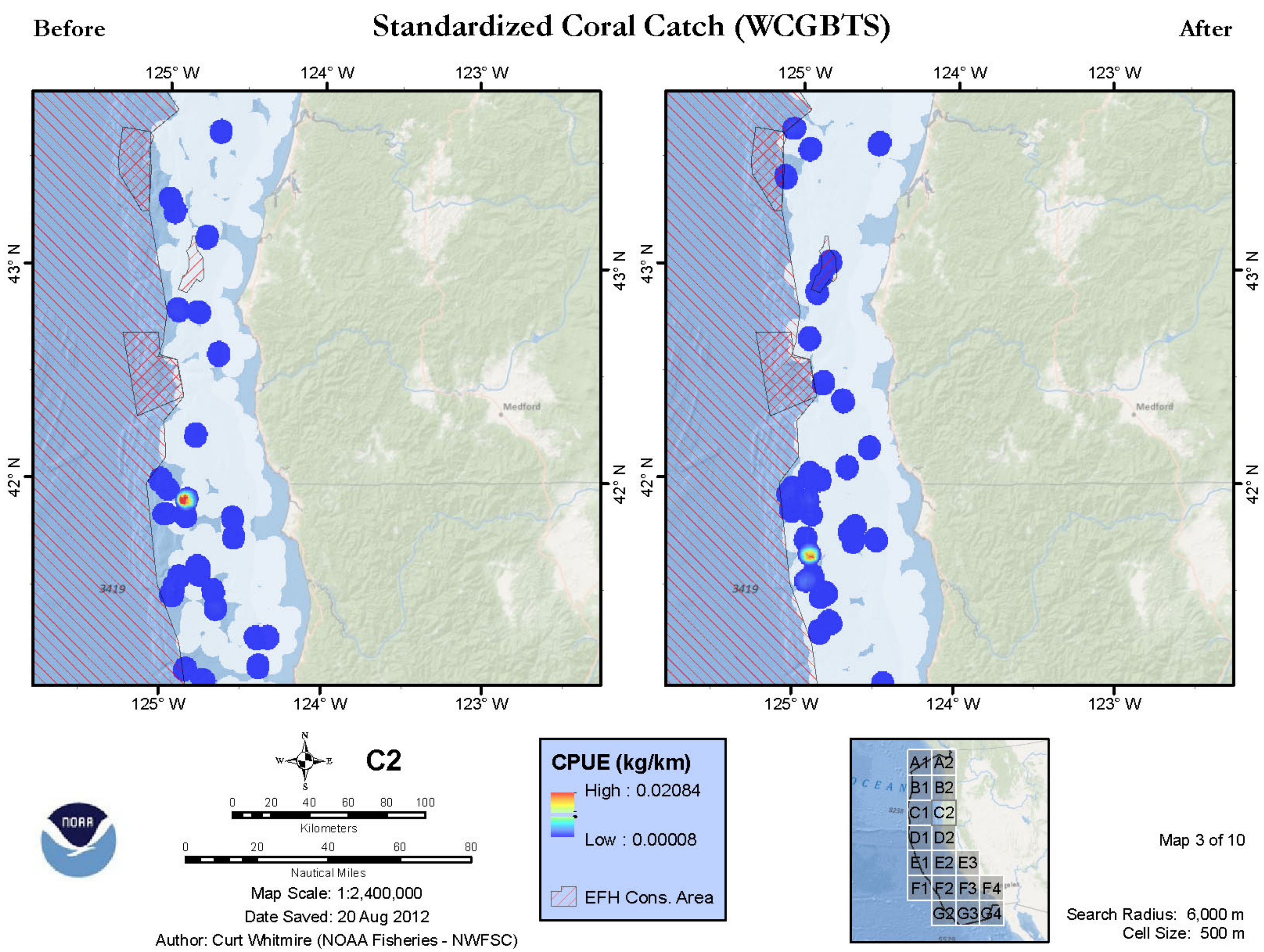
Appendix E-2: WCGBTS Coral

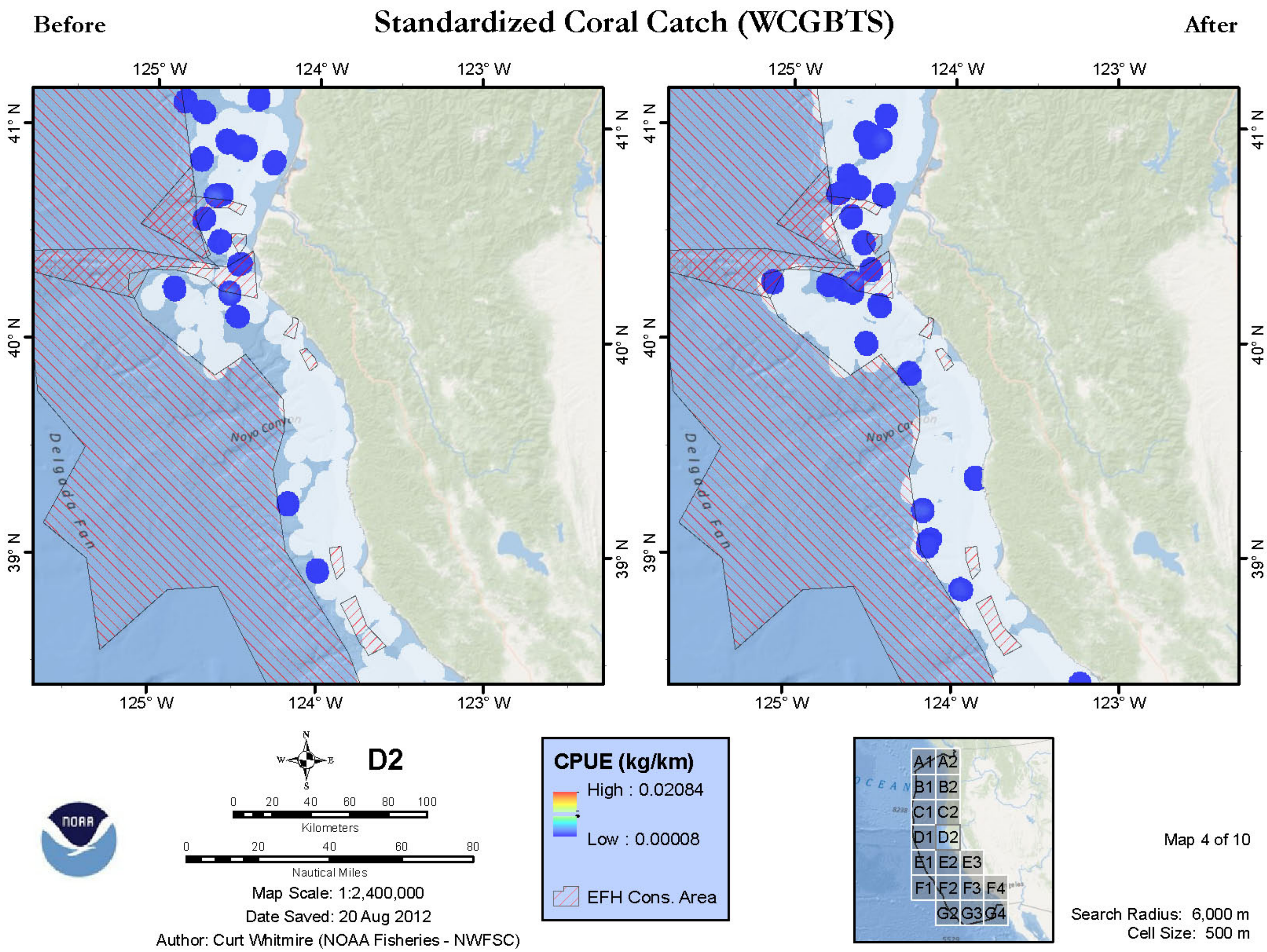


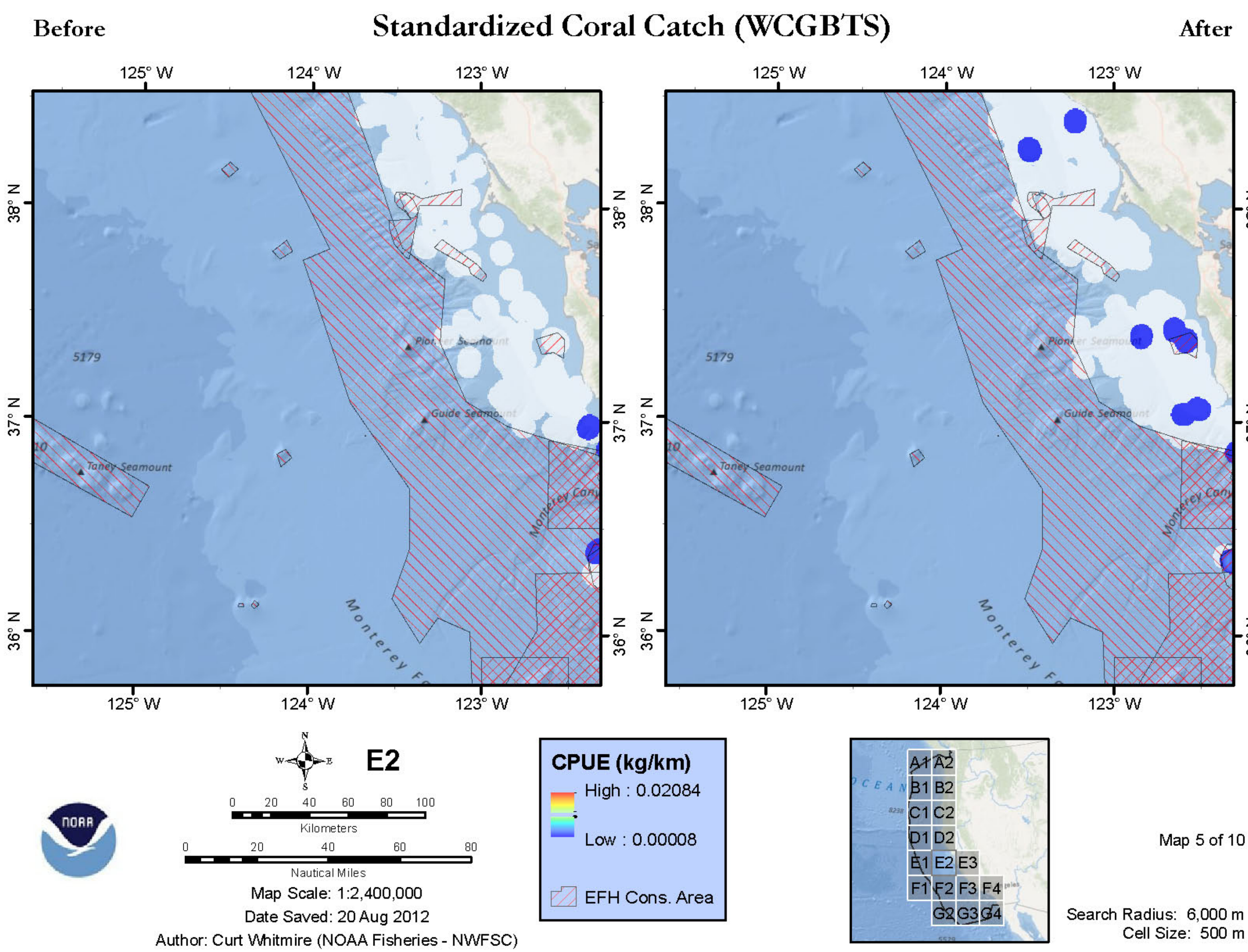
Appendix E-2: WCGBTS Coral

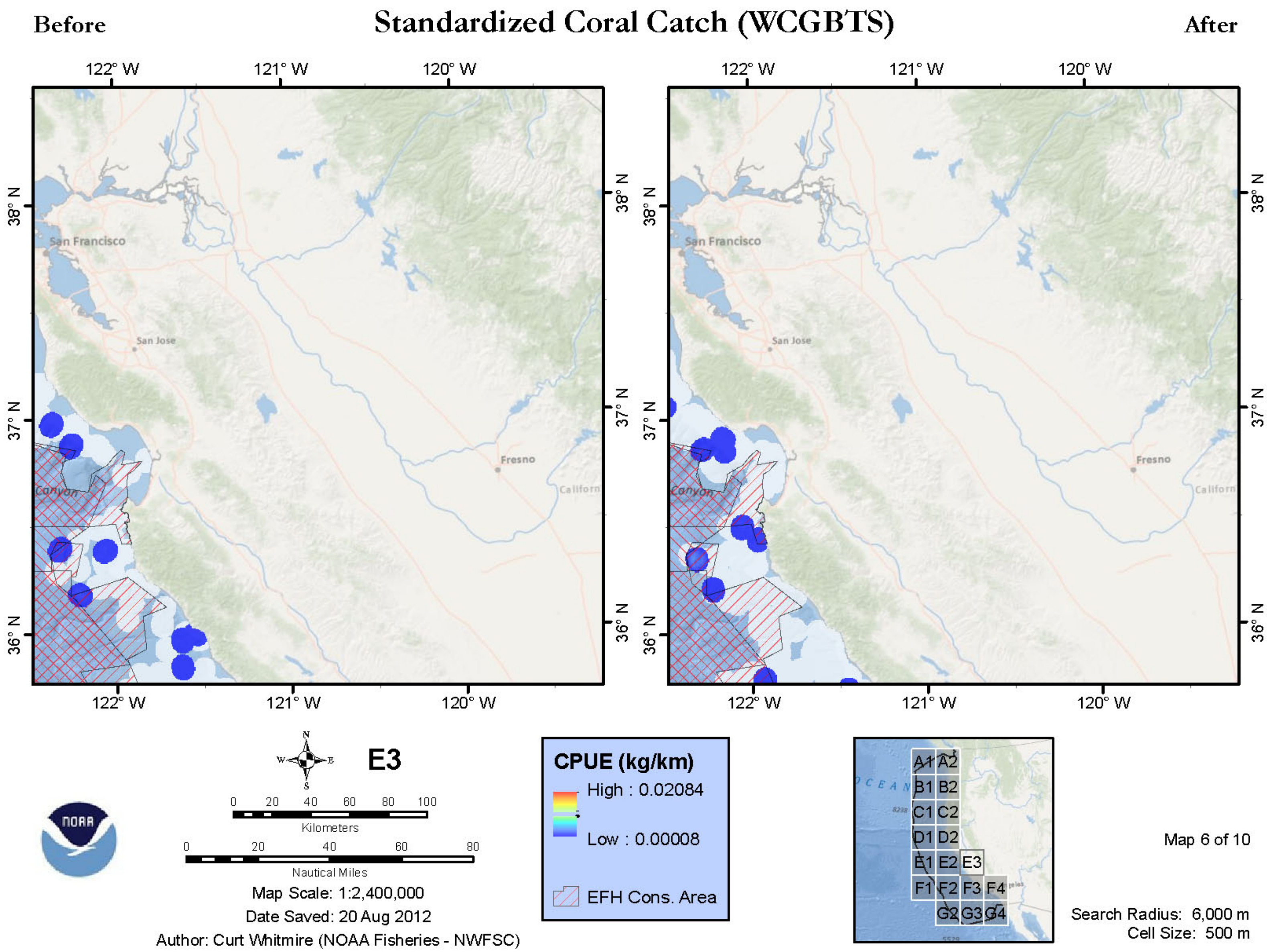


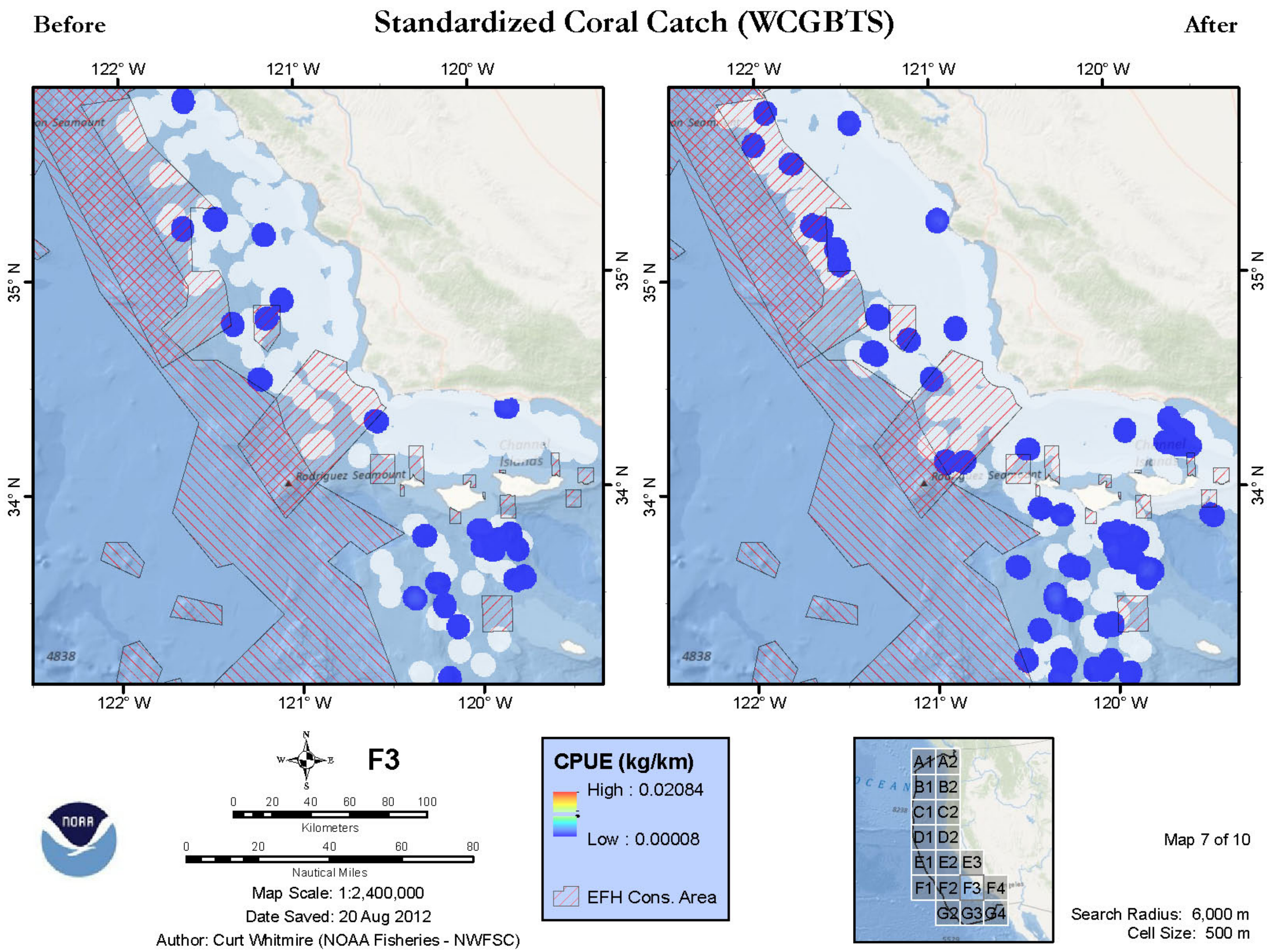
Appendix E-2: WCGBTS Coral

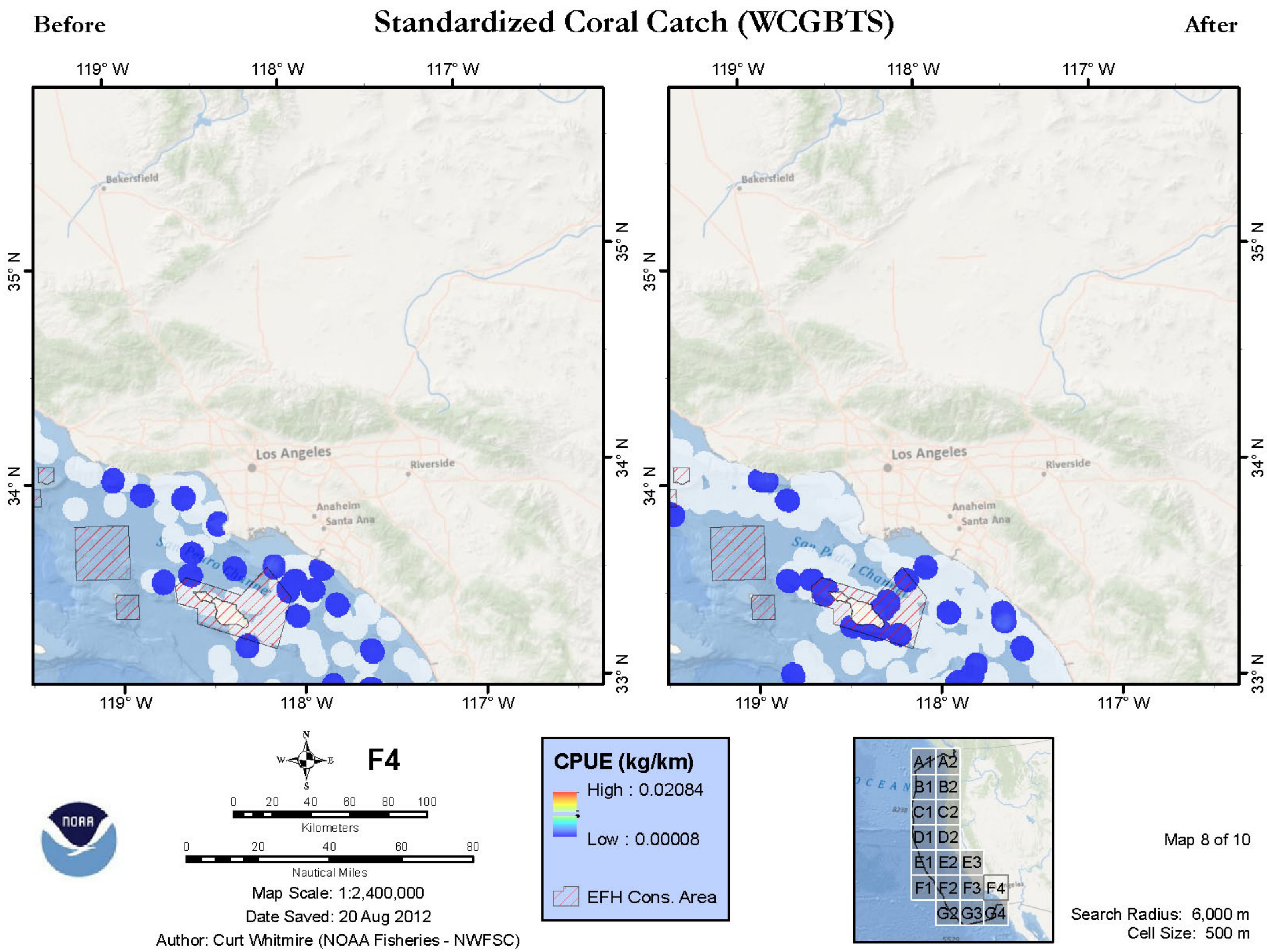


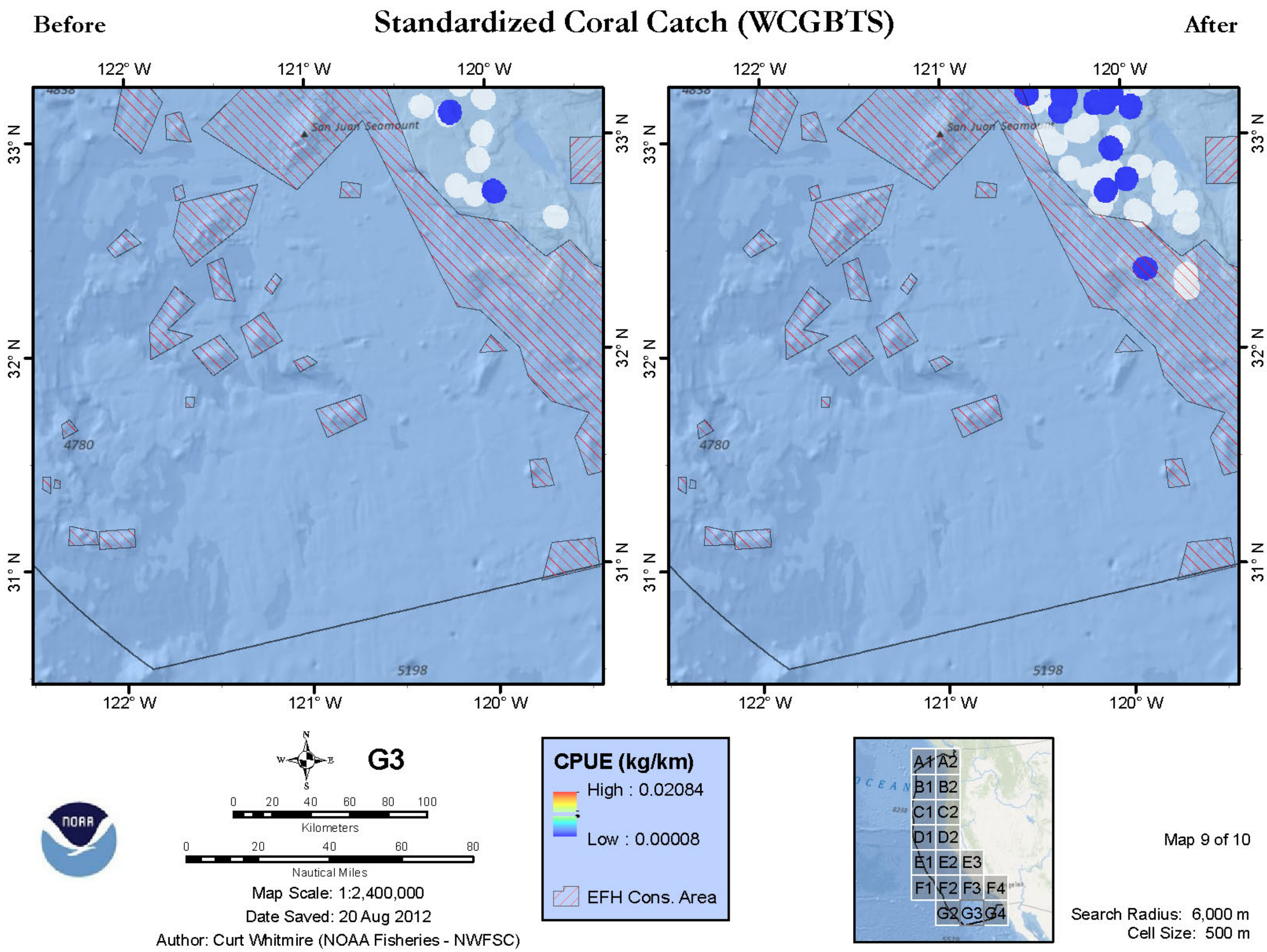

Before
Standardized Coral Catch (WCGBTS)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 10
Search Radius: 6,000 m
Cell Size: 500 m

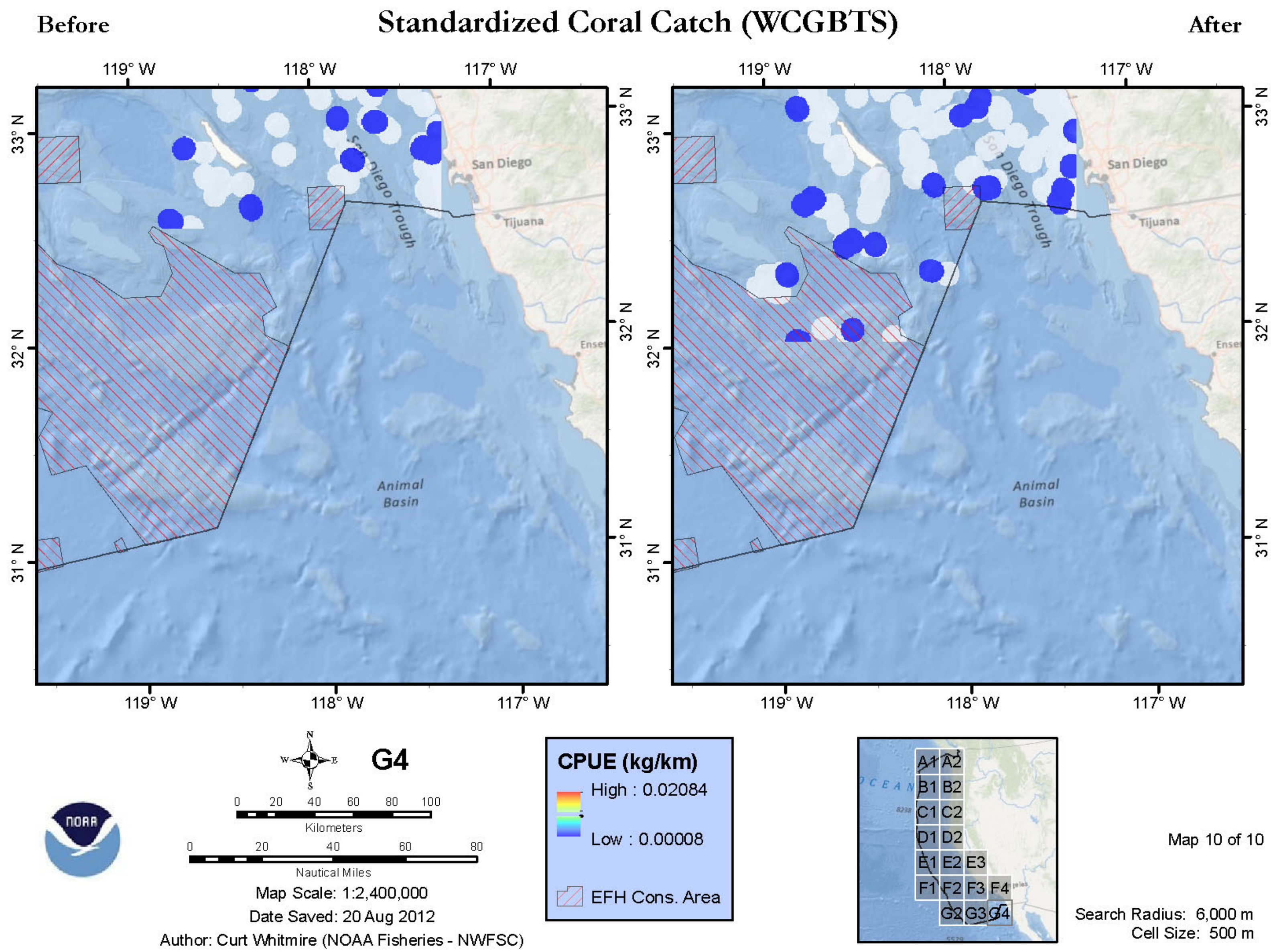

Before
Standardized Coral Catch (WCGBTS)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral Catch (WCGBTS)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 6 of 10
Search Radius: 6,000 m
Cell Size: 500 m

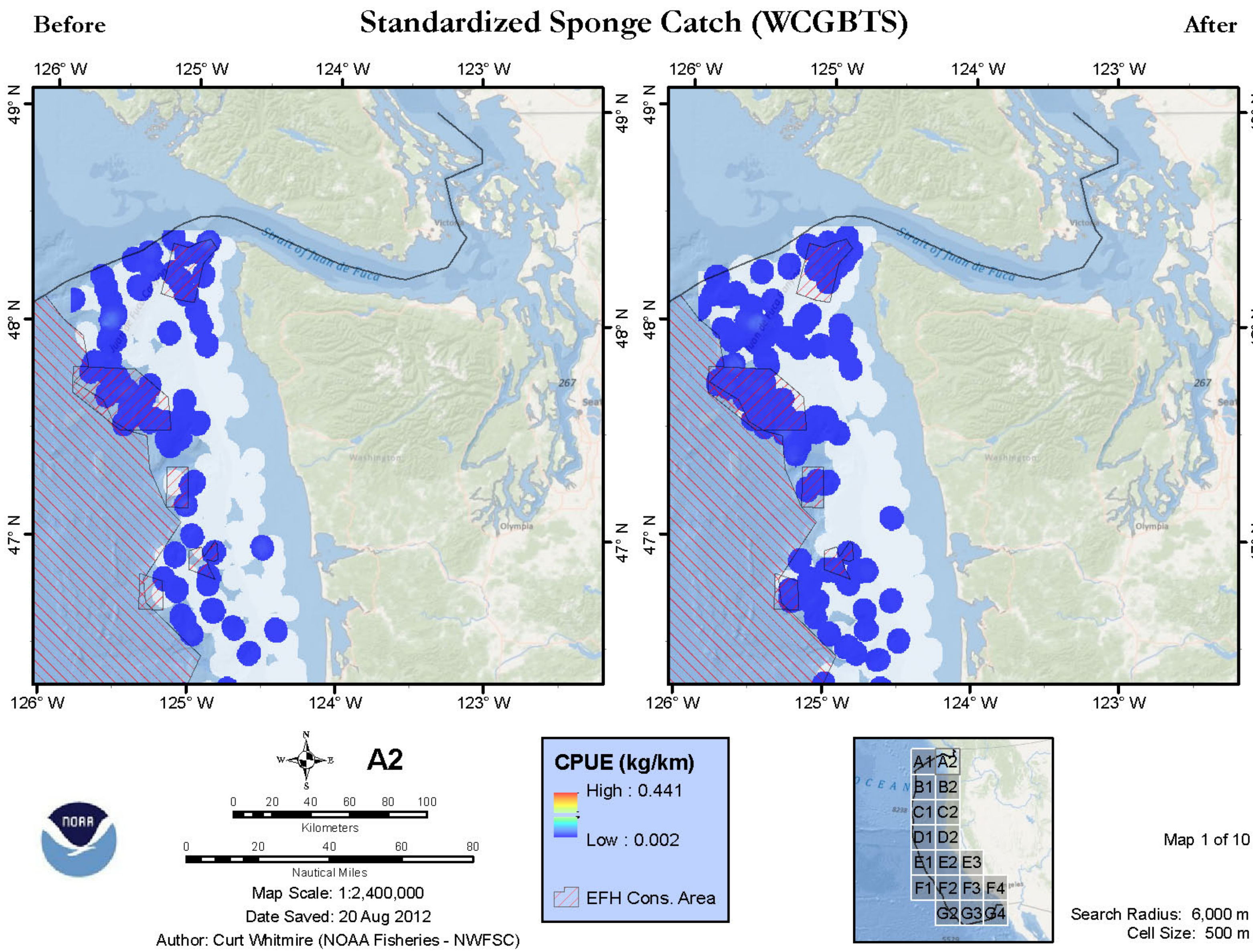

Before
Standardized Coral Catch (WCGBTS)
After
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
Channel Islands
4838
F3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral Catch (WCGBTS)
After
119° W
118° W
117° W
35° N
34° N
33° N
Bakersfield
Los Angeles
Riverside
Anaheim
Santa Ana
San Pedro Channel
F4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 8 of 10
Search Radius: 6,000 m
Cell Size: 500 m

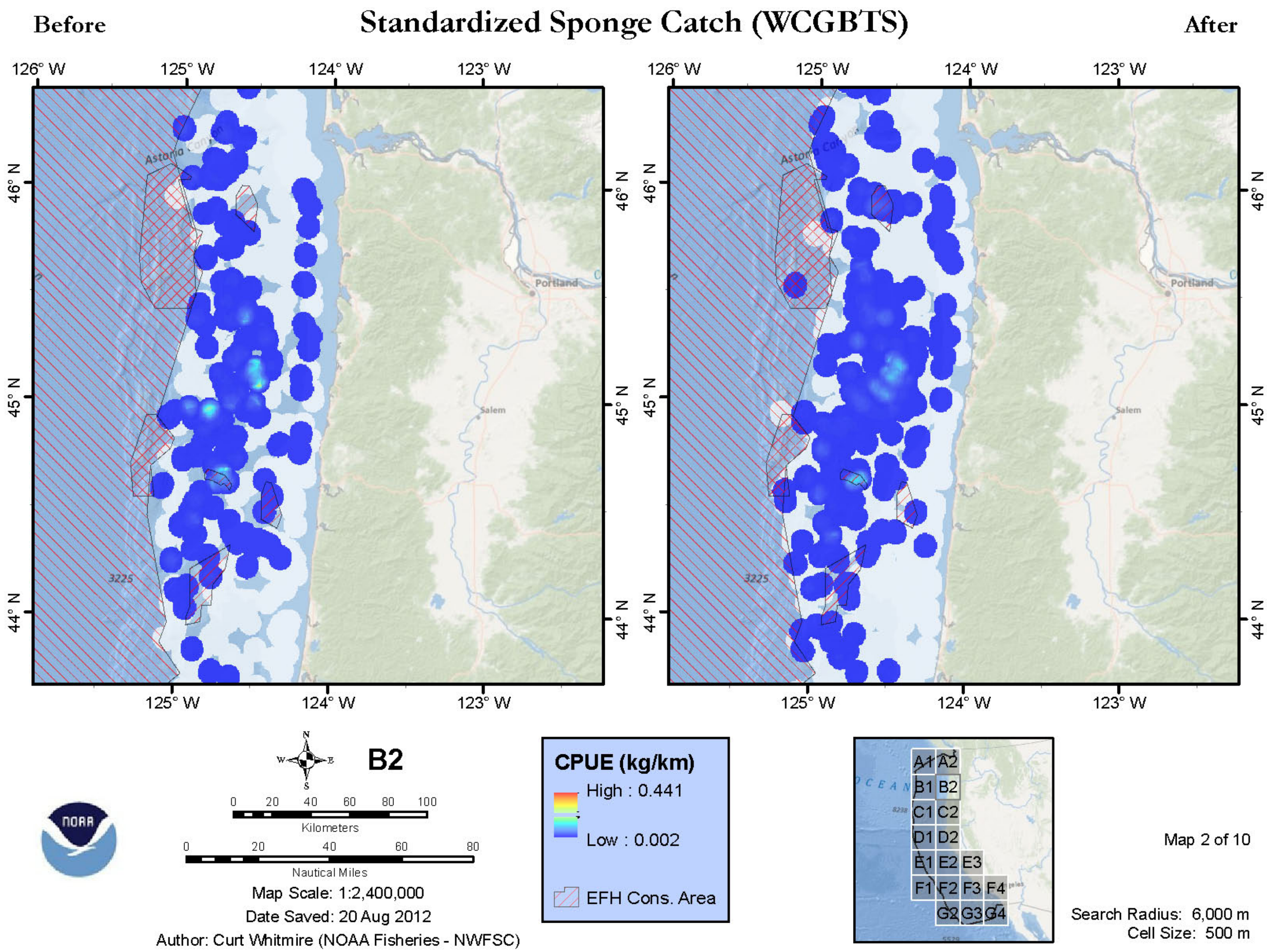

Before
Standardized Coral Catch (WCGBTS)
After
122° W
121° W
120° W
33° N
32° N
31° N
San Juan Seamount
4780
5198
G3
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 9 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Coral Catch (WCGBTS)
After
119° W
118° W
117° W
33° N
32° N
31° N
San Diego
Tijuana
San Diego Trough
Animal Basin
G4
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.02084
Low : 0.00008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 10 of 10
Search Radius: 6,000 m
Cell Size: 500 m

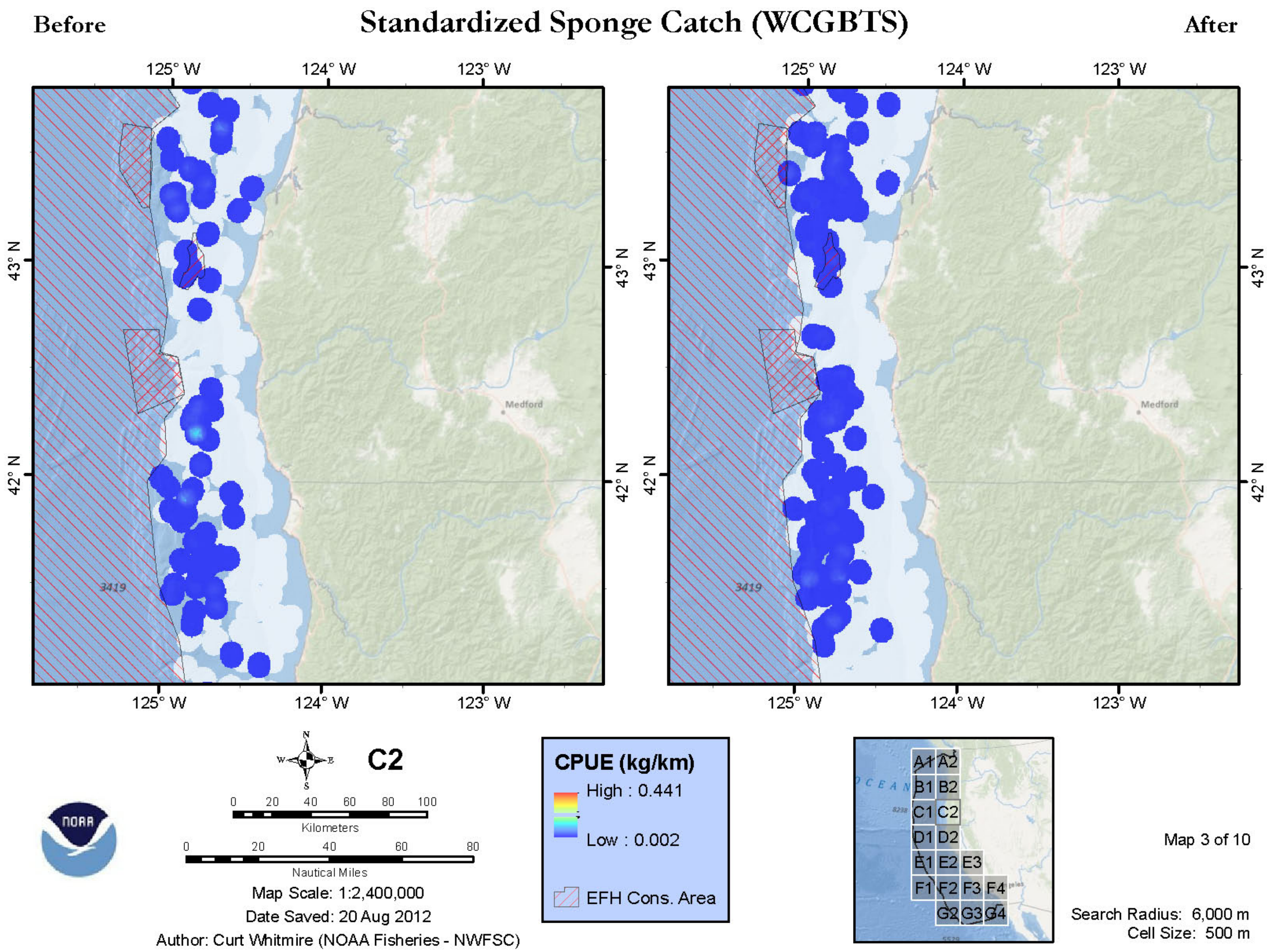
Appendix E-3: WCGBTS Sponge



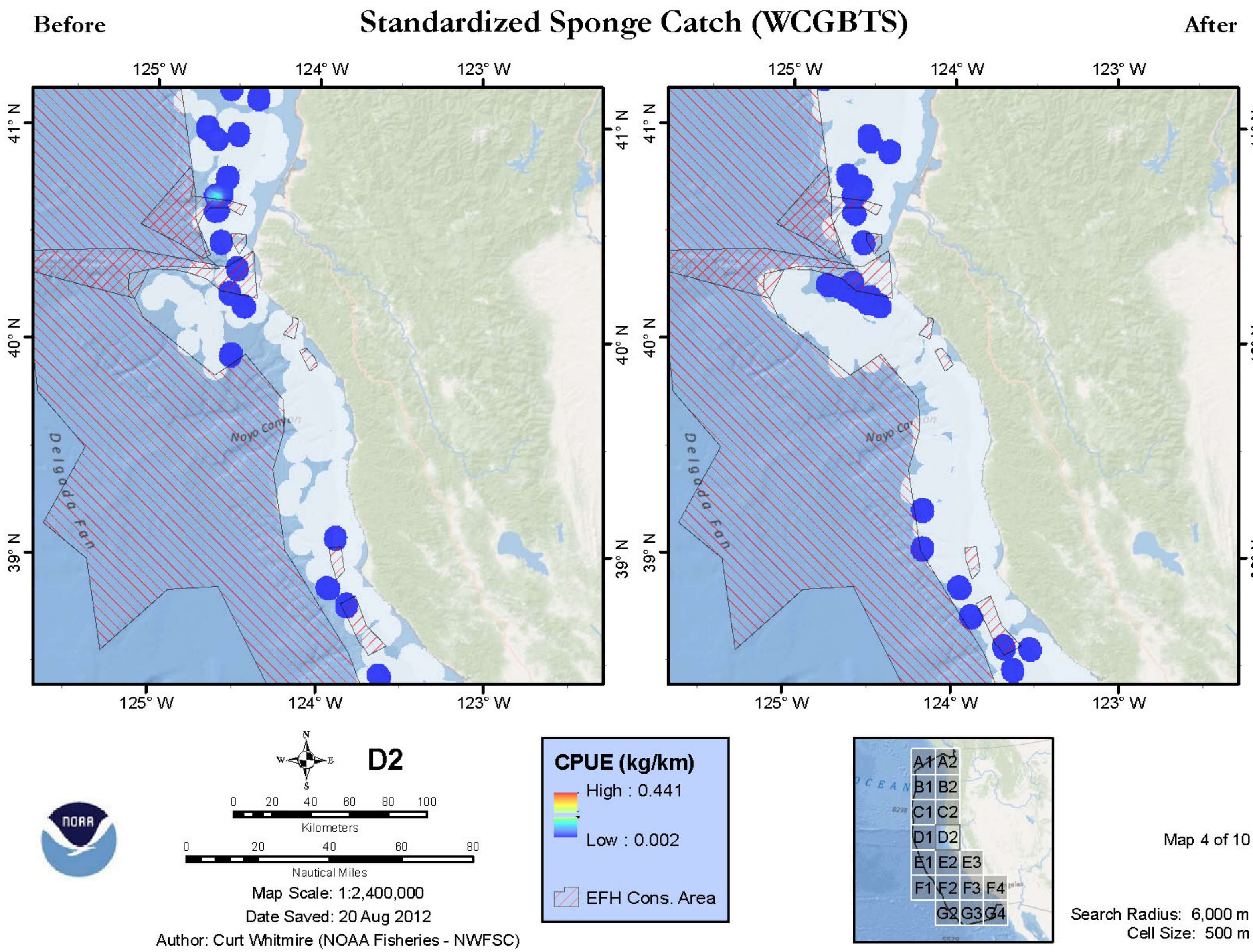
Appendix E-3: WCGBTS Sponge



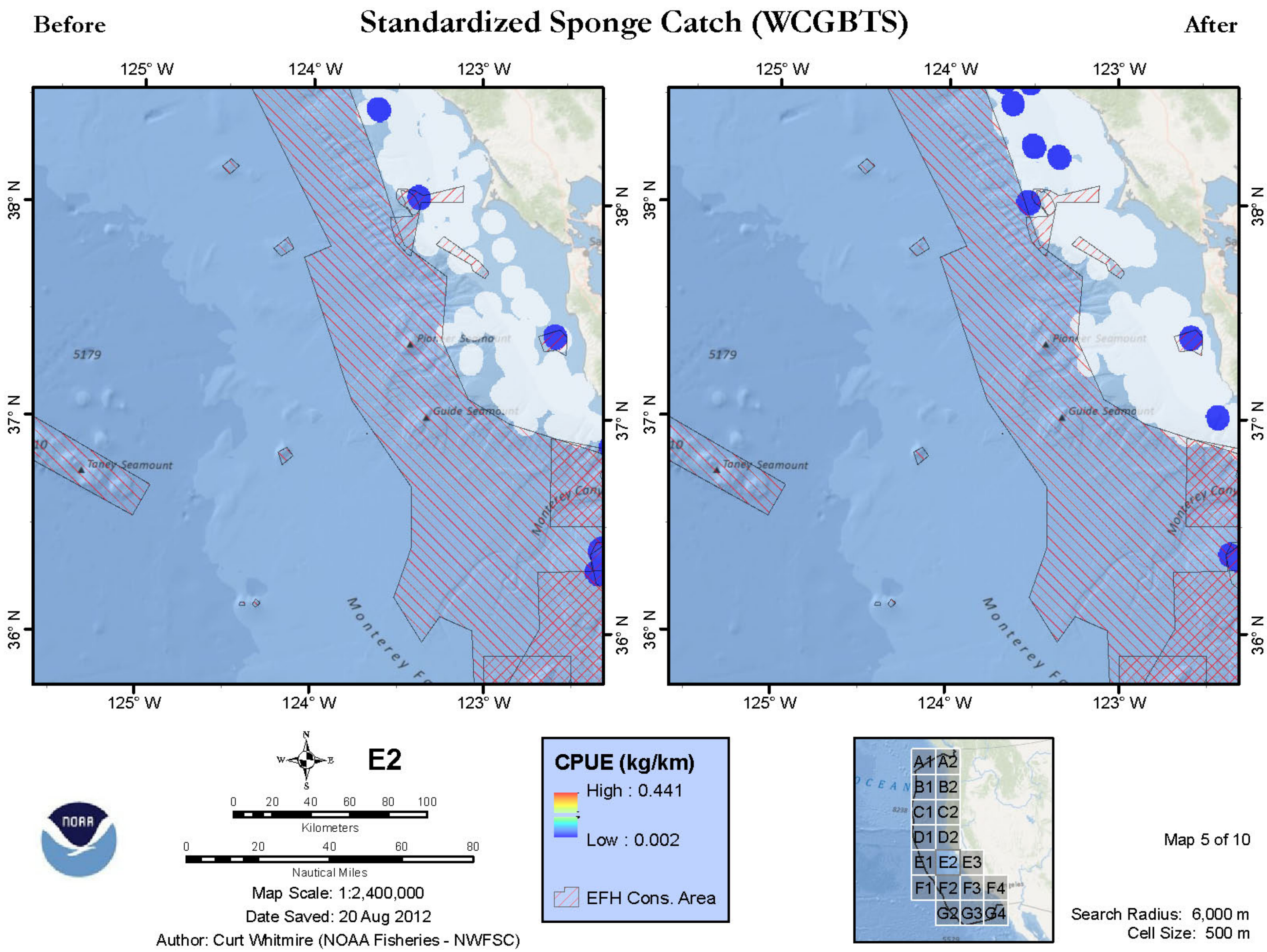
Standardized Sponge Catch (WCGBTS)



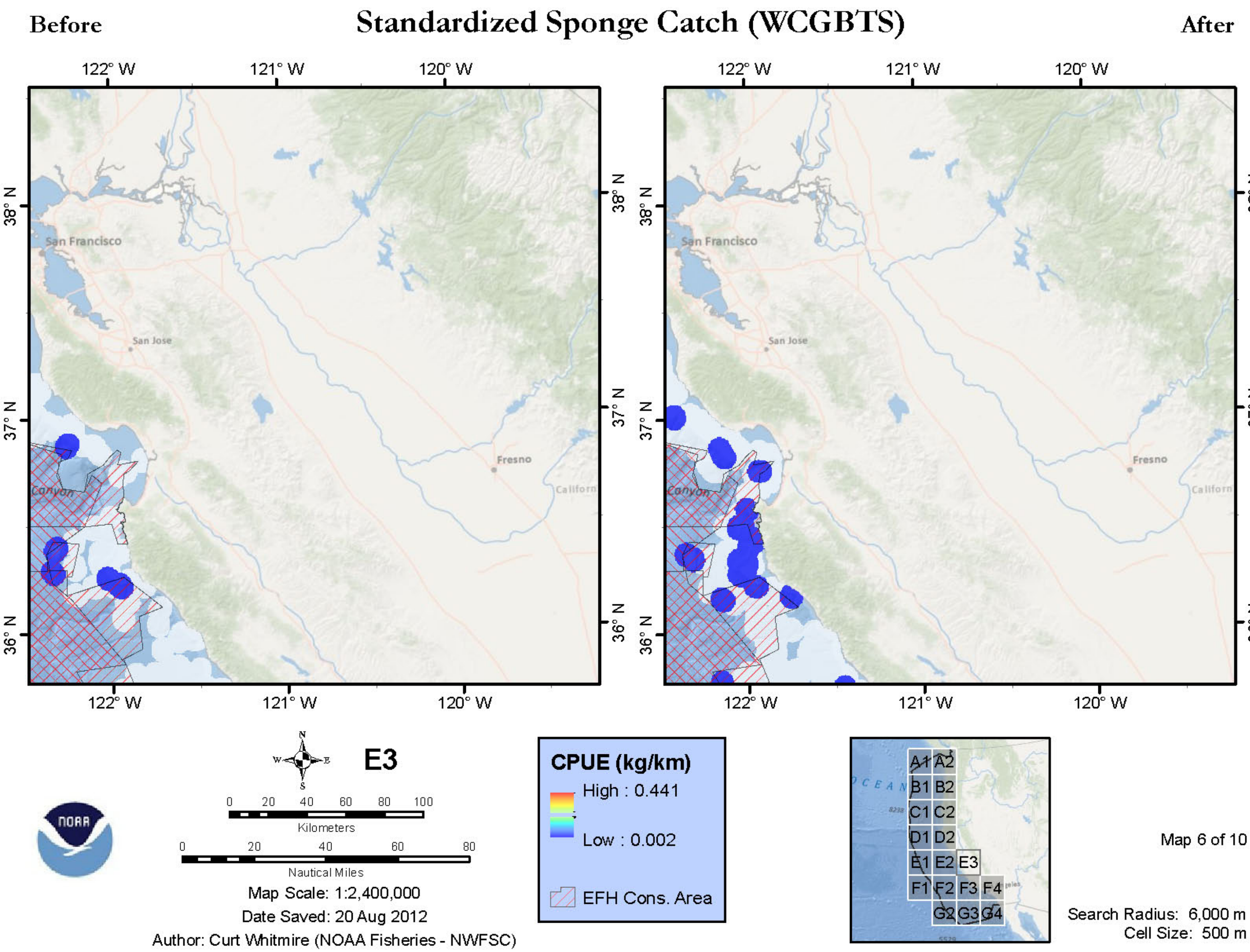
Appendix E-3: WCGBTS Sponge

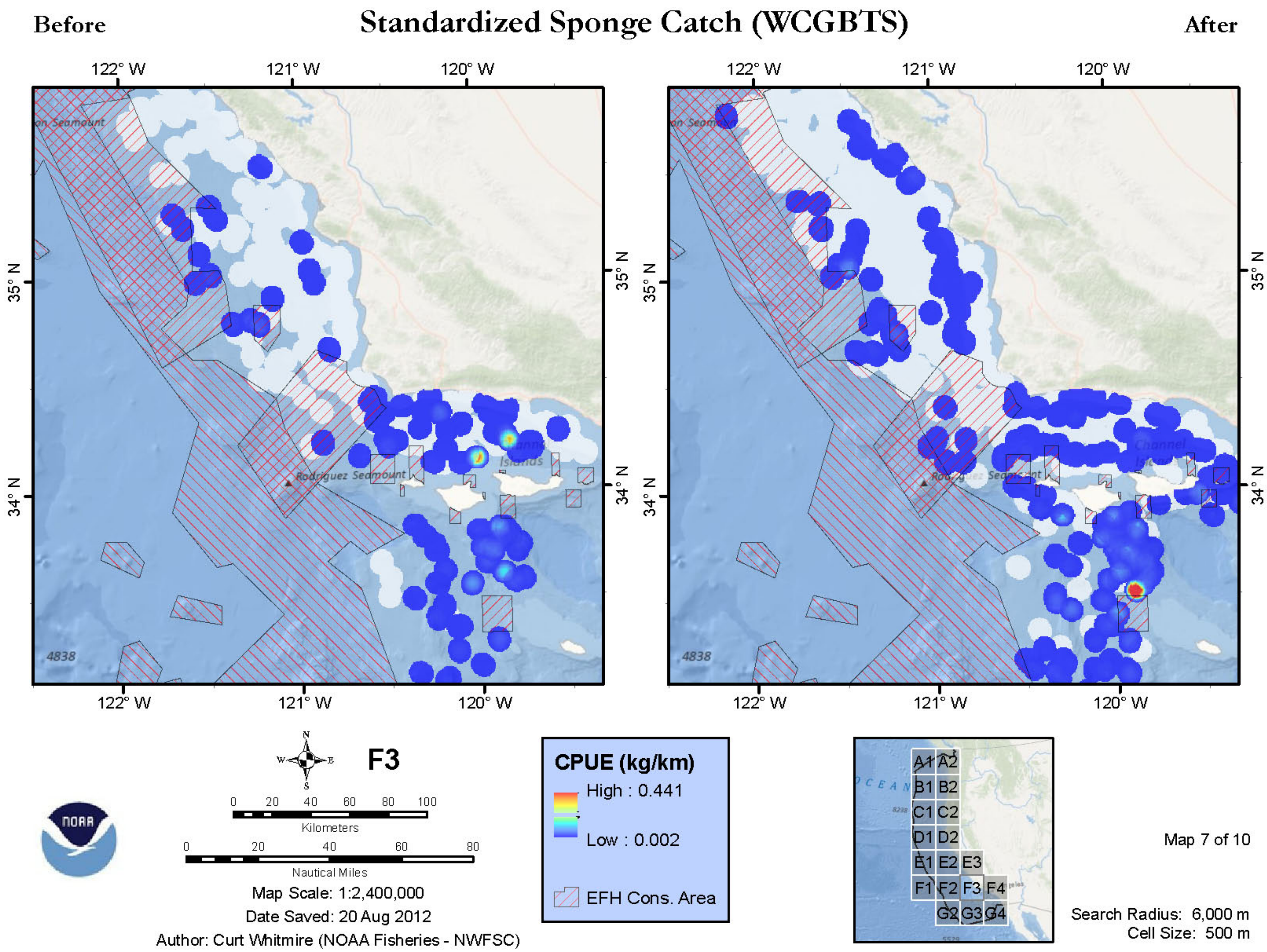


Appendix E-3: WCGBTS Sponge



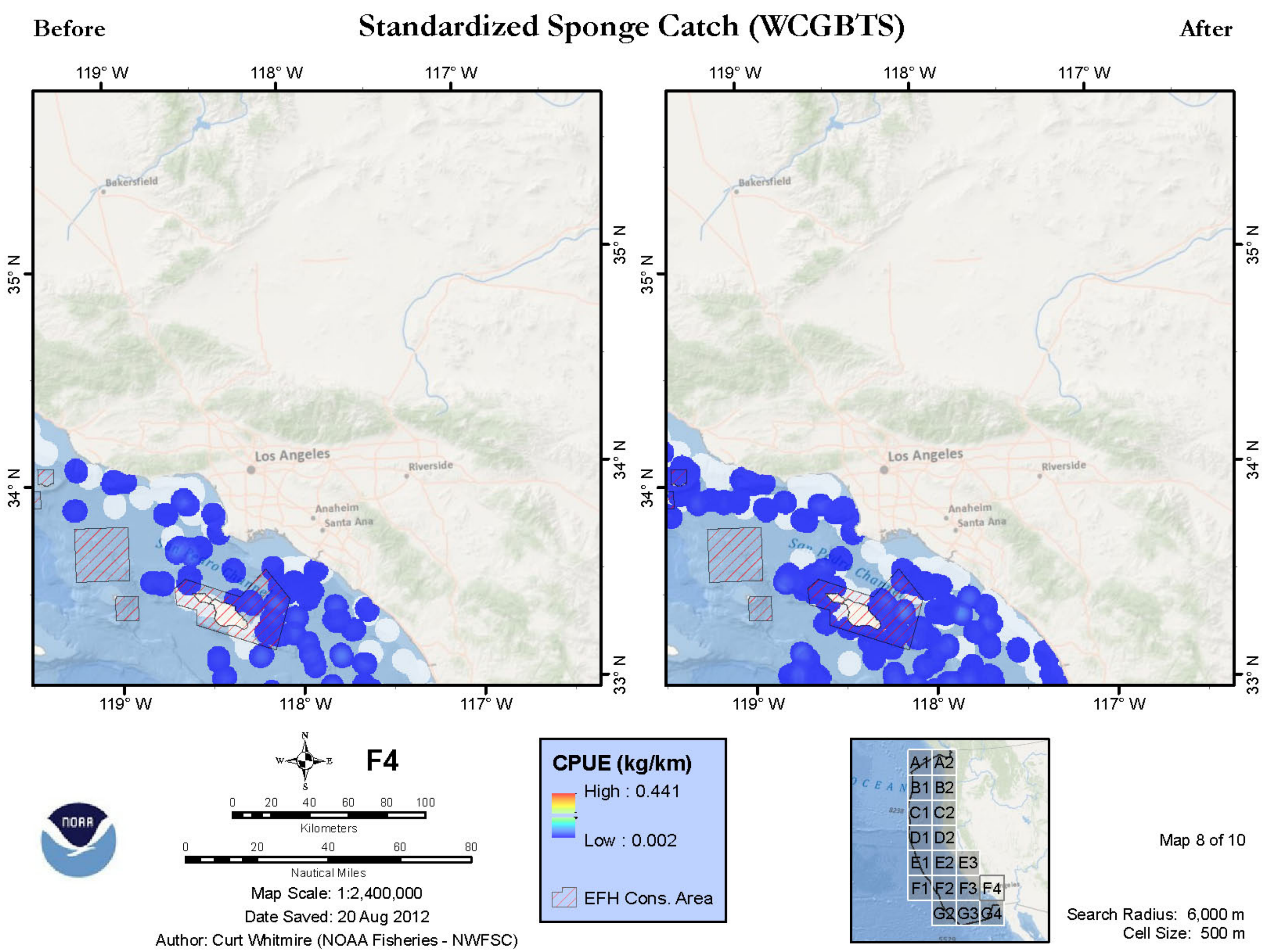
Appendix E-3: WCGBTS Sponge

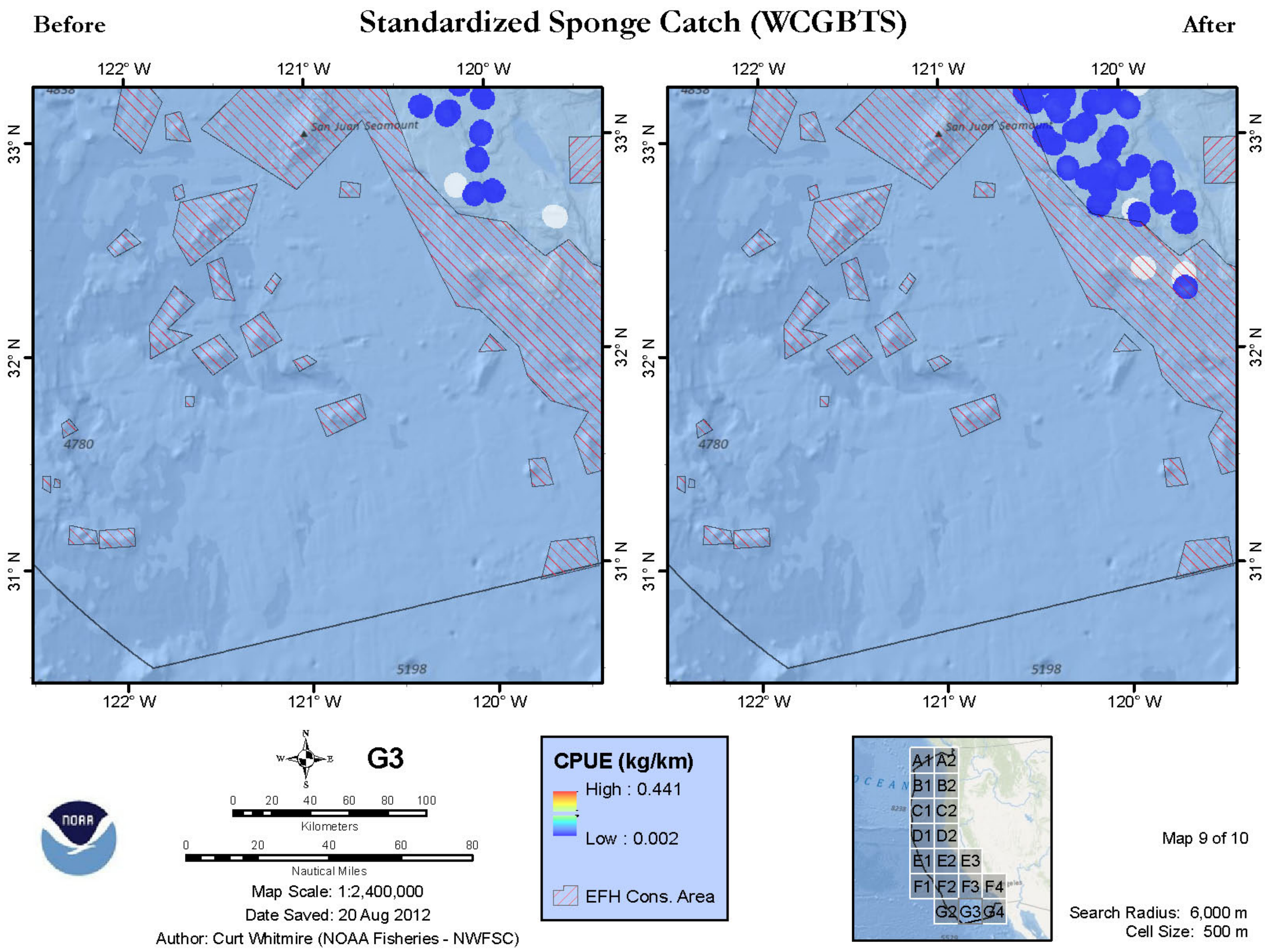


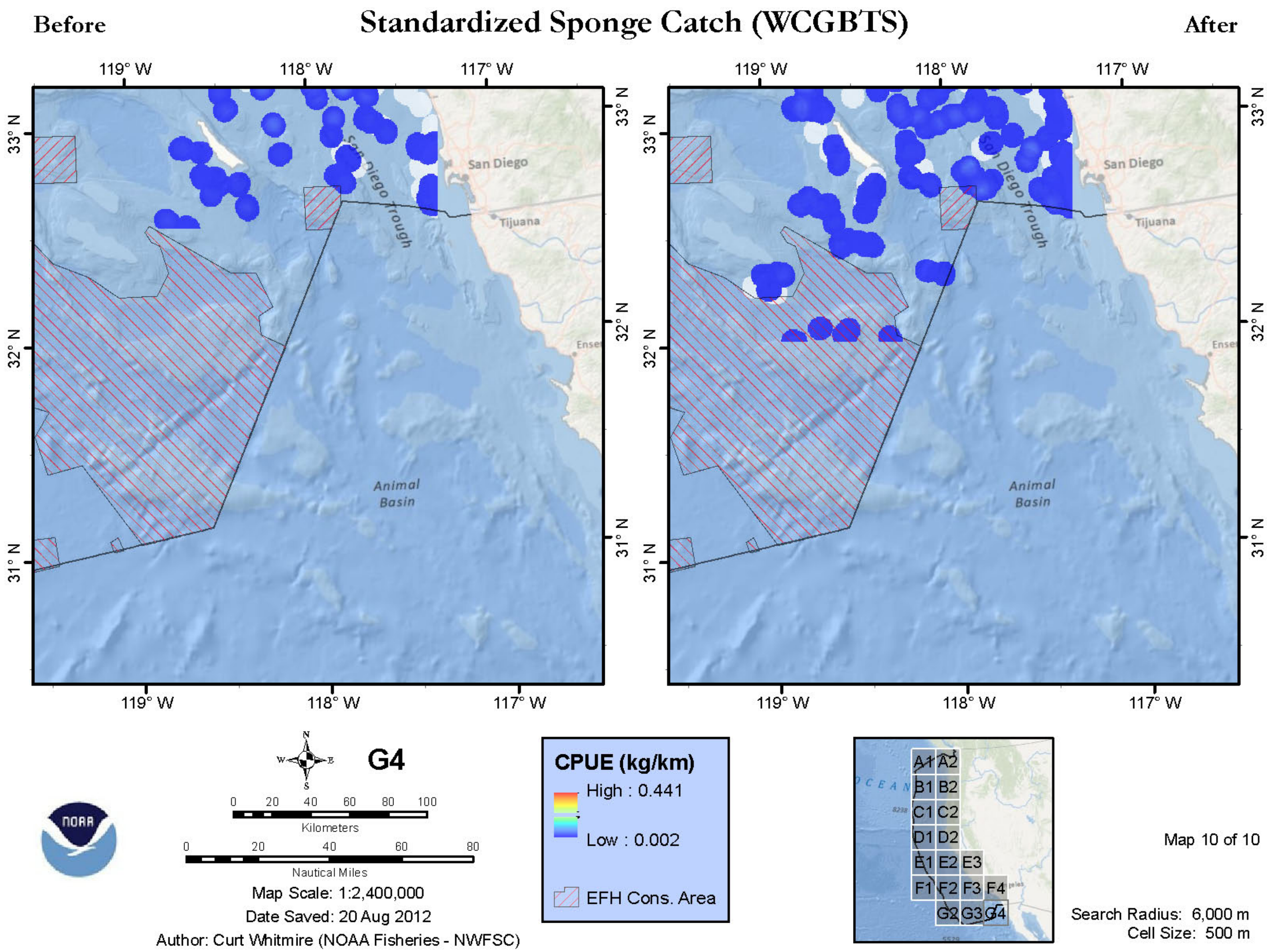


Before
Standardized Sponge Catch (WCGBTS)
After
122° W
121° W
120° W
35° N
34° N
4838
Rodriguez Seamount
F3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
Map 7 of 10
Search Radius: 6,000 m
Cell Size: 500 m

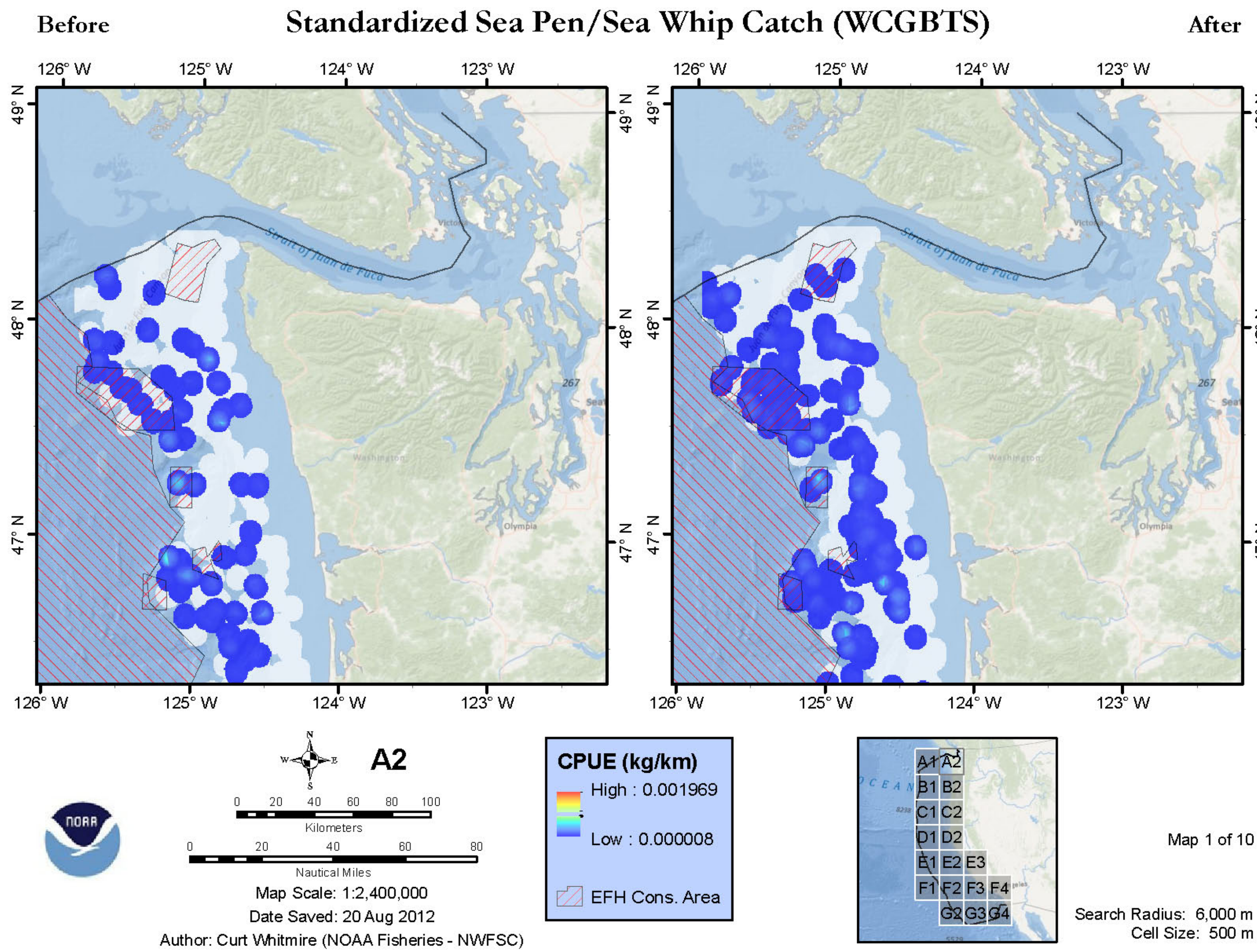
Appendix E-3: WCGBTS Sponge

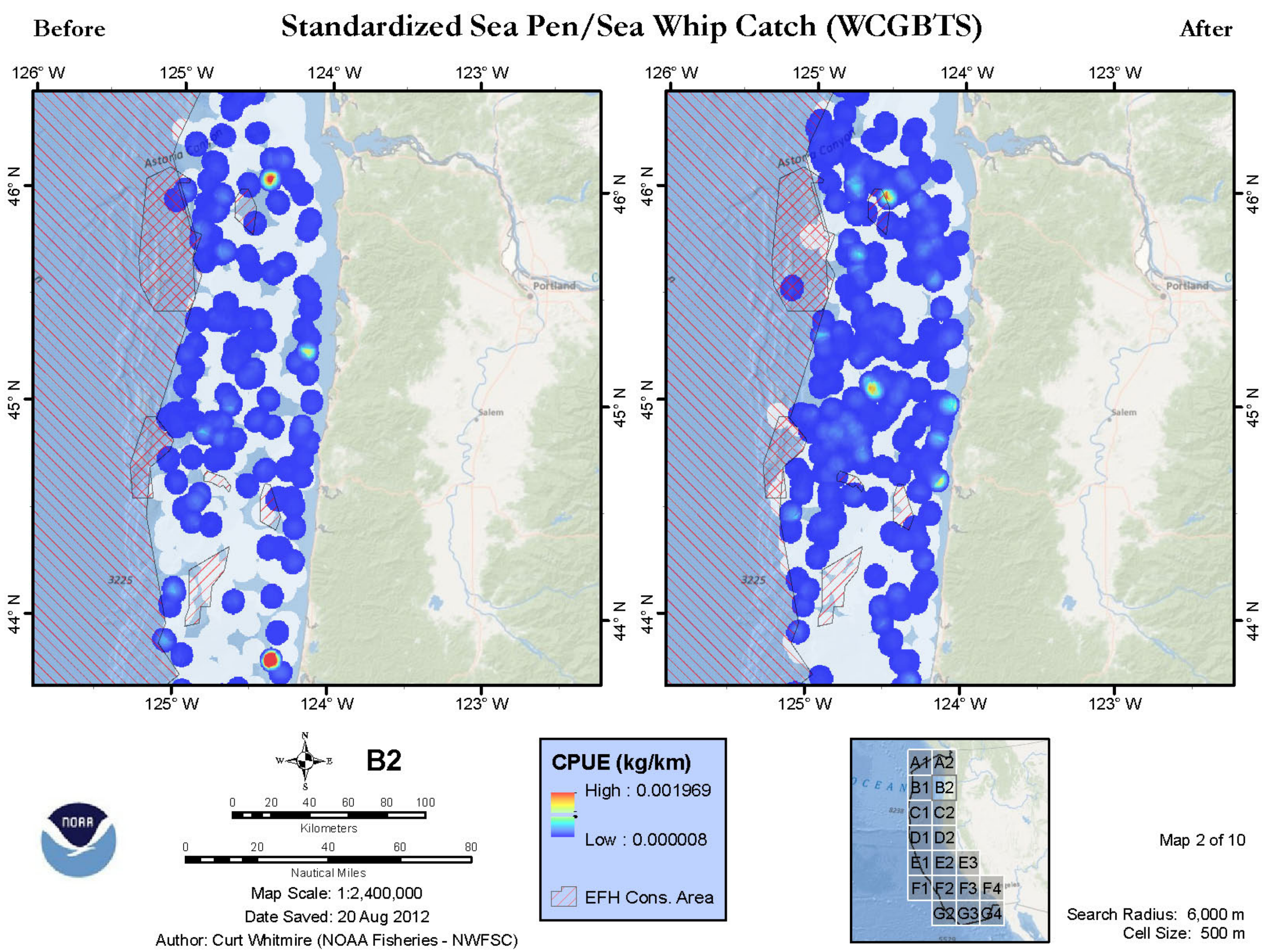


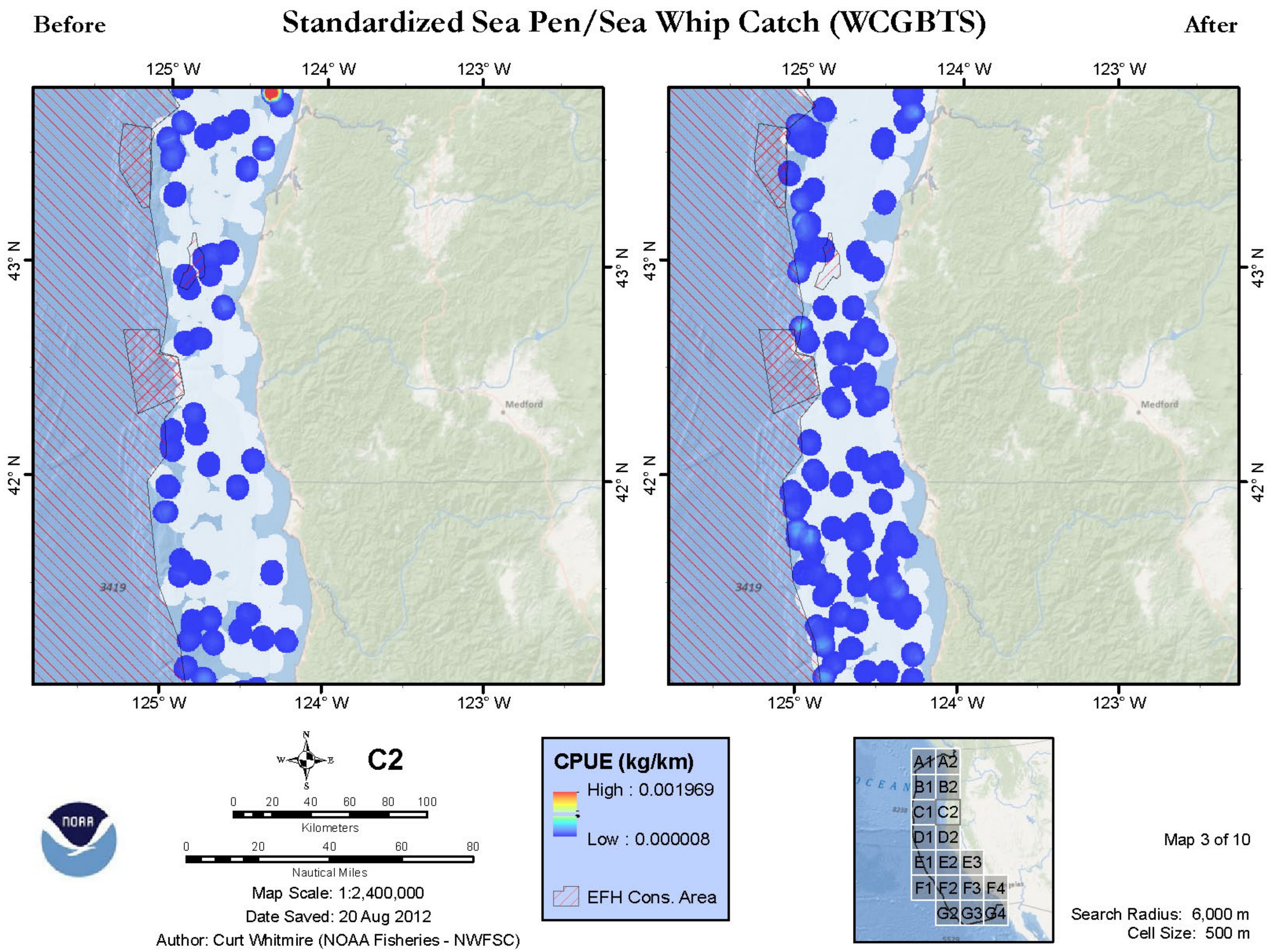

Before
Standardized Sponge Catch (WCGBTS)
After
122° W
121° W
120° W
33° N
32° N
31° N
San Juan Seamount
4780
5198
G3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 9 of 10
Search Radius: 6,000 m
Cell Size: 500 m

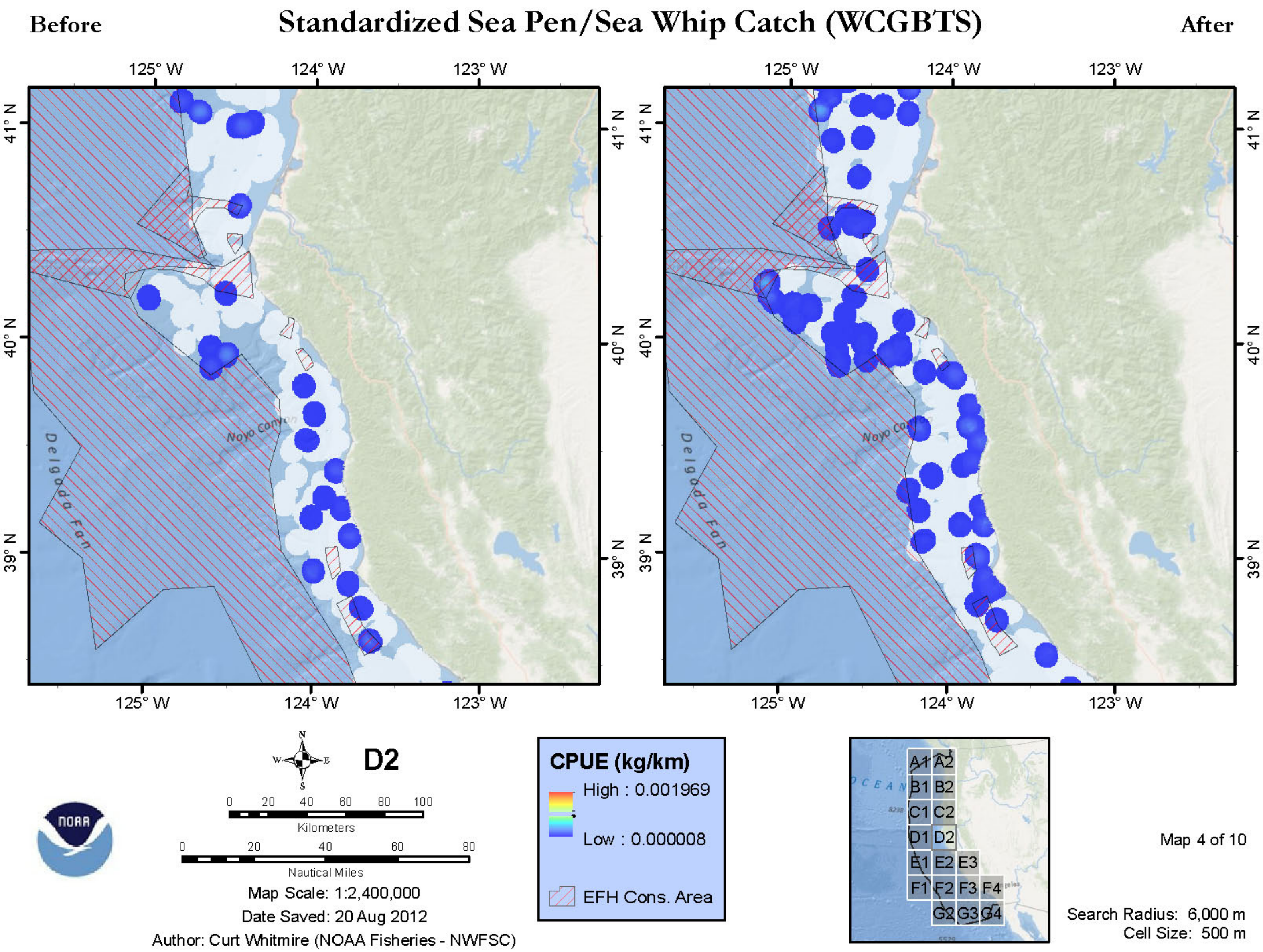

Before
Standardized Sponge Catch (WCGBTS)
After
119° W
118° W
117° W
33° N
32° N
31° N
San Diego
Tijuana
San Diego Trough
Animal Basin
G4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.441
Low : 0.002
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 10 of 10
Search Radius: 6,000 m
Cell Size: 500 m

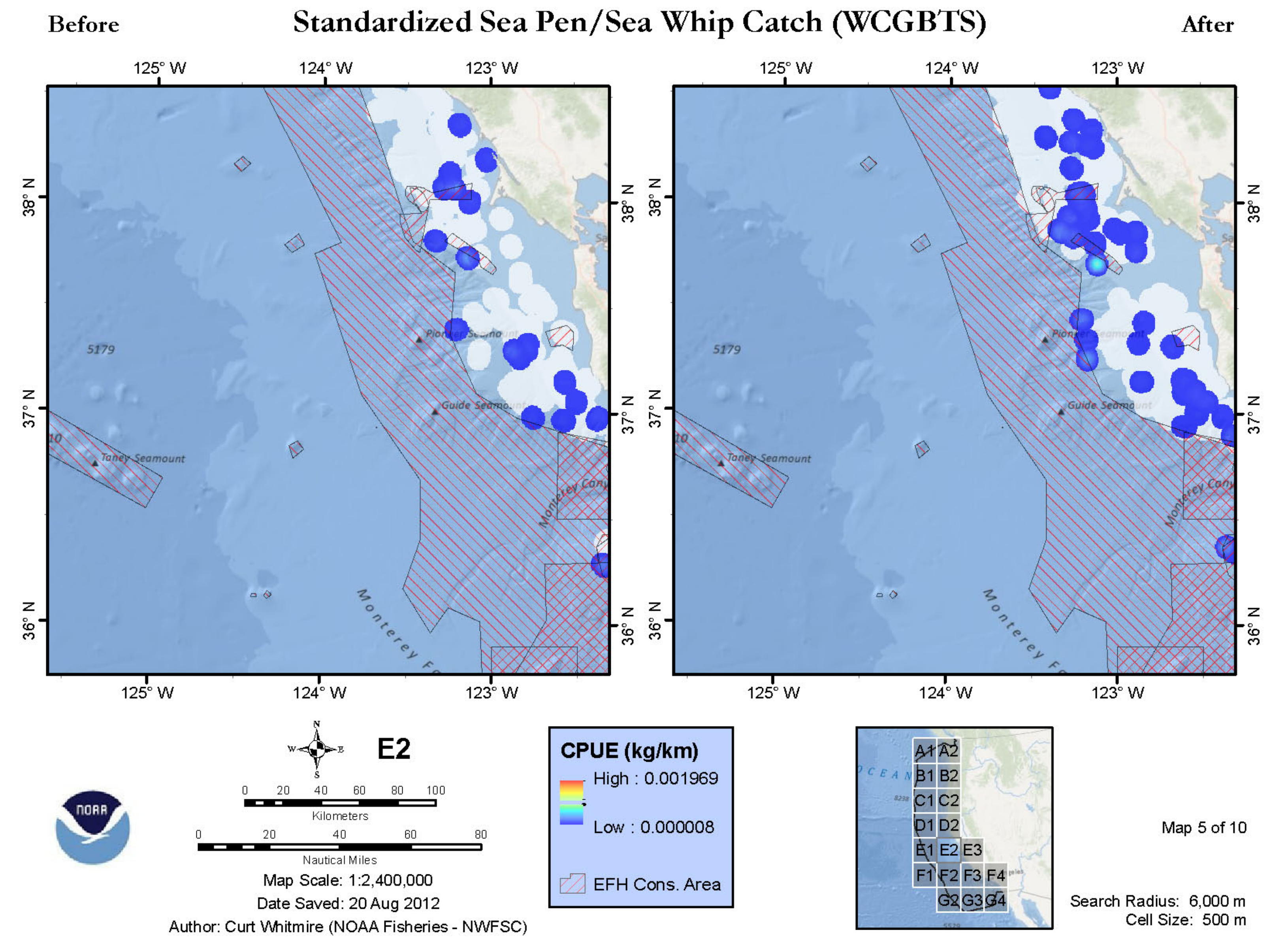
Appendix E-4: WCGBTS Sea Pens/Whips



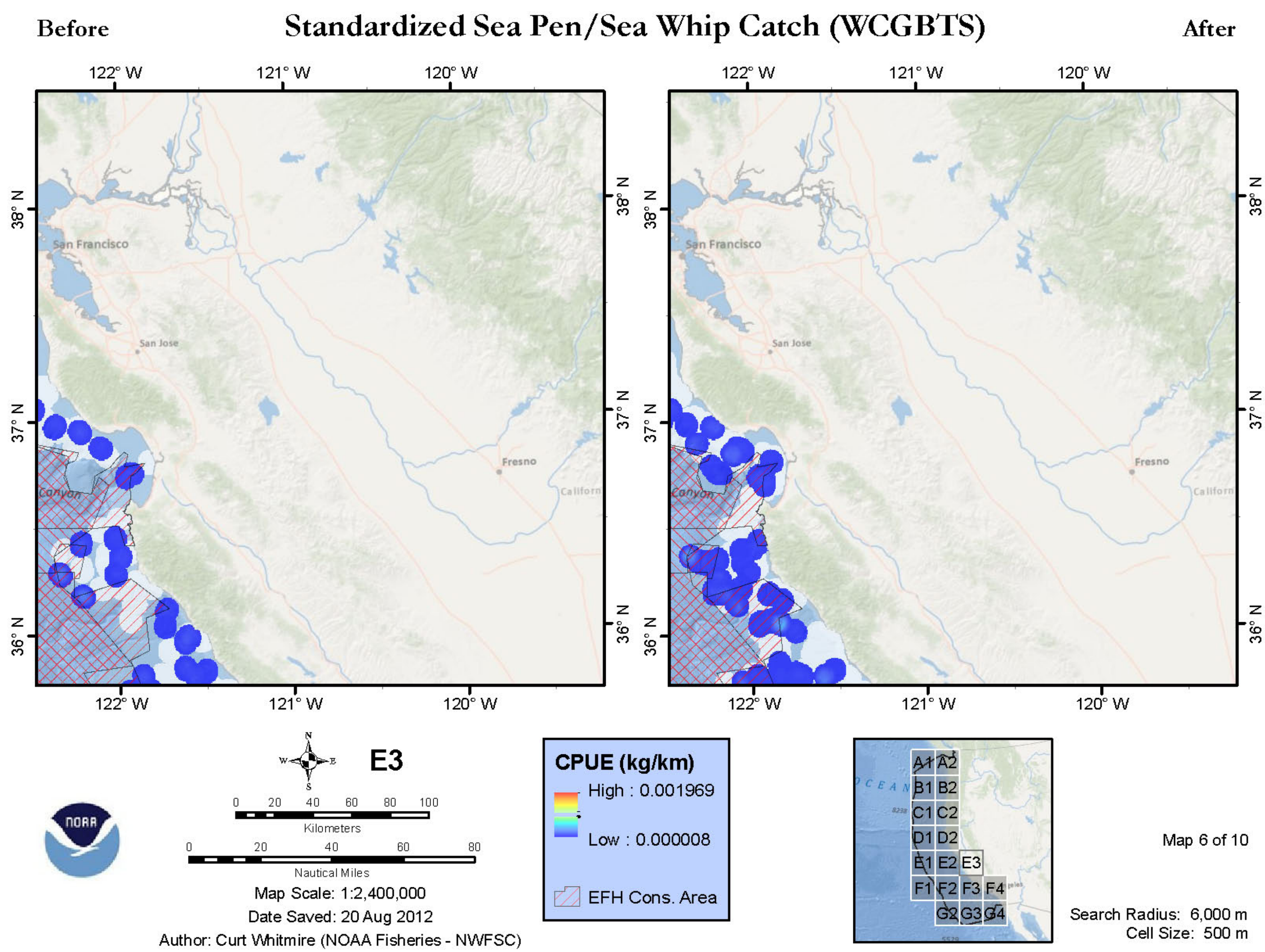

Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
B2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 10
Search Radius: 6,000 m
Cell Size: 500 m

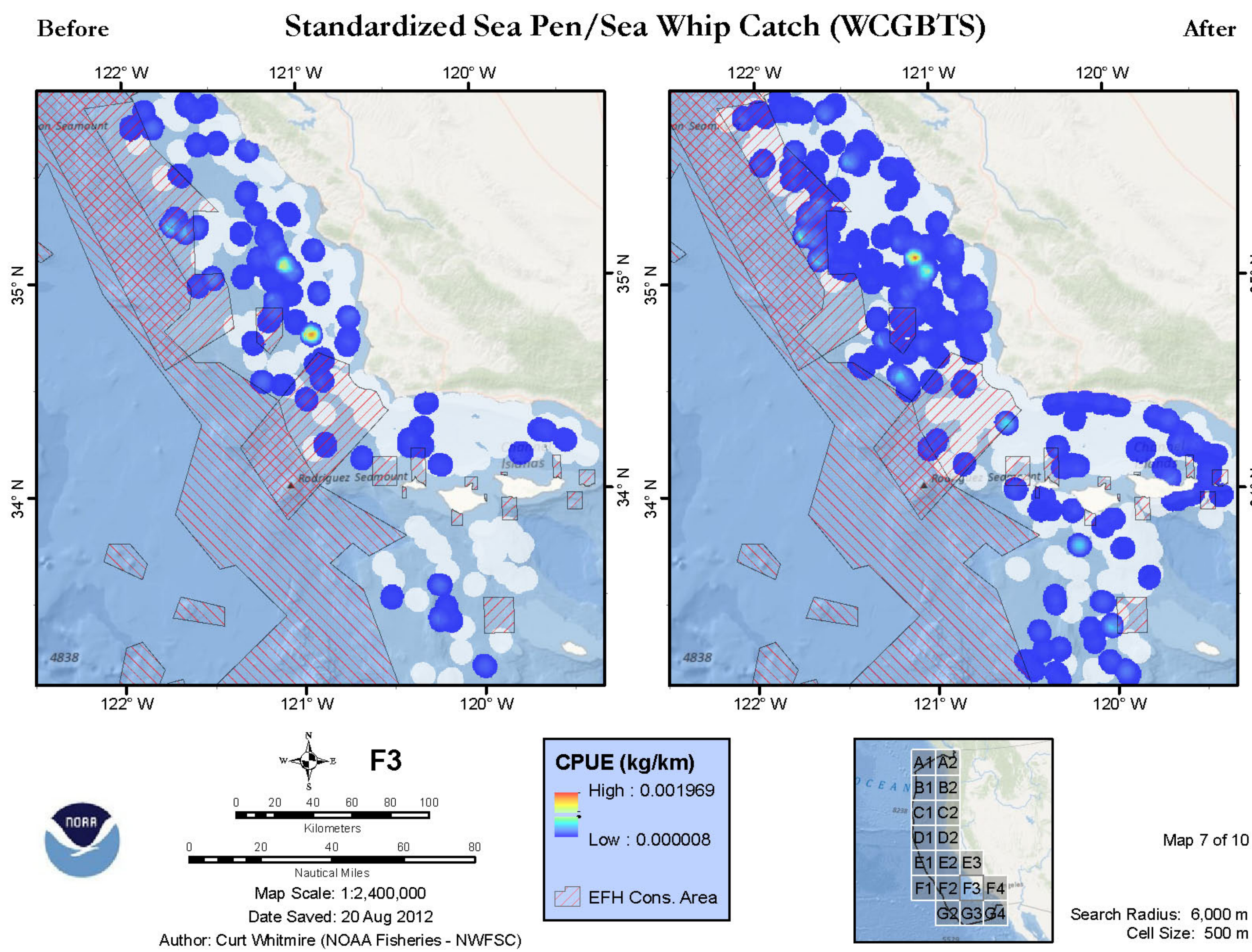

Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 10
Search Radius: 6,000 m
Cell Size: 500 m

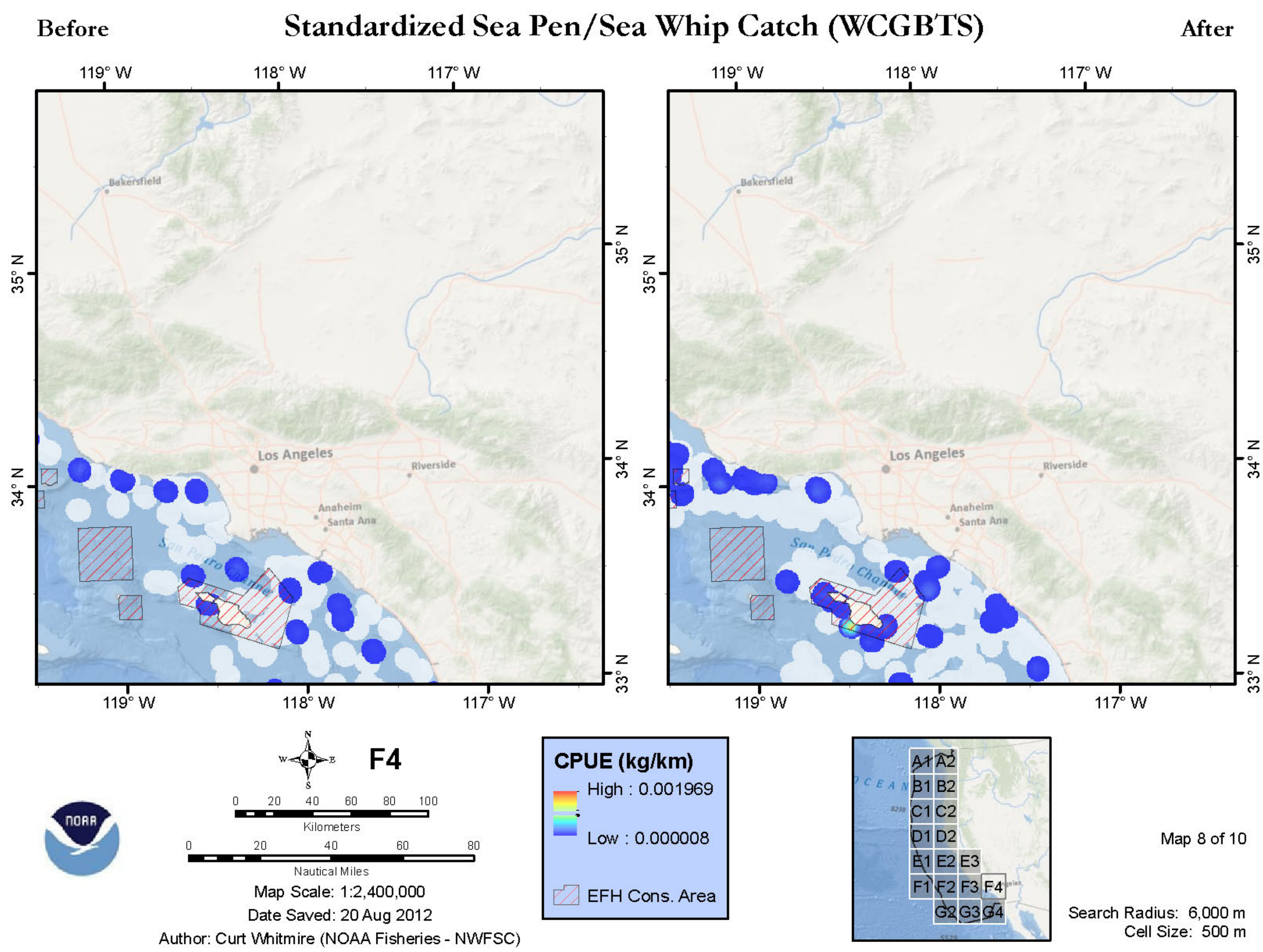


Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 10
Search Radius: 6,000 m
Cell Size: 500 m

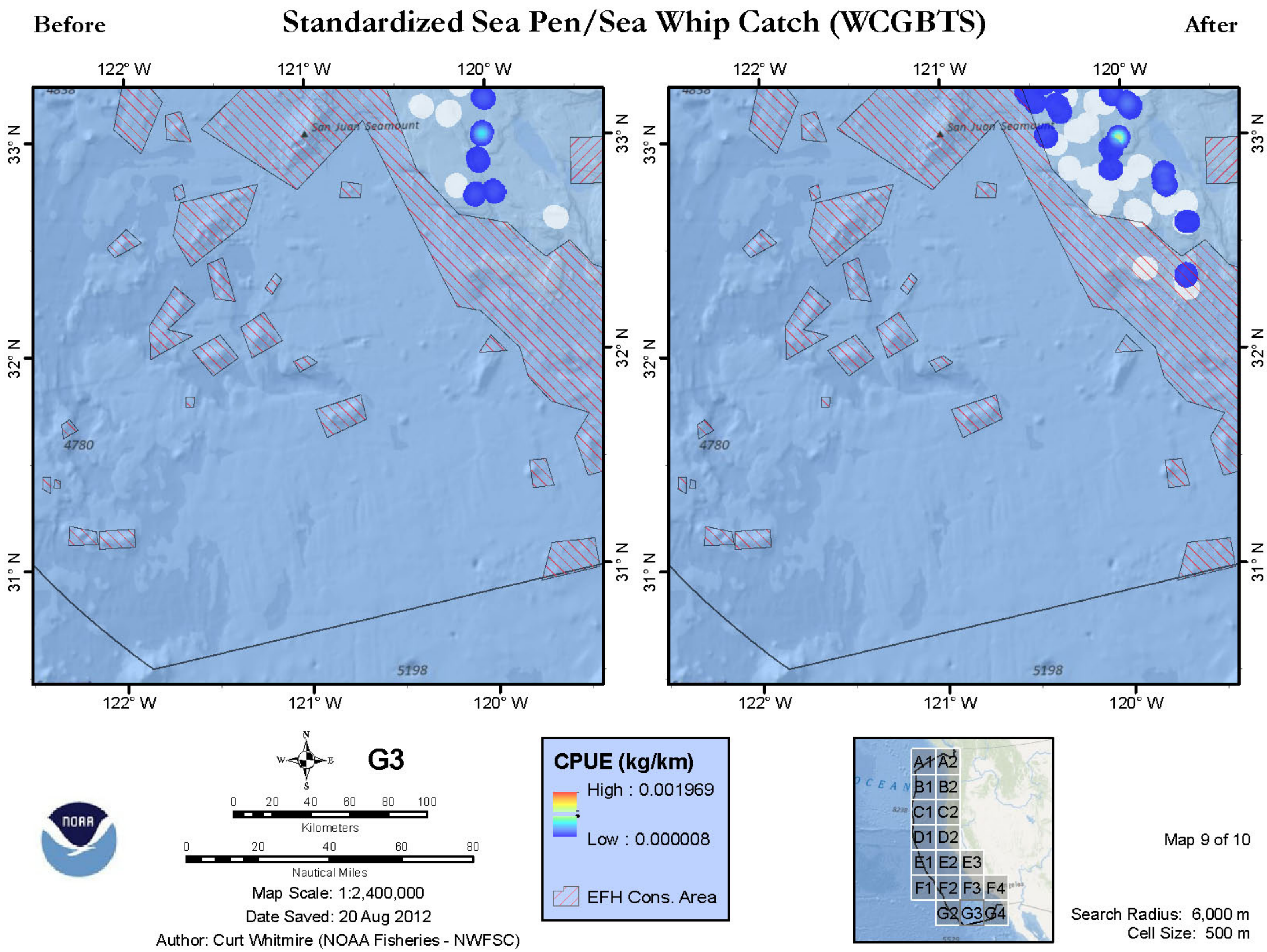

Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 6 of 10
Search Radius: 6,000 m
Cell Size: 500 m


Before
Standardized Sea Pen/Sea Whip Catch (WCGBTS)
After
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
4838
F3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (kg/km)
High : 0.001969
Low : 0.000008
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 10
Search Radius: 6,000 m
Cell Size: 500 m

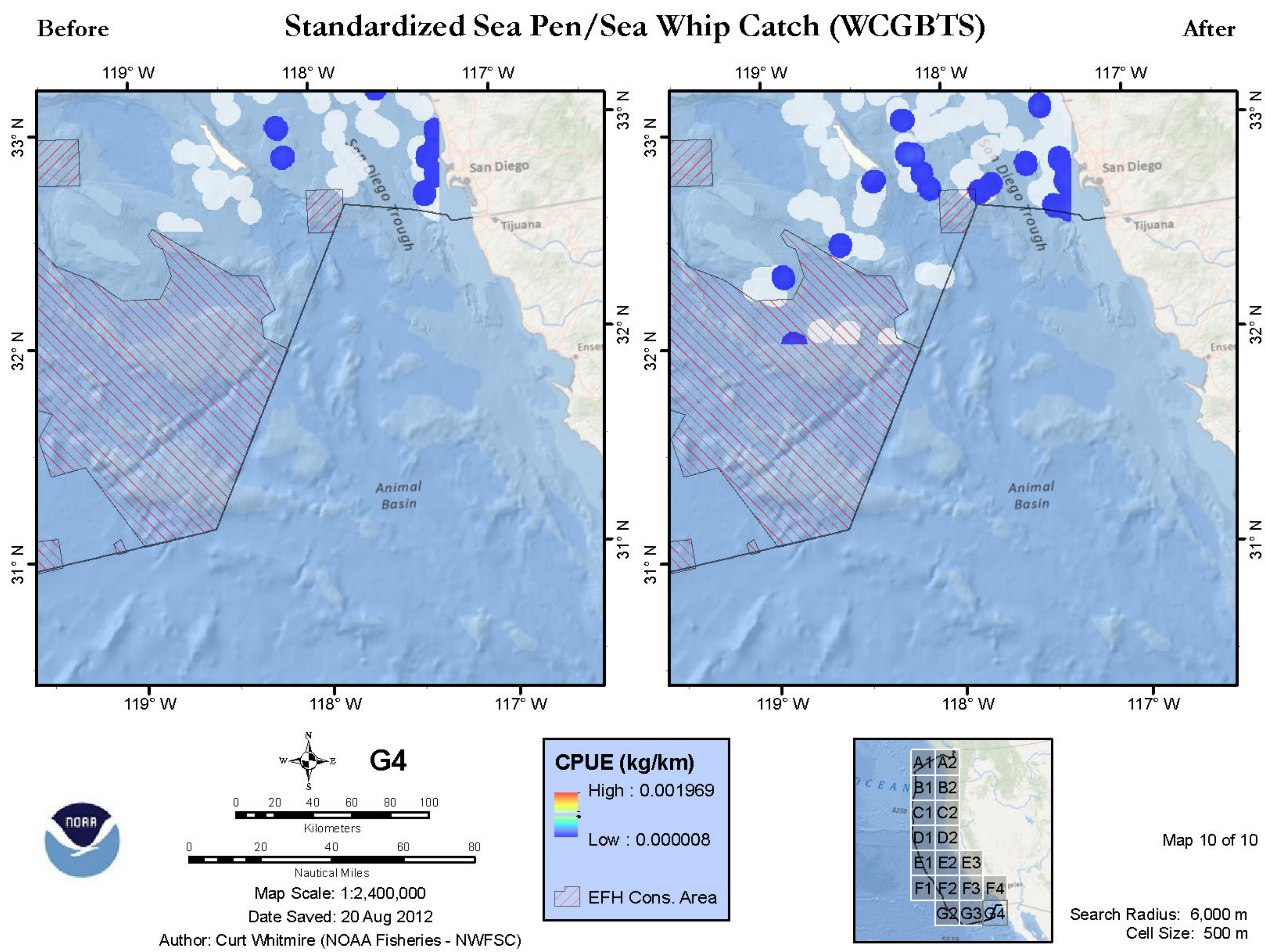
Appendix E-4: WCGBTS Sea Pens/Whips



Appendix E-4: WCGBTS Sea Pens/Whips



Appendix E-4: WCGBTS Sea Pens/Whips



APPENDIX F DISTRIBUTION OF CORALS AND SPONGES IN STANDARDIZED COMMERCIAL BYCATCH FROM WEST COAST GROUNDFISH OBSERVER PROGRAM CONDUCTED BEFORE AND AFTER THE 2006 EFH REVIEW

Appendix F plates depict the spatial distribution of standardized commercial bycatch of corals and sponges within two time periods: "Before" (3 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of limited-entry trawl tows were compiled from one source: observer records from the WCGOP database. The WCGOP database includes records of trips for vessels using a variety of bottom trawl gear configurations, including small and large footrope groundfish trawl, set-back flatfish net, and double rigged shrimp trawl, to name a few. Records of tows using mid-water trawl gear were not included in this analysis, since observers recorded no bycatch of corals or sponges using this gear type. Furthermore, since all fishing operations are not observed, neither the maps nor the data can be used to characterize bycatch completely. We urge caution when utilizing these data due to the complexity of groundfish management and fleet harvest dynamics. Annual WCGOP coverage of the limited-entry trawl sector can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm.

Trawl events were represented by a straight line connecting the start and end points. Towlines intersecting land, outside the U.S. EEZ, deeper than 2,000 m, or with a calculated straight-line speed over 5 knots were removed from the spatial analysis. Bycatch was analyzed for four taxonomic groupings of organisms: 1) corals (excluding sea pens and sea whips) and sponges, 2) corals (excluding sea pens and sea whips), 3) sponges, and 4) sea pens and seas whips. For each of the four taxonomic groups, two standardized bycatch metrics were calculated: 1) standardized CPUE (units: lb/km; Appendix F-1 to F-4), and 2) catch-per-unit-of groundfish catch (i.e., CPUC, units: lb/ton of groundfish; Appendix F-5 to F-8).

The numerator for both bycatch metrics was catch density, calculated using a kernel density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California). Catch density was calculated for all tows with presence of one of the four taxonomic groups of corals and sponges.

The denominator for either the CPUE or CPUC was calculated using the same line density algorithm utilized in the two trawl effort intensity layers. For the CPUC metric, the line density algorithm weights each linear feature representing a tow by the weight of groundfish catch (tons). Effort density of density of groundfish catch was calculated for all tows, regardless of presence of corals or sponges in the catch.

By standardizing catch by either amount of effort (km/km^2; Appendix F-1 to F-4) or catch of groundfish (lb/km^2; Appendix F-5 to F-8), the resulting bycatch outputs were standardized over both space and time. In order to maintain the confidentiality of individual vessels, any cells with density values calculated from fewer than three vessels were removed from the final map layers. This did not significantly change how bycatch was represented since almost all bycatch occurred within areas where more than two vessels were operating. The density parameters used for calculating standardized bycatch were a 3-km search radius and a 500x500 m cell size.

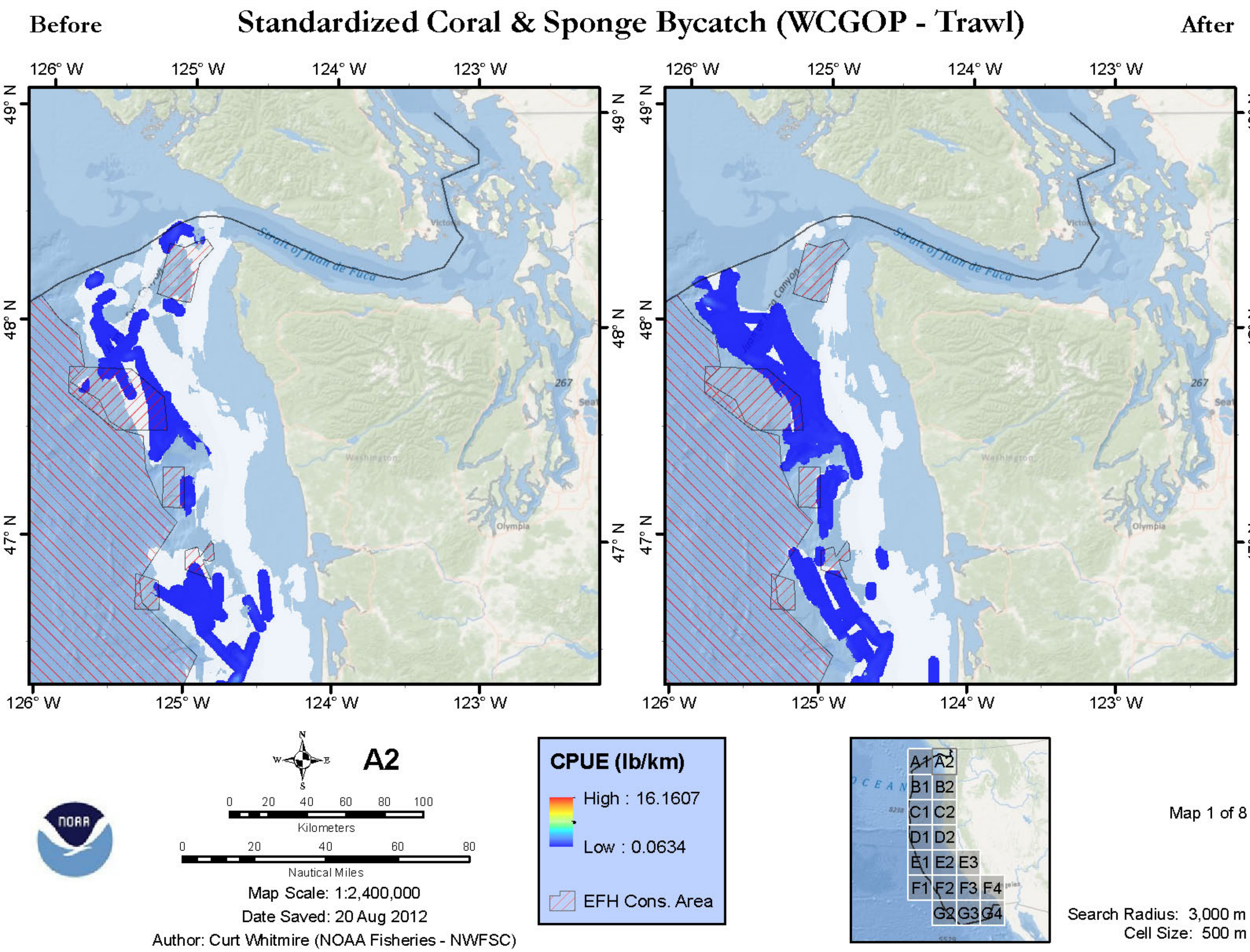
Before interpreting the data and map figures, there are a few points about the methods used to create them that are important to consider. First, trawl tracks are only represented by straight lines connecting start and end points. Trawls rarely follow straight lines; therefore, the longer the line the higher the uncertainty as to its actual path. Second, since we are uncertain as to when bycatch occurred during the course of a trawl, bycatch was assumed to occur consistently and proportionally over the entire course of the straight trawl line. Third, only observed trips are represented. Fourth, different trawl gear configurations will access different types of habitats and topographic relief. Fifth, the boundaries of the trawl rockfish conservation areas have changed throughout both of these time periods, effectively changing access to trawlable (and biogenic) habitats within these areas. Lastly, implementation of the EFH conservation areas in June 2006 significantly curtailed access to some known biogenic habitats. The effects of these closures on protection of biogenic habitats are not fully understood.

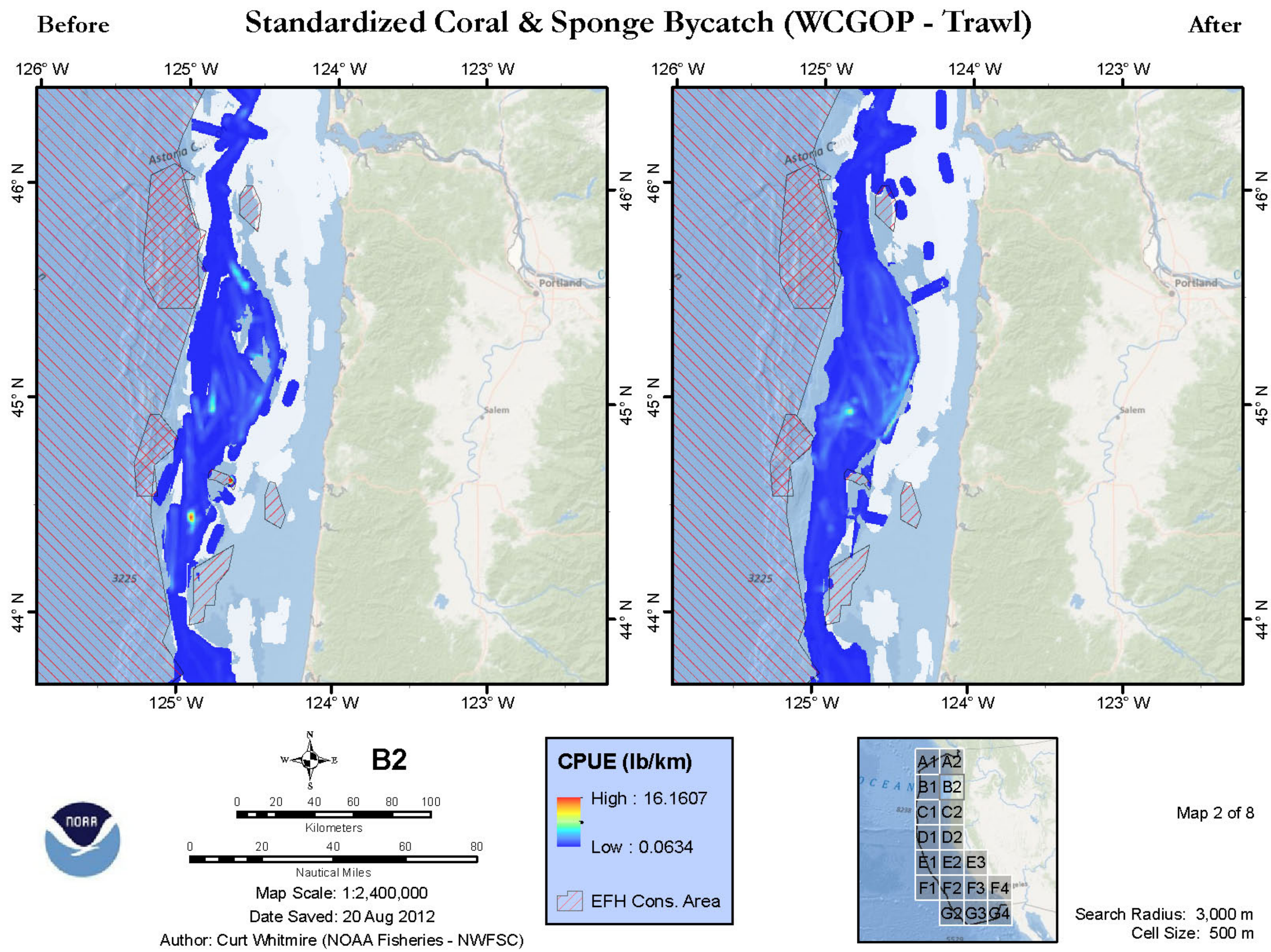
Eight (four taxonomic groups by two bycatch metrics) sets of map figures (Plates) were created to show temporal comparisons of standardized bycatch, (Appendix F). In order to evaluate how bycatch has changed between two time periods in any given map set, the color ramps for the density layers in each time period were scaled to the same range of values. Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. White areas repreent those where no bycatch occurred but where effort still existed. The upper value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

One apparent feature of all map figures is that few areas of high relative bycatch are evident. This is a result of having to scale the color ramps for each panel to facilitate temporal comparison. Since the range of standardized bycatch values between each time period is significantly different and since many values are very low (near zero), most areas of the map layers appear dark blue (zero to low bycatch). The areas of the map that appear lighter blue (teal) or red represent areas where bycatch was higher in one time period versus the other.

For sponges (Appendices F-3 and F-7) and corals/sponges combined (Appendices F-1 and F-5), areas that show consistently higher relative amounts of bycatch are located on the northern Oregon slope (Plate B2) and a couple areas off southern Oregon (Plate C2). Areas of decreased bycatch for sponges (Appendix F-3) and corals/sponges combined (Apendix F-1 and F-5) occur at two small areas on the central Oregon slope (Plate B2) and near the Eel River Canyon (Plate D2). One area of increased bycatch of these taxonomic groups is evident off Cape Arago, Oregon (Plate C2). For corals (Appendicies F-2 and F-6), bycatch has decreased significantly in many areas, especially at one small area off the Columbia River mouth and a number of areas off northern Oregon (Plate B2), and two areas off southern Oregon (Plate C2). Bycatch has only increased in one area off Crescent City, California (Plate C2). And finally, bycatch of sea pens/whips (Appendices F-4 and F-8) has decreased significantly in three areas off northern Oregon (Plate B2) and one small area shoreward of the Bandon High Spot (Plate C2).

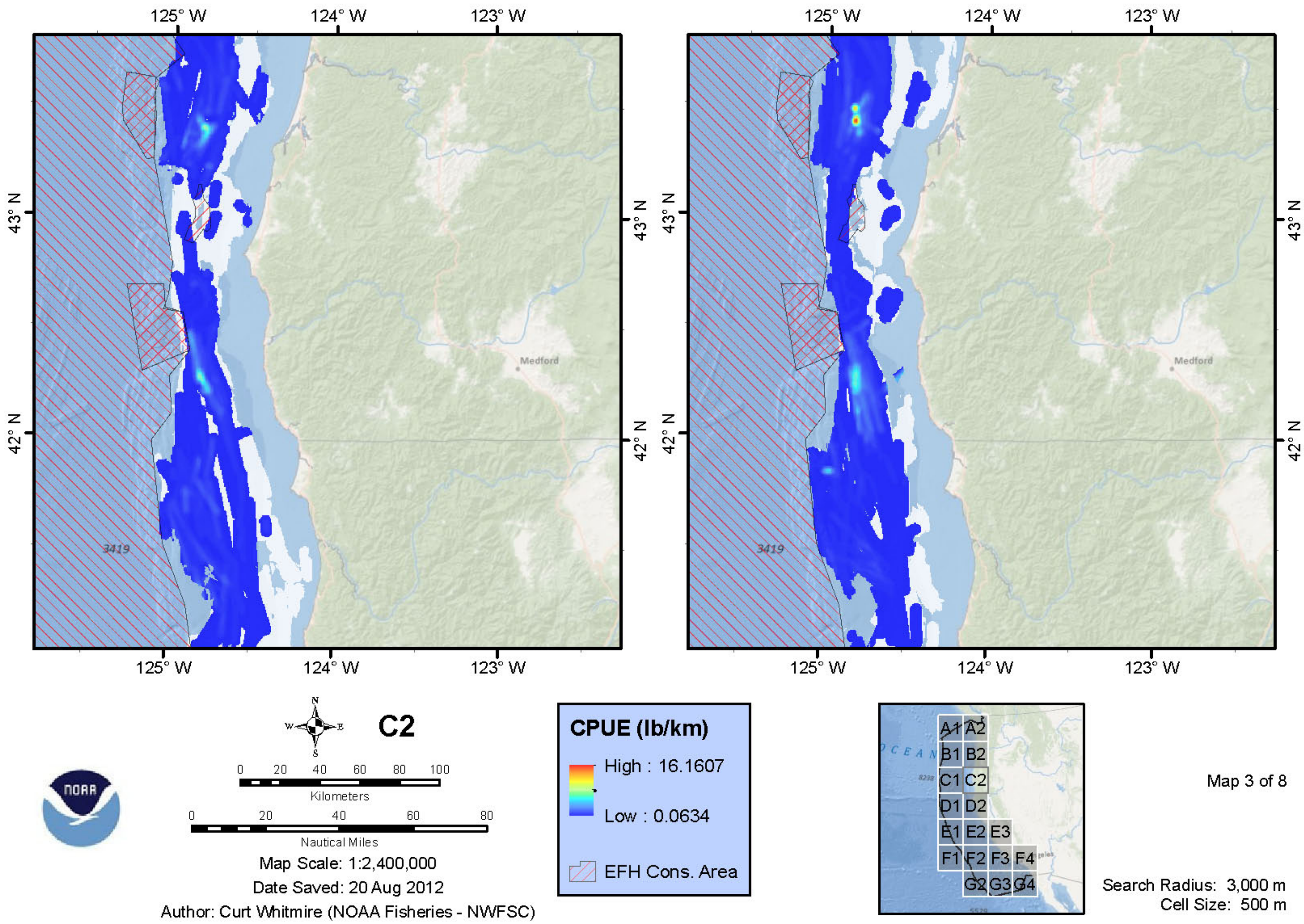
To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/.

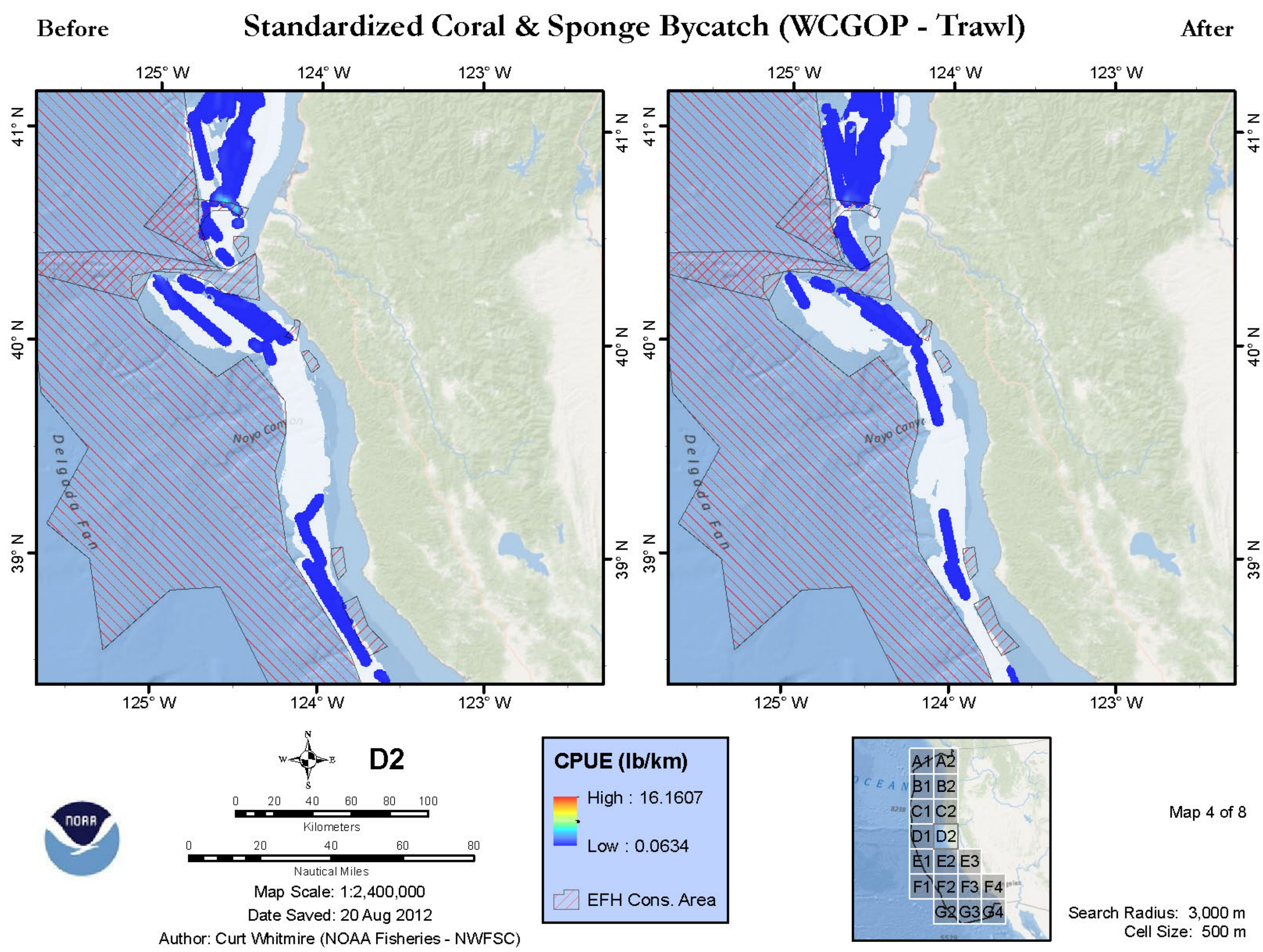

Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1607
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m



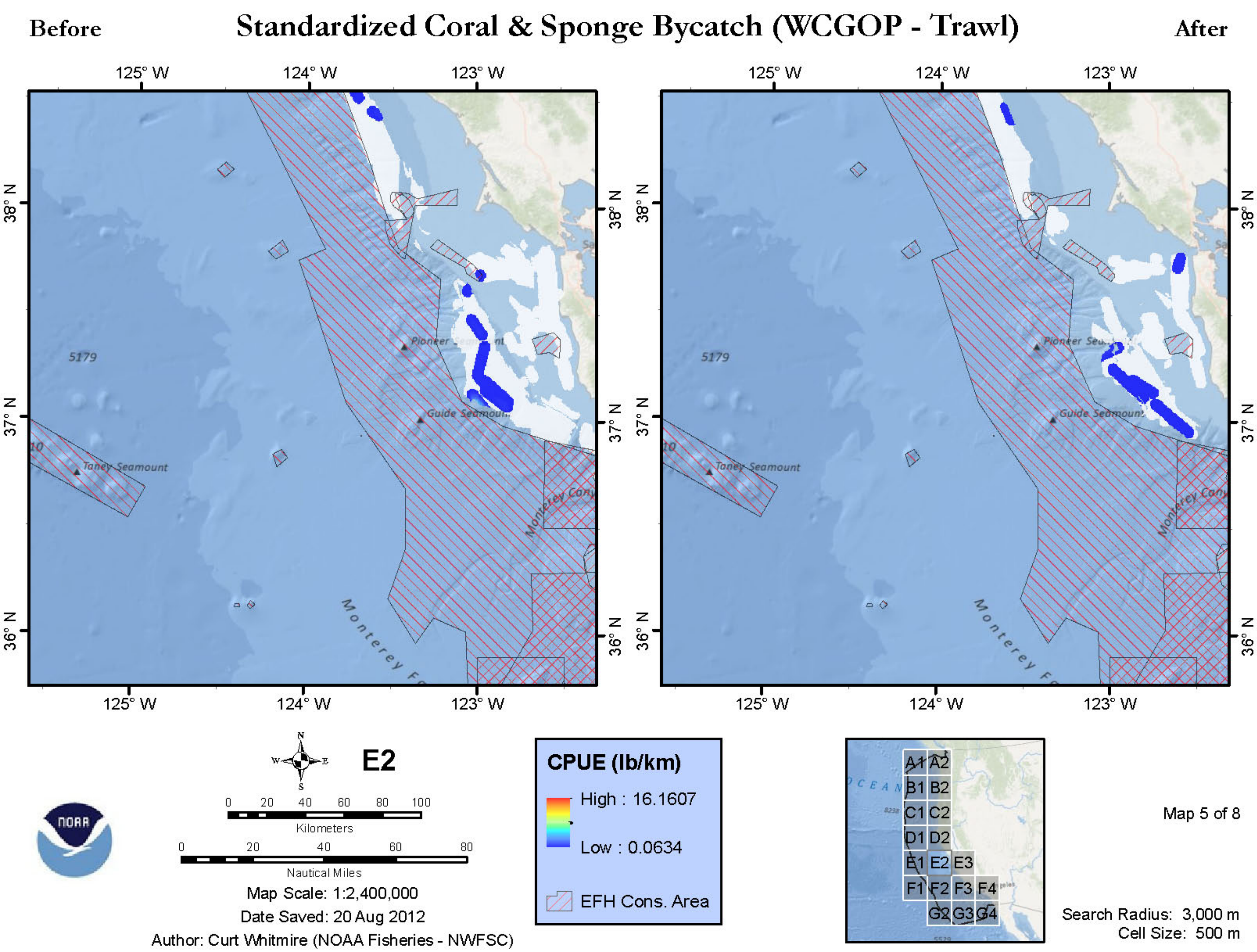
Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria C...
Portland
Salem
3225
B2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1607
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Coral & Sponge Bycatch (WCGOP - Trawl)** **After**

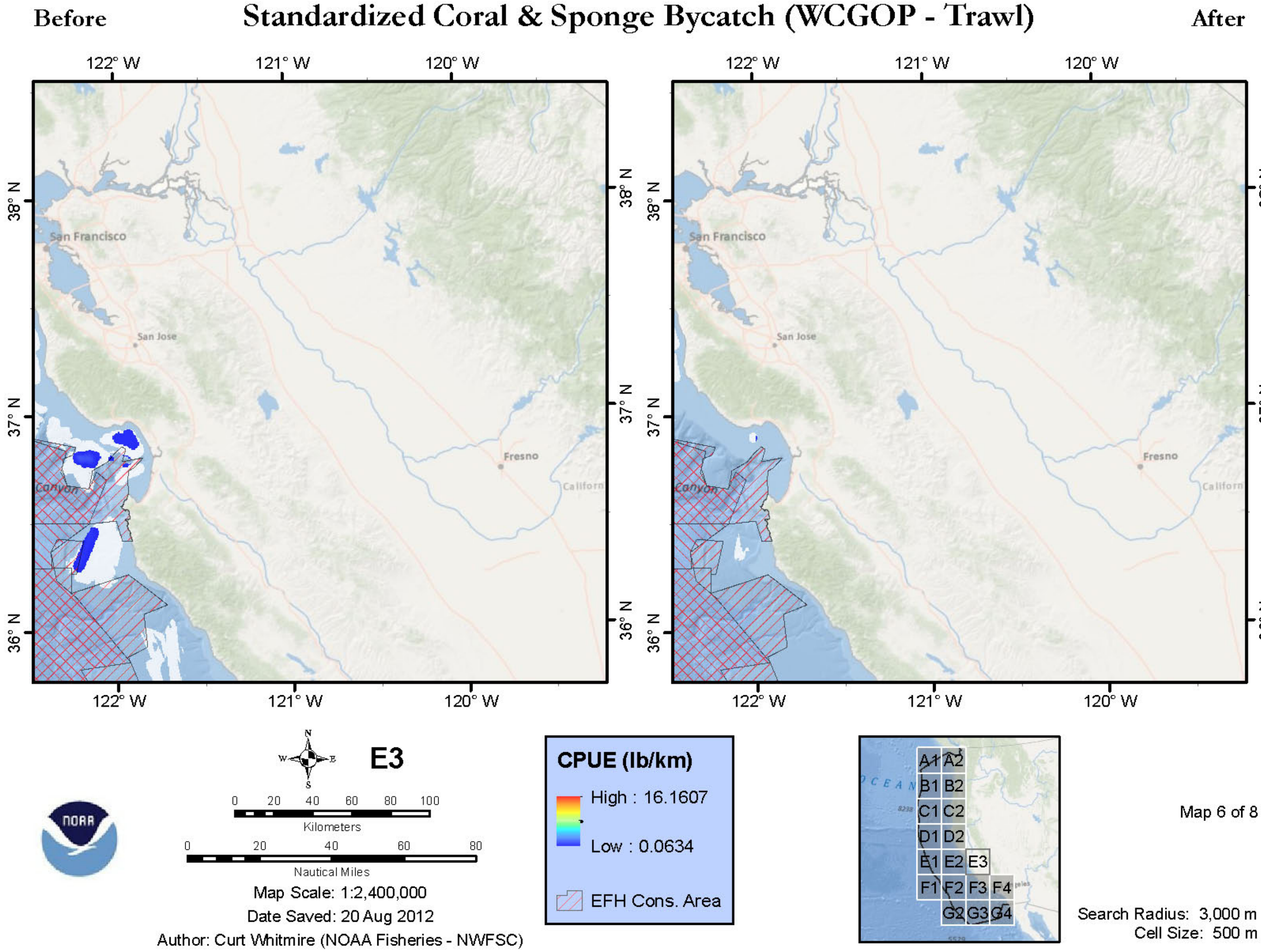




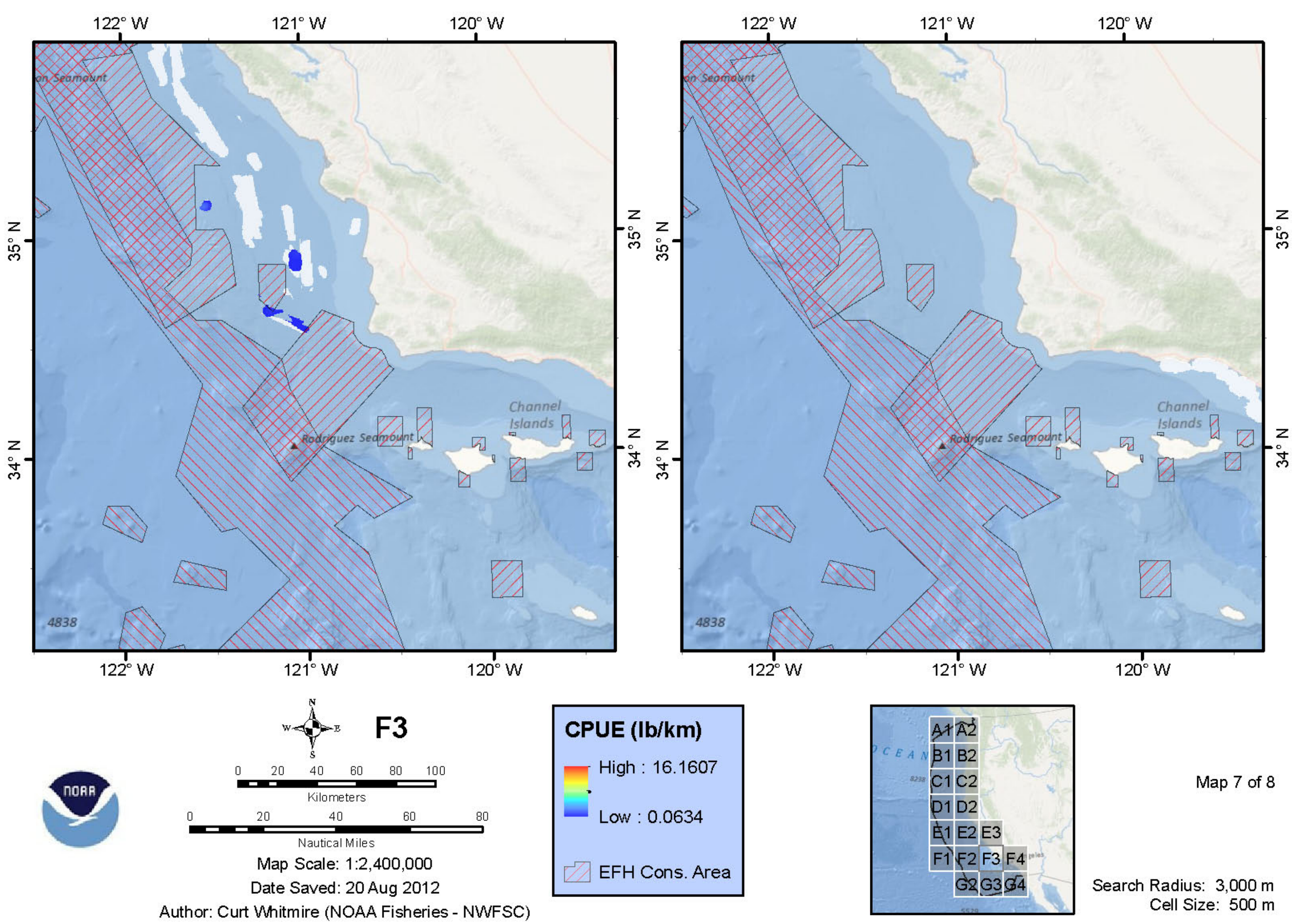
Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1607
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Taney Seamount
Pioneer Seamount
Guide Seamount
Monterey Fan
Monterey Canyon
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1607
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Standardized Coral & Sponge Bycatch (WCGOP - Trawl)



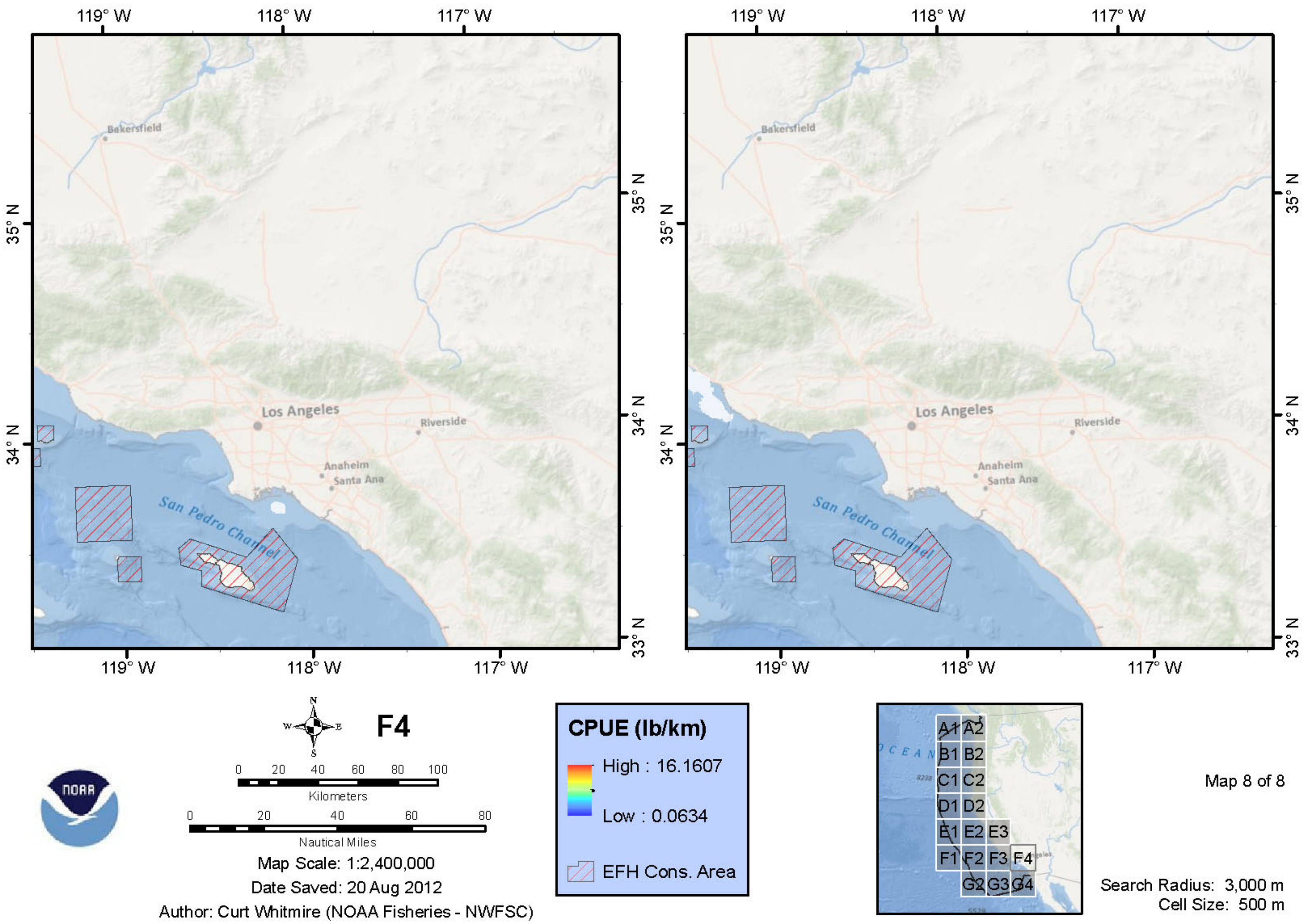
Before **Standardized Coral & Sponge Bycatch (WCGOP - Trawl)** **After**

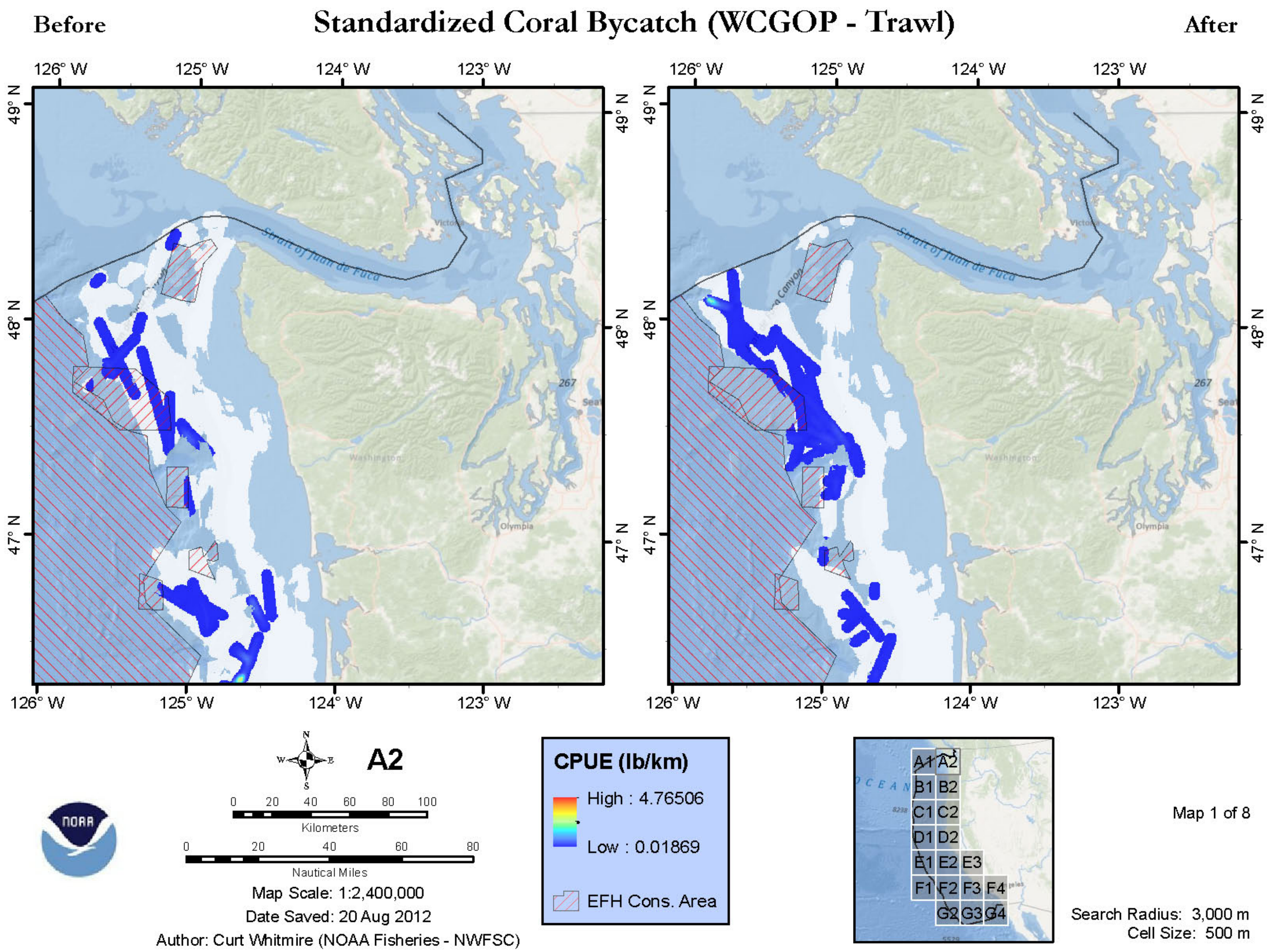


Appendix F-1

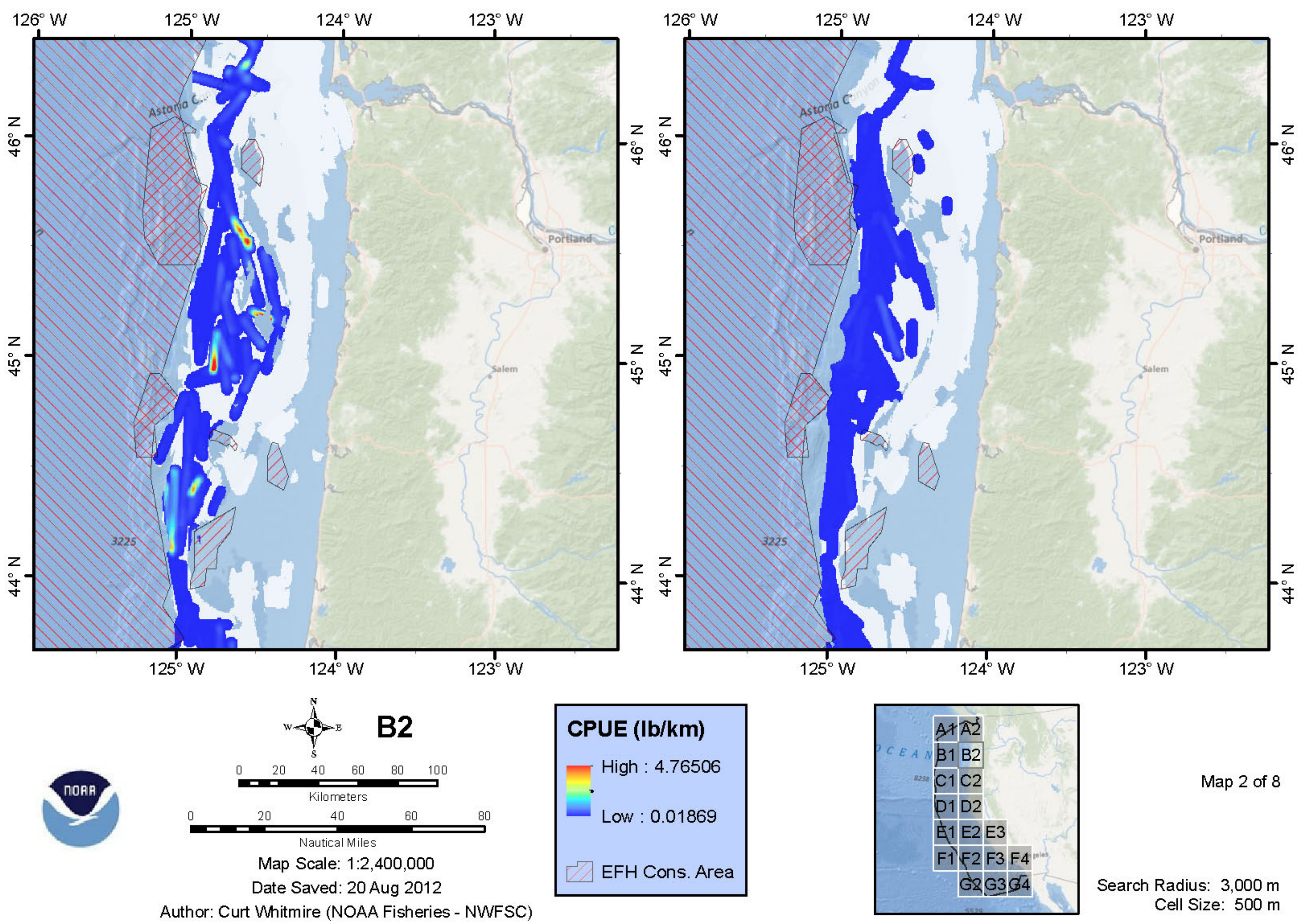
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)

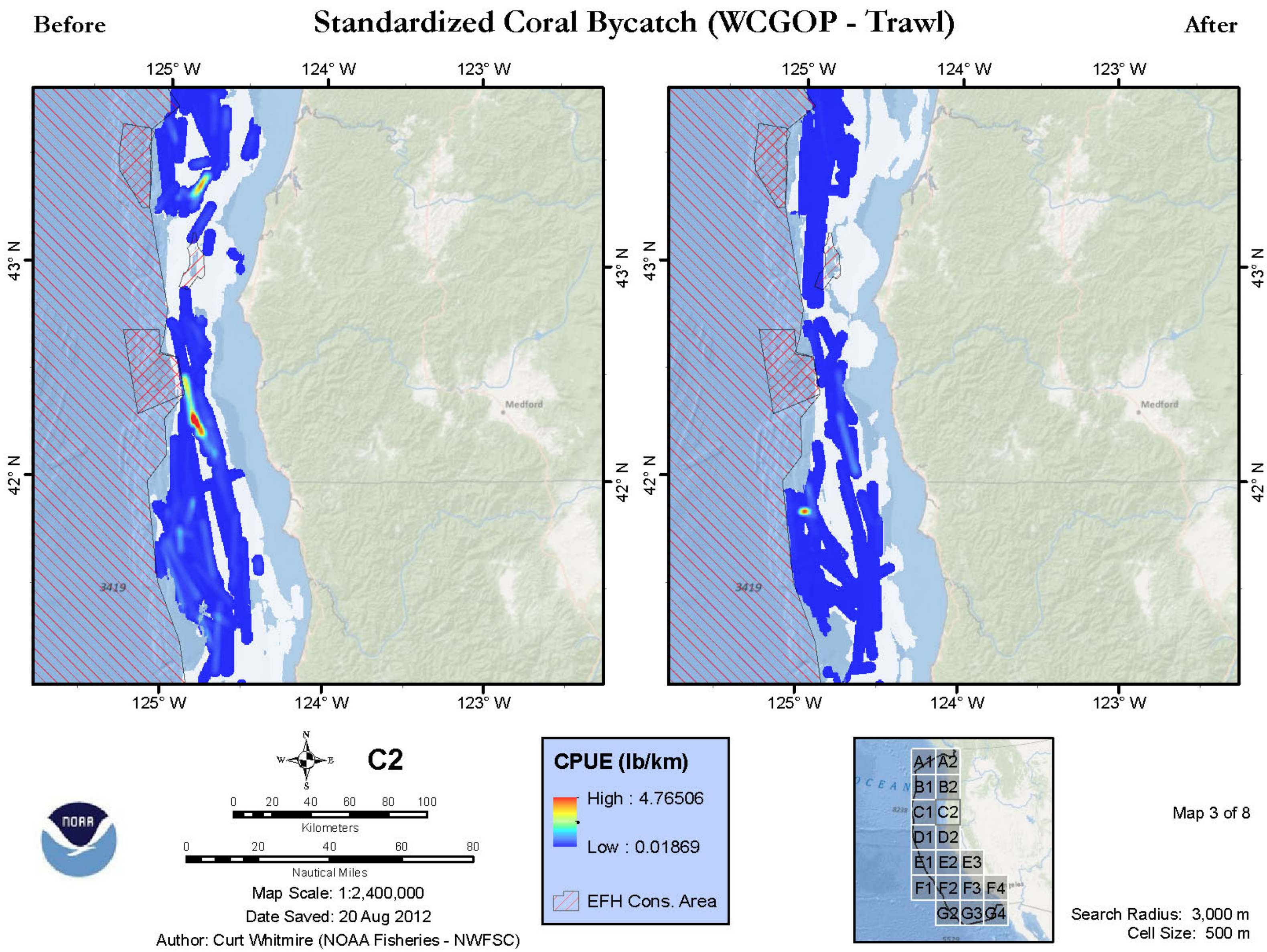
Before | After

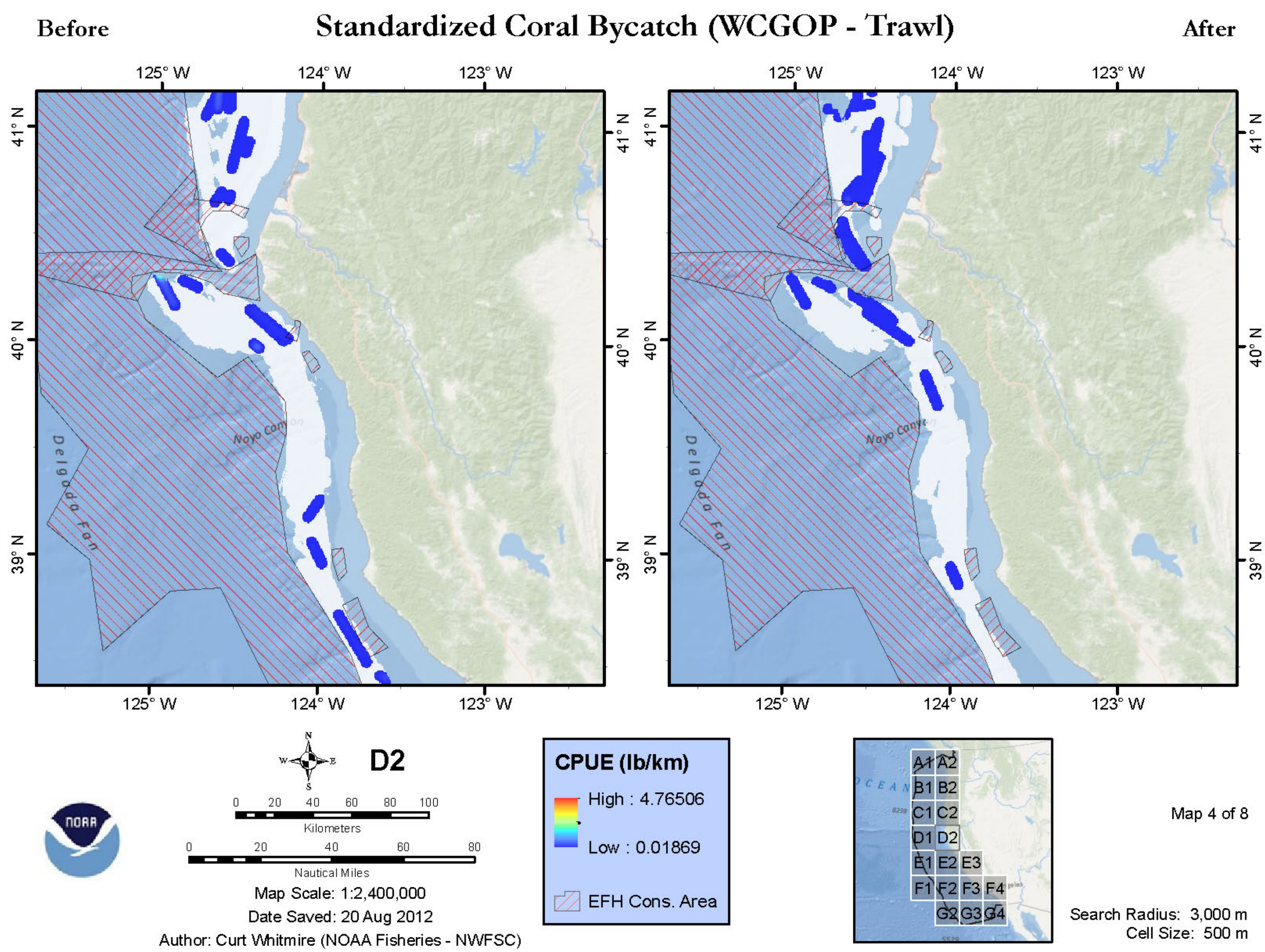


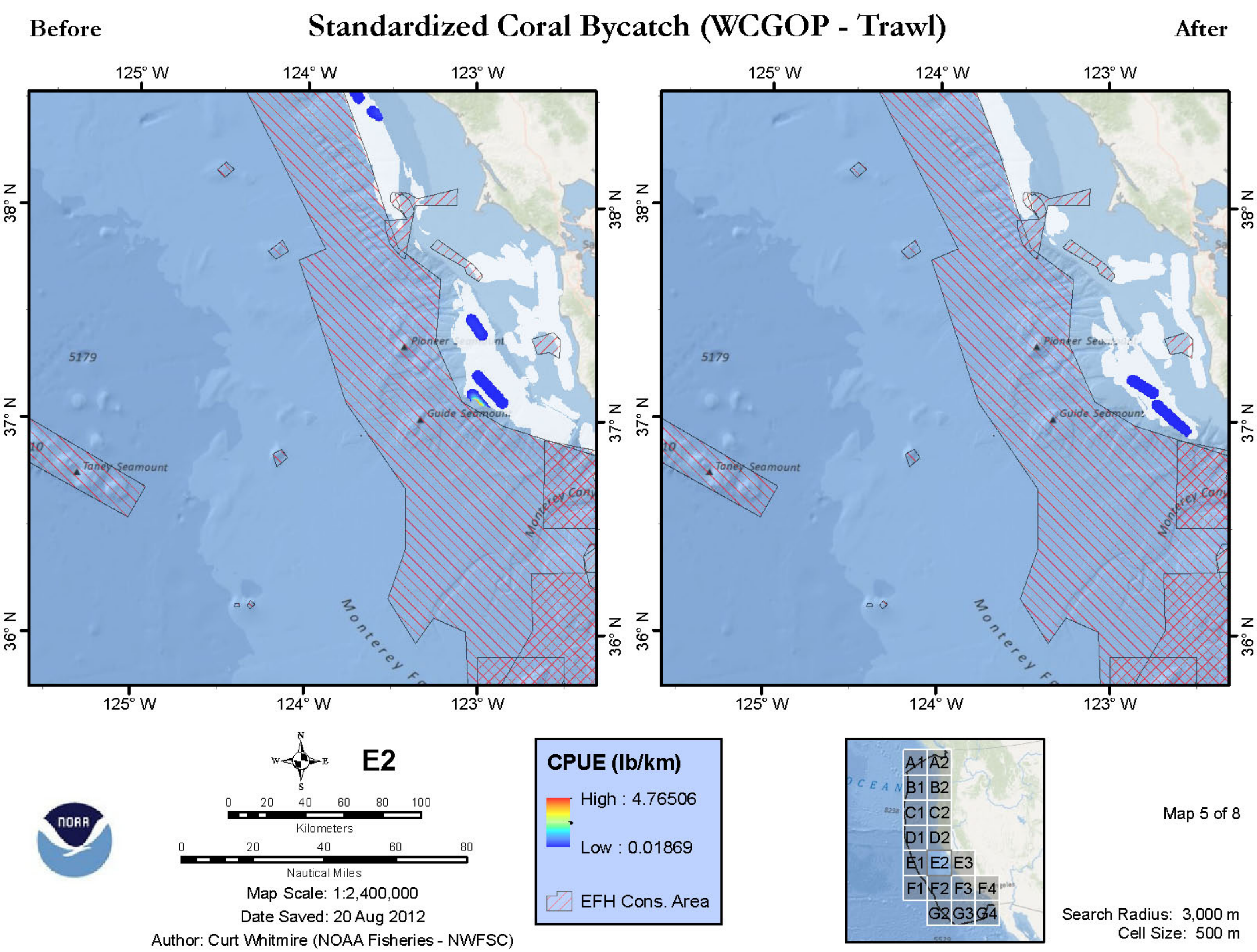

Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 4.76506
Low : 0.01869
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Coral Bycatch (WCGOP - Trawl)** **After**

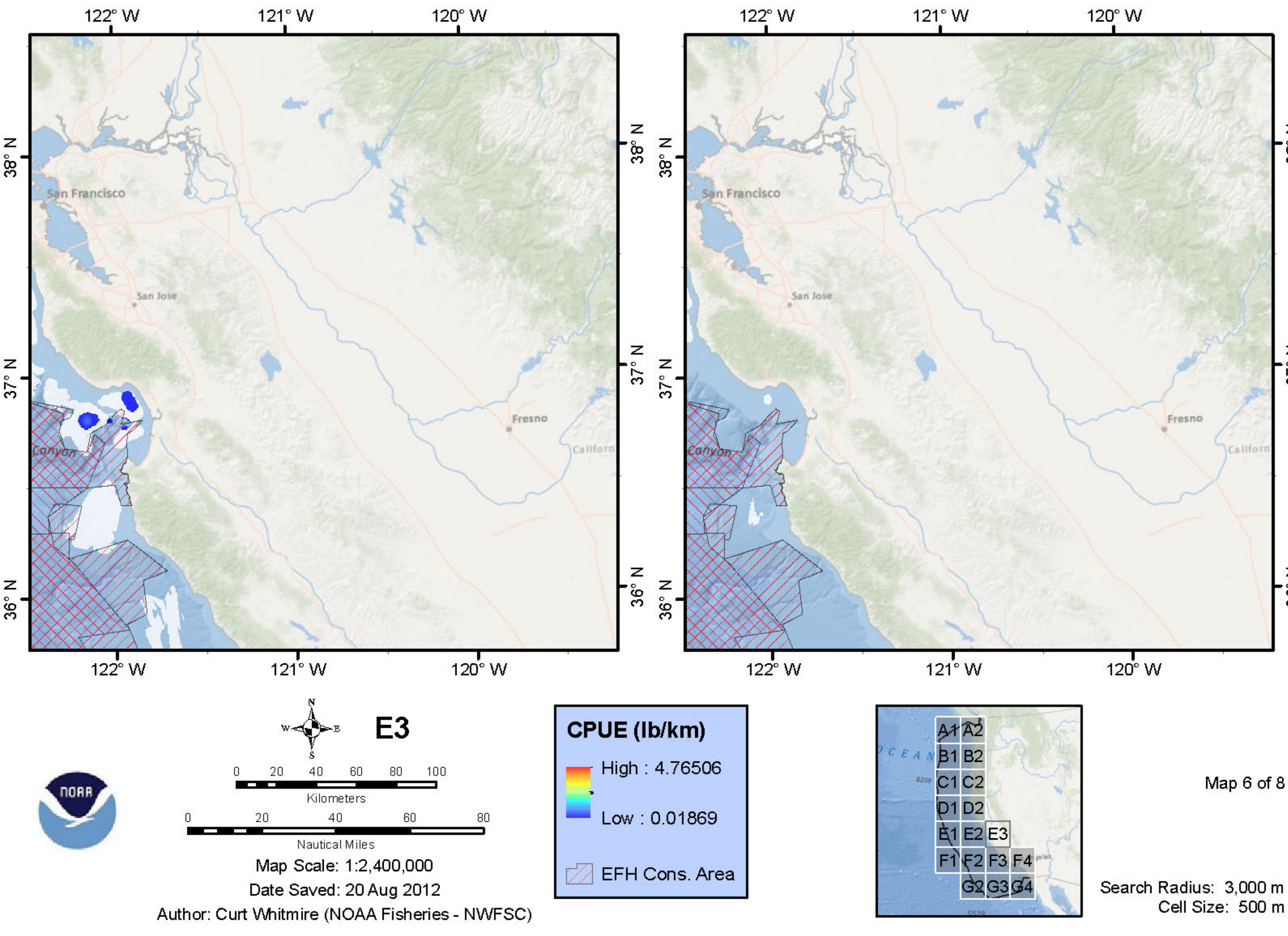



Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 4.76506
Low : 0.01869
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 8
Search Radius: 3,000 m
Cell Size: 500 m

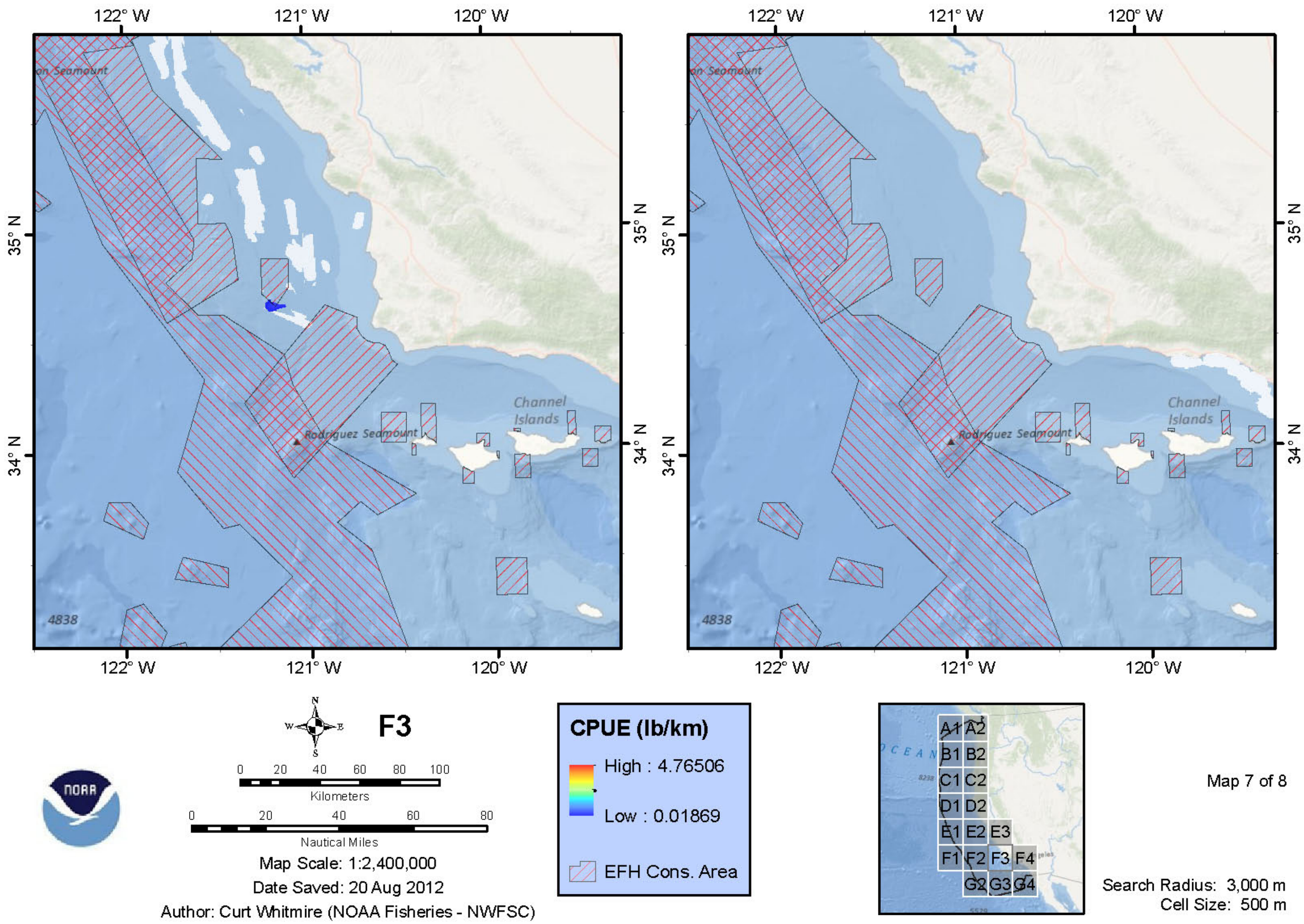

Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 4.76506
Low : 0.01869
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 4.76506
Low : 0.01869
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 8
Search Radius: 3,000 m
Cell Size: 500 m

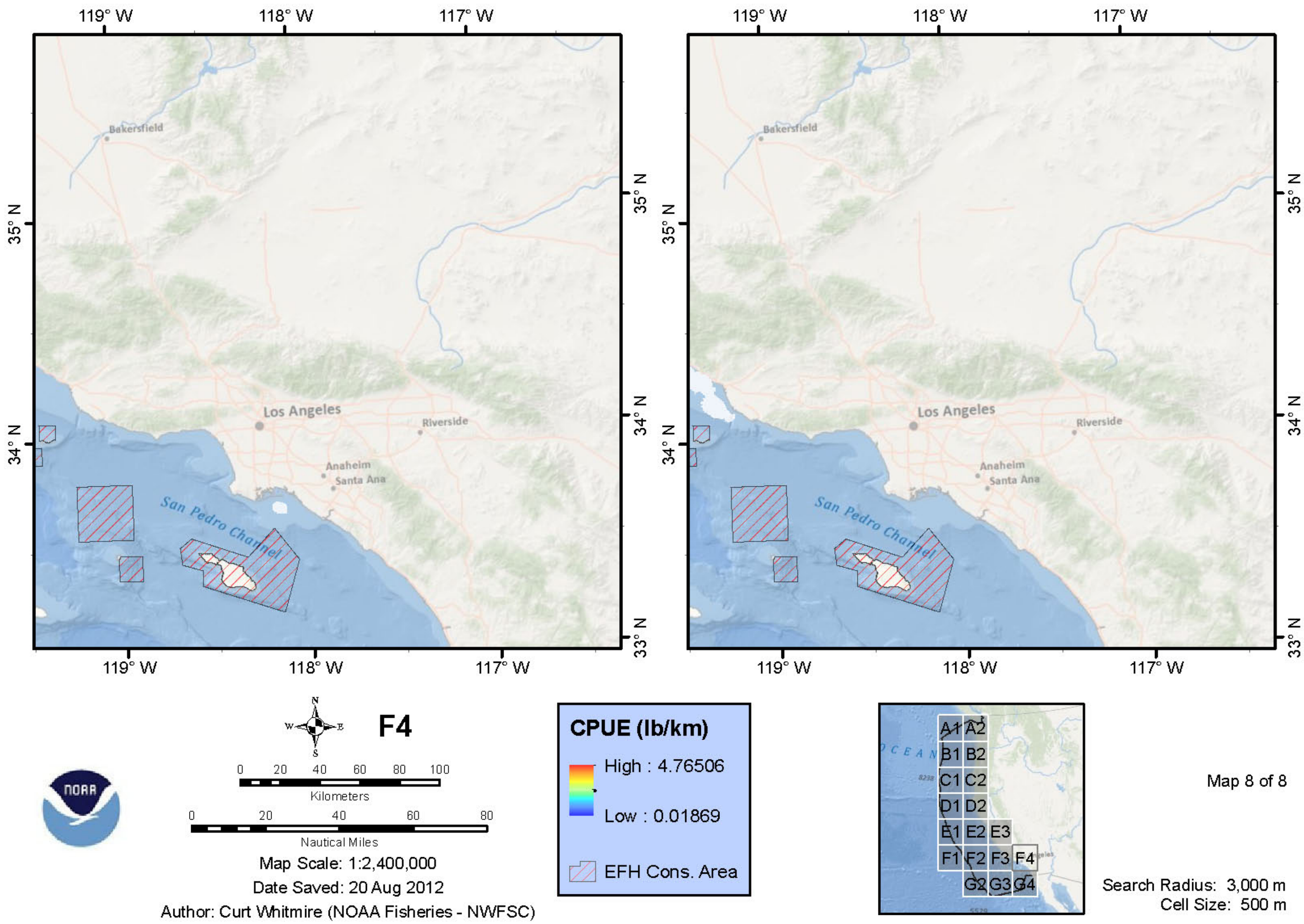
Before **Standardized Coral Bycatch (WCGOP - Trawl)** **After**

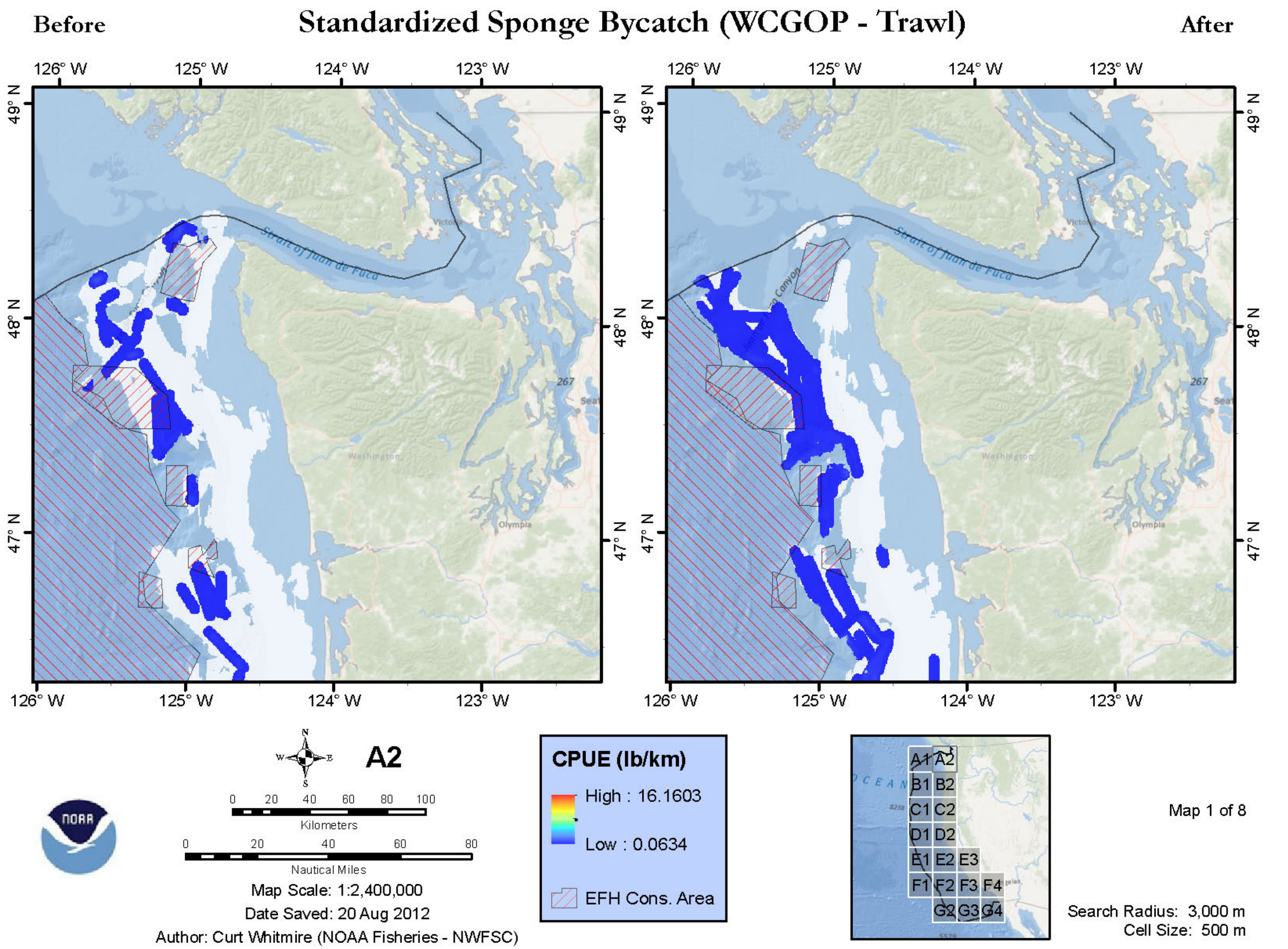


Before **Standardized Coral Bycatch (WCGOP - Trawl)** **After**

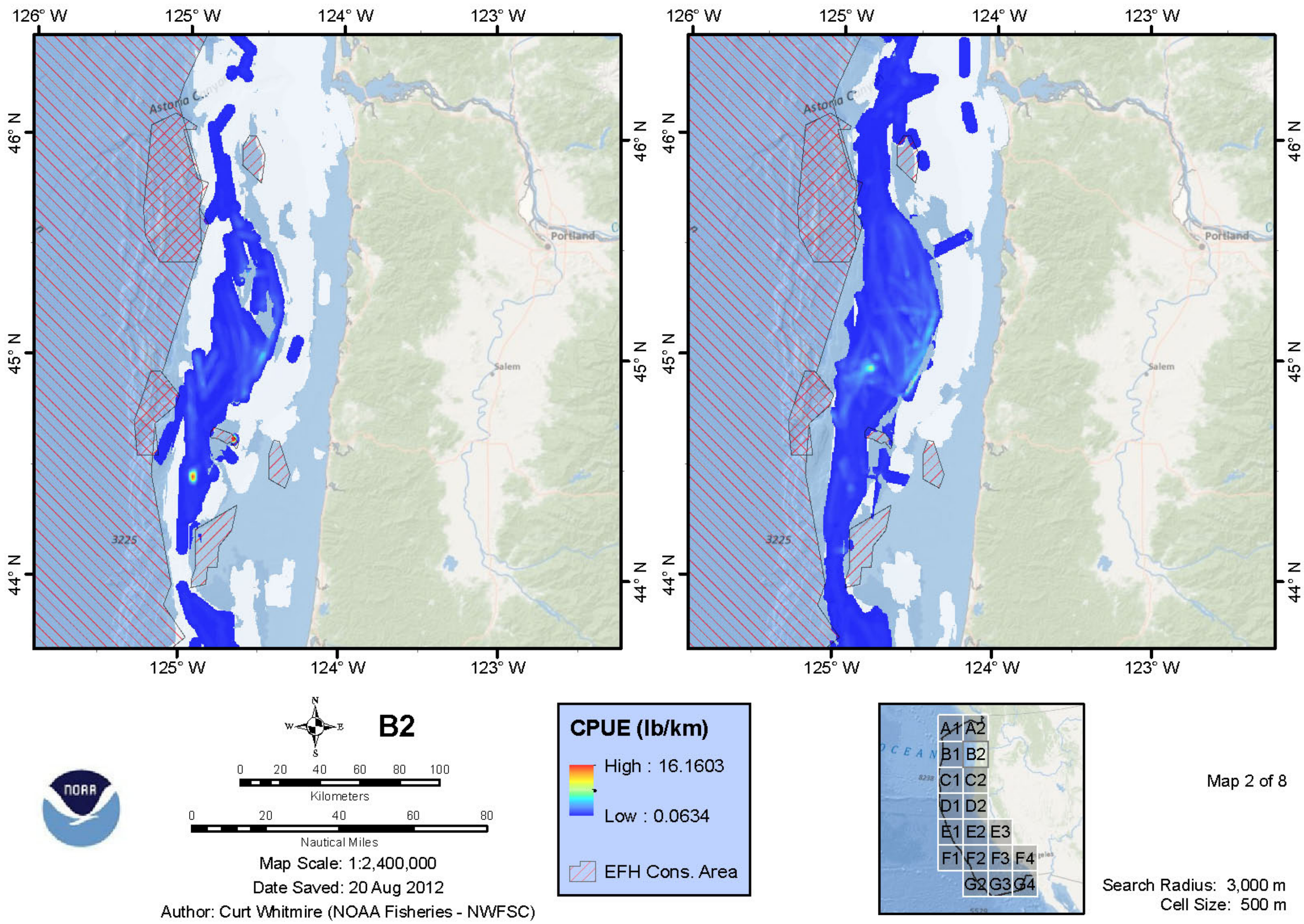


Before **Standardized Coral Bycatch (WCGOP - Trawl)** After

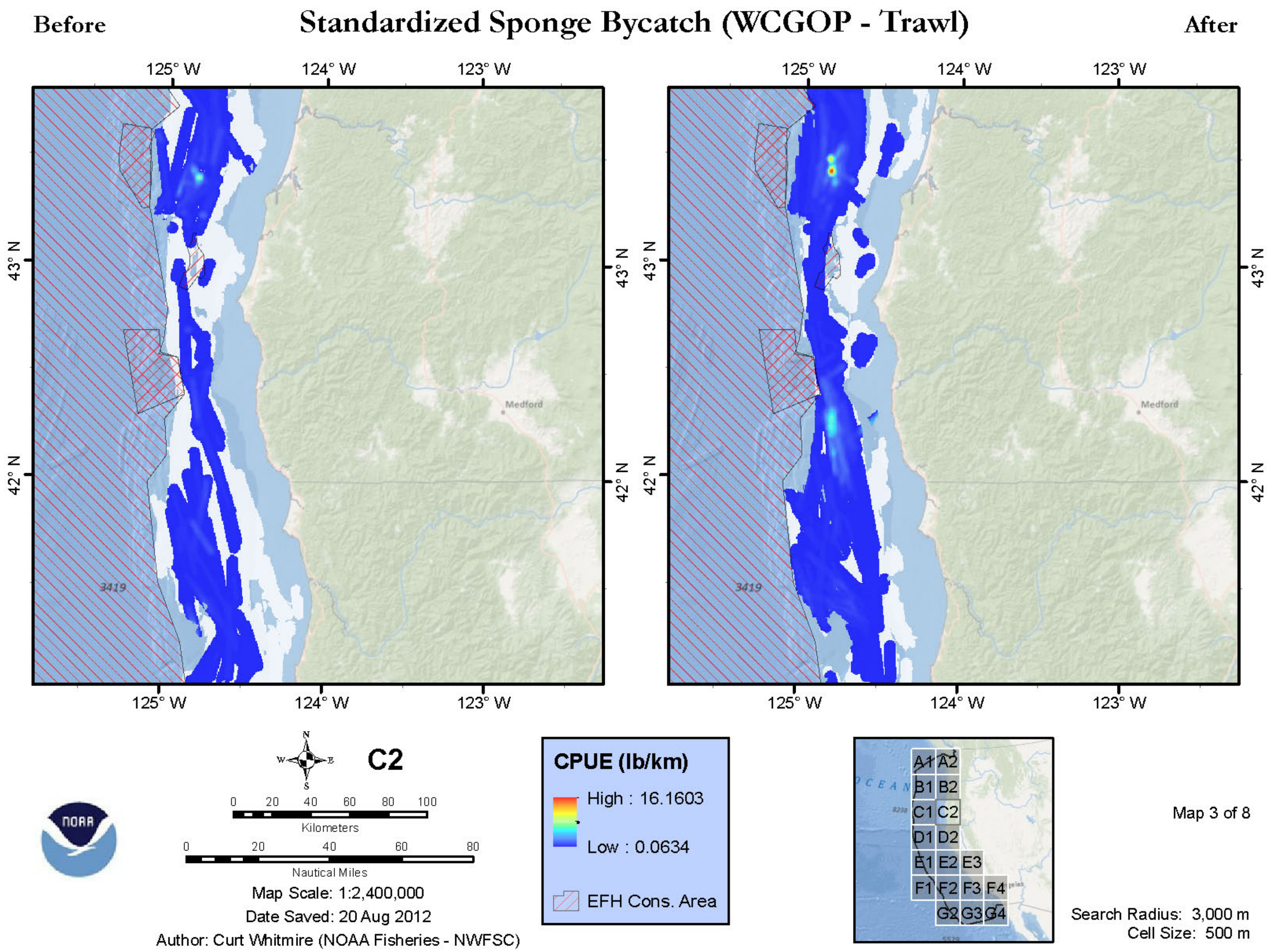



Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1603
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m

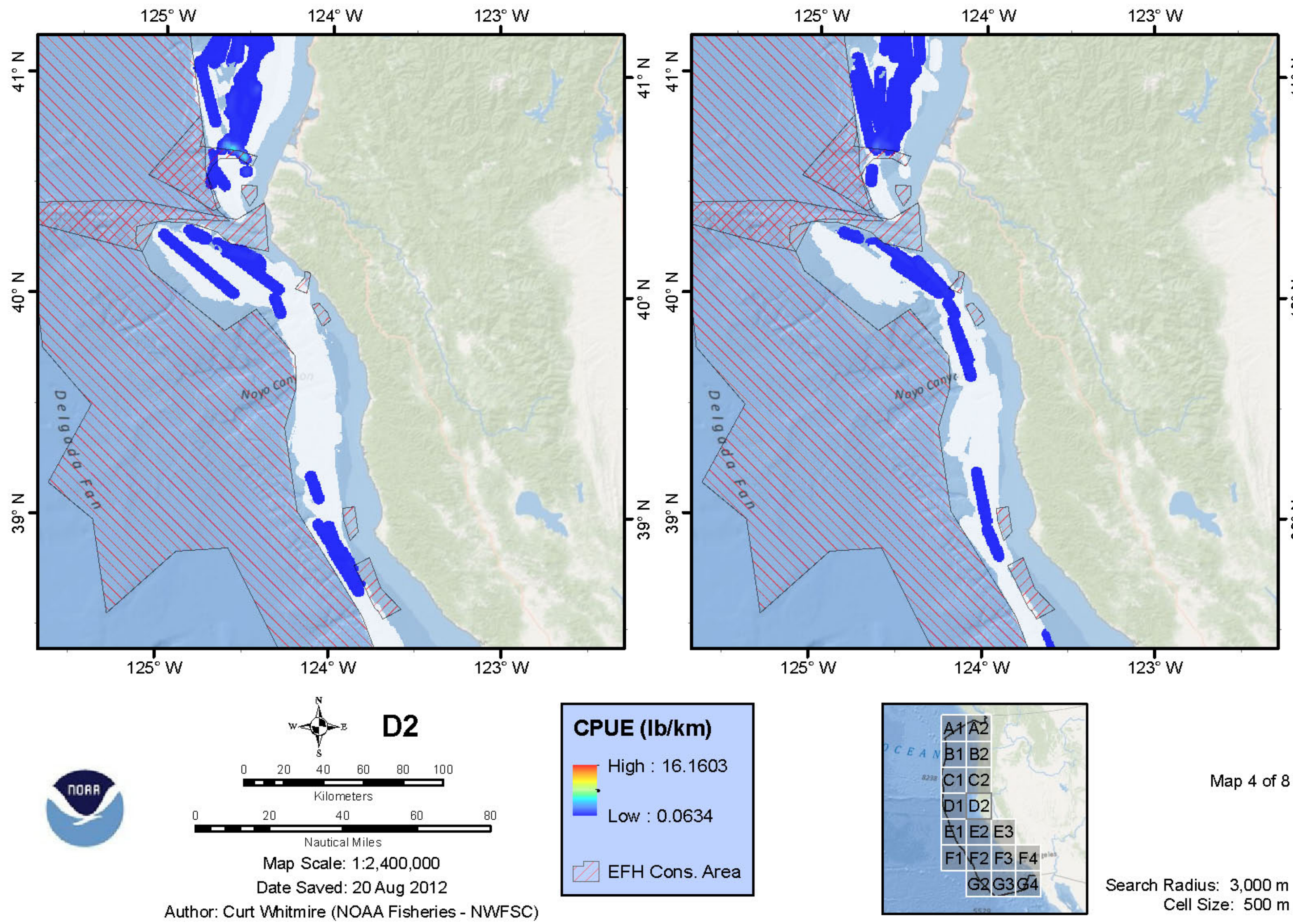
Before **Standardized Sponge Bycatch (WCGOP - Trawl)** **After**

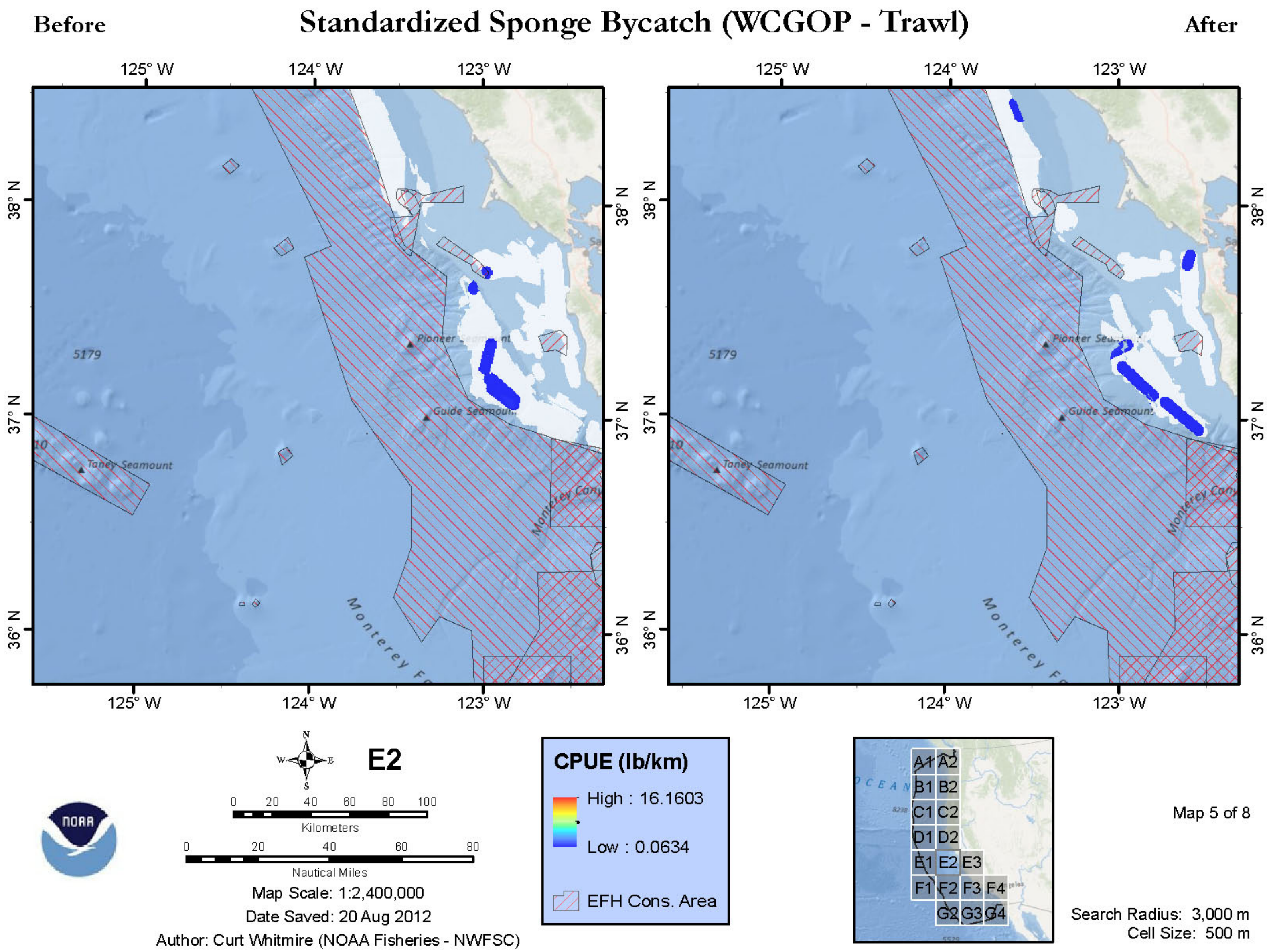


Standardized Sponge Bycatch (WCGOP - Trawl)

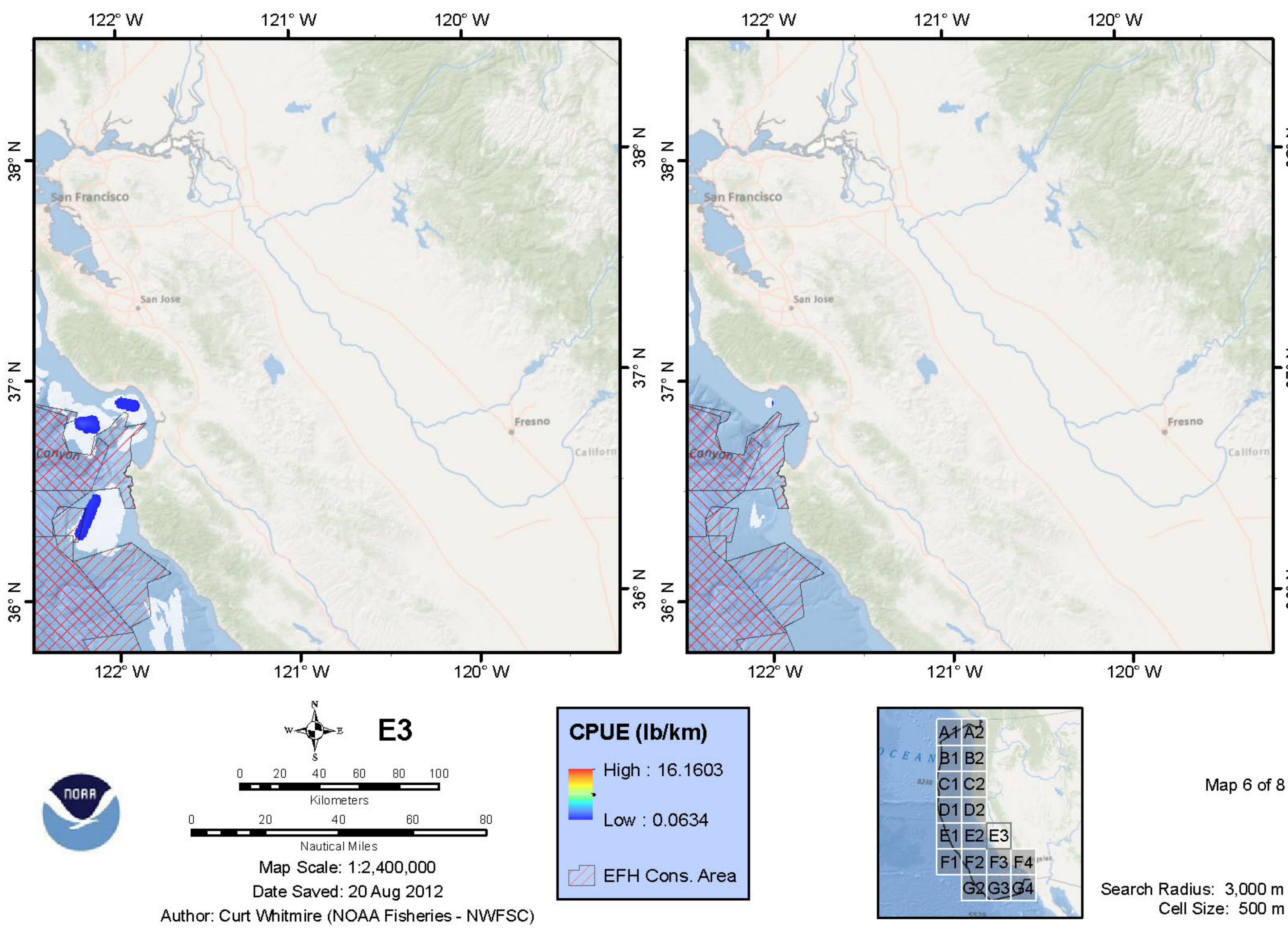


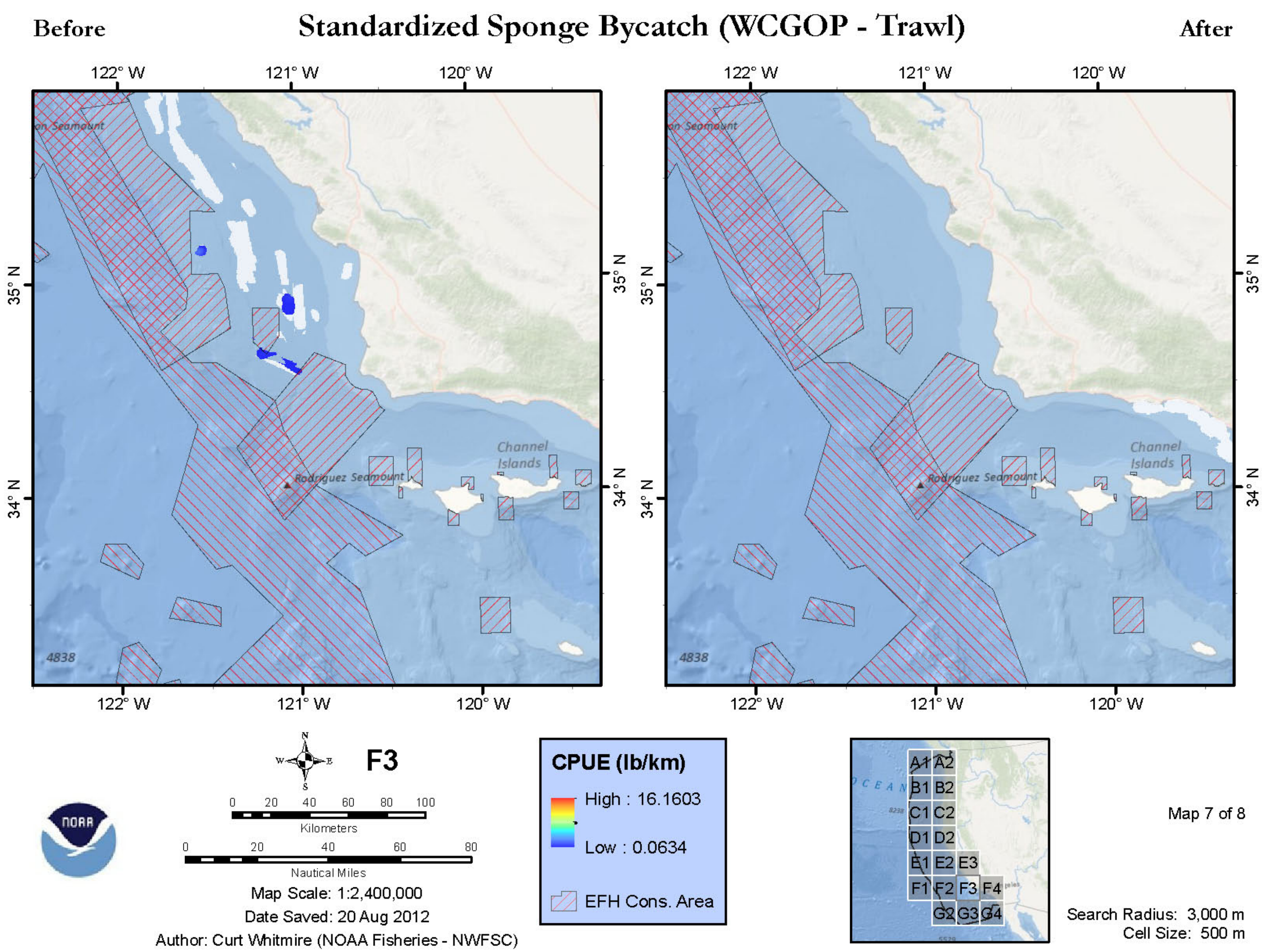
Before **Standardized Sponge Bycatch (WCGOP - Trawl)** After

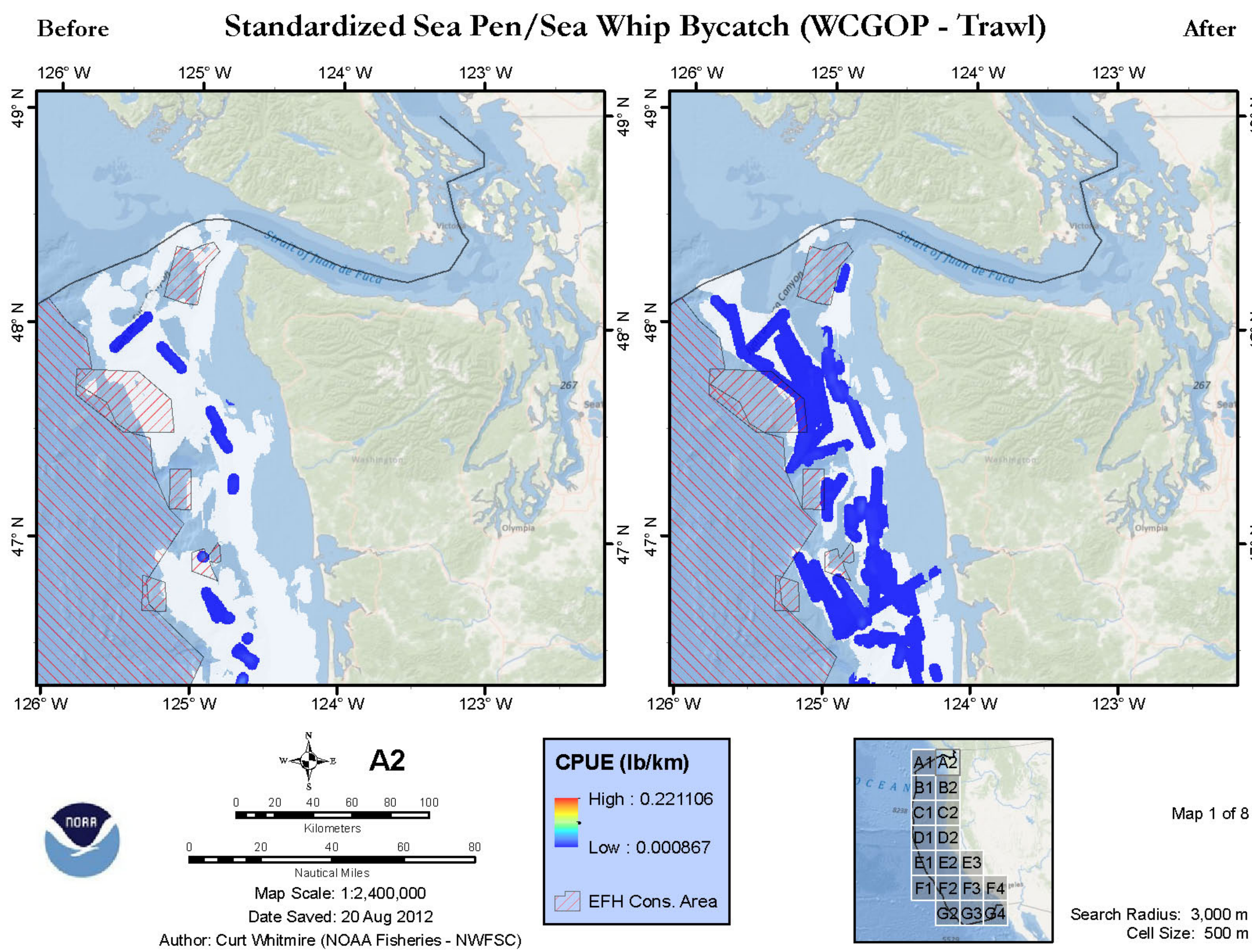


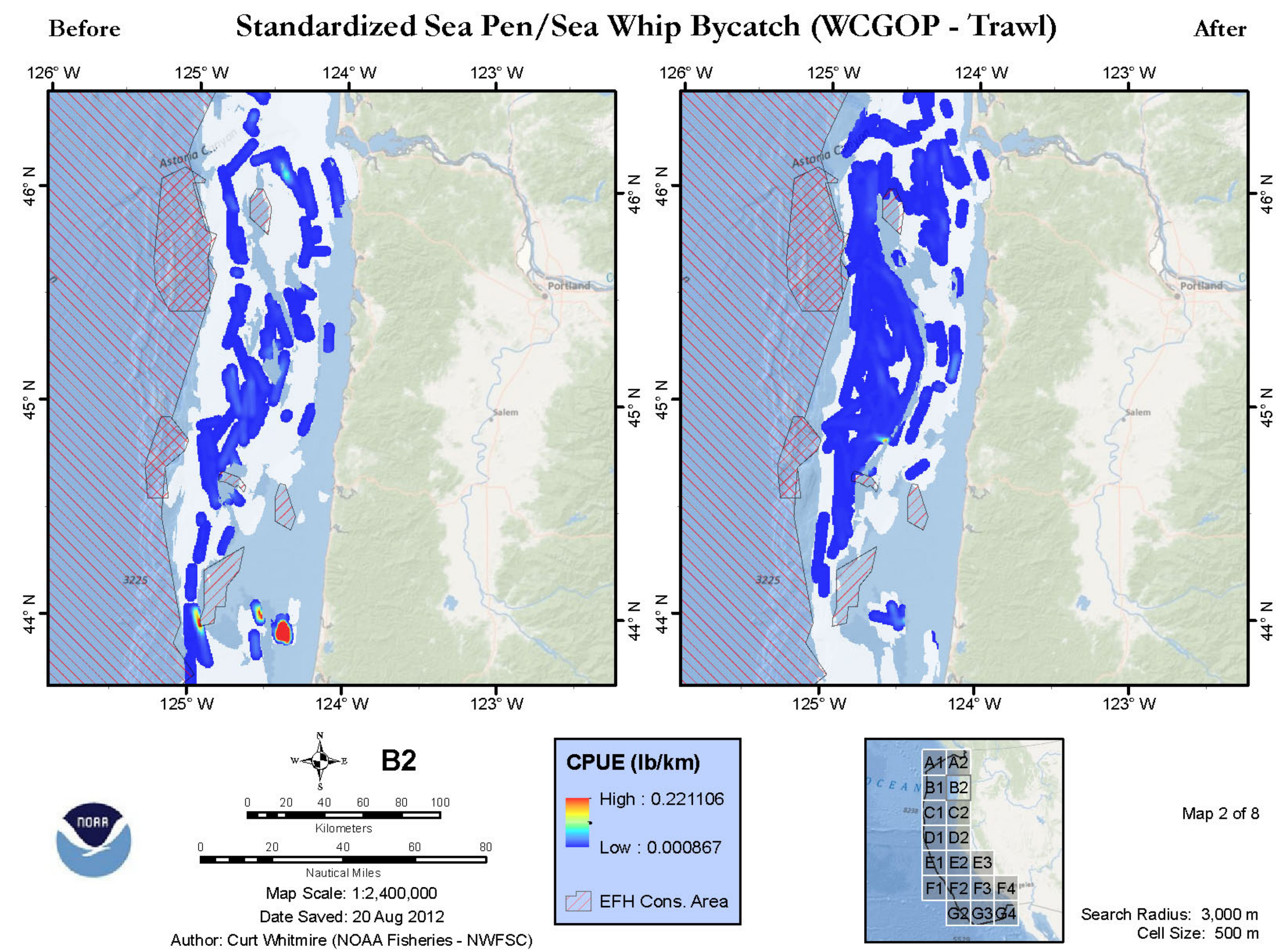

Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Can
Monterey F
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1603
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Sponge Bycatch (WCGOP - Trawl)** After

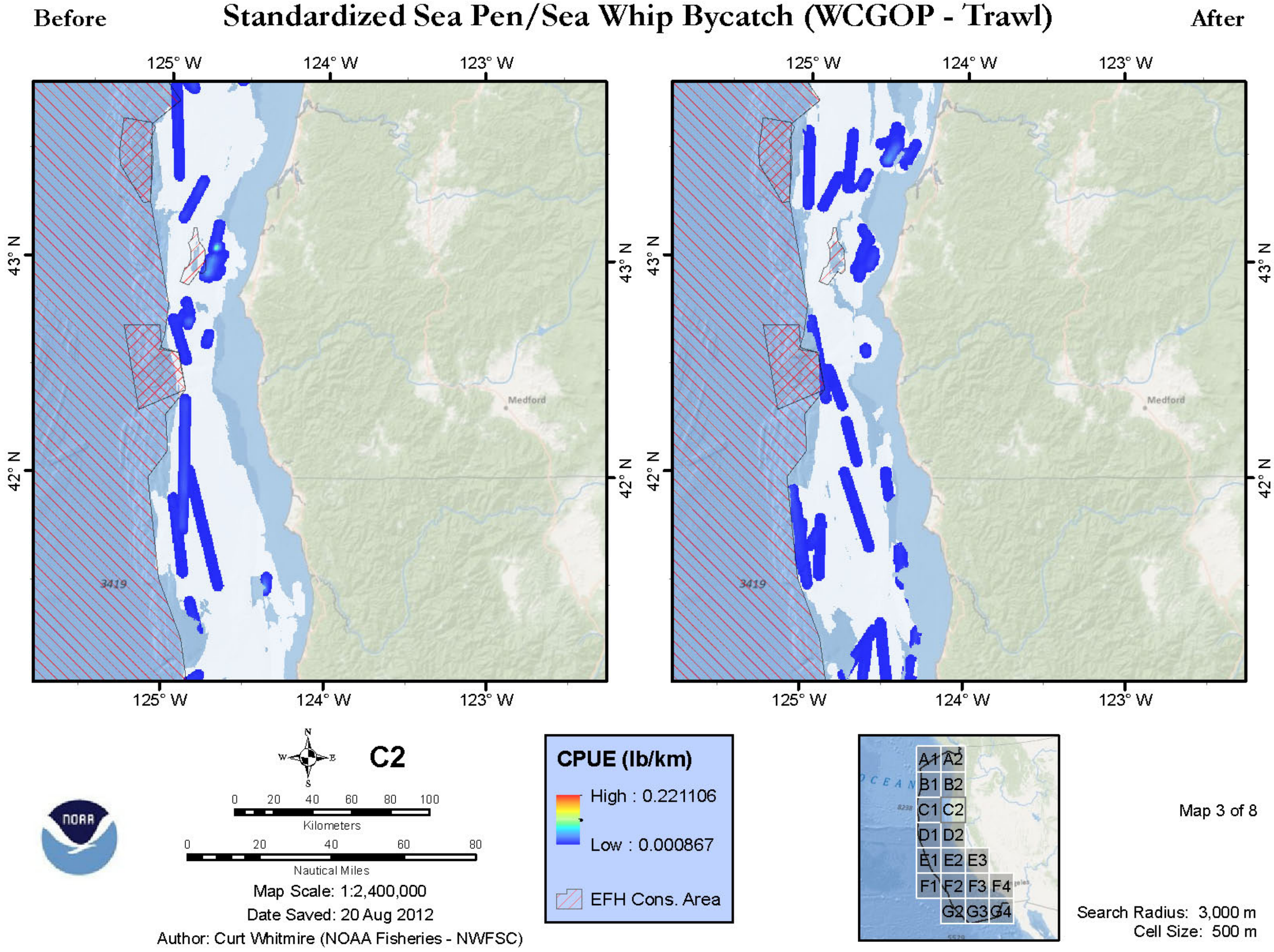



Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
122° W
121° W
120° W
35° N
34° N
Channel Islands
Rodriguez Seamount
4838
F3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 16.1603
Low : 0.0634
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 8
Search Radius: 3,000 m
Cell Size: 500 m

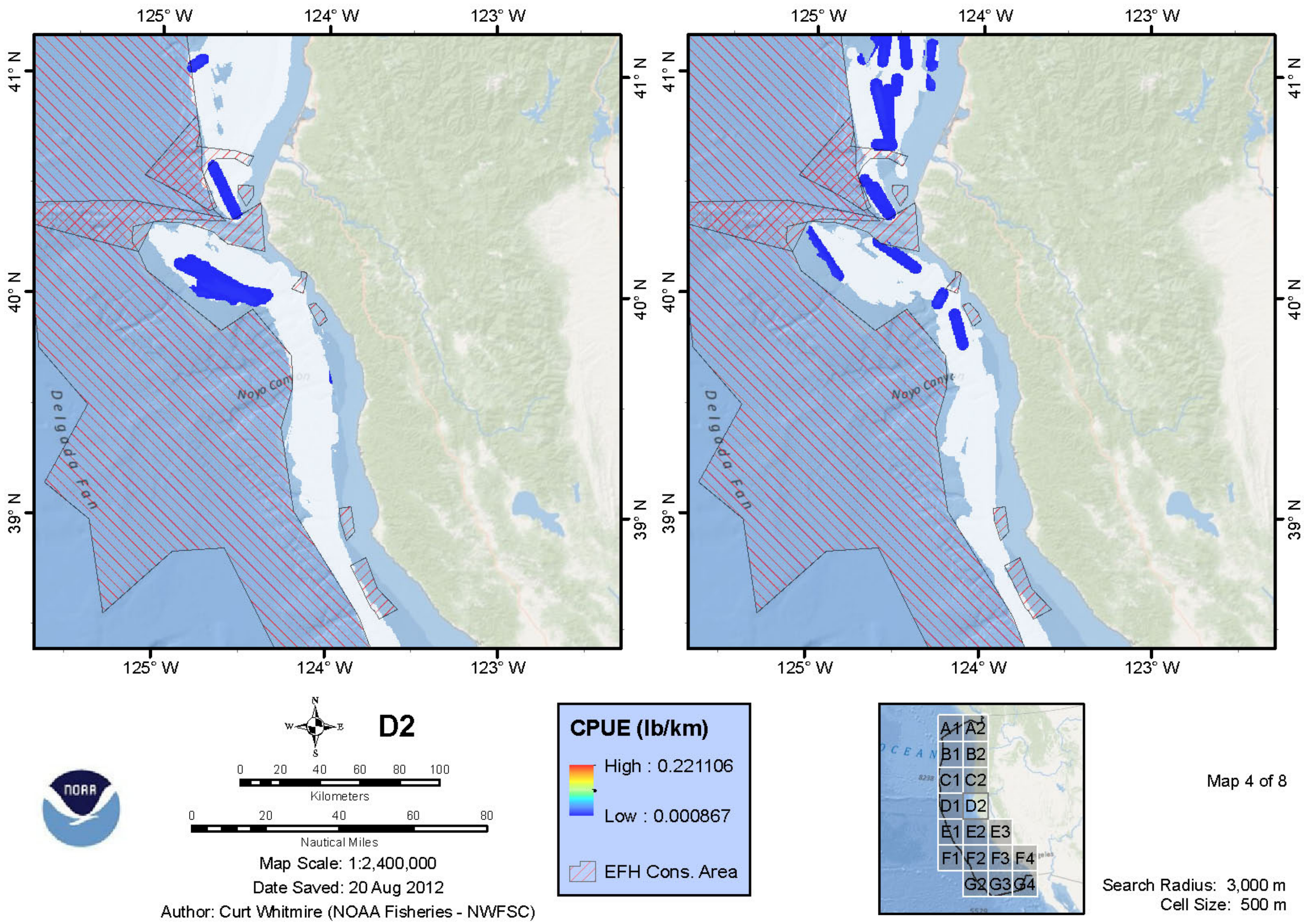

Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 0.221106
Low : 0.000867
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
B2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 0.221106
Low : 0.000867
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 8
Search Radius: 3,000 m
Cell Size: 500 m

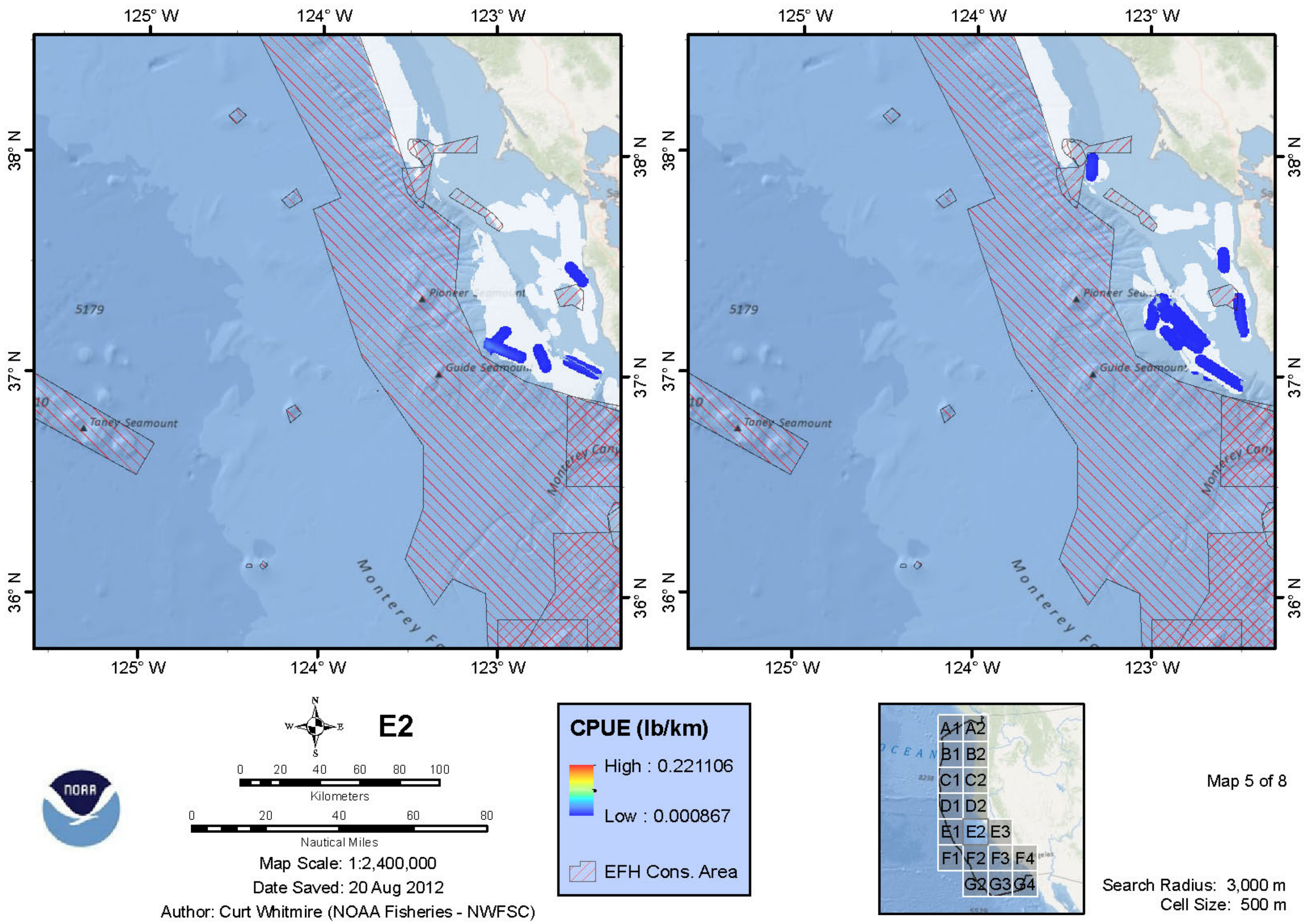
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)



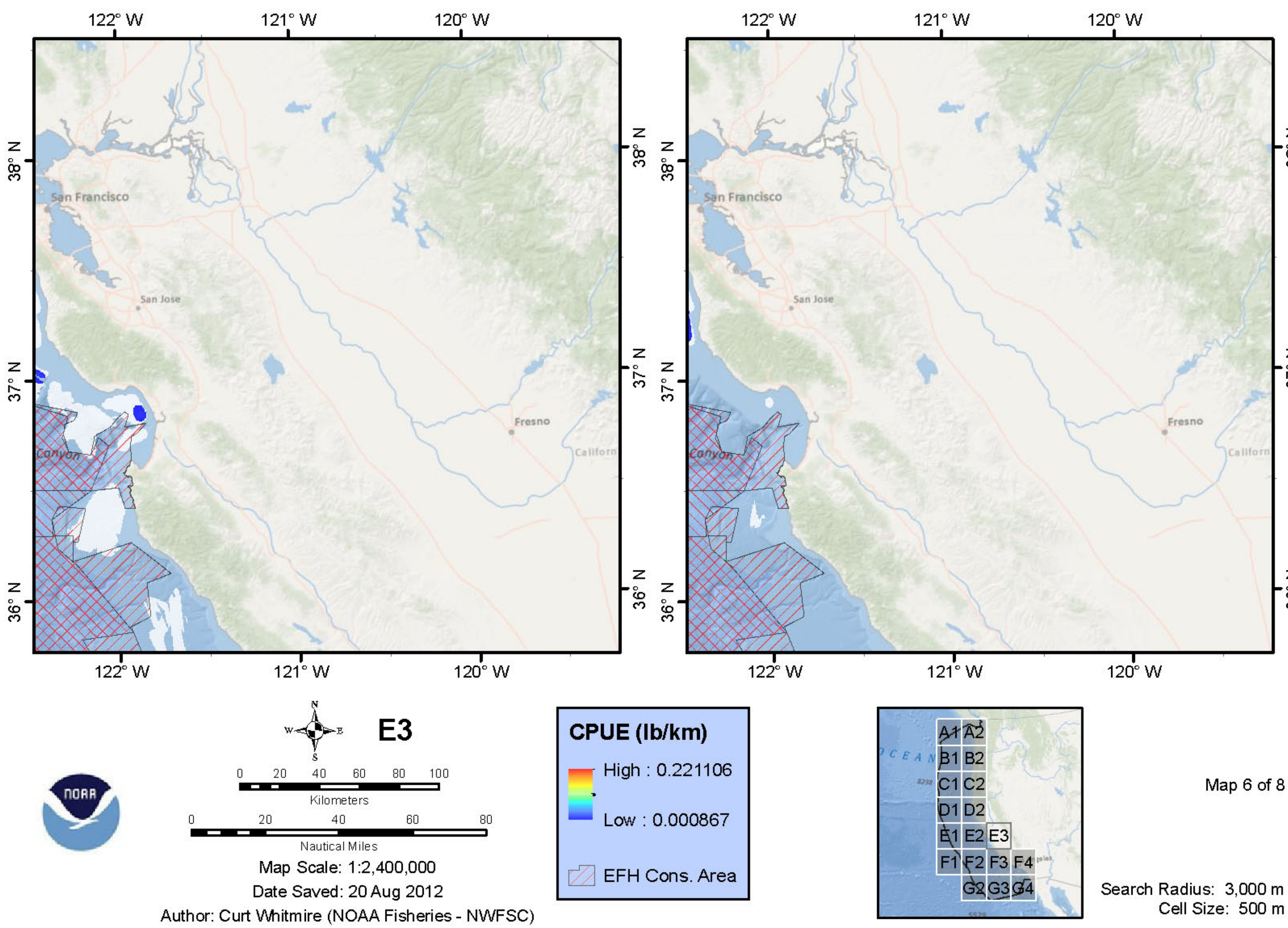
Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** **After**

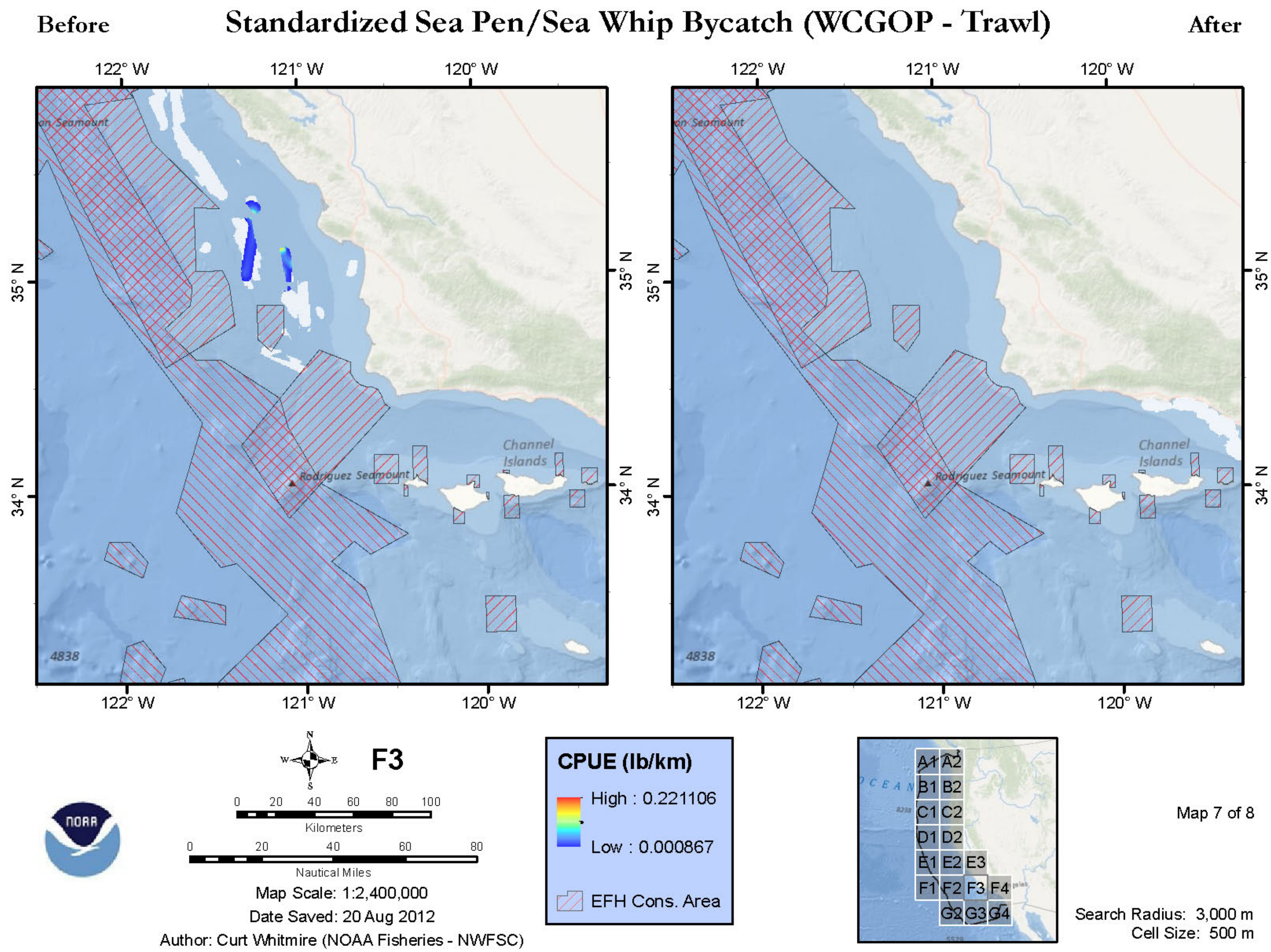


Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** After



Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** **After**

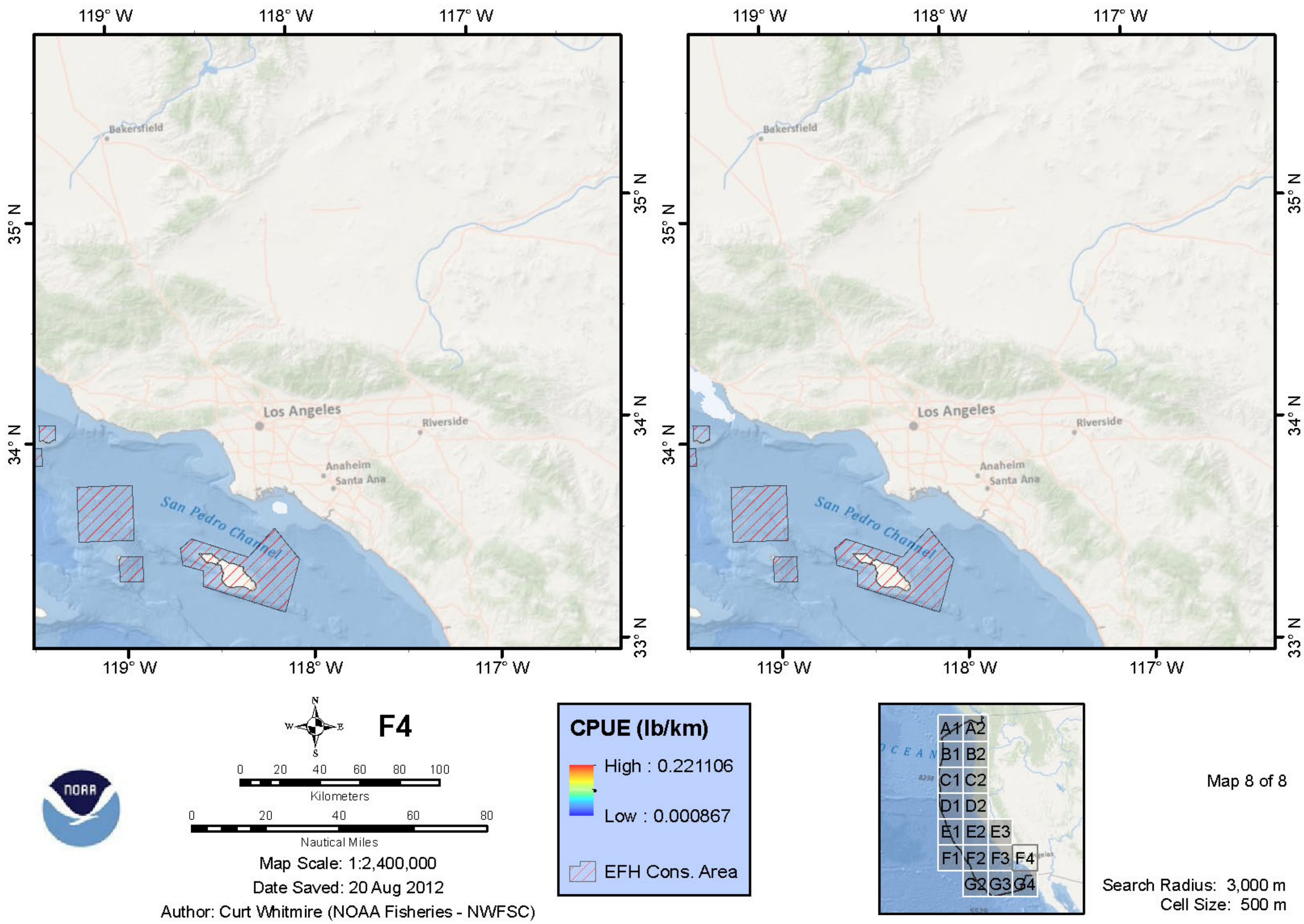


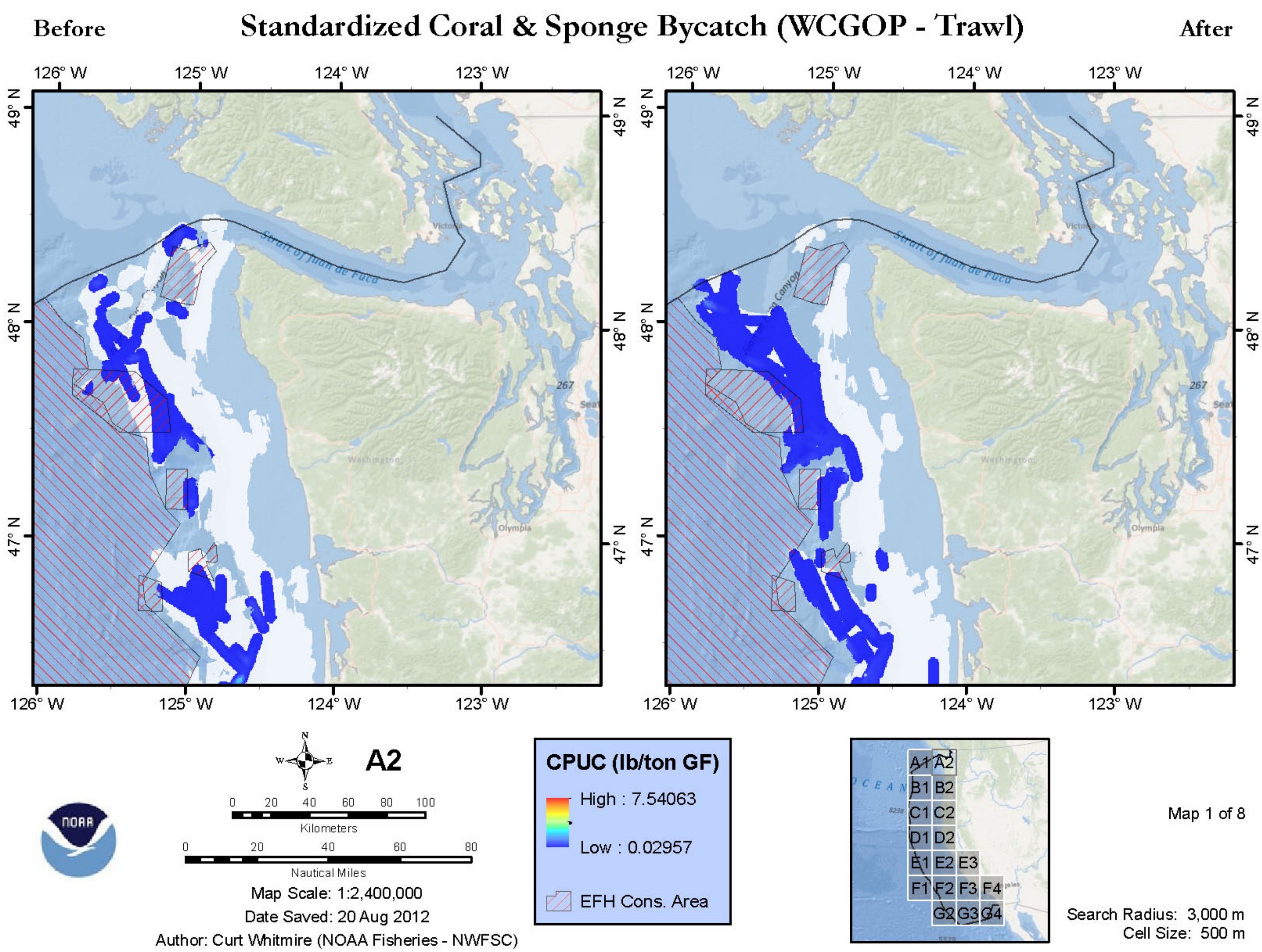


Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
Channel Islands
4838
F3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUE (lb/km)
High : 0.221106
Low : 0.000867
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 8
Search Radius: 3,000 m
Cell Size: 500 m

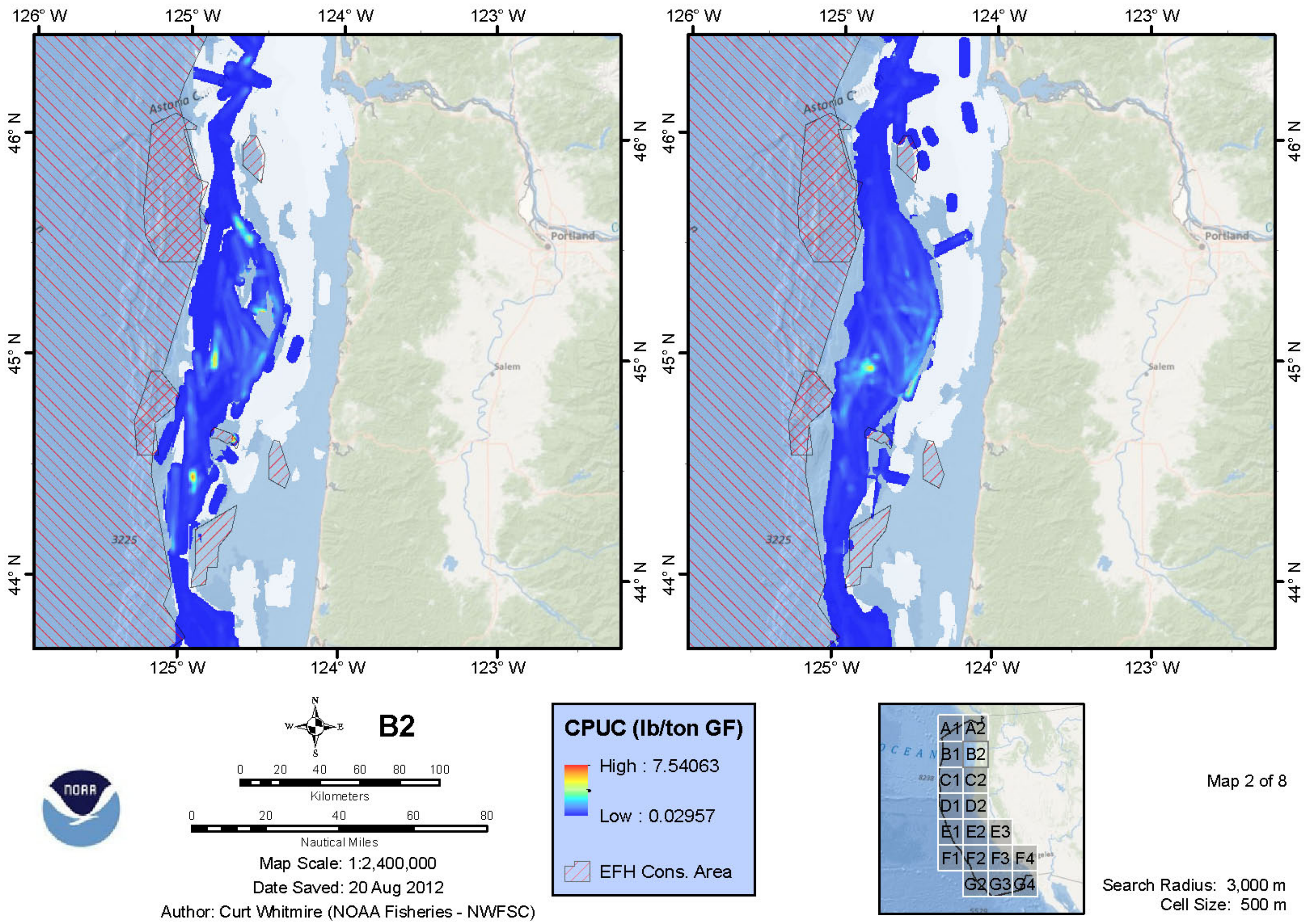
Appendix F-4

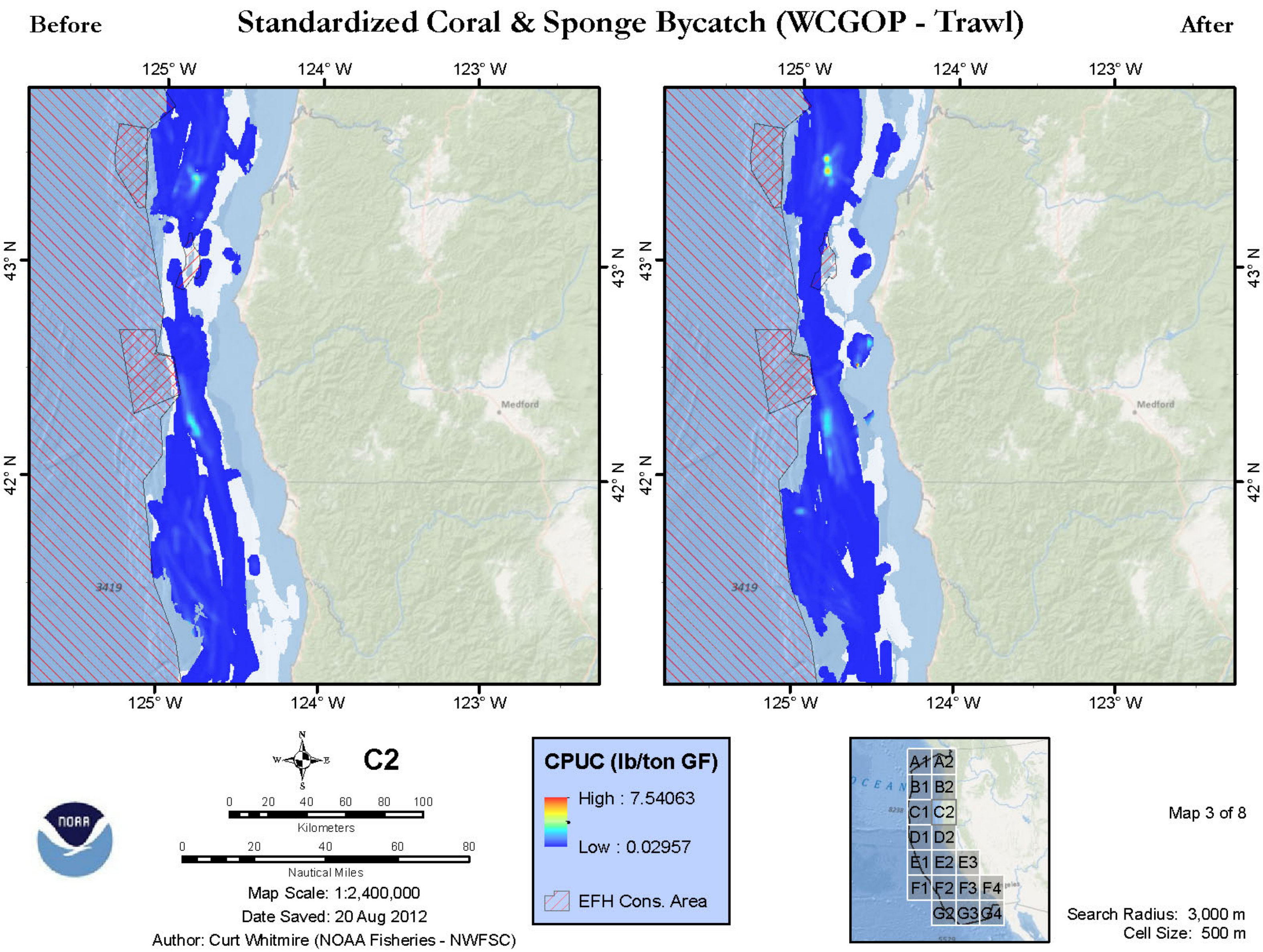
Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** **After**

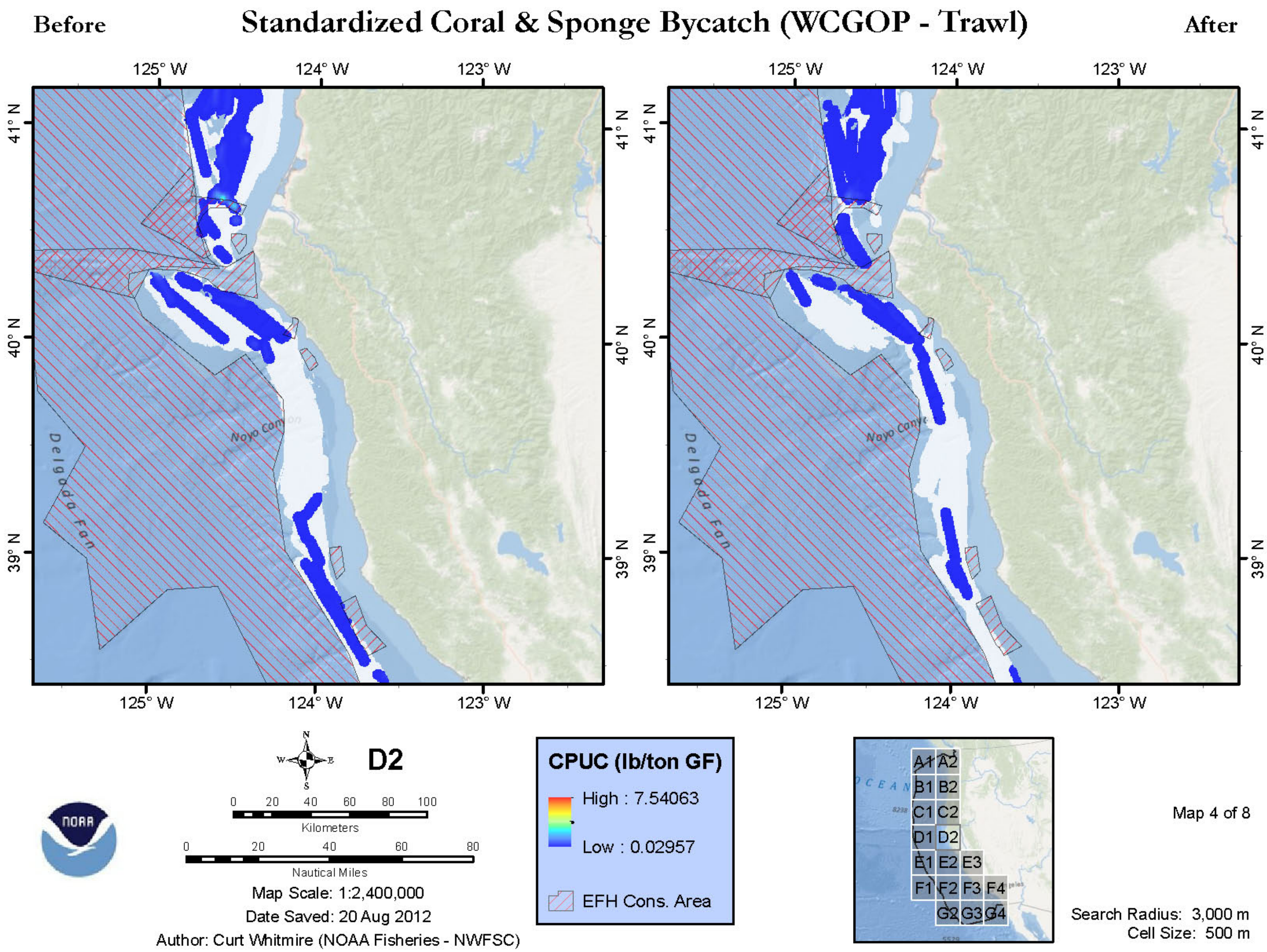


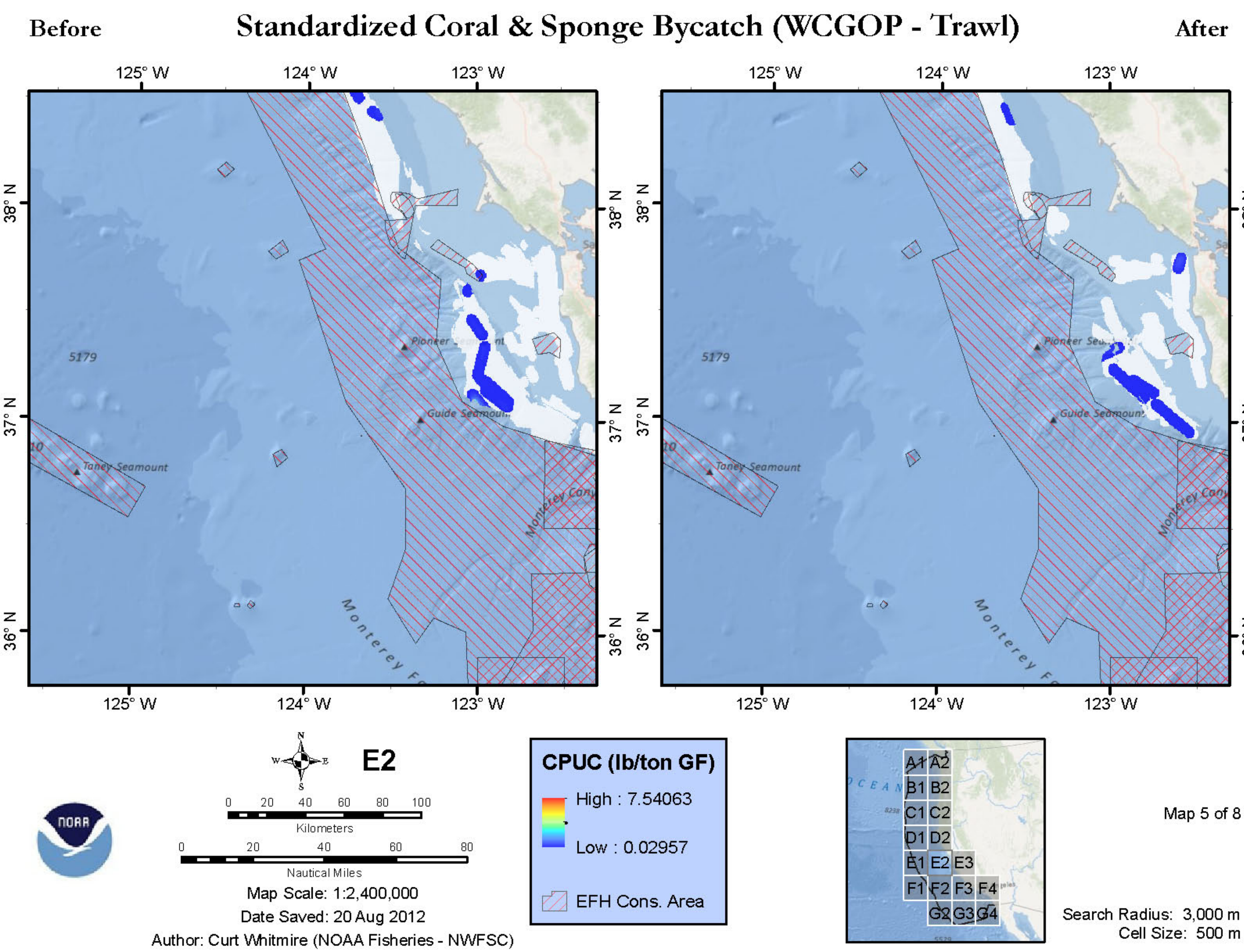

Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m

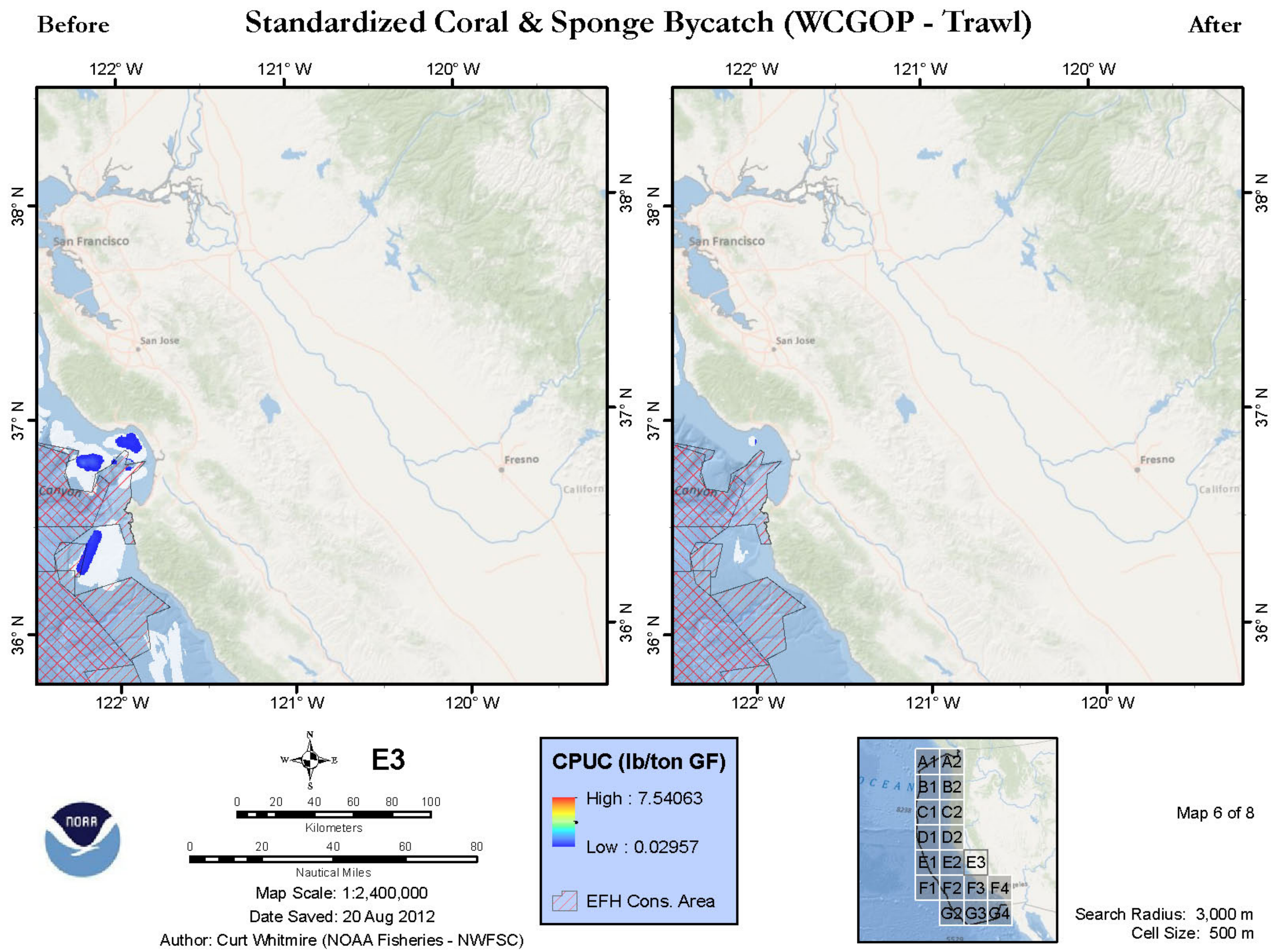
Before **Standardized Coral & Sponge Bycatch (WCGOP - Trawl)** After



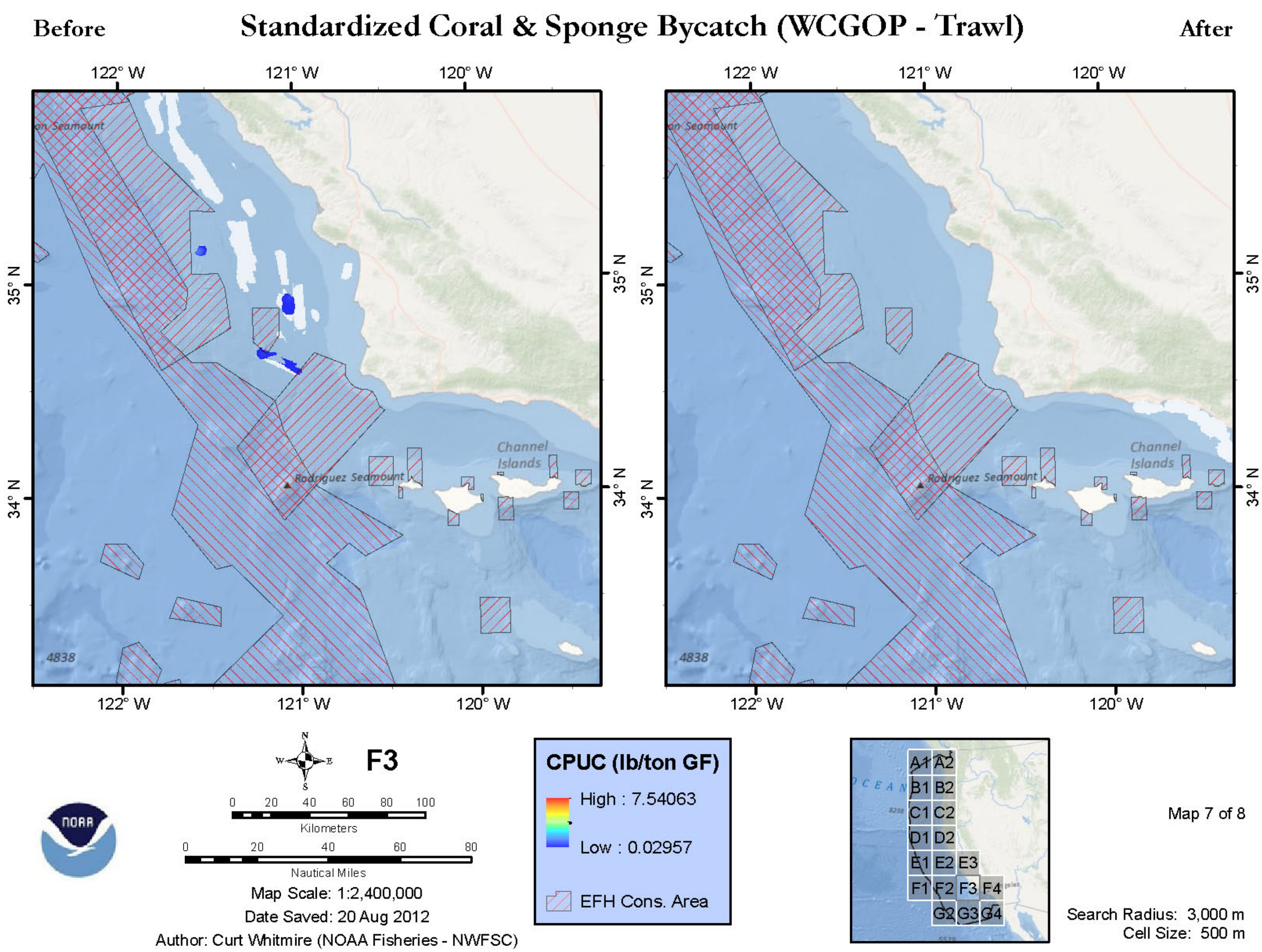

Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 8
Search Radius: 3,000 m
Cell Size: 500 m

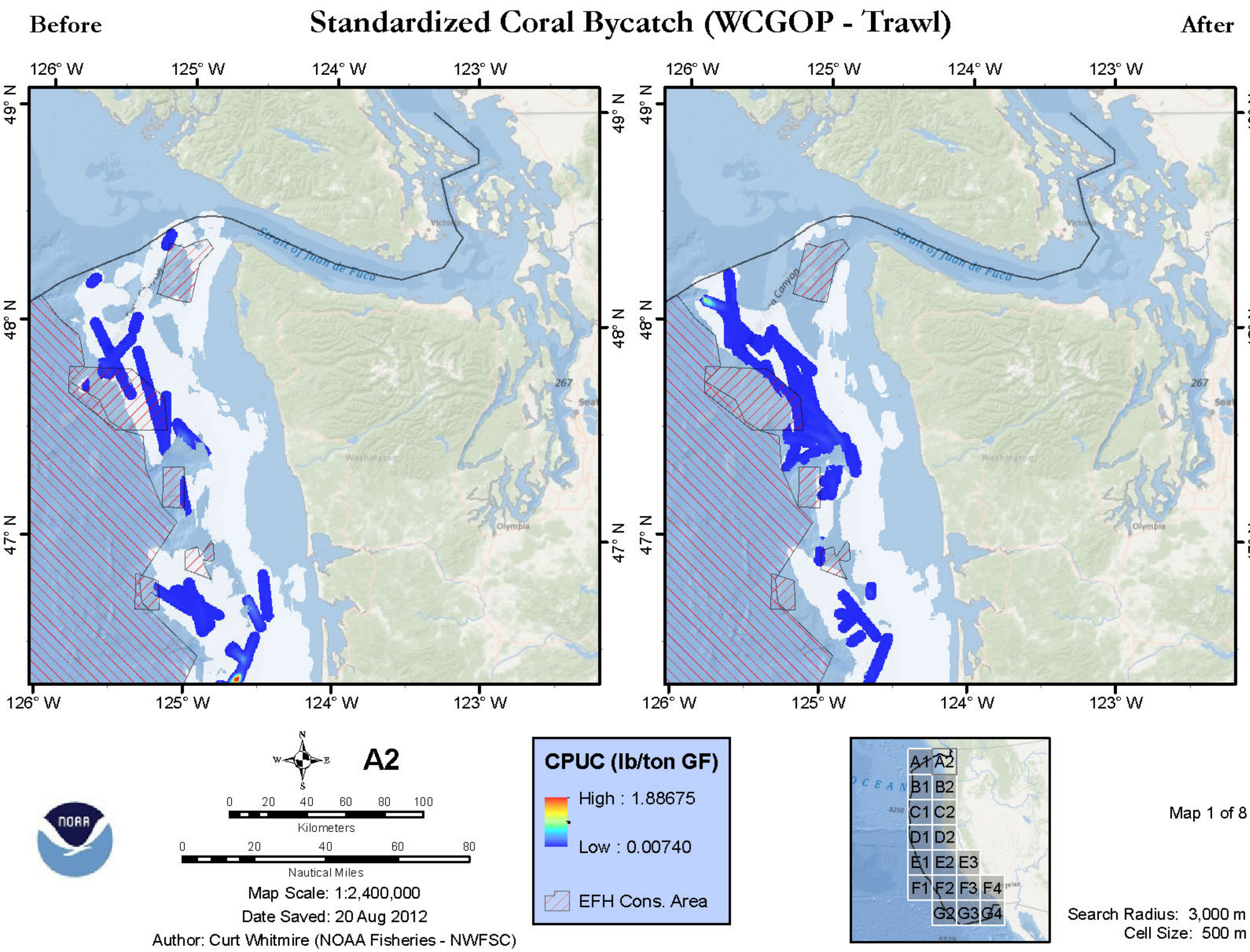

Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 8
Search Radius: 3,000 m
Cell Size: 500 m

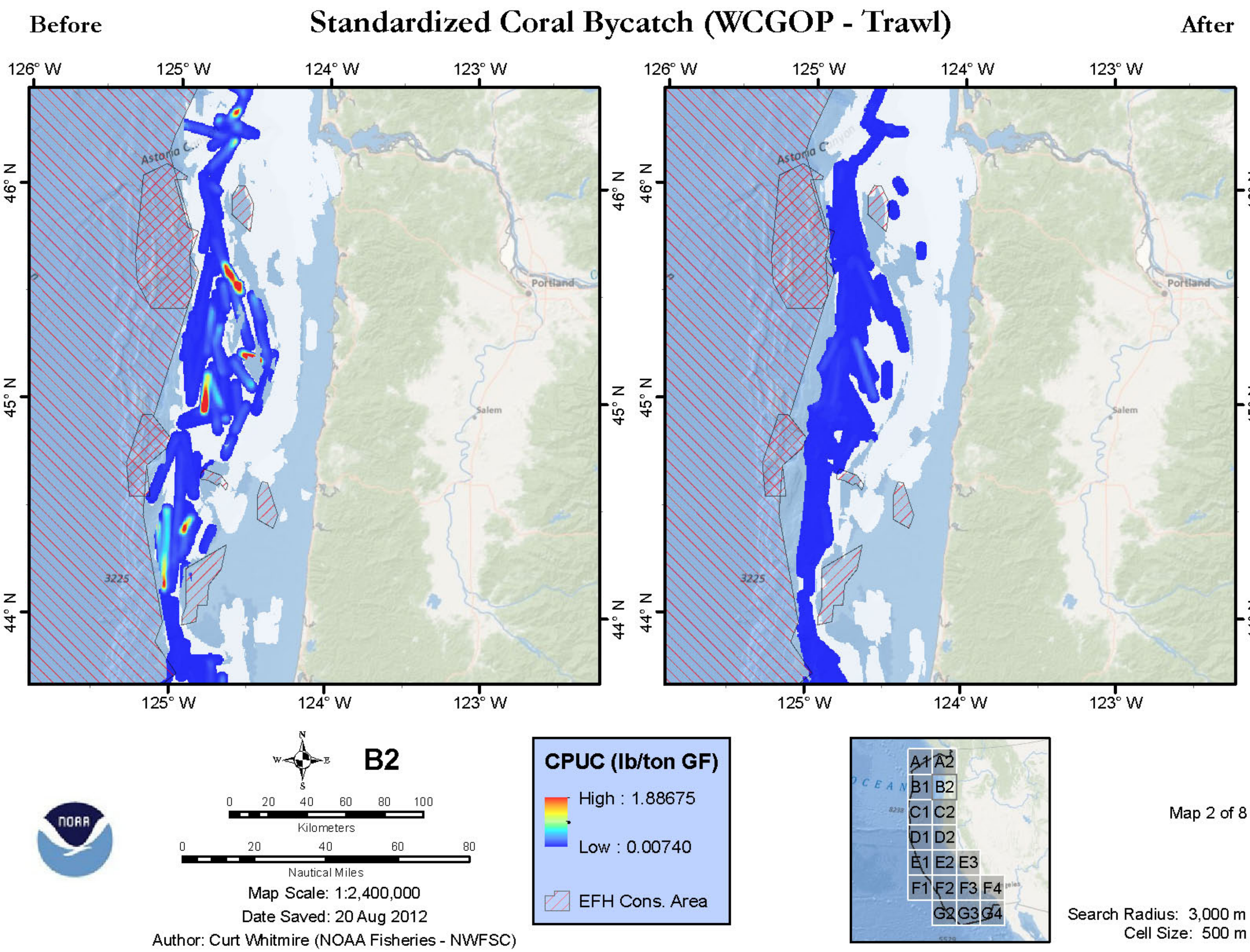

Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
Map 6 of 8
Search Radius: 3,000 m
Cell Size: 500 m

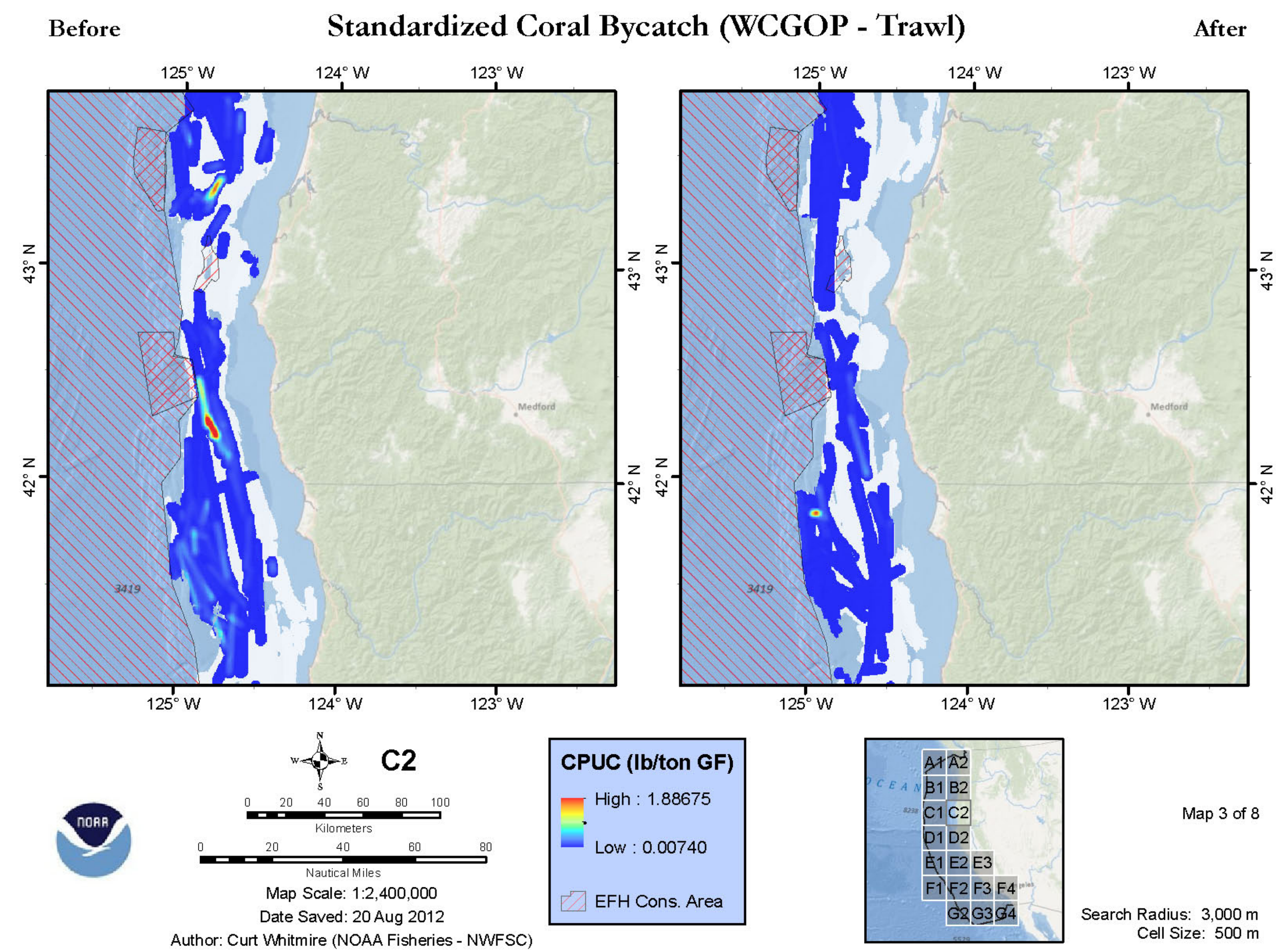
Appendix F-5


Before
Standardized Coral & Sponge Bycatch (WCGOP - Trawl)
After
122° W
121° W
120° W
35° N
34° N
Channel Islands
Rodriguez Seamount
4838
F3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 8
Search Radius: 3,000 m
Cell Size: 500 m

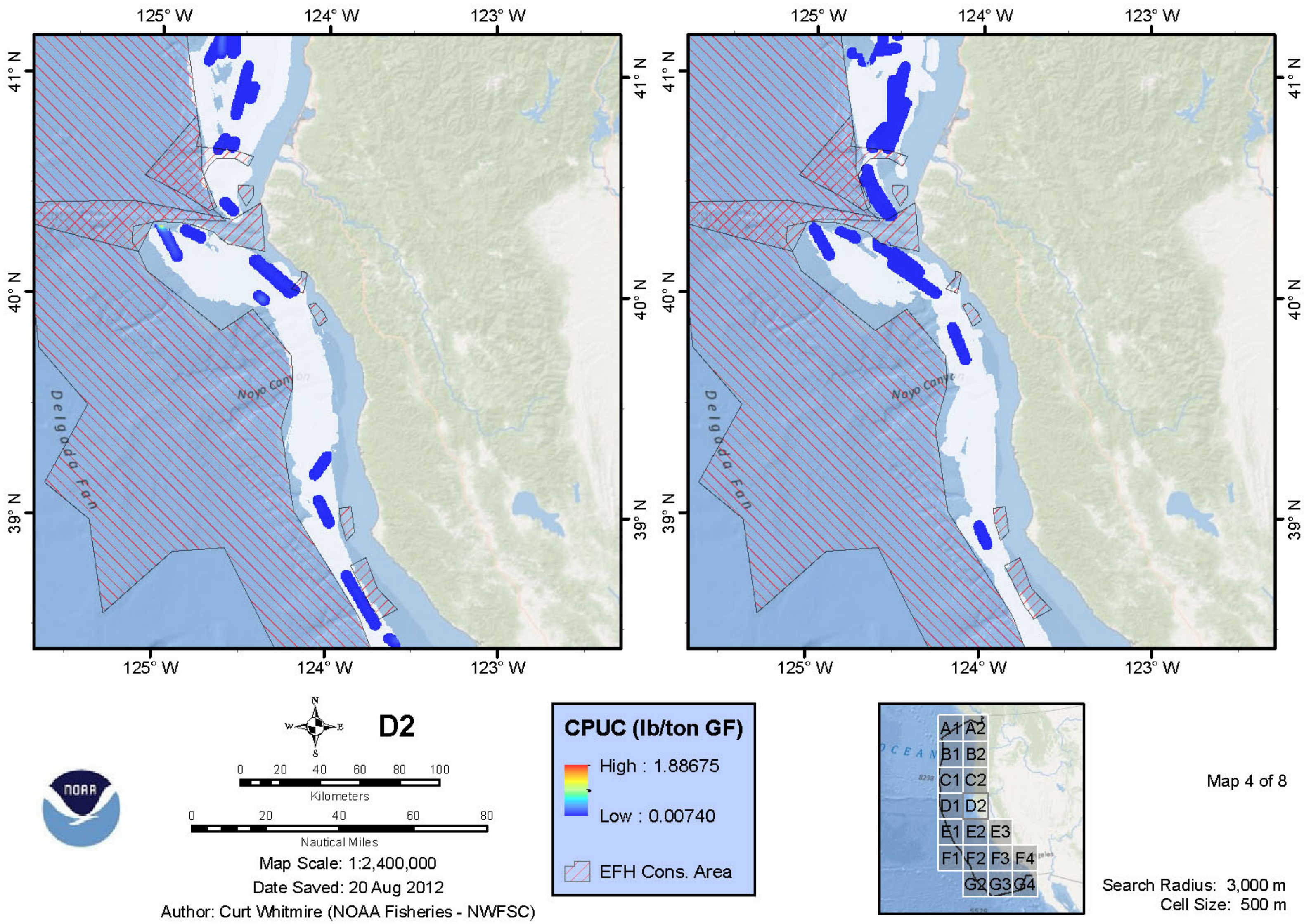

Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 1.88675
Low : 0.00740
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Appendix F-6

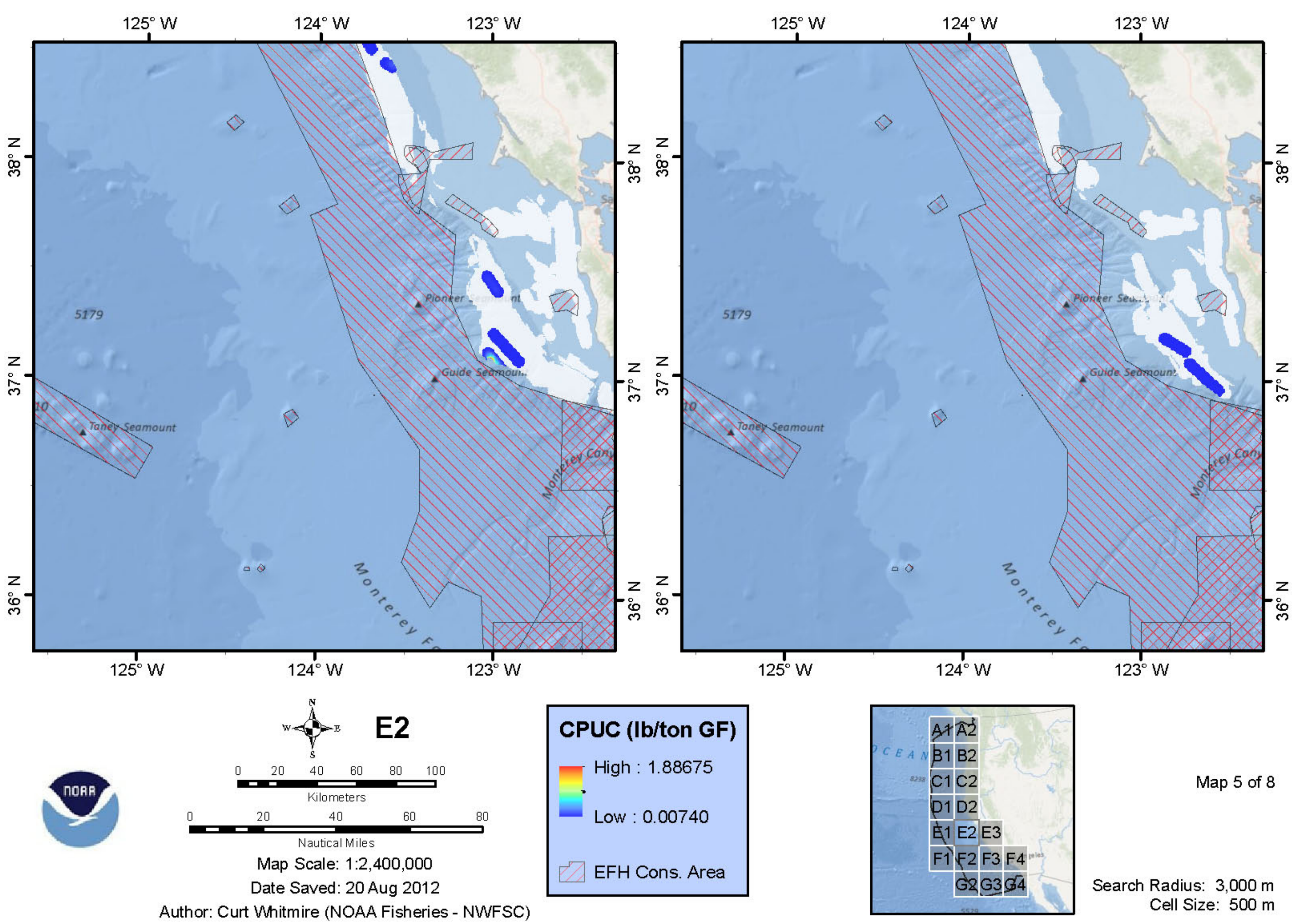

Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria C...
Astoria Canyon
Portland
Salem
3225
B2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 1.88675
Low : 0.00740
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 8
Search Radius: 3,000 m
Cell Size: 500 m

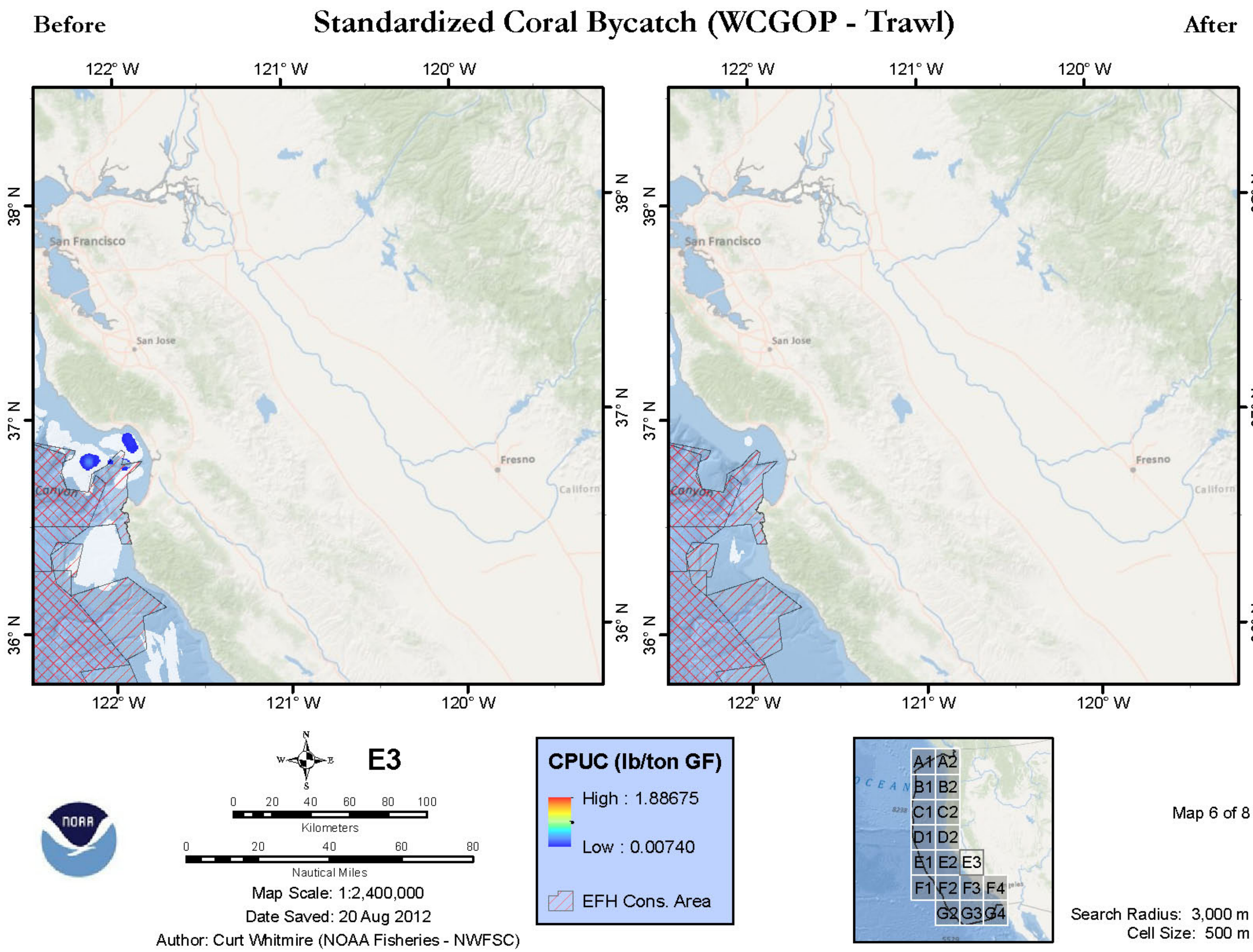

Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 1.88675
Low : 0.00740
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Coral Bycatch (WCGOP - Trawl)** After

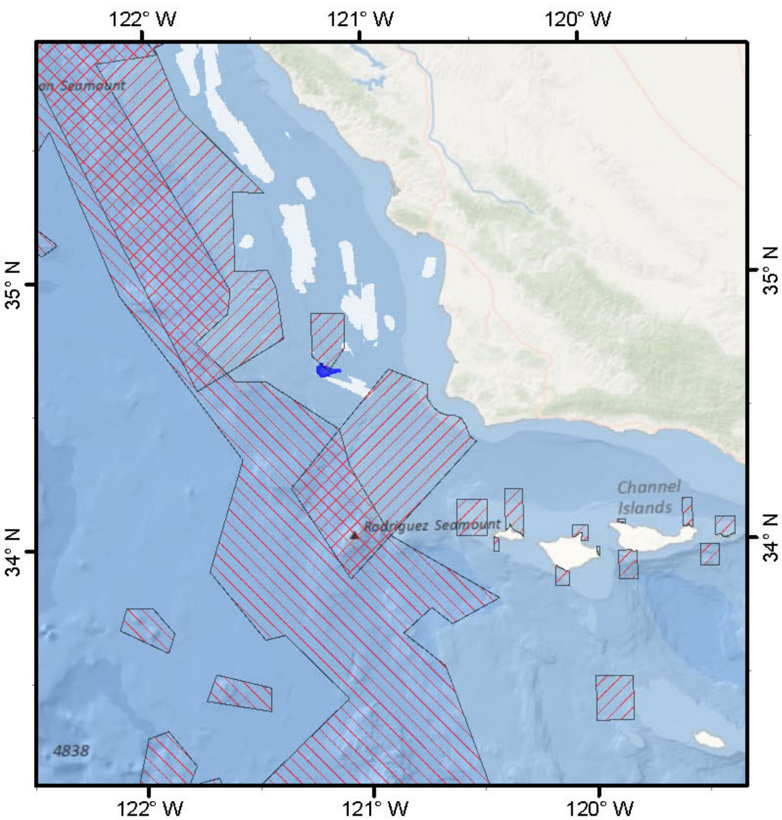


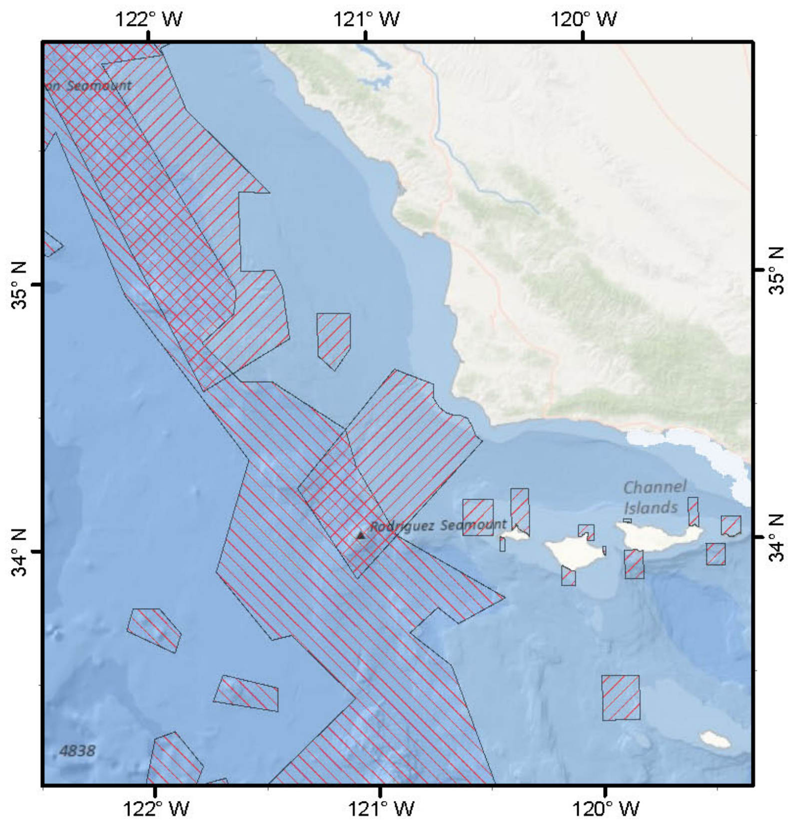
Before **Standardized Coral Bycatch (WCGOP - Trawl)** After

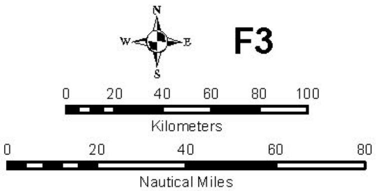



Before
Standardized Coral Bycatch (WCGOP - Trawl)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 1.88675
Low : 0.00740
EFH Cons. Area
Map 6 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Coral Bycatch (WCGOP - Trawl)** After

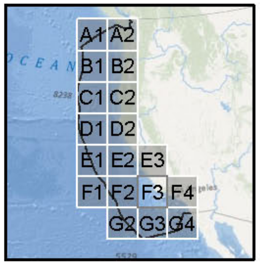






Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)

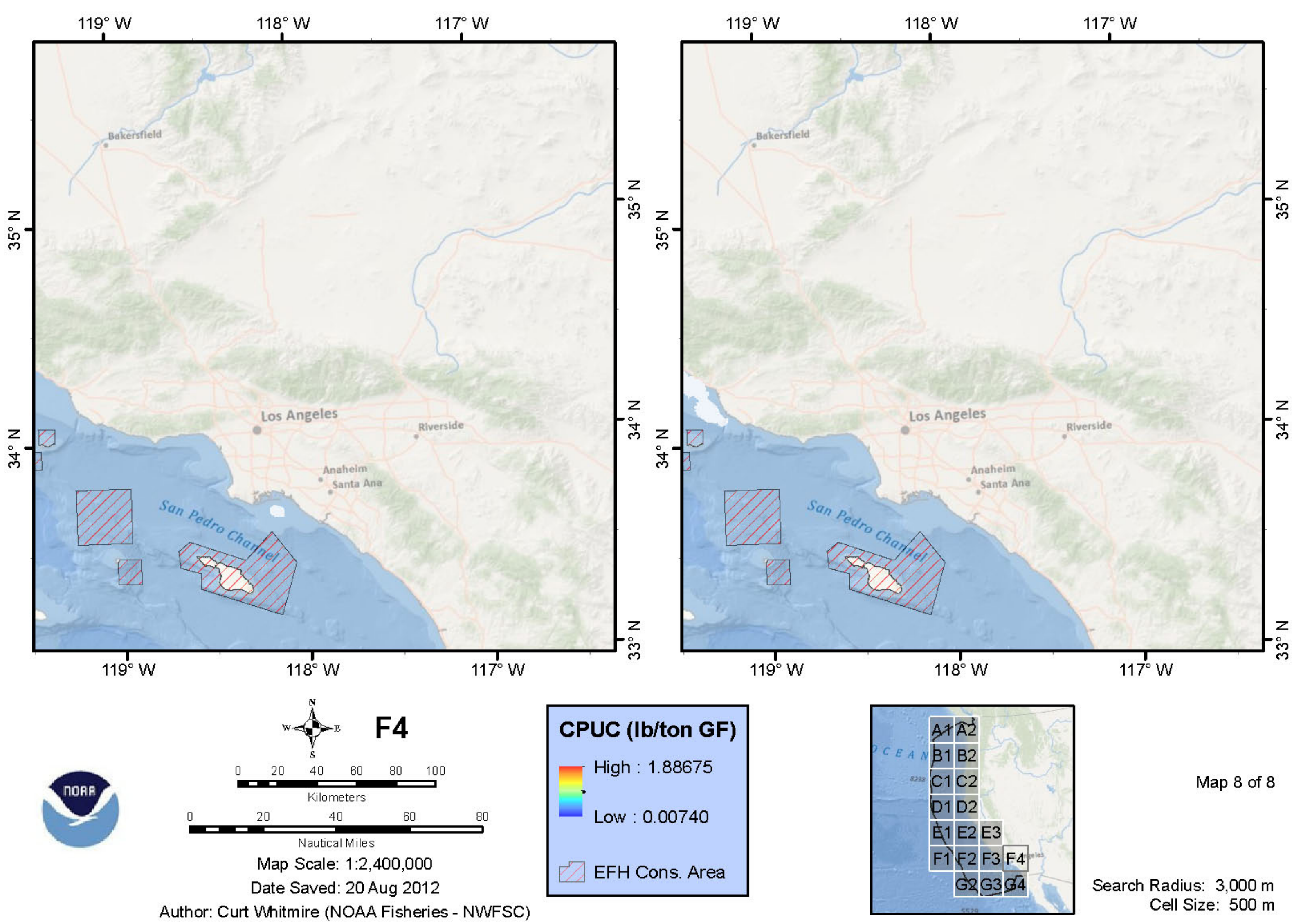
CPUC (lb/ton GF)
High : 1.88675
Low : 0.00740
EFH Cons. Area

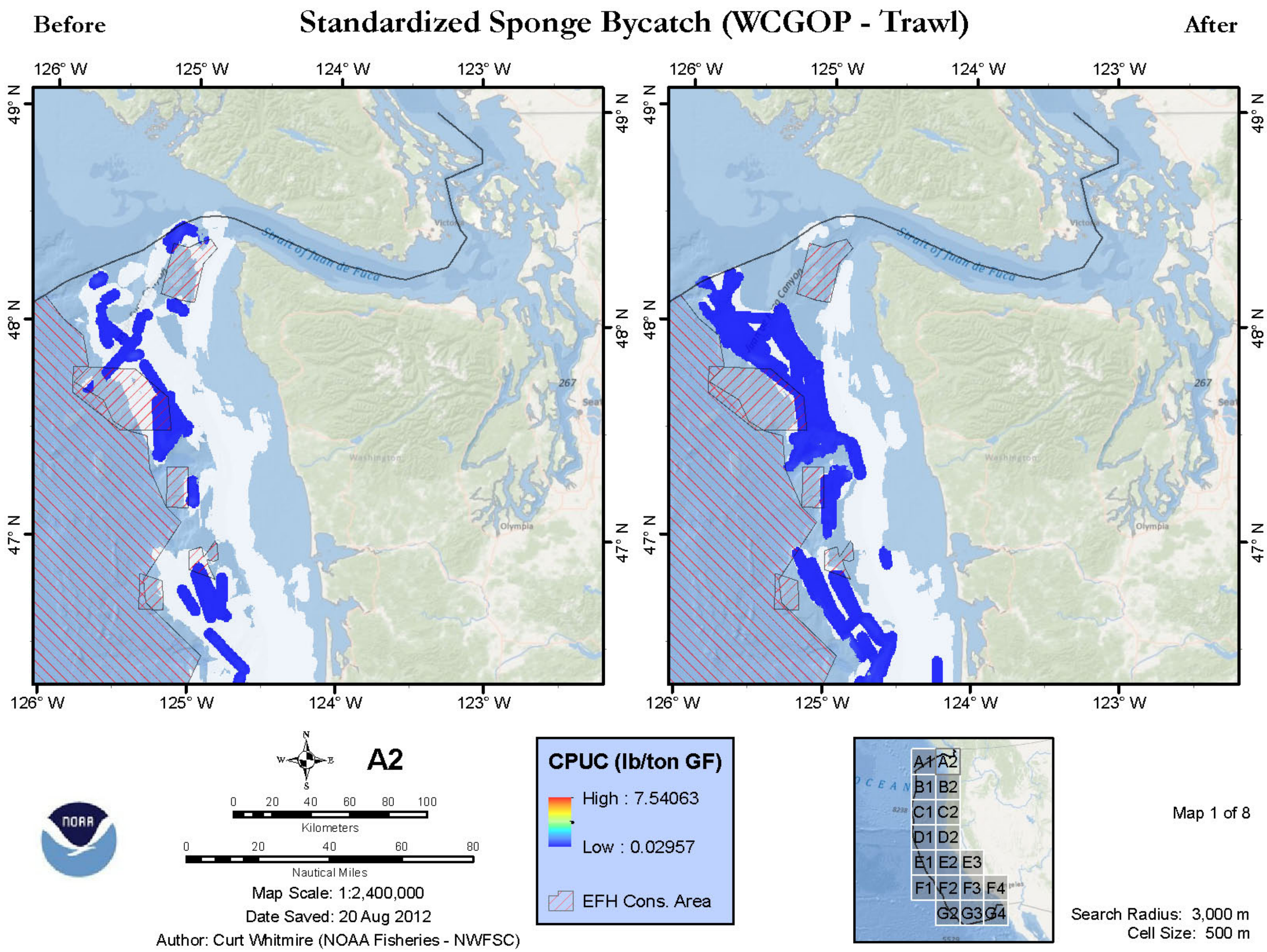


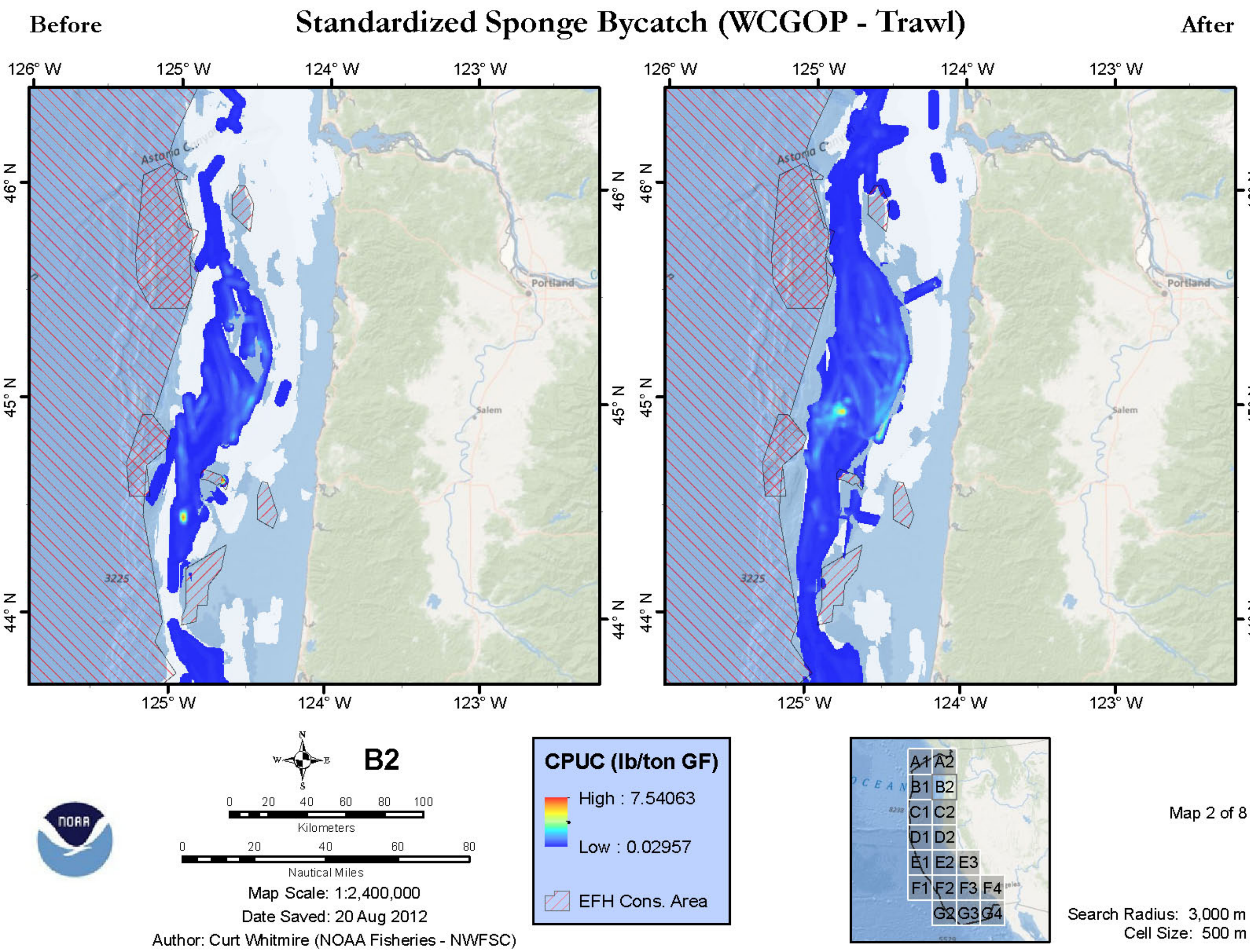
Map 7 of 8

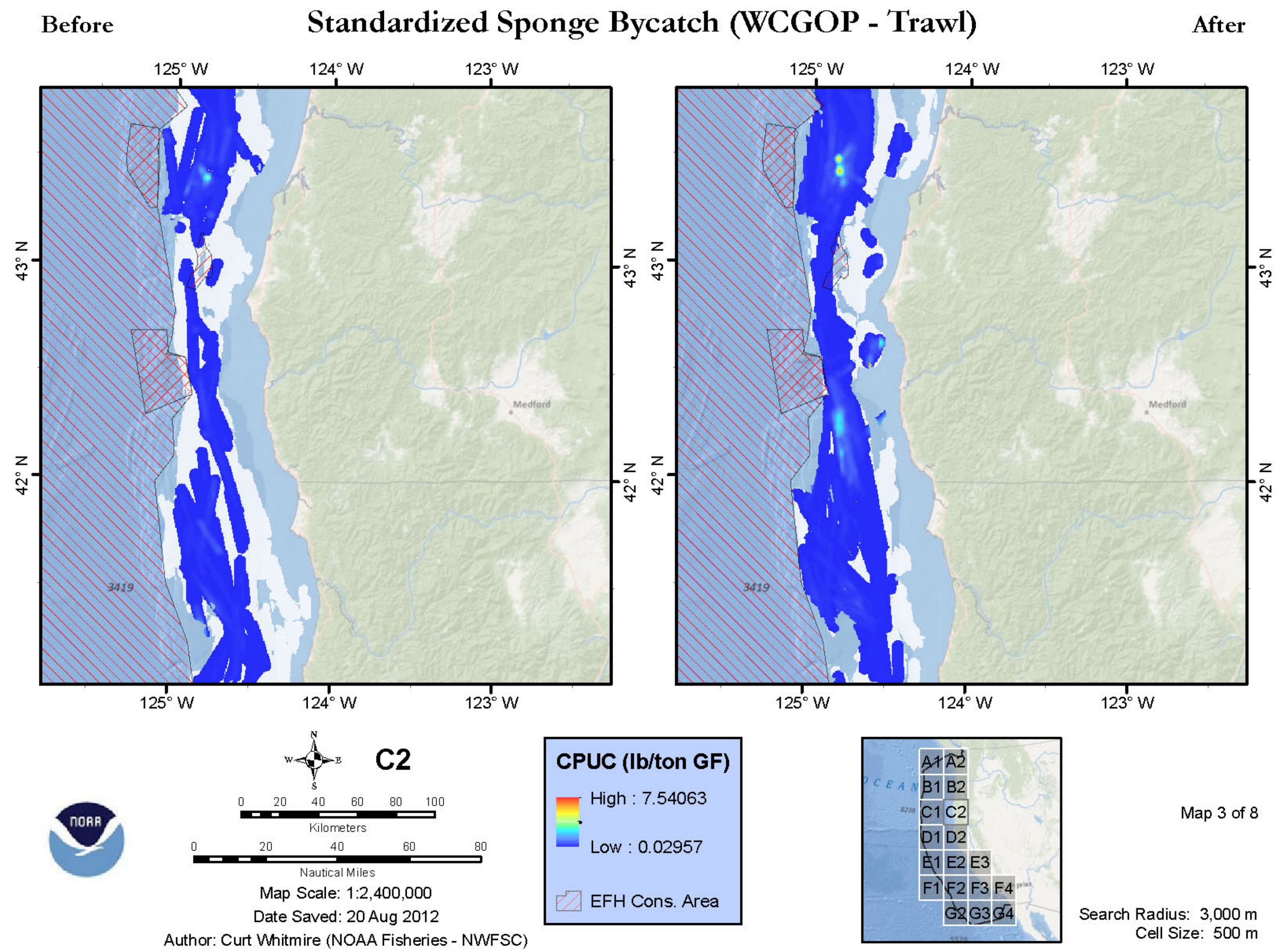
Search Radius: 3,000 m
Cell Size: 500 m

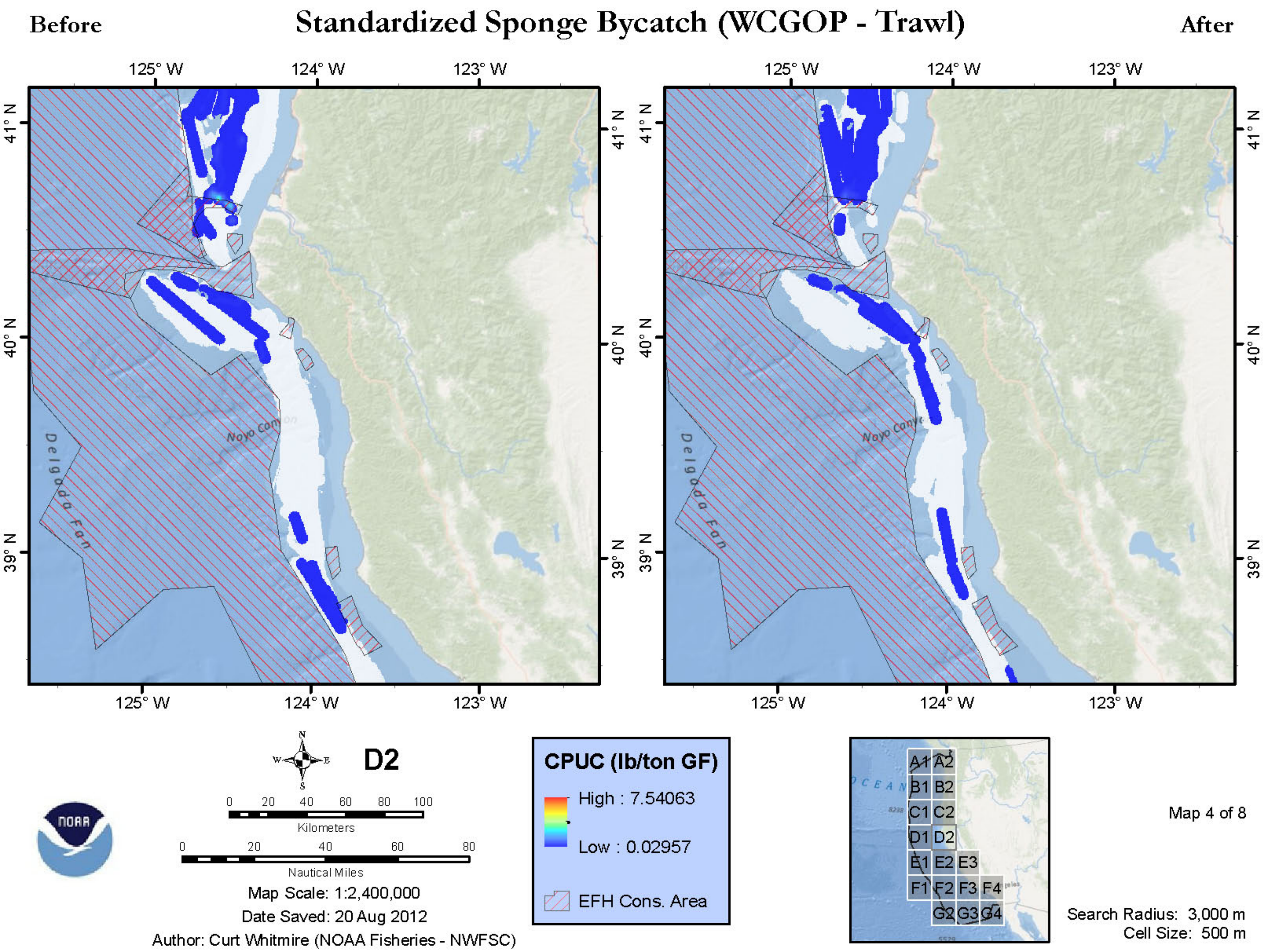
Before **Standardized Coral Bycatch (WCGOP - Trawl)** **After**



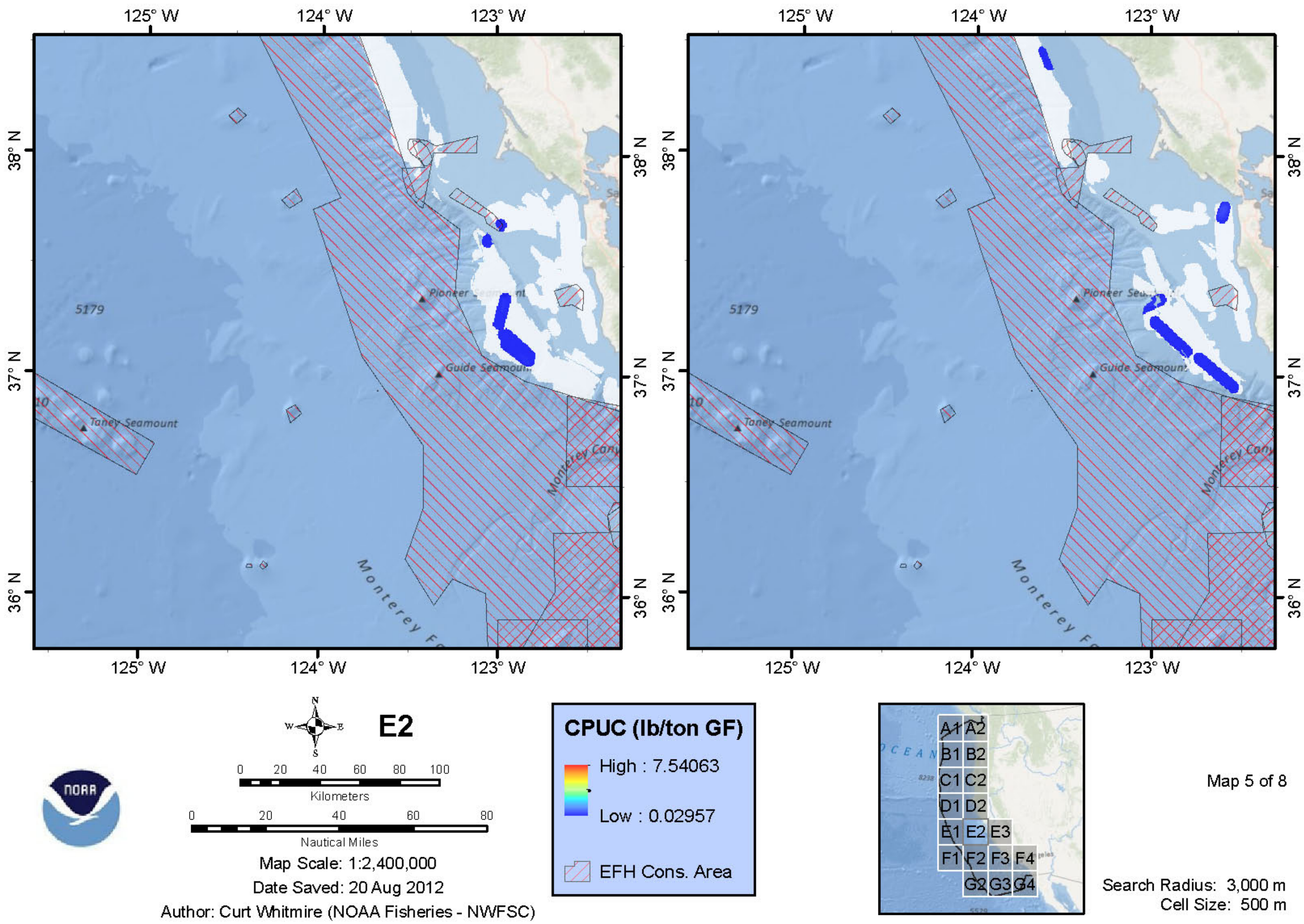

Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
Victoria
Washington
Olympia
267
A2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria C...
Portland
Salem
3225
B2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 8
Search Radius: 3,000 m
Cell Size: 500 m

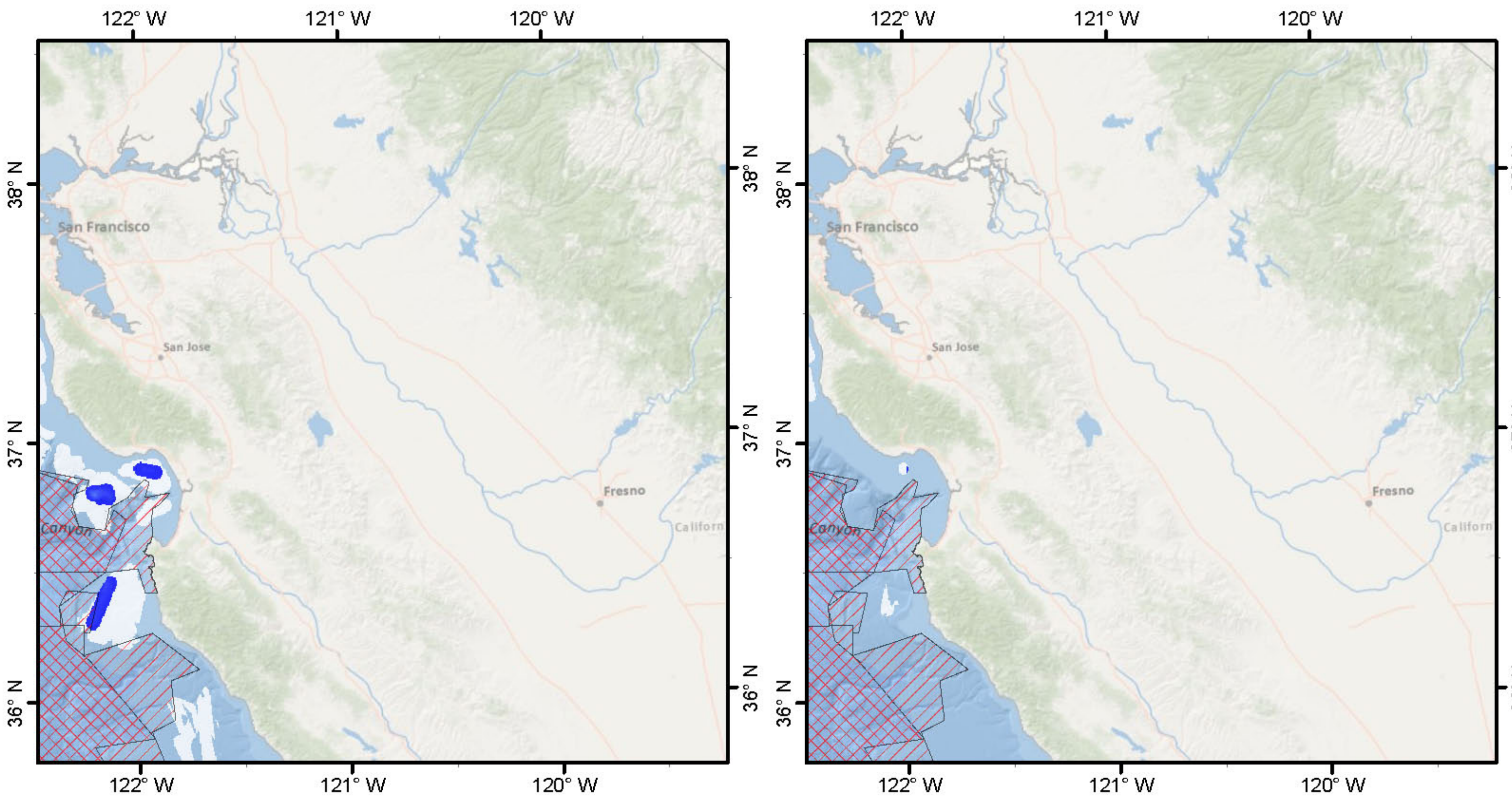

Before
Standardized Sponge Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
N
S
E
W
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Before **Standardized Sponge Bycatch (WCGOP - Trawl)** **After**



Standardized Sponge Bycatch (WCGOP - Trawl)

Before | After



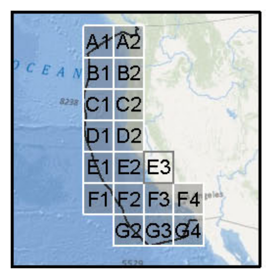
E3

0 20 40 60 80 100
Kilometers

0 20 40 60 80
Nautical Miles

Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)

CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area

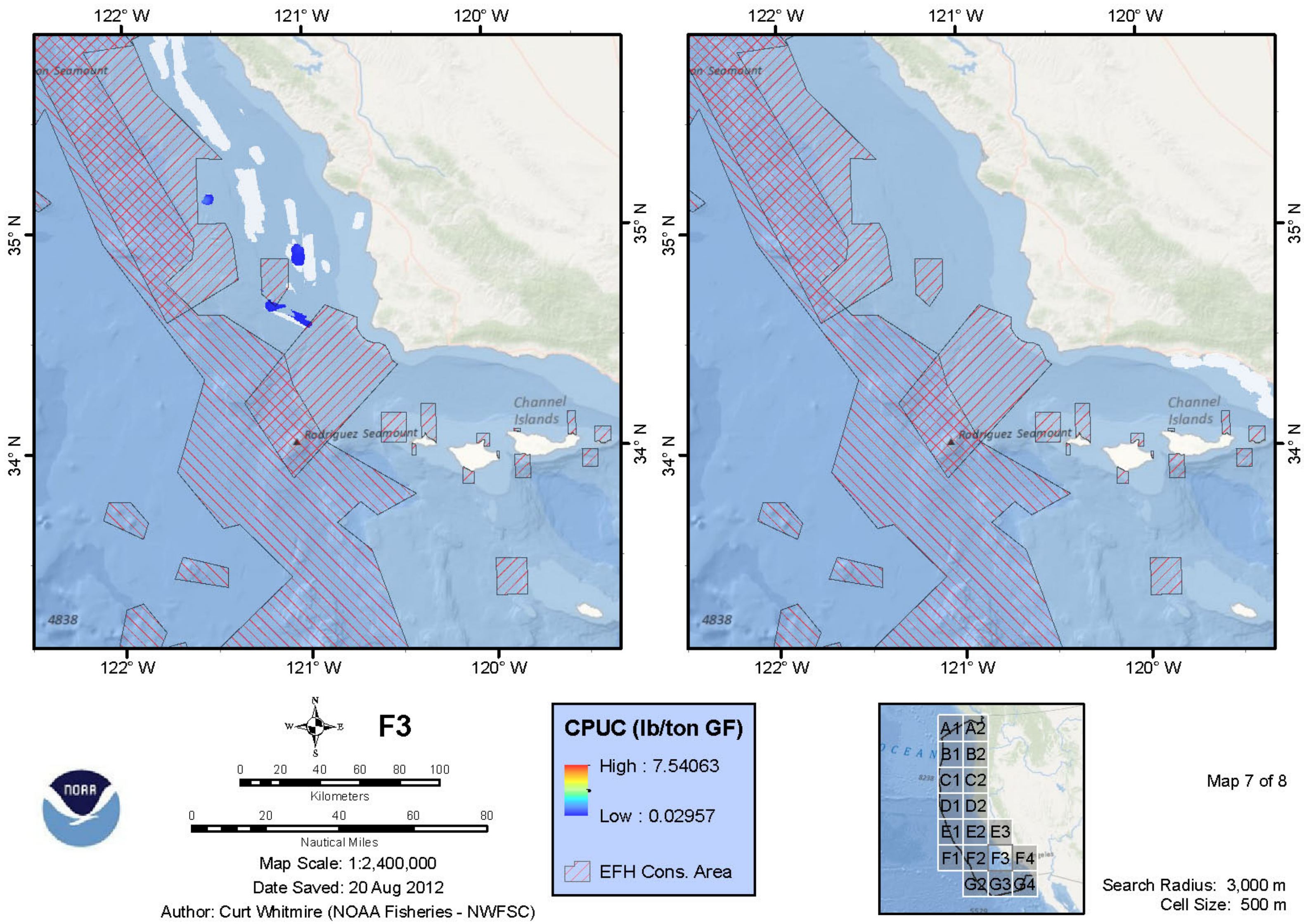


Map 6 of 8

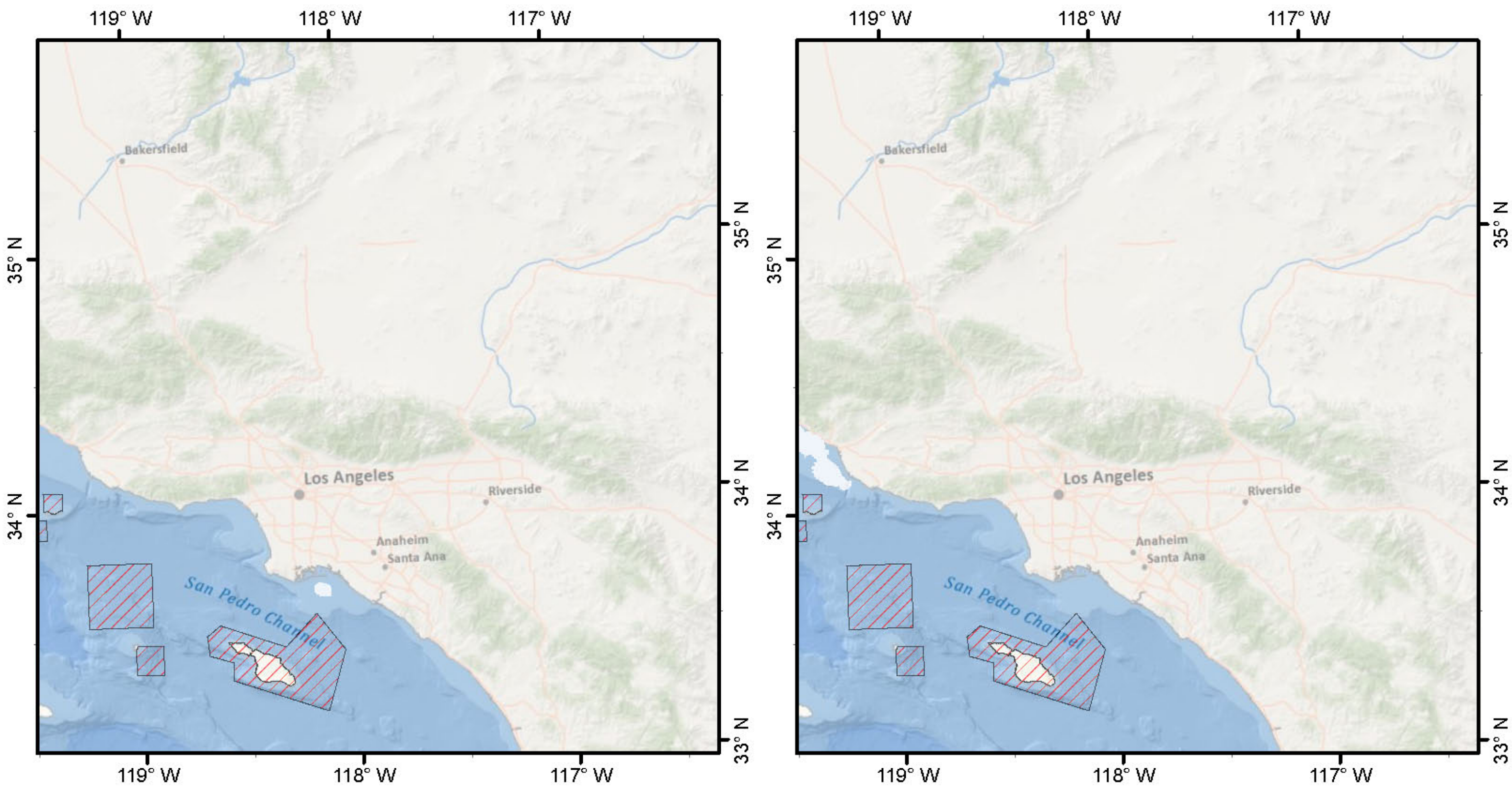
Search Radius: 3,000 m
Cell Size: 500 m

Appendix F-7

Before **Standardized Sponge Bycatch (WCGOP - Trawl)** **After**



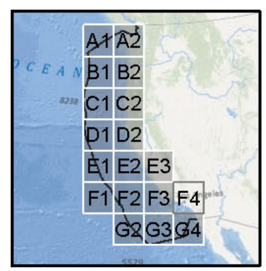
Before — **Standardized Sponge Bycatch (WCGOP - Trawl)** — **After**



F4

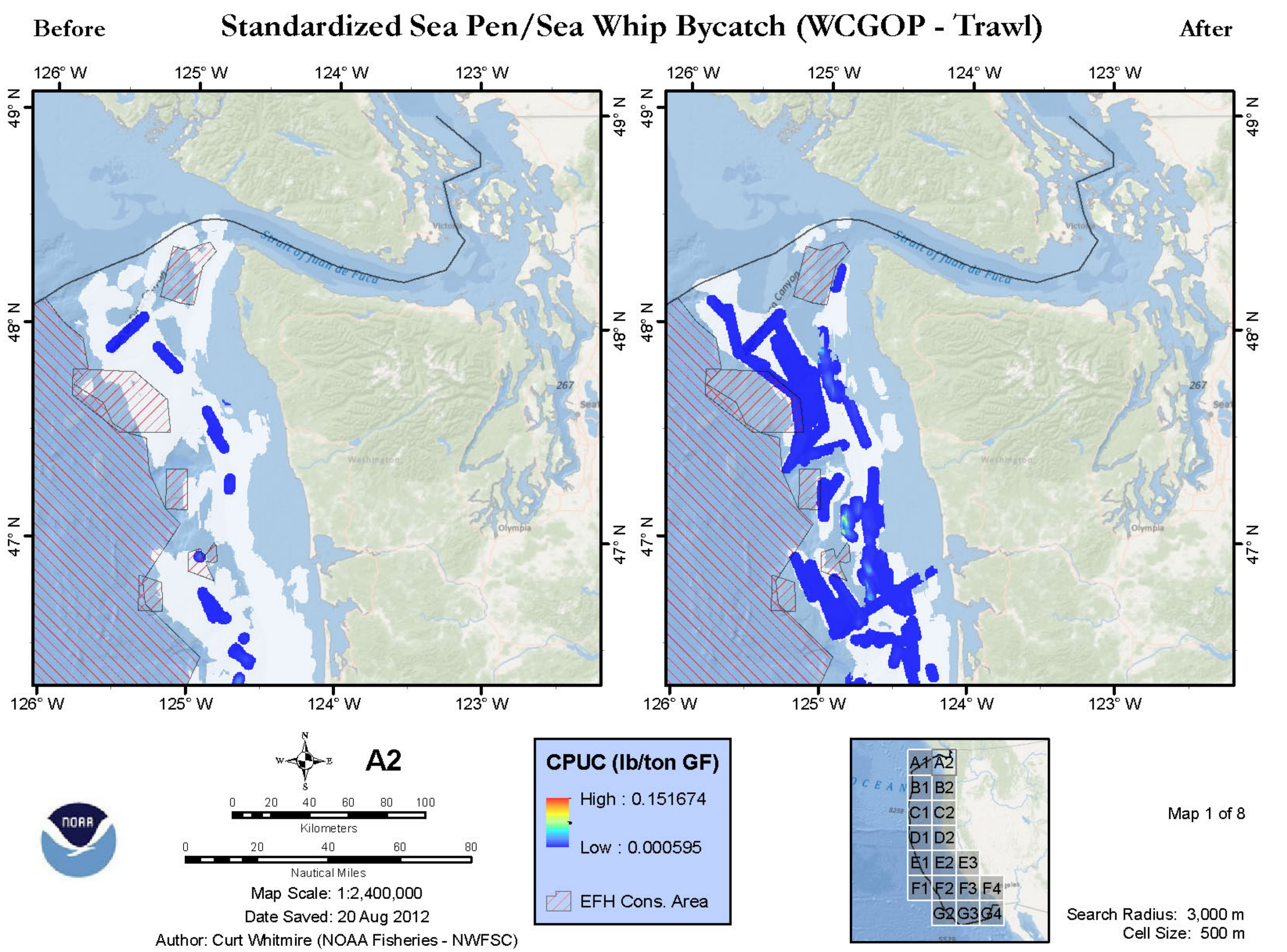
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)

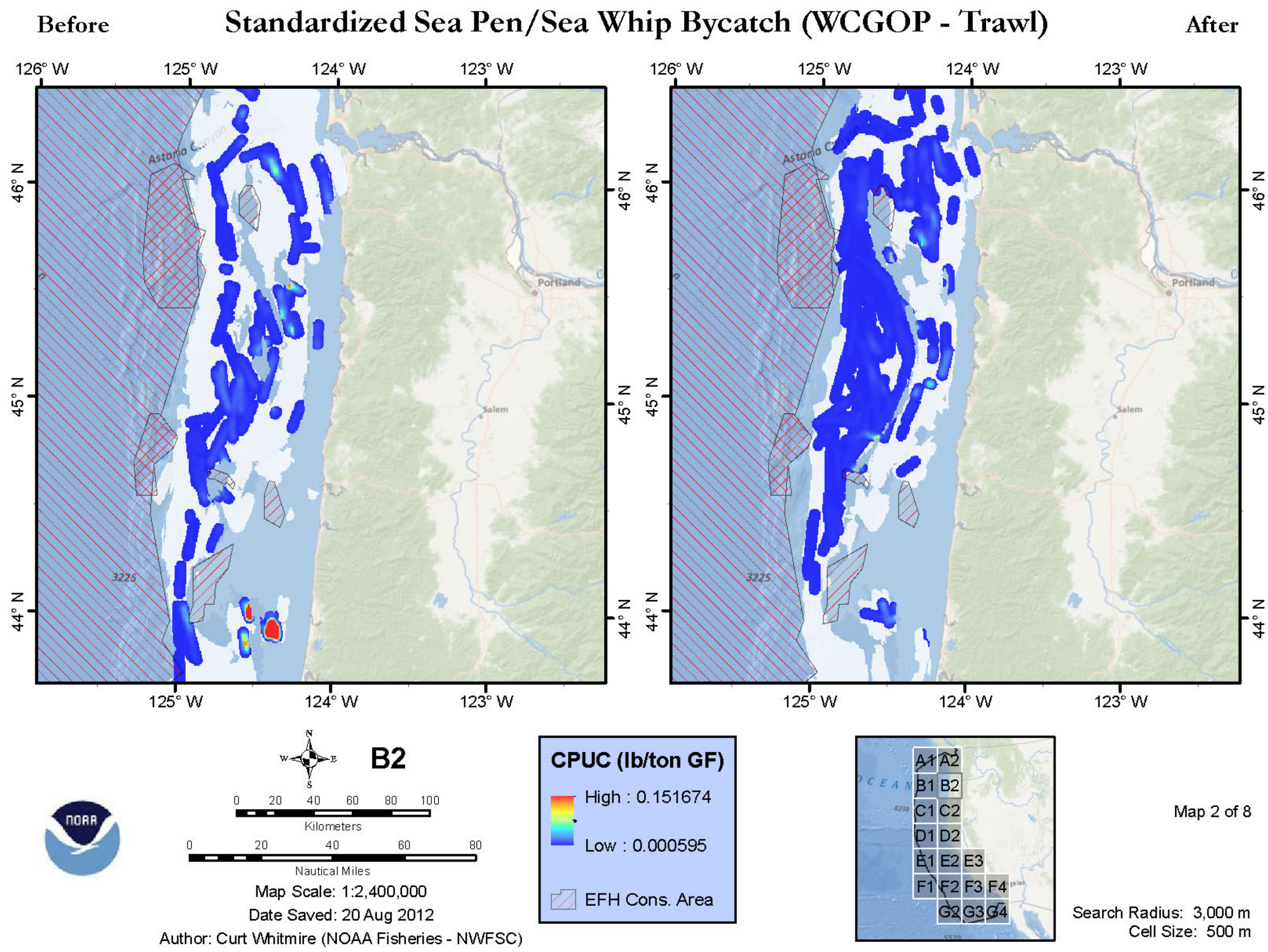
CPUC (lb/ton GF)
High : 7.54063
Low : 0.02957
EFH Cons. Area

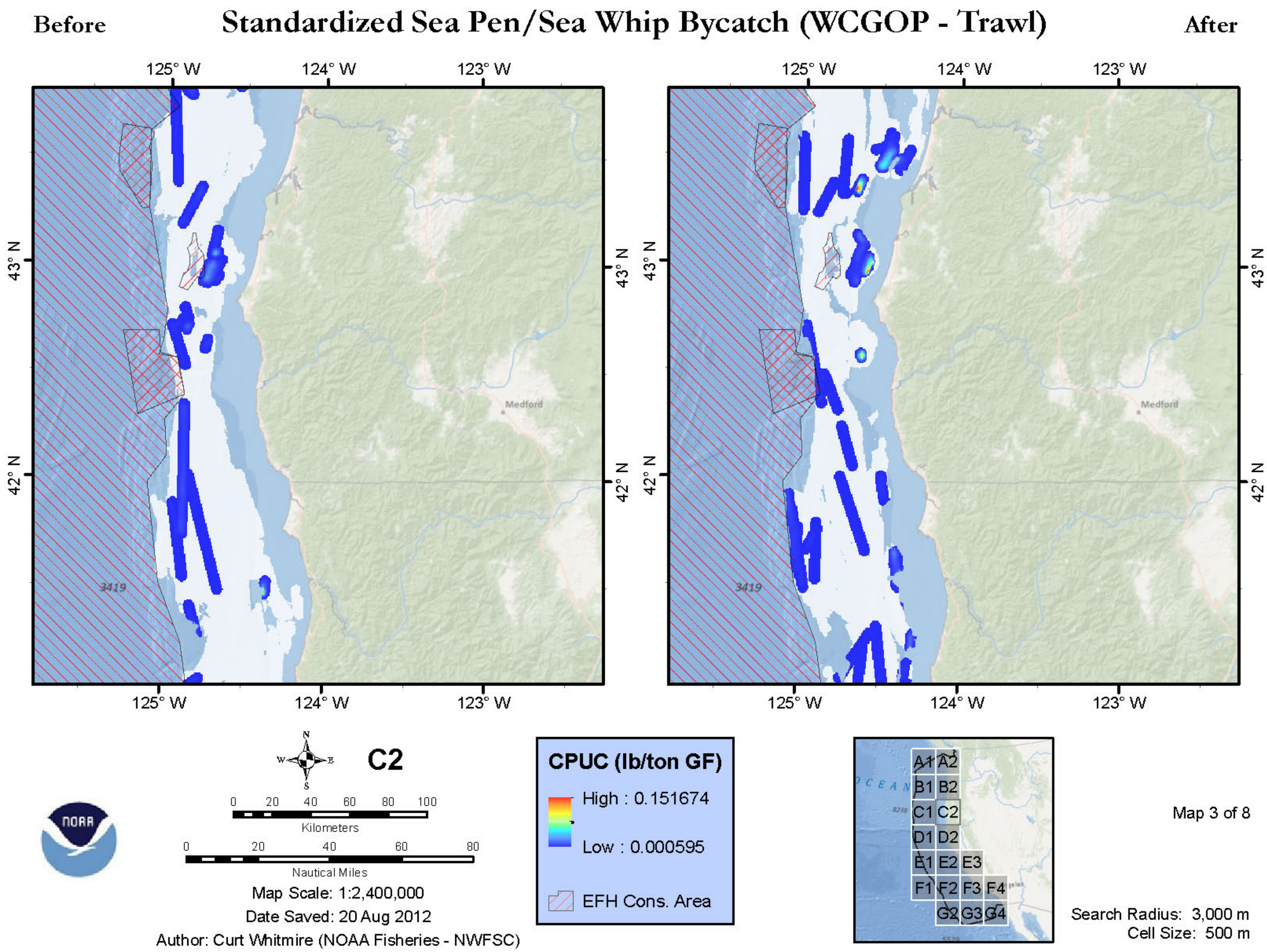


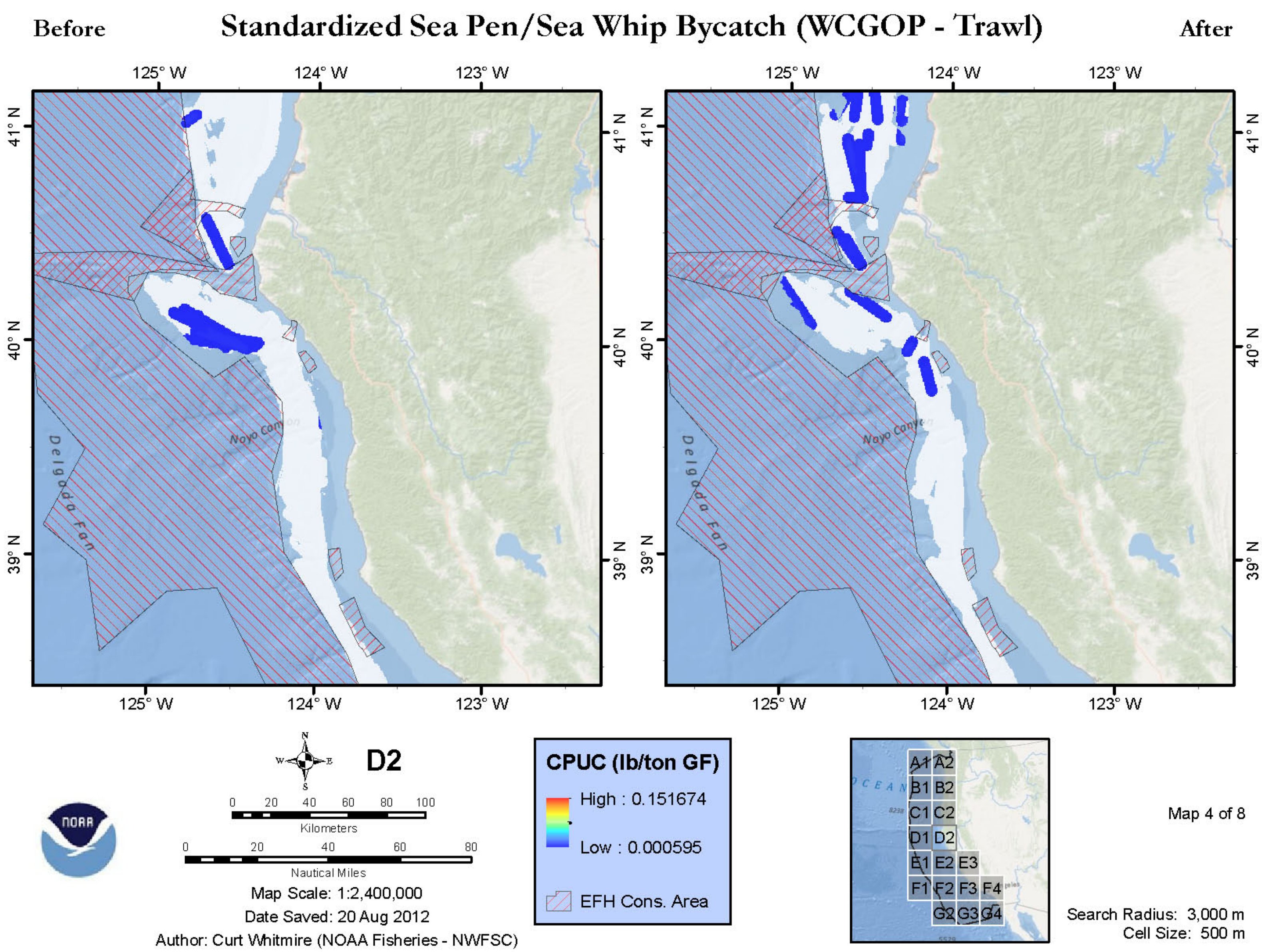
Map 8 of 8

Search Radius: 3,000 m
Cell Size: 500 m

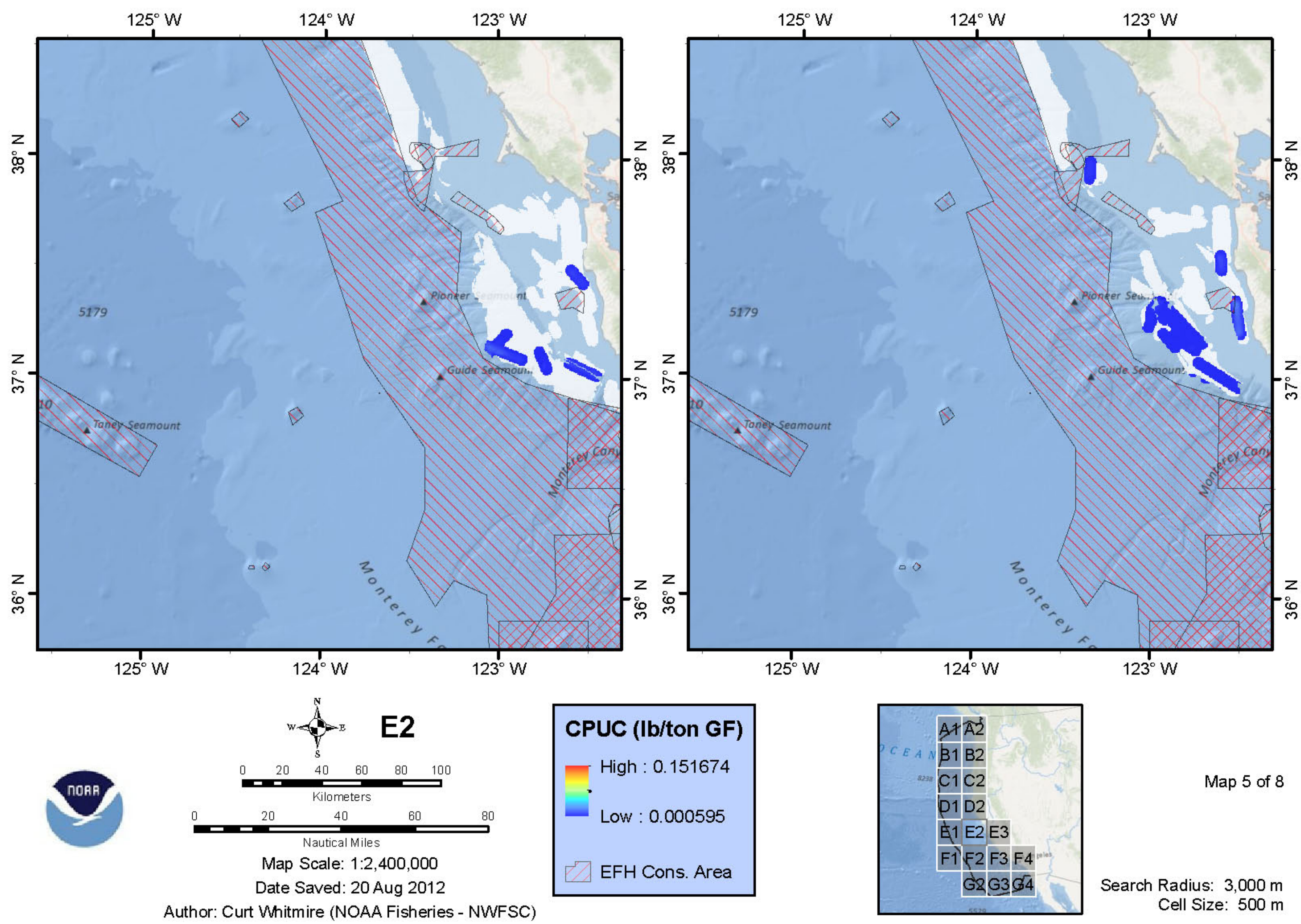

Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
49° N
48° N
47° N
Strait of Juan de Fuca
A2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 0.151674
Low : 0.000595
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 1 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
B2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 0.151674
Low : 0.000595
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 8
Search Radius: 3,000 m
Cell Size: 500 m

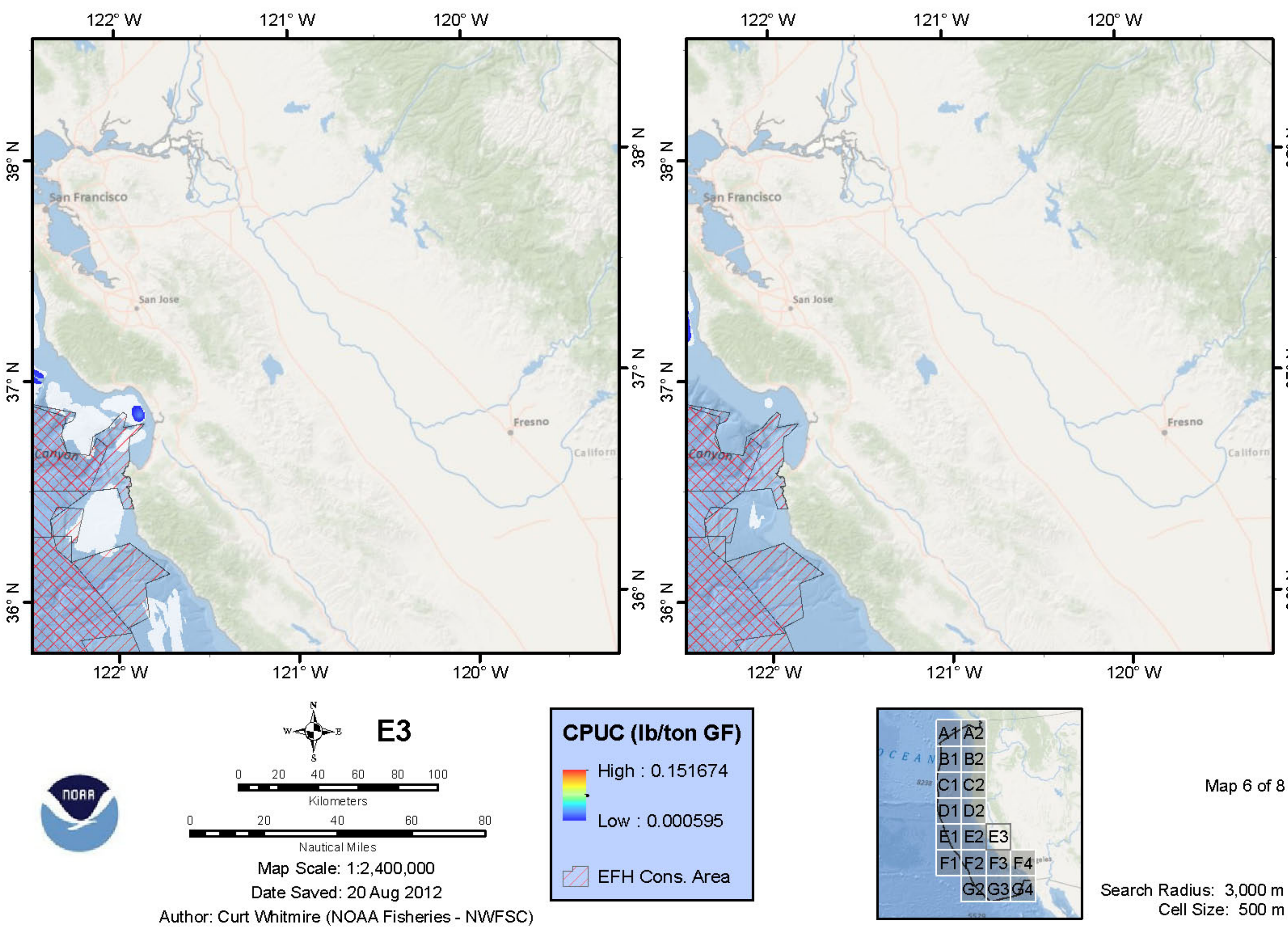

Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 0.151674
Low : 0.000595
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 8
Search Radius: 3,000 m
Cell Size: 500 m


Before
Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Author: Curt Whitmire (NOAA Fisheries - NWFSC)
CPUC (lb/ton GF)
High : 0.151674
Low : 0.000595
EFH Cons. Area
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m

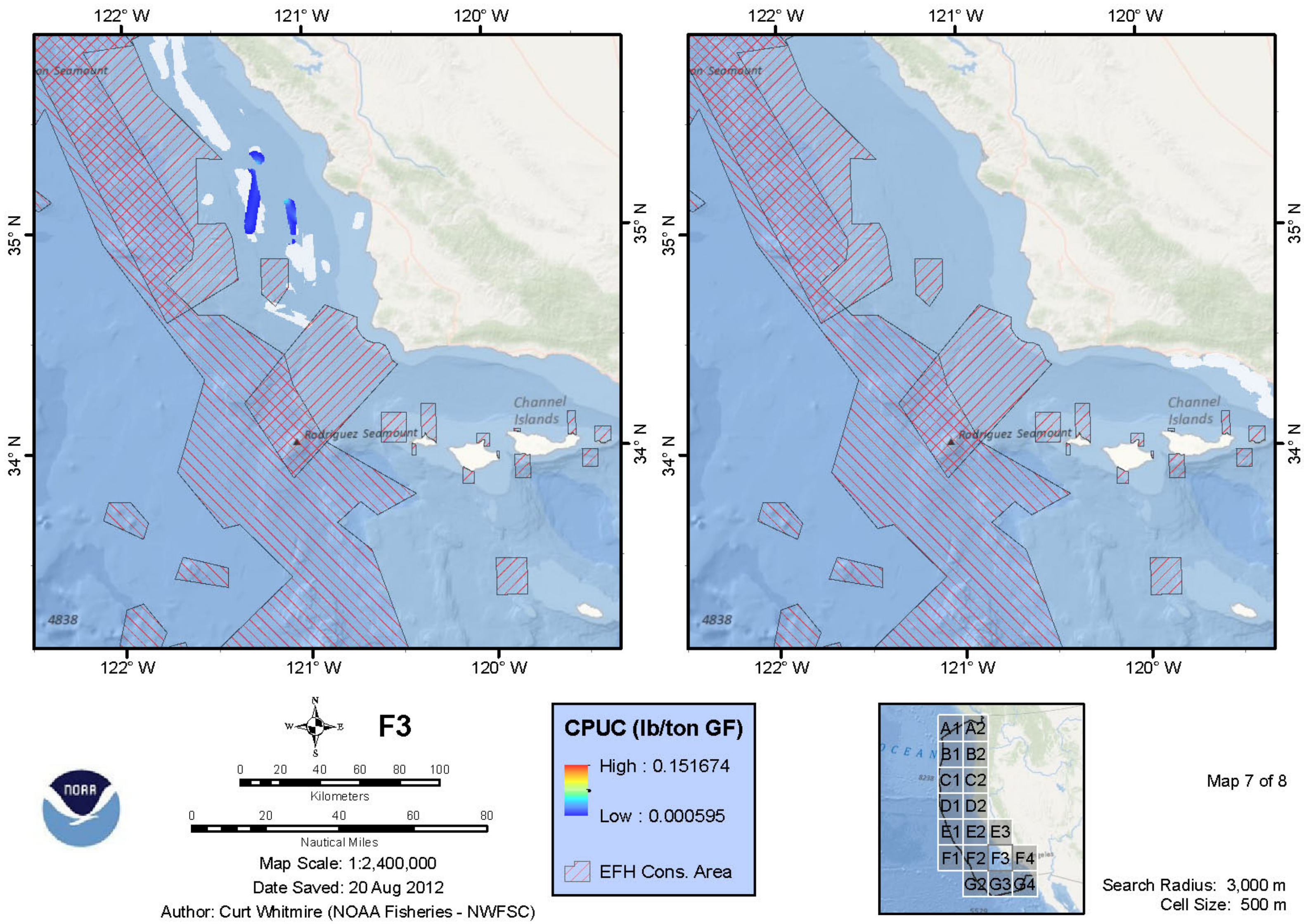
Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** **After**



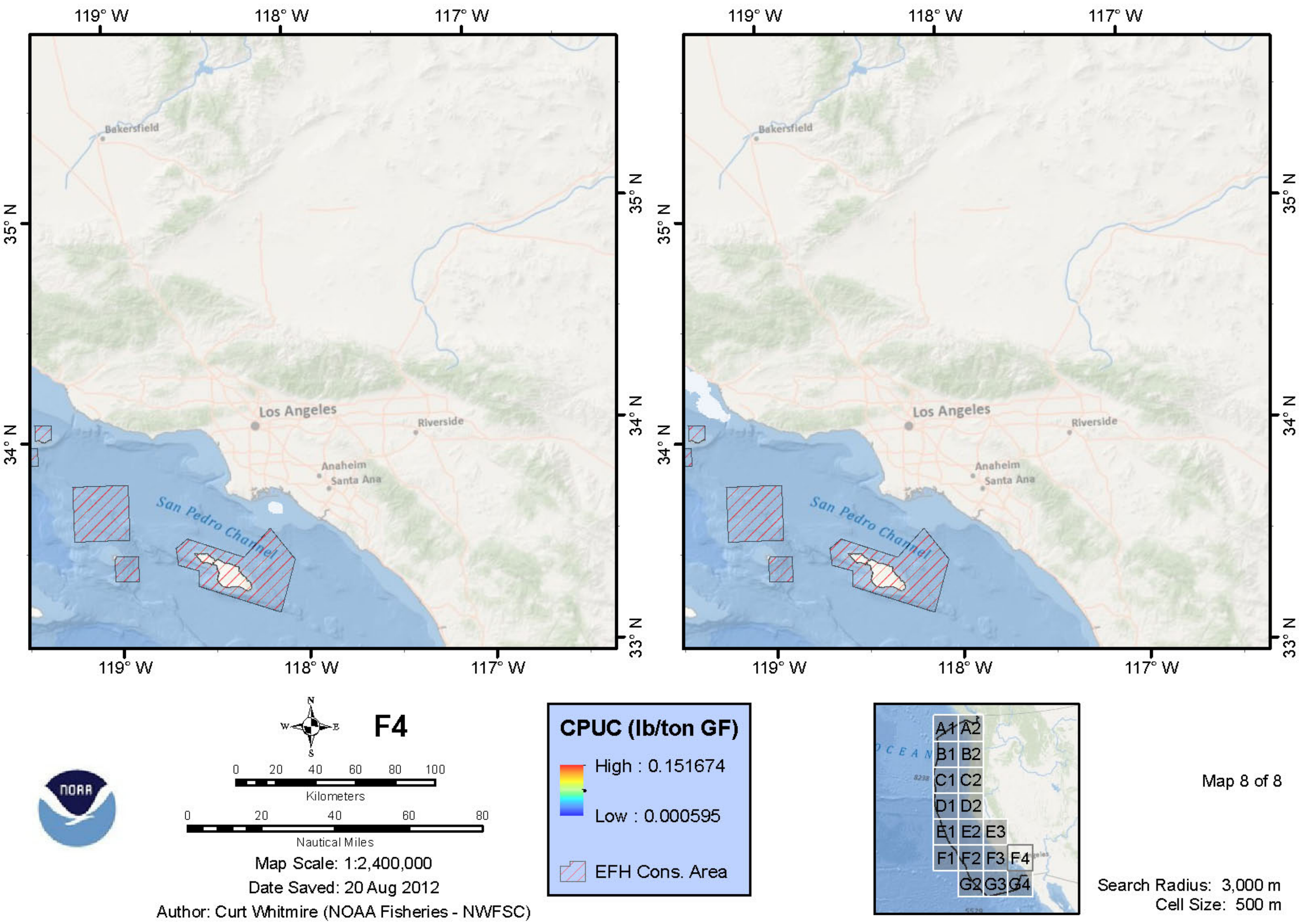
Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** After



Before — **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** — **After**



Before **Standardized Sea Pen/Sea Whip Bycatch (WCGOP - Trawl)** **After**



APPENDIX G GROUNDFISH SPECIES GROUP LIFE HISTORY SUMMARIES

This appendix provides an updated review of spatial and trophic information relevant to the designation of EFH for Pacific Coast groundfishes.

Appendix G-1: Flatfish Group Species Accounts

Appendix G-2: Other Flatfish Group Summary Information

Appendix G-3: Rockfishes Group Summary Information

Appendix G-4: Other Rochfishes Group Summary Information

Appendix G-5: Other Groundfishes Group Summary Information

Appendix G-6: Bibliography of Recent Literature Relevant to EFH for Pacific Coast Groundfishes

Table G-1. List of groundfish species and stocks managed under the Pacific Coast Groundfish Fishery Management Plan (species added to the FMP since 2005 marked with **).

Flatfishes	**Other rockfishes**
Arrowtooth flounder, *Atheresthes stomias*	Aurora rockfish, *Sebastes aurora*
Dover sole, *Microstomus pacificus*	Bank rockfish, *Sebastes rufus*
English sole, *Parophrys vetulus*	Black-and-yellow rockfish, *Sebastes chrysomelas*
Petrale sole, *Eopsetta jordani*	Blue rockfish, *Sebastes mystinus*
	Bronzespotted rockfish, *Sebastes gilli*
Other flatfishes	Brown rockfish, *Sebastes auriculatus*
Butter sole, *Isopsetta isolepis*	Calico rockfish, *Sebastes dallii*
Curlfin sole, *Pleuronichthys decurrens*	California scorpionfish, *Scorpaena guttata*
Flathead sole, *Hippoglossoides elassodon*	**Chameleon rockfish, *Sebastes phillipsi*
Pacific sanddab, *Citharichthys sordidus*	China rockfish, *Sebastes nebulosus*
Rex sole, *Glyptocephalus zachirus*	Copper rockfish, *Sebastes caurinus*
Rock sole, *Lepidopsetta bilineata*	Dusky rockfish, *Sebastes ciliatus*
Sand sole, *Psettichthys melanostictus*	**Dwarf-red rockfish, *Sebastes rufinanus*
Starry flounder, *Platichthys stellatus*	Flag rockfish, *Sebastes rubrivinctus*
	**Freckled rockfish, *Sebastes lentiginosus*
Rockfishes	Gopher rockfish, *Sebastes carnatus*
Black rockfish, *Sebastes melanops*	Grass rockfish, *Sebastes rastrelliger*
Blackgill rockfish, *Sebastes melanostomus*	Greenblotched rockfish, *Sebastes rosenblatti*
Bocaccio, *Sebastes paucispinis*	Greenspotted rockfish, *Sebastes chlorostictus*
Canary rockfish, *Sebastes pinniger*	Greenstriped rockfish, *Sebastes elongates*
Chilipepper, *Sebastes goodie*	**Halfbanded rockfish, *Sebastes semicinctus*
Cowcod, *Sebastes levis*	Harlequin rockfish, *Sebastes variegatus*
Darkblotched rockfish, *Sebastes crameri*	Honeycomb rockfish, *Sebastes umbrosus*
Longspine thornyhead, *Sebastolobus altivelis*	Kelp rockfish, *Sebastes atrovirens*
Pacific ocean perch, *Sebastes alutus*	Mexican rockfish, *Sebastes macdonaldi*
Shortbelly rockfish, *Sebastes jordani*	Olive rockfish, *Sebastes serranoides*
Shortspine thornyhead, *Sebastolobus alascanus*	Pink rockfish, *Sebastes eos*
Splitnose rockfish, *Sebastes diploproa*	**Pinkrose rockfish, *Sebastes simulator*
Widow rockfish *Sebastes entomelas*	**Puget Sound rockfish, *Sebastes emphaeus*
Yelloweye rockfish, *Sebastes ruberrimus*	**Pygmy rockfish, *Sebastes wilsoni*
Yellowtail rockfish, *Sebastes flavidus*	Quillback rockfish, *Sebastes maliger*
	Redbanded rockfish, *Sebastes babcocki*
Other groundfishes	Redstripe rockfish, *Sebastes proriger*
Cabezon, *Scorpaenichthys marmoratus*	Rosethorn rockfish, *Sebastes helvomaculatus*
Lingcod, *Ophiodon elongatus*	Rosy rockfish, *Sebastes rosaceus*
Pacific cod, *Gadus macrocephalus*	Rougheye rockfish, *Sebastes aleutianus*
Pacific hake, *Merluccius productus*	**Semaphore rockfish, *Sebastes melanosema*
Sablefish, *Anoplopoma fimbria*	Sharpchin rockfish, *Sebastes zacentrus*
Big skate, *Raja binoculata*	Shortraker rockfish, *Sebastes borealis*
California skate, *Raja inornata*	Silvergray rockfish, *Sebastes brevispinis*
Kelp greenling, *Hexagrammos decagrammus*	Speckled rockfish, *Sebastes ovalis*
Leopard shark, *Triakis semifasciata*	Squarespot rockfish, *Sebastes hopkinsi*
Longnose skate, *Raja rhina*	Starry rockfish, *Sebastes constellatus*
Pacific flatnose, *Antimora microlepis*	Stripetail rockfish, *Sebastes saxicola*
Pacific grenadier, *Coryphaenoides acrolepis*	**Swordspine rockfish, *Sebastes ensifer*
Spiny dogfish, *Squalus acanthias*	Tiger rockfish, *Sebastes nigrocinctus*
Spotted ratfish, *Hydrolagus colliei*	Treefish, *Sebastes serriceps*
Tope, *Galeorhinus galeus*	Vermilion rockfish, *Sebastes miniatus*
	Yellowmouth rockfish, *Sebastes reedi*

Appendix G-1: Flatfish Group Species Accounts

Arrowtooth Flounder (*Atheresthes stomias*)

Spatial Associations:
The center of distribution for Arrowtooth Flounder is the western Gulf of Alaska and southern Bering Sea, but this species also commonly occurs along the US West Coast. The results of fishery–independent surveys conducted by the NMFS Northwest Fishery Science Center (NWFSC) between the Canadian border and southern Caliornia during May and October of 2000–2002, 2004, and 2005 were recently summarized (Keller et al. 2005, 2006a, 2006b, 2007, 2008). The 2004 and 2005 surveys captured a size range indicative of large juvenile (> 20 cm TL) and adult life stages (Keller et al. 2007, 2008). These life stages were presumably also largely taken in earlier surveys but no measurements were provided. Arrowtooth Flounder occurred in 17.3–21.5% of hauls conducted between 2000–2002 (n_{2000} = 325, n_{2001} = 334, n_{2002} = 427) at depths of 183–1280 m (Keller et al. 2005, 2006a, 2006b). Its distribution was restricted to the outer continental shelf and continental slope (186–626 m) during 2000–2002 surveys with a mean capture depth of approximately 350 m. Changes in design between 2002 and 2004 surveys (minimum target depth range reduced to 55 m, southern extent of survey expanded from 34.5° N to 32.5° N) are probably responsible for observed differences in minimum depth ranges (52–1111 m, mean ~ 200 m) and frequency of occurrence during 2004 (36.0%, n_{2004} = 505) and 2005 (32.4%, n_{2005} = 675) surveys (Keller et al. 2007, 2008). Along the West Coast, Arrowtooth Flounder abundance decreased from north to south, with the great majority of the population (> 90% of survey biomass in all survey years) located north of 43° N (Keller et al. 2005, 2006a, 2006b, 2007, 2008). Among groundfishes, Arrowtooth Flounder was typically among the top 15 most adundant species by biomass, and among the top 3 most abundant species between 47.5° N and the Canadian Border (Keller et al. 2005, 2006a, 2006b, 2007, 2008). Based on a subset of available West Coast survey information collected during 1999–2002 (n = 1159 tows), median depth of capture for Arrowtooth Flounder was 300 m, and the median latitude of capture was 45° N (Tolimieri and Levin 2006).

Arrowtooth Flounder was extremely abundant in fishery–independent surveys conducted in continental shelf waters off Hecate Strait, British Columbia, ranking first and third among groundfishes by biomass during June 2002 (n = 96 tows) and May–June 2003 (n = 94 tows) (Choromanski et al. 2004, 2005). The catch was composed of a wide range of juvenile– and adult–size individuals (male: 11–68 cm TL, n = 2623; female: 11–88 cm TL, n = 4914) (Choromanski et al. 2004, 2005). During 2003, most individuals were caught between 108–126 m (depth range of tows = 18–146 m) (Choromanski et al. 2004). Arrowtooth Flounder occupied deeper waters during the winter (mean = 257 m) than during the summer (mean = 100 m) in this region (Pearall and Fargo 2007). In continental shelf surveys (18–166 m) conducted sporadically during 1985–1987 among a variety of unconsolidated bottom types, Arrowtooth Flounder was the most abundant species by biomass on a silty sand, high current region (55–166 m) (Pearsall and Fargo 2007).

Recent fishery–independent survey results indicated that Arrowtooth Flounder was the most abundant groundfish in the Gulf of Alaska. During summer months (June–August) of 2007 (n = 820 tows) and 2009 (n = 823 tows), Arrowtooth Flounder biomass was overwhelmingly dominant among groundfishes with the highest densities occurring on the broad continental shelf of the western Gulf, especially around the Barren Islands and off northeast Kodiak Island (Von Szalay et al. 2008, 2010). Mean weight of Arrowtooth Flounder generally increased with depth and (presumably) juveniles (< 30 cm TL) were realtively rare below 300 m. Distinct size modes corresponding to large juveniles or early adults typically occurred at depths of 100–500 m (Von Szalay et al. 2008; Von Szalay et al. 2010), with males distributed deeper than females (Von Szalay et al. 2010).

High densities of large juvenile and adult Arrowtooth Flounder recently have been documented in the southern Bering Sea and eastern Aleutian Islands. Arrowtooth Flounder was the most abundant flatfish and among the ten most abundant groundfishes (by biomass) in the Aleutian Island region in fishery–independent surveys conducted between May and August of 2002 (n = 417 tows), 2004 (n = 420 tows), 2006 (n = 358 tows), and 2010 (n = 417 tows) at depths of 1–500 m (Zenger 2004; Rooper 2008; Rooper and Wilkins 2008; Von Szalay et al. 2011). Based on the combined results of these surveys, Arrowtooth Flounder was the dominant groundfish in the southern Bering Sea but catch rates were greatest in the eastern Aleutians. These results are consistent with those of Logerwell et al. (2005) using data from NMFS surveys conducted during May–September 1980–2003. Mean length and weight increased with depth and individuals were larger in the eastern Aleutians than southern Bering Sea (Zenger 2004; Rooper 2008; Rooper and Wilkins 2008). Results of eastern Bering Sea surveys indicated that greatest catch rates were located between 600–800 m during May–August 2004 (n = 231), 2008 (n = 200), and 2009 (2000) (Hoff and Britt 2005, 2009, 2011). This center of distribution is generally deeper than that reported among other regions, although Von Szalay et al. (2011) noted that Arrowtooth Flounder populations were concentrated in deeper water in the southern Bering Sea (301–500 m) than in the Aleutian Islands (201–300 m). No temperature or other information was available to explain the cause of the high observed catch rates in deep waters of the eastern Bering Sea. Based on a General Additive Model, year, depth, and bottom temperature explained 72% of variability in Arrowtooth Flounder CPUE in the eastern Bering Sea during spring and summer months of 1982–2004 (McConnaughey and Syrjala 2009). When backscatter data representing variable substrate types were included, model predictions only increased by 3.5% indicating that substrate type may not be an important predictor of Arrowtooth Flounder distribution.

Changing environmental conditions seem to be affecting the distribution and abundance of Arrowtooth Flounder in the Bering Sea. Warming temperatures have led to an overall increase in the Bering Sea Arrowooth Flounder population from 1982–2007 (Zador et al. 2011). However, abundances generally have not increased in the most densely inhabited regions, and much of the recent population expansion appears to be driven by the increase in larger (adult) individuals caught on outer continental shelf north of Zhemchug Canyon (Zador et al. 2011). Southeastern Bering Sea populations also showed a marked increase in abundance during recent warm years (2003−2005), indicating possible increased physical habitat suitability. The high numbers of small (juvenile) individuals found in the southeastern Bering Sea suggest that this region may be a nursery area (along with the outer shelf). Arrowtooth Flounder movement patterns and geographic distribution appear to be strongly driven by temperature, and specifically the location of the cold pool and 0°C water. During years of large cold pools, distribution is restricted, which may increase density–dependent effects and curtailed population growth (Zador et al. 2011). Arrowtooth Flounder populations are expected to expand their distribution and abundance as the eastern Bering Sea warms (Zador et al. 2011). This species is known to be a strong swimmer and has exhibited active migrations from the northeastern to northwestern Bering Sea (Orlov 2004). This westward movement has been attributed to a warming of the northwestern Bering Sea during the 1990s and the associted weakening of the Kamchatka Current (Orlov 2004).

Seasonal movements, spawning habitat, and distribution patterns of eggs and larvae recently have been described in the Gulf of Alaska. Arrowtooth Flounder primarily spawned along the continental slope east of Kodiak Island from late January to March (Blood et al. 2007). During peak spawning in January and February, mature–size females were concentrated along the continental slope southwest, south and east of Kodiak Island at depths of 190–340 m and as deep as 485 m (Bailey et al. 2008). In early March and in April, most individuals had migrated towards Shelikof Strait. The monthly distribution of mature–size female Arrowtooth Flounder indicated a prompt migration away from the slope once spawning was complete (Bailey et al. 2008). Early–stage eggs were found in tows that sampled to depths of ≥ 450 m. Larvae, which hatch between 3.9 and 4.8 mm standard length, increased in abundance with depth (Blood et al 2007). Larvae of increasing lengths were found inshore of eggs, demonstrating a shoreward movement with ontogeny. There also may be a downstream gradient over the shelf of increasing size, with the smallest larvae around Kodiak Island and the largest mean lengths between the Shumagin Islands and Unimak Pass. The mean depth of Arrowtooth Flounder larvae was ~30 m but there was an ontogenetic movement of larvae to the surface and early stage larvae were commonly found to 150 m (Bailey et al. 2008). Arrowtooth Flounder generally recruited to benthic environments of the inner and mid continental shelf during July–August (Bailey et al. 2008).

Recently published spatial information concerning Arrowtooth Flounder is consistent with and expands upon prior knowledge. Previous findings, such as temperature tolerances of different life stages (McCain et al. 2005), were utilized in some recent studies (e.g., Zador et al. 2011) to build a more complete picture of spatial and temporal distribution patterns and to determine the main factors driving observed patterns. Most of the recently published spatial information on Arrowtooth Flounder was derived from Alaskan waters with West Coast contributions largely limited to the results of NMFS trawl surveys. However, a substantial amount of historic information is available from directed scientific research on the spatial associations of this species along the West Coast (McCain et al. 2005).

Trophic Interactions:
Several new studies are available that detail the food habits of Arrowtooth Flounder. All of these studies used benthic trawl gear deployed during daylight hours to collect specimens and stomach samples in the Gulf of Alaska (Yang 2004; Yang et al. 2005; Yang et al. 2006; Knoth and Foy 2008), eastern Bering Sea (Yang et al. 2005; Lee et al. 2010) and Hecate Strait, British Columbia (Pearsall and Fargo 2007). Data from the Gulf of Alaska were derived from Pavlof Bay (90–123 m; Augst 5–7 1995; Yang 2004), Chiniak and Marmot Bays off Kodiak Island (mostly <100 – 200 m, May and August 2002–2004; Knoth and Foy 2008), the central and western Gulf of Alaska (1999, 2001; Yang et al. 2006) and throughout the Gulf of Alaska (May–September, 1990–2001; < 50–200 m; Yang et al. 2005). In the Gulf of Alaska, Arrowtooth Flounder ate primarily fishes, with a greater proportion fishes noted among (presumably) adults (≥ 40 cm FL; Yang et al. 2006, Knoth and Foy 2008). The dietary contribution of fishes (by weight) ranged from 43.5% (n = 465; Knoth and Foy 2008) to 73% (n = 1359; Yang et al. 2006) in studies with large sample sizes (n > 100). Walleye Pollock was the primary prey species, contributing between 13.3% (2002–2004; Knoth and Foy 2008) and 31.4% (2001; Yang et al. 2006) to diet composition by weight among identified fishes. Pacific Sand Lance and Capelin also were commonly ingested in the Gulf of Alaska (Yang et al. 2005, 2006). Crustaceans, especially pandalid shrimps (%Weight (%W) = 7–12, Yang et al. 2006) and euphausiids (%W = 17.7%; Knoth and Foy 2008), were also regularly consumed, especially by (presumably) juvenile specimens (< 40 cm FL; Yang et al. 2006). A relatively low proportion of stomachs with prey items (53.8% (n = 80; Yang 2004) to 76.2% (Yang et al. 2006)) were indicative of the episodic feeding of a piscivorous predator. In addition to the previously noted ontogenetic differences in diet composition, temporal dietary variability was documented in the Gulf of Alaska. In 2002 and 2003, Walleye Pollock was the dominant prey item of adult Arrowtooth Flounder in the western Gulf of Alaska, but its importance declined substantially in 2004 with an associated increased reliance on euphausiids and Pacific Sand Lance (Knoth and Foy 2008). The importance of euphausiids in the diet of Arrowtooth Flounder also decreased significantly from May to August, whereas the importance of capelin increased during the same time period. Temporal changes in feeding activity were more pronounced in smaller, likely juvenile, individuals (Knoth and Foy 2008). Temporal dietary variability was largely attributed to differences in local prey availability, suggesting that Arrowtooth Flounder is a generalist feeder. In addition, the prevalance of pelagic prey was interpreted to reveal that Arrowtooth Flounder feedsf mainly in the water column (Knoth and Foy 2008).

New studies conducted in the eastern Bering Sea also indicated piscivory by Arrowtooth Flounder. Fishes composed 72.2% of diet composition by weight during 1979–1985 in waters < 500 m (Lee et al. 2010). Walleye Pollock (64%) dominated diet composition, followed by large zooplankton (20.1%) and shrimp (7.1%). Forage fishes composed a smaller proportion of diet (5.9%; Lee et al. 2010) compared to the Gulf of Alaska population (Yang et al. 2006; Knoth and Foy 2008). Capelin, for instance, constituted 1.0% of Arrowtooth Flounder diet composition in the eastern Bering Sea during 1970–2001, compared to 8.8% in the Gulf of Alaska during 1990–2001 (Yang et al. 2005). Dietary overlap with Greenland Turbot was substantial during 1979–1985 (0.882) and trophic level was estimated at 3.93 (Lee et al. 2010).

In the waters of Hecate Strait, British Columbia, fishes also were the primary prey taxa, although species composition varied. Pearsall and Fargo (2007) collected a size range representative of juvenile and adult Arrowtooth Flounder in trawl surveys conducted during June and September–October 1985, January 1986, and May–June 1987. Trawls were fished during daylight hours in four distinct regions at depths of 18–166 m and bottom types ranging from sandy silt to a mixture of coarse sand, gravel, pebbles, and cobbles. The great majority of stomach samples (n = 977) contained prey items (93.1%) (Pearsall and Fargo 2007). Based on %W, Arrowtooth Flounder in Hecate Strait fed mainly on fishes, with most undentified (50.5%). Among identified prey taxa, Pacific Herring (12.9%), Pacific Sand Lance (9.8%) and lobsters (7.4%) contributed > 5% to diet composition (Pearsall and Fargo 2007). Adult–size Arrowtooth Flounder fed on a greater proportion of fishes than juvenile–size individuals and on a different species composition. Adults consumed a greater proportion of forage fish and herring whereas juveniles ate greater amounts of macrobenthos, as well as more euphausiids and shrimps (Pearsall and Fargo 2007). Pronounced temporal variability was reported in the relative contribution of prey taxa within and among regions. In general, however, a greater proportion of fishes was noted on a sand, gravel, pebbles, and cobbles habitat, whereas more shrimp and plankton were consumed on a sandy silt habitat with strong currents (Pearsall and Fargo 2007). Diet composition of juveniles and adults was similar and samples were pooled to estimate trophic level (between 3.8–4.0) and for interspecific comparisons. Arrowtooth Flounder diet composition was most similar to that of of upper trophic level species such as dogfish (0.946), adult Pacific Cod (0.919), juvenile Pacific Cod (0.873), and Lingcod (0.824) (Pearsall Fargo 2007).

Seabirds, pinnipeds, and other fishes were reported as predators of Arrowtooth Flounder in recent studies. Common Murres (n = 15), Thick–Billed Murres (n = 76), Red–Legged Kittiwakes (n = 52), and Black–Legged Kittiwakes (n = 92) sampled on St. Paul and St. George Islands (Pribilof Islands) and Bogoslof Island (Aleutian Archipelago) during 1999–2000 all consumed (presumably) juvenile Arrowtooth Flounder. The relative dietary contribution differed among species and between short–term (stomach content analysis) and long–term (fatty acid analysis) feeding trends. Dietary contributions of Arrowtooth Flounder ranged from trivial amounts to nearly 30% (Iverson et al. 2007). Based on 2760 scat samples collected on Kodiak Island during September 1999 to March 2005, juvenile and adult Arrowtooth Flounder (<16–70 cm TL) were the third most important species in the diet of Steller Sea Lions (%Number (%N) = 5.6, %Frequency of Occurrence (%FO) = 34.7). Arrowtooth Flounder was more important to Steller Sea Lions diets in the summer as compared to the winter, and increased in dietary importance during 2000–2004 when Walleye Pollock numbers declined (McKenzie and Wynne 2008). Arrowtooth Flounder also were important components of Pacific Cod diets (n = 1438) off Southeast Alaska during 1993–1999 (Trites et al. 2007). The occurrence of Arrowtooth Flounder in Pacific Cod diet was similar among seasons, ranging from 13.2% (spring) to 20.3% (winter) (Trites et al. 2007). Pacific Halibut (%W = 9.8, n = 152), Bocaccio (%W = 2.3%, n = 8), Rock Sole (%W = 0.5%, n = 347) and Pacific Sanddab (%W = 1.7%, n = 90) also consumed Arrowtooth Flounder (Pearsall and Fargo 2007).

Recent published information concerning Arrowtooth Flounder trophic interactions is consistent with and augments previous findings. A rather large body of information indicates a primarily piscivorous diet with a high proportion of Walleye Pollock in Alaskan waters. A previously reported dietary shift from crustaceans to small forage fishes between small and large juveniles (McCain et al 2005) was reinforced by recent studies (Yang et al. 2006; Knoth and Foy 2008). Newly available information on Arrowtooth Flounder predators considerably augments prior documentation (McCain et al. 2005).

DOVER SOLE (*MICROSTOMUS PACIFICUS*)

Spatial Associations:

A substantial amount of new information is available regarding the spatial associations of Dover Sole in the eastern North Pacific. Along the West Coast, this information is derived from fishery–independent surveys of NMFS–NWFSC and from directed scientific research. NMFS–NWFSC conducted surveys from the US/Canadian border to southern California between May and October of 2000–2002, 2004, and 2005 (Keller et al. 2005, 2006a, 2006b, 2007, 2008). The depth range of tows was expanded to include a shallower portion of the continental shelf during the 2004 and 2005 surveys (55–1280 m; 2000–2002: 183–1280 m) and the southern limit was extended (2000–2002: 34.5° N; 2004–2005: 32.5° N). Surveys captured a size range indicative of large juvenile (> 20 cm TL) and adult life stages. Dover Sole was caught at depths of 186–1241 m during 2000–2002 (#tows: n_{2000} = 325, n_{2001} = 334, n_{2002} = 427) with a mean capture depth of 549–581 m. A shallower depth range (52–1235 m) and mean depth of capture (359 m) observed during 2004 and 2005 (#tows: n_{2004} = 505, n_{2005} = 675) are presumably attributable to differences in survey depths. Dover Sole had the highest overall biomass among groundfish species for all surveys conducted during 2000–2005 (Keller et al. 2005, 2006a, 2006b, 2007, 2008). It was distributed throughout the survey region, but occurred in greatest abundance in cotinental slope and upper contiental shelf regions (< 550 m). Dover Sole was especially abundant between 184–549 m (Keller et al. 2007, 2008). In directed studies using NMFS trawl survey data derived from 1999–2002 (n = 1020 tows), Dover Sole was the second most common fish numerically and most common species by biomass (Tolimieri and Levin 2006; Tolimieri 2007). It numerically dominated hauls from 400–500 m (Tolimieri 2007) and inhabited progressively deeper depths on a gradient from north to south. For example, it was the most common species by biomass from 200–300 m at 40–43° N, and also the most common species at 700–900 m at 34–37° N (Tolimieri and Levin 2006). The median latitude of capture was 41° N (Tolimieri and Levin 2006). The region from central California to the Canadian border represent the center of distirbution for this species in US waters; its abundance declined in the southern portion of the survey and was considerably less in the Gulf of Alaska (Tolimieri 2007; Von Szalay et al. 2008, 2010, 2011).

Dover Sole were abundant in fishery–independent surveys conducted in continental shelf waters off Hecate Strait, British Columbia, ranking third and fourth among groundfishes by biomass during June 2002 (n = 96 tows) and May–June 2003 (n = 94 tows) (Choromanski et al. 2004; 2005). The catch was composed of a wide size range suggestive of juveniles and adults (male: 15–52 cm TL, n = 3845; female: 13–68 cm TL, n = 4643) (Choromanski et al. 2004; 2005). During 2003, most individuals were caught between 72–108 m (depth range of tows = 18–146 m) (Choromanski et al. 2004). Dover Sole occupied deeper waters during March (mean = 334 m) than during the summer (mean = 163 m) in this region (Pearall and Fargo 2007) in continental shelf trawl surveys (18–166 m) conducted sporadically during 1985–1987. These findings are consistent with those of Fargo and Westrheim (2007), who demonstrated that tagged adult Dover Sole (n = 852 recovered) migrated to deep water off the west coast of Queen Charlotte Island to spawn during witner months, with male migrations preceeding those of females. Large juvenile– and adult–size Dover Sole (21.3–61.0 cm TL, n = 1824 measures) were relatively less adundant off the West Coast of Vancouver Island than in Hecate Strait, ranking 8th by biomass among groundfishes surveyed between 50–500 m (n = 165 tows) (Workman et al. 2008).

Recent studies indicated that Dover Sole was extremely resilient to disturbance and low oxygen concentrations and reinforced its association with muddy habitats. Based on sampling conducted on Hecate Bank, Oregon during September 1988–2000 (67–360 m), Dover Sole was most abundant in mud–dominated seafloors from 200–360 m (n = 42 submersible dives) that included boulders, cobbles, and pebbles (Tissot et al. 2007). Densities were ~5x greater on trawled mud seafloors of Coquille Bank, Oregon when compared to untrawled regions (Hixon and Tissot 2007). Trawling results in a general increase in sedmentation, turdity, and the suspension of epibenthic invertebrates. Since Dover Sole primarily inhabit mud bottoms and use chemoreception to forage, all of these consequences are probably beneficial (Hixon and Tissot 2007). Dover Sole also do not seem to be adversely affected by low oxygen levels. In a recent study, conducted off the Oregon coast at depths of 50 m and 70 m (n = 17 tows), Dover Sole exhibited no significant effects of hypoxia (Keller et al. 2010). Biomass of Dover Sole was not significantly related to dissolved oxygen concentration along the hypoxic gradient, and condition factors were actually somewhat higher in low oxygen waters (Keller et al. 2010).

The early life history and reproductive movements of Dover Sole were recently investigated off central Oregon and in the Gulf of Alaska. Toole et al. (2001) collected a complete size range of juveniles and adults (3–55 cm TL; mean = 13.2 cm TL) using a small–mesh shrimp trawl deployed off central Oregon (50–400 m) during 1989–1994. Dover Sole settled on the outer continental shelf and slope, moved inshore to nursery areas < 150 m and, after reaching ~20 cm TL, moved to progressively deeper water with ontogeny (Toole et al. 2011). A massive amount of historic and contemporary data (1953–2006) were synthesized in two related studies conducted in the Gulf of Alaska that provided detailed descriptions of Dover Sole distribution and movement patterns. Adults were widely distributed from the inner shelf to outer slope during non–spawning months (n = 37,752 combined tows) but aggregated almost exclusively along the slope (310–500 m) in a few specific locations (off northern and southwestern Kodiak Island) when spawning (Bailey et al. 2008; Abookire and Bailey 2008). Peak spawning season in the Gulf of Alaska was April to mid–June but extended from late January to July (Bailey et al. 2008; Abookire and Bailey 2008). Spawning and egg concentrations tended to co–occur, indicating that adults maintained a protracted occupation in outer shelf spawning habitats (Bailey et al. 2008). Eggs were mainly found from 200–1000 m (n = 10,776 tows) on the outer continental shelf and slope in accordance with spawning events (Abookire and Bailey 2008), but rose to epipelagic waters shortly thereafter (Bailey et al. 2008). Mean depth of developing eggs and larvae was about 25 m, suggesting a comparative lack of directed, onshore movement with ontogeny (Bailey et al. 2008). In accordance, all size categories of larvae (n = 10,776 tows) were distributed evenly across the shelf and into oceanic waters and data implied facultative settling of juvenile habitats (n = 13,347 combined tows) (Abookire and Bailey 2008; Bailey et al. 2008). Small juveniles were found in bays and to a lesser extent scattered over the continental shelf, possibly indicating higher post–settlement mortality in offshore regions (Bailey et al. 2008). Juveniles recruited to much shallower depths than those reported along the West Coast (Bailey et al. 2008).

Dover Sole is a rather well–studied species throughout its range, in accordance with its high relative abundance, broad distribution, and commercial importance. New information concerning Dover Sole spatial associations are consistent with and expand upon prior knowledge (McCain et al. 2005). Considerable advancements have been made in the determination of ontogenetic movements, especially as they relate to reproduction and early life history (Abookire and Bailey 2008; Bailey et al. 2008; Toole et al. 2011). New information concerning the impact of hypoxic conditions (Keller et al. 2010) and trawling disturbance (Hixon and Tissot 2007) on distribution and abundance patterns of Dover Sole represents a major advancement in understanding the habitat requirements and physiological limitations of this species.

<u>Trophic Interactions:</u>
Two studies have been recently published that describe the diet composition of Dover Sole. One of these studies provides historical information collected in Hecate Strait, British Columbia during June and September–October 1985, January 1986, and May–June 1987 (Pearsall and Fargo 2007). Trawl surveys were conducted during daylight hours in four distinct regions at depths of 18–166 m on bottom types ranging from sandy silt to a mixture of coarse sand, gravel, pebbles, and cobbles. The great majority of stomach samples (n = 305) contained prey items (98.4%). Juvenile and adults were distinguished but sample size of each group and sex were not reported. Based on pooled results using %W, Dover Sole in Hecate Strait fed mainly only benthic invertebrates, with polychaetes (54.3%) dominating diet composition. Echinoderms (18.4%), and cnidarians (11.9%) were of distant secondary importance, and

crabs (5.1%) were the only other prey taxon that contibuted more than 5% to diet composition. Fishes were not typically consumed by the study population(%W < 0.01%). Temporal and spatial results of this study were confounded by small and/or uneven sample sizes and cannot be uncoupled for comparisons. However, meiobenthos and secondarily macrobenthos constituted > 97% of the diet composition for each region and time period. Diet composition of juveniles and adults was extremely similar and samples were pooled for interspecific comparisons and to estimate trophic level (between 3.2–3.3). Dover Sole diet composition was most similar to that of adult (0.969) and juvenile (0.930). English Sole, and adult Rock Sole (0.878).

Diet composition of a small number of Dover Sole (n = 35) was estimated in the central and western Gulf of Alaska from trawl–derived samples collected during 1999 and 2001 (Yang et al. 2006). Most stomach samples (91.4%) contained prey items. Among individuals with full stomachs, the average fork length (FL) was 44.4 $\pm$ 1.7 cm (range = 34–60 cm FL), sizes that correspond to late juveniles and adults (Yang et al. 2006). Among the sampled population, polychaetes were the most abundant prey taxon, constituting 49% of prey items by weight and 27% by frequency of occurrence. Brittle stars were of secondary importance (%W = 24, %FO = 25) and echiuran worms (%W = 5, %FO 22), gammarid amphipods (%W < 1, %FO = 22), and cumaceans (%W = < 1, %FO = 17) were frequently encountered but contributed modestly to total prey weight (Yang et al. 2006).

Pinnipeds and Pacific Halibut were documented as predators of Dover Sole in recent publications. Dover Sole contributed trivially to the diet compositions of Pacific Halibut (%W = 0.01, n = 152); Pearsall et al. 2007) and Steller Sea Lions (%FO = 0.2, %N < 0.1, n = 2760; McKenzie and Wynne 2008) in Hecate Strait and off Kodiak Island, respectively. Cumulative prey curves indicated that an adequate number of samples was collected for precise dietary estimates of the Steller Sea Lion study population. Dover Sole also was reported in the diet composition of Pacific Harbor Seals (%FO = 8.8) sampled in Alesa Estuary, Oregon during 1996–2002 (n = 3370) (Riemer and Mikus 2006). Juvenile Dover Sole (%FO = 70.6%, n = 339) were mainly consumed by Pacific Harbor Seals based on aged otoliths recovered from scat samples. The greatest overall contribution of Dover Sole to diet composition of Pacific Harbor Seals and the broadest observed age range occurred during summer months, coinciding with adult migrations to estuaries for spawning (Riemer and Mikus 2006).

Recent published information concerning Dover Sole trophic interactions was generally consistent and supported prior findings. Polychaetes, bivalves, brittlestars, and small benthic crustaceans have been previously reported as the main diet items of juvenile and adult Dover Sole (McCain et al. 2005). These were also the main prey taxa reported in recent publication, although bivalves were of only minor dietary importance (Yang et al. 2006; Pearsall and Fargo 2007). Fishes were extremely rare or absent in the diet of Dover Sole by all accounts. McCain et al. (2005) reported that flatfishes, including English Sole, were among the main competitors of Dover Sole. This conclusion was supported by the results of Pearsall et al. (2007). Marine mammals, but not Pacific Halibut, were previously reported as predators of Dover Sole (McCain et al. 2005).

ENGLISH SOLE (*PAROPHRYS VETULUS*)

Spatial Associations:

Fishery independent surveys provided new information on distribution and abundance patterns of juvenile and adult English Sole along the US West Coast. NMFS–NWFSC conducted surveys from the US/Canadian border to south of Point Conception, CA between May and October of 2000–2002 (#tows: n_{2000} = 325, n_{2001} = 334, n_{2002} = 427), 2004 (n = 505), and 2005 (n = 675) (Keller et al. 2005, 2006a, 2006b, 2007, 2008). The depth range of tows was expanded to include a shallower portion of the continental shelf during the 2004 and 2005 surveys (55–1280 m; 2000–2002: 183–1280 m) and more southern coverage (from 34.5° to 32.5° N). More recent surveys and presumably older surveys captured size ranges indicative of large juvenile (> 15 cm TL) and adult life stages (Keller et al. 2007, 2008). English Sole was caught at depths of 188–382 m during 2000–2002 with a mean capture depth of 257–271 m. A shallower depth range (52–404 m), mean depth of capture (123 m), and higher frequency of occurrence (2000–2002: 11.4–21.5%; 2004–2005: 46.9–47.0%) during 2004 and 2005 surveys can be attributed to differences in survey design. English Sole did not register among the top twenty most abundant groundfish by biomass during 2000–2002 (Keller et al. 2005, 2006a, 2006b), but ranked 6th during 2004 (Keller et al. 2007) and 16th during 2005 at depths of 55–183 m (Keller et al. 2008). The bulk of English Sole biomass along the West Coast was distributed between 36–43° N (Keller et al. 2007, 2008), with a median latitude of 39° N (Tolimieri and Levin 2006). In a directed study using NMFS trawl survey data derived from 1999–2002 between 33–47° N (n = 1159 tows), English Sole was the 24th most abundant fish species by biomass and was captured at depths of 200–500 m (median depth = 300 m) (Tolimieri and Levin 2006).

English Sole was abundant in fishery–independent surveys conducted in continental shelf waters off Hecate Strait, British Columbia, ranking third and second among groundfish by biomass during June 2002 (n = 96 tows) and May–June 2003 (n = 94 tows) (Choromanski et al. 2004; 2005). The catch was composed of a wide size range of juveniles and adults (male: 11–48 cm TL, n = 6564; female: 11–53 cm TL, n = 8730) (Choromanski et al. 2004; 2005). During 2003, most individuals were caught between 54–72 m in a region of sandy silt with strong currents (depth range of tows = 18–146 m) (Choromanski et al. 2005). In continental shelf trawl surveys (18–166 m) conducted sporadically during 1985–1987, English Sole occupied similar depths during May (mean = 90 m) and December (mean = 113 m), and was most abundant on fine to coarse sand habitats (Pearall and Fargo 2007). In contrast to its high relative abundance in Hecate Strait, juvenile and adult English Sole (12.5–61.3 cm TL, n = 1334 measures) ranked only 16th among groundfishes surveyed between 50–500 m off the west coast of Vancouver Island (n = 165 tows) (Workman et al. 2008).

A considerable amount of contemporary research has been devoted to the role of estuaries in the life history of English Sole. English Sole are believed to be carried to estauries during periods of downwelling (Parnel et al. 2008). Brown (2006a) demonstrated that juveniles collected in estuaries could be distinguish from those collected in nearby coastal regions off central California using multi–elemental analysis of otoliths. Specifically, Sr was considerably higher and Li was substantially lower in estuarine fish. These differences remained consistent over a large geographic region and among three very different oceanic years (1998–2000) (Brown 2006a). A companion study estimated that 45–57% of the adult English Sole population off central California used estuaries as juvenile nursery habitat (Brown 2006b). A similar conclusion was drawn from a study conducted in Oregon and Washington estuaries during 1985–1988 and June–August 1998–2000 (n = 800 tows) (Rooper et al. 2004). Rooper et al. (2004) suggested that the English Sole population on the Oregon–Washington shelf could potentially be supported soley by estuarine production, with production stabilized by the size of available nursery areas. Within estuaries, densities of age–0 individuals were much higher and more spatially variable shortly after settlement in June than in August (Rooper et al. 2004). Spatial variability in estuary use also was reported by Chittaro et al. (2009) between June 2006 (n = 130 fish) and August 2005 (n = 99 fish) using otolith microchemistry. However, observed spatial variability could not be explained by the density of recently settled fish, the available area of nearshore habitat, or measured environmental variables (e.g., temperature, salinity, dissolved oxygen) (Chittaro et al. 2009). Based on trawl surveys (n = 431) conducted in Oregon and Washington estuaries during June and August 1998–2000, English Sole density anomalies were significantly higher at lower side channel sites (especially during June) than at other estuarine locations. Juvenile English Sole are thought to compete for space in estuaries with Pacific Sanddab, which are not as tolerant of the relatively warm water (13–17.5° C) found in side channels (Rooper et al. 2006). Despite the conspicuous feeding behavior of English Sole, low predator densities and high turbidity allow juveniles to thrive in shallow, estuarine regions (Boersma et al. 2008). Substrate type may not be an important determinant of English Sole distribution in estuaries, as a recent study conducted in Willapa Bay, WA found no statistical differences in abundance for individuals of unspecified maturity (n = 2128) among eelgrass, oyster beds, and mudflats (Hosack et al. 2007).

English Sole show enhanced tolerance to low oxygen conditions. In a recent study, conducted off the Oregon coast at depths of 50 m and 70 m (n = 17 tows), no significant effects of hypoxia were noted (Keller et al. 2010). Condition factors for English Sole was lower in low oxygen waters, but biomass was not affected (Keller et al. 2010).

Recent scientific studies have greatly expanded the available information on English Sole distribution patterns and habitat associations, especially regarding the use of estuaries and their influence on population dynamics. Some integrated studies (e.g., Tolimieri and Levin 2006; Keller et al. 2010) also have used survey data and knowledge gained from prior studies to better understand English Sole spatial associations in offshore waters. Newly acquired information, when comparable, is generally consistent with that reported by McCain et al. (2005).

Trophic Interactions:

New information concerning English Sole trophic interactions is limited to a single study, conducted in Hecate Strait, British Columbia during June and September–October 1985, January 1986, and May–June 1987 (Pearsall and Fargo 2007). Samples were collected from trawl surveys fished in four distinct regions at depths of 18–166 m on bottom types ranging from sandy silt to a mixture of coarse sand, gravel, pebbles, and cobbles. The great majority of English Sole stomach samples (n = 433) contained prey items (97.0%). Juvenile and adults were distinguished but sample size of each group and sex were not provided. Based on pooled results using %W, English Sole in Hecate Strait fed mainly on benthic invertebrates, with polychaetes (58.7%) dominating diet composition. Bivalves (10.2%), Pacific Sand Lance (8.2%), echiurans (7.1%), and echinoderms (6.2%) were of distant secondary importance, and no other prey taxon contibuted more than 5% to diet composition. Although they were a relatively minor prey item when the overall diet was considered, Pacific Sand Lance dominated diet (84.1%) of a small number of English Sole (n = 11) collected during September–October 1985 on silty sand with high current activity. Temporal and spatial results of this study are confounded by small and/or uneven sample sizes and cannot be uncoupled for most comparisons. However, diet composition of English Sole collected during September–October 1985 (n = 62) and January 1986 (n = 125) was similar, and consisted mainly of polychaetes and other meiobethos. Juveniles and adults overlapped substantially in diet composition (0.989) and had similar estimated trophic levels (between 3.2–3.4). Diets of adult and juvenile English Sole also overlapped considerably with Dover Sole (0.969 and 0.930, respectively) and adult Rock Sole (0.873 and 0.886, respectively). The following predators of English Sole were indentified: Lingcod (8.5%, n = 25), Rock Sole (0.6%, n = 350), and Spiny Dogfish (0.2%, n = 799).

Recently published information concerning English Sole diet composition generally supports previous findings. Polychaetes have been consistently reported as the primary prey taxon for large juveniles and adults, with the remainder of the diet consisting mainly of other benthic invertebrates (McCain et al. 2005; Pearsall and Fargo 2007). Amphipods and cumaceans were found to be common prey items in the diet of adult English Sole off Oregon (McCain et al. 2005), but contributed little to the diet of juvenile and adult English Sole collected in Hecate Strait (Pearsall and Fargo 2007). Fishes were not indicated as prey items by McCain et al. (2005) but Pacific Sand Lance were episodically ingested in large quantitites by some English Sole in Hecate Strait (Pearsall and Fargo 2007).

PETRALE SOLE (*EOPSETTA JORDANI*)

Spatial Associatons:

New spatial information on Petrale Sole is somewhat limited and mainly derived from fishery independent surveys. NMFS–NWFSC conducted a survey along the US West Coast between May and

October of 2000–2002, 2004, and 2005 (Keller et al. 2005, 2006a, 2006b, 2007, 2008). The 2004 and 2005 surveys (and presumably earlier surveys) captured a size range indicative of large juvenile (> 20 cm TL) and adult life stages (Keller et al. 2007, 2008). Petrale Sole was infrequently captured during 2000–2002, occurring in 3.6–7.3% of tows conducted during 2000 (n = 325 tows), 2001 (n = 334 tows), and 2002 (n = 427 hauls) at depths of 175–581 m (Keller et al. 2005, 2006a, 2006b). Shallower tows were fished (from 55 m) during 2004 (n = 505) and 2005 (n = 675), however, and the depth profile shifted (52–434 m) to reveal a greater reliance on shelf waters (mean depth of capture ~125 m) (Keller et al. 2007; 2008). Based on a directed study using 2004 NMFS–NWFSC survey data (n = 252 tows) and ocenographic data, Petrale Sole was found to be most abundant at productive, northern latitudes (median latitude 45.7° N) (Juan–Jorda et al. 2009). It was not, however, especially abundant in nearshore waters of Britisth Columbia, ranking 15th in biomass among groundfish surveyed in Hecate Strait during June 2002 (18–146 m; n = 94 tows) and 26th off Western Vancouver Isalnd during May–June 2006 (50–500 m; n = 165) (Choromanski et al. 2004; Workman et al. 2008). Petrale Sole exhibited a much wider and deeper distribution during winter months in Hecate Strait (mean = 302 m) when compared to summer moths (n = 108 m) (Pearsall and Fargo 2007). This species is negatively affected by hypoxic conditions, and abundance and physical condition declined significantly at oxygen concentrations < 1.0 ml/l (Keller et al. 2010).

Other than the results of Keller et al. (2010) concerning the effects of hypoxia, the new spatial information provided for Petrale Sole adds little to general body of knowledge regarding this species (McCain et al. 2005). It does, however, provide area–specific information on distribution and abundance patterns that is useful for monitoring purposes.

Trophic Interactions:

Recently published information concerning Petrale Sole trophic interactions is limited to a single study, conducted in Hecate Strait, British Columbia during June and September–October 1985, January 1986, and May–June 1987 (Pearsall and Fargo 2007). Samples were collected from trawl surveys fished in four distinct regions at depths of 18–166 m on bottom types ranging from sandy silt to a mixture of coarse sand, gravel, pebbles, and cobbles. The great majority of Petrale Sole stomach samples (n = 106) contained prey items (98.1%). Most samples were obtained during September–October 1985 (n = 55) and January 1986 (n = 45). No size or sex information was provided, but fishes represented a mixture of juveniles and adults. Based on pooled results using %W, Petrale Sole in Hecate Strait were largely piscivorous, with fishes accounting for 72.9% of diet composition. The primary prey taxon was Pacific Herring (47.2%). Unidentified fishes (21.1%) and mysids (19.4%) were of secondary dietary importance, and no other prey taxon contributed substantially to diet composition. Diet composition differed markedly between fish collected on fine to coarse sand in January 1986, and those collected on coarse sand, gravel, pebbles, and cobbles during September–October 1985. During the former collection, diet composition was largely composed of Pacific Herring (70.7%), whereas mysids and other epibenthic organisms (58.6%) were dominant during the latter collection. The relative weight of stomach contents also was greater during the former collection. Unfortunately, temporal and spatial results of this study cannot be uncoupled.

The prey taxa consumed by Petrale Sole in Hecate Strait were generally similar to those reported by McCain et al. (2005) from a synthesis of several studies. However, whereas McCain et al. (2005) indicated a greater reliance on shrimp and decapods, fishes and mysids were the most important prey items in Hecate Strait (Pearsall and Fargo 2007). In addition, cannibalism was not noted by Pearsall and Fargo (2007) but was indicated to be a substantial source of mortality for juvenile Petrale Sole by McCain et al. (2005). Yellowtail Rockfish was reported to be a predator of Petrale Sole in Hecate Strait, although the dietary contribution was trivial (0.25%). This interaction is noteworthy since it was not previously demonstrated (McCain et al. 2005).

Flatfishes: Relevant Literature

Abookire and Bailey 2007; Aydin and Mueter 2007; Bailey et al. 2008; Blood et al. 2007; Boersma et al. 2008; Bredeson et al. 2006; Brown 2006a, 2006b; Chittaro et al. 2009; Choromanski et al. 2004, 2005; Cloern et al. 2007; Csepp et al. 2011; Fargo and Westrheim 2007; Gaichas and Francis 2008; Gaichas et al. 2010; Hart et al. 2010; Hixon and Tissot 2007; Hoff and Britt 2005, 2009, 2011; Hosack et al. 2006; Hulbert et al. 2005; Iverson et al. 2007; Juan–Jorda et al. 2009; Keller et al. 2005, 2006a, 2006b, 2007, 2008, 2010; Knoth and Foy 2008; Lee et al. 2010; Logerwell et al. 2005; Love and York 2005; Love et al. 2009; McConnaughey and Syrjala 2009; McKenzie and Wynne 2008; Orlov 2004; Orr et al. 2004; Palsson et al. 2008; Parnel et al. 2008; Pearsall and Fargo 2007; Phillips et al. 2009; Riemer and Mikus 2006; Rooper 2008; Rooper and Wilkins 2008; Rooper et al. 2004, 2006; Speckman et al. 2005; Stewart 2007; Thedinga et al. 2008; Tissot et al. 2007; Tolimieri 2007; Tolimieri and Levin 2006; Toole et al. 2011; Trites et al. 2007; Vigilant and Silver 2007; Vollenweider et al. 2006; Von Szalay et al. 2008, 2010, 2011; Womble and Sigler 2006; Workman et al. 2008; Yamanaka et al. 2004, 2008; Yang 2004, 2007; Yang et al. 2005, 2006; Zador et al. 2011; Zenger 2004

Appendix G-2: Other Flatfish Group Summary Information

New literature on spatial associations and trophic interactions of the Other Flatfishes group consisted of 66 publications, with several publications providing information for multiple species. Most Other Flatfishes were well studied, with rex sole (41 publications), flathead sole (38 publications), and rock sole (31 publications) foremost among them. Curlfin sole (10 studies) and sand sole (12 publications) were referenced least among the accumulated literature, with most relevant information contained in survey reports. Data on Pacific and speckled sanddabs and southern and northern rock sole were occasionally pooled because of uncertain identification (e.g., Love and York 2005; McKenzie and Wynne 2008) or for convenience during multi–species analyses (e.g., Hoff 2006; Gaichas and Francis 2008). To avoid confusion, the current designation of "rock sole" should be changed to the proper common name of "southern rock sole" in accordance with American Fisheries Society guidelines. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the U.S. West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). In addition, many directed studies provided information on a wide variety of topics related to EFH (e.g., habitat associations, physiological tolerances, trophic relationships), at various levels of detail. Much more new spatial information was available when compared to trophic information, and no new diet composition information was produced along the West Coast.

Contemporary spatial information about other flatfishes was substantial and diverse. Fishery-independent surveys provided information on distribution and abundance patterns of juveniles and adults, but additional information on eggs and larvae was also available. In the Gulf of Alaska, integrated data sets were used to determine spawning locations and distribution patterns of eggs and larvae of rex sole (Abookire and Bailey 2008; Bailey et al. 2008) and flathead sole (Porter et al. 2005). In the northern California Current, Pacific sanddab was among the most abundant ichthyoplankton species surveyed, and rex sole was also commonly observed (Phillips et al. 2009). Habitat associations were determined for several species of Other Flatfishes. Pacific sanddabs were found predominantly in muddy, benthic habitats off central California (Anderson and Yoklavich 2007) but were also commonly encountered in pelagic sampling off Oregon and Washington (Brodeur et al. 2009), and in association with heavily encrusted oil platform beams off Southern California (Love and York 2006). Starry flounder exhibited no preference among mud, oyster, and eelgrass habitats in Willapa Bay, Washington (Hosack et al. 2006) and preferred sand to cobble, and cobble to bedrock (Thedinga et al. 2008); however, sample sizes were low for both studies. Patterns of estuary nursery use and evidence for habitat partitioning was provided for sand sole, starry flounder, and Pacific sanddab in the Pacific Northwest (Rooper et al. 2005). Early juvenile starry flounder typically occupy upper regions of estuaries, and this distribution pattern is facilitated by the development of a strong low-salinity tolerance during early ontogeny (Wada et al. 2007).

Contemporary information on trophic interactions was available for all members of the Other Flatfishes group but the great majority of this information was derived from Canadian and Alaskan waters. For example, diet composition studies were limited to those conducted off British Columbia (Pearsall et al. 2007) and in Alaskan waters (Yang 2004; Yang et al. 2004, 2005). In Hecate Strait, British Columbia, diet composition, seasonal and spatial dietary variability, and dietary overlap were evaluated for flathead sole, Pacific sanddab, rex sole, rock sole, and sand sole (Pearsall et al. 2007). In the Gulf of Alaska, diet composition was determined for flathead sole, rex sole, and rock sole (Yang et al. 2006) based on small sample sizes, and flathead sole and rock sole were lumped in an "other flatfish" group to investigate predation on capelin (Yang et al. 2005). Stellar sea lions were found to prey on several species of Other Flatfishes off Kodiak Island, but only rock sole (combined) contributed more than a trivial proportion to diet by percent frequency of occurrence (Trites et al. 2007; McKenzie and Wynne 2008). Similarly, harbor seals in the Umpqua River (Oregon) frequently consumed rex sole, and ate butter sole, Pacific sanddab, and starry flounder less commonly. In California waters, Pacific sanddab was a minor prey item of California sea lions (Weise and Harvey 2008; Orr et al. 2011). A large number of predator (n = 4) and prey (n = 44) linkages were determined for flathead sole based on benthic food web modeling in the Gulf of Alaska, and rex sole (1 predator link, 13 prey links) was also an importance source of energy flow in this region. The longnose skate was found to be a major predator of small flatfishes in the Gulf of Alaska, including flathead sole, rex sole, and rock sole (Gaichas et al. 2010).

Literature Cited
Nelson, J.S., Crossman, E.J., Espinosa–Pérez, H., Findley, L.T., Gilbert, C.R., Lea, R.N., and Williams, J.D. 2004. Common and scientific names of fishes from the United States and Mexico, sixth edition. American Fisheries Society. Bethesda, MD.

Other Flatfish: Relevant Literature
Abookire and Bailey 2007; Anderson and Yoklavich 2007; Aydin and Mueter 2007; Bailey et al. 2008; Brodeur et al. 2005; Choromanski et al. 2004, 2005; Csepp et al. 2011; Davies et al. 2006; Duffy–Anderson et al. 2006; Gaichas and Francis 2008; Gaichas et al. 2010; Hart et al. 2010; Hixon and Tissot 2007; Hoff 2006; Hoff and Britt 2005, 2009, 2011; Hosack et al. 2006; Juan–Jorda et al. 2009; Keller et al. 2005, 2006a, 2006b, 2007, 2008, 2010; Lee et al. 2010; Logerwell et al. 2005; Love and York 2005, 2006; Love et al. 2006; Lundsten et al. 2009; McConnaughey and Syrjala 2009; McKenzie and Wynne 2008; Orlov 2004; Orr et al. 2004, 2011; Palsson et al. 2008; Parnel et al. 2008; Pearsall and Fargo 2007; Phillips et al. 2009; Porter 2005; Preti et al. 2004; Rooper 2008; Rooper and Wilkins 2008; Rooper et al. 2005, 2006; Speckman et al. 2005; Thedinga et al. 2008; Tissot et al. 2007; Tolimieri 2007; Tolimieri and Levin 2006; Toole et al. 2011; Trites et al. 2007; Vigilant and Silver 2007; Vollenweider et al. 2006; Von Szalay et al. 2008, 2010, 2011; Wada et al. 2007; Weise and Harvey 2008; Westrheim and Fargo 2005; Workman et al. 2008; Yamanaka et al. 2004, 2008; Yang 2004; Yang et al. 2005, 2006; Yeung and McConnaughey 2008; Zenger 2004

Appendix G-3: Rockfishes Group Summary Information

From 2004–2011, 90 publications that contain information on spatial associations and/or trophic interactions were located for the Rockfishes group. Most publications reported information for multiple species and species were occasionally combined for convenience or because identification was uncertain (e.g., Lauth et al. 2004; Wilson et al. 2008; Marilave and Challenger 2009). Shortspine thornyhead (34 publications) and Pacific ocean perch (30 publications) were the most studied Rockfishes, whereas blackgill (6 publication) and chilipepper (8 publications) were the least studied. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the US West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). However, the great majority of this information was derived from trawl surveys, which are limited in their capability to sample rocky substrates and therefore under–represent the distribution and abundance patterns of most rockfishes (PFMC 2008). Results of these surveys should therefore be interpreted cautiously for the Rockfishes group. In addition, many directed studies focused on specific aspects of resource utilization (i.e., spatial associations, trophic relationships) and provided detailed information that was relevant for the description of EFH. Only 15 of the 89 contemporary publications contained trophic information, and there is a dearth of recent diet composition information for Rockfishes throughout the eastern North Pacific.

A substantial amount of new information is available concerning spatial associations of species in the Rockfishes group. Several studies used manned submersibles or, to a lesser extent, ROVs to determine habitat associations of Rockfishes (and Other Rockfishes) along the US West Coast, including southern California (e.g., Love and York 2005; Love et al. 2009), central California (e.g., Anderson and Yoklavich 2007; Laidig et al. 2009), and Oregon (Tissot et al. 2007; Hart et al. 2010). Habitat associations were typically determined for individual species and often combined to investigate co–occurrence or to create habitat guilds. In southern California, several publications determined that oil platforms serve an important function as artificial reefs for a variety of rockfishes, including bocaccio and cowcod (e.g., Love and York, 2006; Love et al. 2006). A submersible study on Coquille Bank, Oregon compared species assemblages on trawled and untrawled seafloor and found similar densities of splitnose rockfish in each habitat (Hixon and Tissot 2007). A species–specific study determined the following information for juvenile cowcod in southern California: 1) the observed depth range was 32–330 m; 2) small juveniles (5–20" TL) were associated with cobbles and cobbles/small boulders, with larger juveniles occupying higher relief rocky habitats, and 3) small juveniles were found with pygmy and swordspine rockfishes, whereas larger juveniles were associated with juvenile bocaccio and widow rockfish (Love and Yoklavich 2008). Several studies provided information on spatial associations during larval stages, especially in the California Current region (e.g., Field and Ralston 2005; Sakuma et al. 2006; Phillips et al. 2009). Field and Ralston (2005) found that 51–72% of year–to–year variability in recruitment was shared coastwide among chilipepper, widow, and yellowtail rockfishes, with a lesser fraction associated with fine scale geographic features. Off Oregon and Washington, Miller and Shanks (2004) determined that black rockfish exhibited limited larval dispersal (< 120 km). A study of black rockfish populations along the US West Coast, however, found only weak genetic differentiation among regions (Sivasundar and Palumbi 2010). By contrast, yellowtail rockfish exhibited a strong genetic break between Monterey and Oregon (Sivasundar and Palumbi 2010). Young-of-the year (YOY) Black rockfish were observed in the rocky intertidal of central California from May to August with peak abundance in May or June and interannual variability in number of recruits (Studebaker and Mulligan 2008). Telemetry studies were conducted for black (Parker et al. 2007; Green and Starr 2011; Hannah and Rankin 2011), bocaccio (Lowe et al. 2009), canary (Hannah and Rankin 2011), widow (Lowe et al. 2009), and yelloweye (Hannah and Rankin 2011) rockfish with all of these studies conducted along the US West Coast. Black rockfish exhibited medium to high site fidelity, but large vertical movements were observed (Hannah and Rankin 2011) and some individuals traveled more than 50 km from the capture site (Green and Starr 2011). Yelloweye (Hannah and Rankin 2011) and widow (Lowe et al. 2009) rockfish exhibited high site fidelity, whereas canary rockfish (Hannah and Rankin 2011) and bocaccio (Lowe et al. 2009) exhibited low site fidelity.

New information on trophic interactions was available for most members of the Rockfishes group and, although limited, covered a wide range of topics. In the Aleutian Islands, diet composition of juvenile Pacific ocean perch consisted mainly of a mixture of large copepods and euphausiids, but size–based, temporal, and spatial differences were observed (Boldt and Rooper 2009). Euphausiids were the primary prey items of larger juvenile Pacific ocean perch in the Aleutian Islands (Boldt and Rooper 2009), as well as large juveniles and adults in the Gulf of Alaska (Yang et al. 2006) and Hecate Strait, British Columbia (Pearsall and Fargo 2007). Canary and widow rockfish off Oregon exhibited high temporal dietary variability coinciding with environmental changes due to ENSO conditions (Lee and Sampson 2009). By contrast, canary rockfish in this region had a very consistent diet composed almost exclusively of euphausiids (Lee and Sampson 2009). Diet composition of juvenile canary (euphausiids, copepods), darkblotched (gelatinous zooplankton, crustaceans), widow (gelatinous zooplankton), and yellowtail (copepods) rockfish was investigated throughout the US West Coast (Miller and Brodeur 2007). In Carmel Bay, Johnson (2006) determined that juvenile bocaccio can alter patterns of density dependence in kelp, gopher, black and yellow rockfish. Several predators of species in the Rockfishes group were identified. Shortbelly rockfish were of minor importance in the diet of jumbo (or Humboldt) squid in the California Current (Field et al. 2007), and juvenile canary, darkblotched, and widow rockfish were minor prey items of Pacific hake in the same region (Harvey et al. 2008). However, at higher consumption rates, Pacific hake could considerably prolong rebuilding times of canary rockfish (Harvey et al. 2008). Shortbelly and splitnose rockfish were minor components of longnose skate diet off central California (Robinson et al. 2007), and thornyheads (combined) were eaten in trivial quantities by Stellar sea lions off Kodiak Island, Alaska (McKenzie and Wynne 2008).

Literature Cited
PFMC. 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 19 (including Amendment 15). Pacific Fishery Management Council. Portland, OR.

Rockfishes: Relevant Literature
Anderson and Yoklavich 2007; Black et al. 2008; Boldt and Rooper 2009; Bowles et al. 2011; Caselle et al. 2010; Choromanski et al. 2004, 2005; Csepp et al. 2011; Du Preez and Tunnicliffe 2011; Field and Ralston 2005; Field et al. 2007; Gaichas and Francis 2008; Gray et al. 2006; Green and Starr 2011; Hamilton and Konar 2007; Hannah and Rankin 2011; Hart et al. 2010; Harvey 2009; Harvey et al. 2008; Hixon and Tissot 2007; Hoff 2006; Hoff and Britt 2005, 2009, 2011; Johnson 2006; Juan–Jorda et al. 2009; Keller et al. 2005, 2006a, 2006b, 2007, 2008; Krishka et al. 2005; Laidig et al. 2007, 2009; Lauth et al. 2004; Lee and Sampson 2009; Lochead and Yamanaka 2006; Logerwell et al. 2005; Love and Schroeder 2007; Love and Yoklavich 2008; Love and York 2005, 2006; Love et al. 2005, 2006, 2009; Lowe et al. 2009; Lundsten et al. 2009; Marliave and Challenger 2009; Marliave et al. 2009; Martin and Yamanaka 2004; McKenzie and Wynne 2008; Miller and Brodeur 2007; Miller and Shanks 2004; Ostrand et al. 2004; Palsson et al. 2008; Parker et al. 2007; Parnel et al. 2008; Pearsall and Fargo 2007; Phillips et al. 2009; Reilly and Thompson 2007; Reuter and Spencer 2007; Robinson et al. 2007; Rodríguez–Romero et al. 2008; Rooper 2008; Rooper and Wilkins 2008; Rooper et al. 2007, 2010; Sakuma et al. 2006, 2007; Sivasundar and Palumbi 2010; Starr et al. 2004; Studebaker and Mulligan 2008, 2009; Studebaker et al. 2009; Thedinga et al. 2008; Tissot et al. 2007; Tolimieri 2007; Tolimieri and Levin 2006; Toole et al. 2011; Von Szalay et al. 2008, 2010, 2011; Watson et al. 2010; Westrheim and Stanley 2006; Wilson et al. 2008; Workman et al. 2008; Yamanaka et al. 2004, 2008; Yang et al. 2005, 2006; Zenger 2004.

Appendix G-4: Other Rockfishes Group Summary Information

New literature on spatial associations and trophic interactions of the Other Rockfishes group consists of 85 publications, with several publications providing information for multiple species. Species were sometimes combined for convenience or because identification was uncertain (e.g., Beaudreau and Essington 2007; Wilson et al. 2008; Frid and Marliave 2010). The most studied Other Rockfishes were rougheye (26 publications), copper (25 publications), greenstriped (25 publications), and redbanded (25 publications). Many species received sparse scientific attention, and no information was available for bronzespotted, California scorpionfish, chameleon, and semaphore rockfishes. Data summaries from fishery–independent surveys provided a great deal of general information on distribution and abundance patterns along the US West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g. Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). In addition, many directed studies were published and provided information on a wide variety of topics related to EFH (e.g., habitat associations, genetics/distribution, movement patterns). Although a substantial amount new spatial information was available, trophic information was comparatively sparse, a situation that reflects the relative amount of scientific attention as well as the substantial contribution of newly published fishery–independent survey data. Nine new species were added to the Other Rockfishes group since the last EFH review was conducted (chameleon, dwarf–red, freckled, halfbanded, pinkrose, Puget Sound, pygmy, and semaphore, and swordspine rockfishes). Literature reviews for these species were performed from 2002–2011 and references published during 2002–2003 (Bernardi et al. 2009; Johnson et al. 2009) are listed below. For historic information on these species, refer to Love et al. (2002). In addition, the species name of the dusky rockfish is listed incorrectly as Sebastes ciliatus in the current list of FMP groundfish species. Sebastes ciliatus refers to the more northernly distributed dark rockfish, whereas the dusky rockfish (S. variabilis) ranges throughout most of the US West Coast (Orr and Blackburn 2004). The information and literature referenced here therefore refers to the dusky (S. variabilis), not dark (S. ciliatus), rockfish.

Contemporary spatial information is available to a highly variable degree for the many species contained in the Other Rockfishes group. Much of the information is derived from trawl surveys (e.g., Choromanski 2004; Hoff and Britt 2007; Keller et al. 2008), which are biased in their ability to accurately represent rockfish distribution and abundance patterns (PFMC, 2008) and typically do not report many additional findings that are useful for EFH determination. Depth distributions, however, are regularly reported in data summaries from surveys and present important baseline information about general occurrence patterns. These data have been used in detailed, assemblage-level analyses of groundfishes, including Other Rockfishes, throughout the US West Coast (Tolimieri and Levin 2006; Tolimieri 2007). Considerable, detailed habitat association information is available for some species, as many Other Rockfishes have been incorporated into assemblage-level studies along the West Coast (e.g., Tissot et al. 2007; Marliave and Challenger 2009; Du Preez and Tunnicliffe 2011) and especially off California (e.g., Anderson and Yoklavich 2007; Love and Schroeder 2007; Laidig et al. 2009). Anderson and Yoklavich (2007) reported habitat associations at three different scales for a groundfish assemblage that included several Other Rockfishes (e.g., greenstriped, rosy, squarespot) on the outer continental slope and upper continental shelf of central California. Laidig et al. (2009) determined that several Other Rockfishes (pygmy, rosy, squarepot, starry, vermillion) were strongly associated with boulder habitat off central California. Both of these studies grouped co-occurring species into habitat guilds. Love and York investigated the importance of oil pipelines (2005) and platforms (2006) off southern California and determined that some species (e.g., copper, greenbltoched, halfbanded, stripetail, vermillion) were found in higher locally densities in association with these structures. Off the coast of British Columbia, Marliave et al. (2009) determined that subadult and adult greenstriped and redstriped rockfishes were associated with bioherms, whereas juvenile quillback rockfish were associated with sponge gardens. On Coquille Bank, Oregon, greenstriped and sharpchin rockfish were only found on untrawled seafloor, whereas halfbanded rockfish were only found on trawled grounds (Hixon and Tissot 2007). Based on a laboratory study, Lee and Berejikian (2009) determined that juvenile china rockfish exhibited site fidelity and territoriality with size-based dominance centered on competition for structurally complex habitats. Watson et al. (2010) found a strong correspondence between realized and potential distribution patterns of larval kelp rockfish, suggesting that circulation patterns dictate spatial distribution of this species. In population genetic studies conducted primarily along the US West Coast, Buonaccorsi et al. determined that grass (2004) and brown (2005) rockfish only moved about 10 km per generation, suggesting limited larval dispersal. Movement patterns of several Other Rockfishes were studied, primarily along the US West Coast (e.g., Jorgensen et al. 2006; Lowe et al. 2009; Tolimieri et al. 2009). Off Oregon, Hannah and Rankin (2011) found high site fidelity and limited vertical movements (2-3 m) for china, quillback, tiger and vermillion rockfishes. Lowe et al. (2009) determined that some rockfishes exhibited high site fidelity to oil platforms (e.g., flag, treefish) whereas others did not (e.g, blue, Mexican, vermillion).

Contemporary information on trophic interactions was extremely limited and only available for a small proportion of the species in the Other Rockfishes group. Yang et al. (2006) provided diet composition results for 5 Other Rockfishes in the Gulf of Alaska, but sample sizes were quite low for most species (< 6 for dusky, redbanded, sharpchin, and shortraker). Based on a larger sample size (n = 25), rougheye rockfish in the Gulf of Alaska had a very diverse diet, with pandalid shrimps and euphausiids contributing most by weight (Yang et al. 2006). Diets of greenstriped (euphausiids), redbanded (shrimp, crabs, bivalves, anomurans) and silvergray rockfish (fish, euphausiids) were estimated in Hecate Strait, British Columbia (Pearsall and Fargo 2007). Diet compositions of these species exhibited little spatial variation, but silvergray exhibited temporal differences in diet and variation with size (greater proportion of fishes in larger specimens). Studebaker and Mulligan (2008) found a high degree of interannual dietary variation in juvenile blue rockfish sampled in the rocky intertidal off northern California, especially with regard to the relative proportion of gammarid amphipods, their dominant prey type. In eelgrass beds of the same region, Studebaker and Mulligan (2009) determined that the diet of YOY copper rockfish consisted largely of harpactacoid copepods, gammarid amphipods, and caprellid amphipods. The effects of predation on Other Rockfishes was the subject of some contemporary studies. One such study determined that juvenile bocaccio can alter patterns of density dependence in kelp, gopher, black and yellow rockfish in Carmel Bay, California (Johnson 2006). Frid and Marliave (2010) reported that lingcod had an indirect positive effect on pandalid shrimps by eating pygmy, copper, and quillback rockfish (which probably mediate competition between pandalid shrimps). Beaudreau and Essington (2007) determined that pygmy, copper, and quillback rockfish (mainly 4-24 cm, standard length) collectively totaled 11% of lingcod diet by weight in the San Juan Archipelago, Washington. However, consumption was 5-10 times greater in marine reserves, which apparently served as predator sinks (Beaudreau and Essington 2009). In Monterey Bay, California, stripetail rockfish were a minor prey item (1.3% of diet by weight) longnose skate diet (Robinson et al. 2007). In addition, trophic linkages, ranging from 3 in harlequin rockfish to 42 in rougheye rockfish, were determined and incorporated into a food web model for the Gulf of Alaska (Gaichas and Francis 2008).

Literature Cited

PFMC. 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 19 (including Amendment 15). Pacific Fishery Management Council. Portland, OR.

Bernardi, G., Findley, L., and Rocha–Olivares, A. 2003. Vicariance and dispersal across Baja California in disjunct marine fish populations. Evolution 57: 1599–1609.

Johnson, S.W., Murphy, M.L., and Csepp, D.J. 2003. Distribution, habitat, and behavior of rockfishes, Sebastes spp., in nearshore waters of southeastern Alaska: observations from a remotely operated vehicle. Environmental Biology of Fishes 66: 259–270.

Love, M.S., Yoklavich, M., and Thorsteinson, L. 2002. The rockfishes of the Northeast Pacific. University of California Press. Berkeley, CA.

Orr, J.W. and Blackburn, J.E. 2004. The dusky rockfishes (Teleostei : Scorpaeniformes) of the North Pacific Ocean: resurrection of Sebastes variabilis (Pallas, 1814) and a redescription of Sebastes ciliatus (Tilesius, 1813). Fishery Bulletin 102: 328–348.

Other Rockfishes: Relevant Literature
Anderson and Yoklavich 2007; Beaudreau and Essington 2007, 2009, 2011; Bowles et al. 2011; Buonaccorsi et al. 2004, 2005; Burford 2009, Burford et al. 2011; Caselle et al. 2010; Choromanski et al. 2004, 2005; Clarke et al. 2009; Coates et al. 2007; Csepp et al. 2011; Du Preez and Tunnicliffe 2011; Frid and Marliave 2010; Gaichas and Francis 2008; Gharrett et al. 2007; Gray et al. 2006; Hannah and Rankin 2011; Hart et al. 2010; Hayden–Spear and Gunderson 2007; Hixon and Tissot 2007; Hoff and Britt 2005, 2009, 2011; Hyde et al. 2008; Johansson et al. 2008; Johnson 2006, 2007; Jorgensen et al. 2006; Juan–Jorda et al. 2009; Keller et al. 2005, 2006a, 2006b, 2007, 2008; Laidig et al. 2007, 2009; Lee and Berejikian 2009; Lochead and Yamanaka 2006; Logerwell et al. 2005; Love and Schroeder 2007; Love and Yoklavich 2008; Love and York 2005, 2006; Love et al. 2006, 2009; Marliave and Challenger 2009; Marliave et al. 2009; Martin and Yamanaka 2004; Miller and Brodeur 2007; Palsson et al. 2008; Pearsall and Fargo 2007; Reilly and Thompson 2007; Reum and Essington 2011; Reuter and Spencer 2007; Reynolds et al. 2010; Robinson et al. 2007; Rodríguez–Romero et al. 2008; Rooper 2008; Rooper and Wilkins 2008; Rooper et al. 2010; Sakuma et al. 2006; Sivasundar and Palumbi 2010; Standish et al. 2011; Studebaker and Mulligan 2008, 2009; Studebaker et al. 2009; Tissot et al. 2007; Tolimieri 2007; Tolimieri and Levin 2006; Tolimieri et al. 2009; Toole et al. 2011; Von Szalay et al. 2008, 2010, 2011; Watson et al. 2010; Wilson et al. 2008; Workman et al. 2008; Yamanaka et al. 2004, 2008; Yang et al. 2006; Zenger 2004.

Appendix G-5: Other Groundfishes Group Summary Information

The Other Groundfishes group contains 15 species that, unlike the other groups, are not monophyletic (i.e., derived from a single, common ancestral species). Therefore, for the purposes of this review, the following subcategories were established based on taxonomic relatedness: 1) chondrichthyan, or cartilaginous, fishes (big skate, California skate, leopard shark, longnose skate, spiny dogfish, spotted ratfish, tope), 2) gadiform fishes, or cods (Pacific cod, Pacific flatnose, Pacific grenadier, Pacific hake), and 3) scorpaeniform, or mail–cheeked, fishes (cabezon, kelp greenling, lingcod, sablefish). New literature on spatial associations and trophic interactions of Other Groundfishes consisted of 120 publications, with the designated subgroups receiving comparable scientific attention (Chondrichthyes, N = 58; Gadiformes, N = 64; Scorpaeniformes, N = 63). Among species, lingcod (N = 42), Pacific cod (N = 42), and Pacific hake (N = 34) were most studied, whereas few publications contained relevant information about cabezon (N = 2), tope (N = 5), or California skate (N = 5).Most of the available information, and certainly the most comprehensive, was obtained from directed studies. However, fishery–independent surveys provided general information on distribution and abundance patterns along the US West Coast (e.g., Keller et al. 2005, 2007, 2008) and throughout Canadian (e.g., Choromanski et al. 2004, 2005; Workman et al. 2008; Yamanaka et al. 2008) and Alaskan waters (e.g., Hoff and Britt 2005; Rooper 2008; von Szalay et al. 2010). The North Pacific spiny dogfish population was recently determined to be distinct from other global populations of spiny dogfish, Squalus acanthias, and renamed the spotted spiny dogfish, S. suckleyi (Ebert et al. 2010). This name change should be reflected in future documents. More new spatial information was available when compared to trophic information, a situation that reflects the relative amount of scientific attention as well as the substantial contribution of newly published fishery–independent survey data.

Spatial information concerning eastern North Pacific chondrichthyan fishes has increased substantially since the last EFH review. The longnose skate, spotted ratfish, and spotted spiny dogfish occur in considerable abundance throughout the West Coast and are among the most common groundfishes encountered in this region (Tolimieri and Levin 2006; Tolimieri 2007). These species are typically found on the outer continental shelf and upper continental slope, with spotted spiny dogfish occurring patchily throughout the water column in large schools (Taylor et al. 2009). The tope, whose regional population was negatively impacted by directed overfishing in the early/mid 20th century and incidental catch in nearshore gillnets until 1994, seems to be recovering in Southern California (Pondella and Allen 2008). Studies of the movement patterns of three chondrichthyan species were recently conducted. Female leopard sharks showed strong site fidelity within Elkhorn Slough and exhibited tidal movements that were probably related to foraging activity, and especially access to intertidal mudflats (Carlisle and Starr 2009, 2010). Leopard sharks also occupied relatively warm regions of southern California embayments during daylight hours, possibly to improve digestion and reproductive development (Hight and Lowe 2007). A large–scale tagging effort was conducted in British Columbia on big skate (King and McFarlane 2010) and spiny dogfish (McFarlane and King 2009). Although 75% of recaptures occurred within 21 km of the initial capture site, a small proportion of big skates (mainly females) traveled considerable distances (to 2340 km) (King and McFarlane 2010). Spiny dogfish tagged in the Strait of Georgia were largely recaptured within the same region, but a complex movement pattern and considerable exchange with North Puget Sound were evident (McFarlane and King 2009). The big skate and spotted spiny dogfish exhibited significant decreases in abundance with decreasing dissolved oxygen levels (Keller et al. 2010). Love et al. (2008) discovered a nursery area for the longnose skate between 125–151 m and 9.1–10.1º C on a high–relief rocky ridge off southern California.

Trophic studies were additionally conducted for a number of chondrichthyan species. A directed diet study in the Monterey Bay region showed that big and California skates ate similar portions of crabs, fishes, and shrimps when at similar sizes (< 60 cm TL), but that comparably sized longnose skates ate mainly shrimps and fishes, with cephalopods also taken supplementally (Bizzarro et al. 2007). By contrast, diets of large (> 60 cm TL) big and longnose skates differed substantially from those of small skates of all species, and contained a much greater proportion of fishes and marked reduction in the proportion of shrimps (Bizzarro et al. 2007). A detailed, directed study of longnose skate diet was also conducted off central California and indicated dietary variability with increasing depth (more cephalopods and euphausiids) and size (decreasing amounts of crustaceans, increasing amounts of fishes and cephalopods) (Robinson et al. 2007). Leopard sharks in Humboldt Bay ate primarily jack silverside eggs in early May, switching to cancer crabs in late May (Ebert and Ebert 2005). Several recent trophic studies suggested that spotted spiny dogfish have a diverse diet with considerable spatial and size–based variability (Miller and Brodeur 2007; Andrews and Foy 2009, Beamish and Sweeting 2009; Brodeur et al. 2009). Predators of spiny dogfish were identified, including sixgill sharks (Gallucci and Langseth 2009), salmon sharks (Hurlburt et al. 2005), Stellar sea lions (Vollenweider et al. 2006), and California sea lions (Orr et al. 2011).

Contemporary spatial information on the gadiform subgroup is largely restricted to Pacific cod and Pacific hake, with few detailed studies concerning Pacific grenadier or Pacific flatnose. Several studies concerned distribution and abundance patterns of Pacific cod and showed that new recruits occur in shallow waters (< 20 m) and move to deeper water with ontogeny (Abookire et al. 2007; Laurel et al. 2009). New recruits and early juveniles appear to prefer structured habitats (e.g., kelp, seagrass beds, sea cucumber mounds) (Abookire et al. 2007; Laurel et al. 2007; Hamilton and Konar 2007), whereas larger juveniles and adults are highly mobile and found in more open habitats (Laurel et al. 2007; Conners and Munro 2008). Agostini et al. (2006) determined that Pacific hake are associated with subsurface poleward, which defines adult habitat and migration patterns, rather than temperature. Age–0 Pacific hake are one of the most common micronekton along the West Coast (Phillips et al. 2009). Nursery areas are principally along the coastal shelf and slope of California, but shift northward during ENSO events (Phillips et al. 2007; Agostino et al. 2008; Funes–Rodriguez et al. 2009). In addition, spawning and recruitment sites of Pacific hake have expanded northward, probably in relation to increased winter/spring temperatures in the northern California Current (Phillips et al. 2007). The Pacific grenadier is among the most abundant groundfish species in continental slope waters of the West Coast (Keller et al. 2005; Tolimieri 2007), but specific patterns of distribution and abundance are not addressed in the contemporary literature. However, this species and the Pacific flatnose are commonly found at California seamounts (Lundsten et al. 2009).

Contemporary trophic information on the gadiform subgroups is also largely focused on Pacific cod and Pacific hake. Several recent diet studies were conducted on Pacific cod in British Columbia and the Gulf of Alaska. Pacific cod were found to be major predators of herring (Schweigert et al. 2010) and capelin (Yang et al. 2005). Young Pacific cod eat copepods and other small crustaceans (Abookire et al. 2007), with older, larger fishes eating larger crustaceans (e.g., shrimps, tanner crab) and other fishes (e.g., sand lance, pollock) (Yang et al. 2006). Dietary variability was noted with size and depth (Abookire et al. 2007) and, since this species feeds opportunistically, likely also includes temporal and spatial differences. Observed, long–term dietary changes in Pacific cod have been attributed to changing environmental conditions and shifting bottom–up and top–down control (Yang et al. 2004; Litzow and Ciannelli 2007). Contemporary diet studies of Pacific hake were mainly focused on commercially important prey items. Pacific hake predation was not determined to have a major effect on Columbia River salmon populations (Emmett and Krutzikowsky 2008) but could impact canary rockfish recovery in California (Harvey et al. 2008). Pacific hake were also one of the main predators of Pacific herring off British Columbia (Schweigert et al. 2010). Scavenging is an important component of diet of Pacific grenadiers and Pacific flatnose, probably as a result of low standing prey biomass in the deep ocean (Yeh and Drazen 2011). Because of their high relative abundance, Pacific cod and Pacific hake are important prey items for a wide variety of species. Pacific cod are eaten in high proportions by Stellar sea lions between Oregon and the Aleutian Islands (e.g., Bredeson et al. 2006; Csepp et al. 2011) and are also present in the diet of Aleutian skates (Yang 2007), arrowtooth flounder (Yang et al. 2006), Pacific halibut (Yang et al. 2006), and sablefish (Yang et al. 2006). Pacific hake are commonly eaten by Stellar sea lions (Bredeson et al. 2006, Csepp et al. 2011), harbor seals (Orr et al. 2004), California sea lions (Orr et al. 2011), Humboldt squid (Field et al. 2007), albacore (Glaser 2010), and thresher sharks (Preti et al. 2004).

Some contemporary spatial information is available for all of the members of the scorpaeniform subgroup, although most attention has been focused on lingcod and sablefish. Cabezon tagged at an oil platform in Southern California were rather sedentary with a strong 24–hour activity cycle, but vertical movements along the platform may have obscured residency results (Lowe et al. 2009). No significant difference in occurrence was found for kelp greenling among mud, oyster, and eel grass habitats in a Washington estuary (Hosack et al. 2006); however, this species was also reported in association with boulders (Hart et al. 2010), cobble and bedrock (Thedinga et al. 2008). Canopy and understory kelp supported year–round populations of (primarily kelp) greenlings in Cook Inlet, Alaska (Hamilton and Konar 2007). No difference in abundance of lingcod was noted between day and night surveys at Hecate Bank (Hart et al. 2010), or among mud, oyster or eelgrass habitats in a Washington estuary (Hosack et al. 2010). This species can be considered a habitat generalist but it prefers some structure to open (mud or sand) seafloors (Love and York 2005, 2006; Anderson and Yoklavich 2007), especially during the juvenile stage (Petrie and Ryer 2006). Juvenile lingcod have high site fidelity (Petrie and Ryer 2006; Reynolds et al. 2010) and variable home ranges. In the San Juan Islands, sizes corresponding to adult lingcod (70–80 cm TL) exhibited much larger home ranges (21,272 + 13,630 m2, Beaudreau and Essington 2011) than a mixture of presumably juvenile and adult lingcod (45–68 cm TL) in Puget Sound (~500–2200 m2). Starr et al. (2004, 2005) determined that larger, adult lingcod (> 80 cm TL) frequently left the boundaries of a reserve off Sitka, Alaska, but only for short periods of time and generally showed high site fidelity. In the Gulf of Alaska, twenty years of tag returns showed that sablefish move to deeper water with age, and exhibit a general, counterclockwise migration pattern (Maloney and Sigler 2008). Sablefish are highly mobile and may migrate to (and spawn in) the western Bering Sea (Orlov 2004).

Trophic information is available for lingcod, sablefish, and kelp greenling. Juvenile lingcod in the northern California Current ate primarily large copepods with small fishes also contributing substantially to diet composition (Miller and Brodeur 2007), whereas a wide size range of juvenile and adult lingcod (15–110 cm TL) were predominantly piscivorous in the San Juan Islands regardless of length. Lingcod were major predators of Pacific herring (Schweigert et al. 2010) and rockfish (Beaudreau and Essington 2007) in British Columbia and northern Washington, respectively. Rockfish consumption was estimated to be 5–10 times greater in marine reserves than non–reserves in the San Juan Island region (Beaudreau and Essington 2009). Predation on rockfish by lingcod may indirectly increase abundance of pandalid shrimps, a major prey item of rockfish, in southern British Columbia (Frid and Marliave 2010). Juvenile sablefish ate mainly euphausiids in the northern California Current, with crabs and fishes also contributing substantially to diet composition (Miller and Brodeur 2007). In the Gulf of Alaska, a mixture of juvenile and adult sablefish ate primarily pollock, with cephalopods and gammarid amphipods also important prey taxa (Yang et al. 2006). Sablefish are one of the main predators of Pacific herring off British Columbia (Schweigert et al. 2010) and predation of salmon juveniles could negatively impact returns of adults in Southeast Alaska (Sturdevant et al. 2009). Scavenging behavior was reported for sablefish (Yang et al. 2006; Yeh and Drazen 2011) and kelp greenling (Davies et al. 2006). Kelp greenling has been reported in the diets of Alaska skates (Yang 2007), Stellar sea lions (Vollenweider et al. 2006; McKenzie and Wynne 2008), California sea lions (Orr et al. 2011), and pigeon guillemots (Robinette et al. 2007). Lingcod has recently been reported in the diet of harbor seals (Orr et al. 2004) and pigeon guillemots (Robinette et al. 2007). Sablefish has been reported as common prey of Stellar sea lions off Southeast Alaska (Csepp et al. 2011) and salmon sharks in Prince William Sound (Hurlburt et al. 2005). Sperm whale depredation of sablefish from longline gear is common, especially in the central and eastern Gulf of Alaska (Sigler et al. 2008).

Literature Cited:

Ebert, D.A., White, W.T., Goldman, K.J., Compagno, L.J.V., Daly–Engel, T.S. and Ward, R.D. 2010. Resurrection and redescription of Squalus suckleyi (Girard, 1854) from the North Pacific, with comments on the Squalus acanthias subgroup (Squaliformes: Squalidae). Zootaxa: 22–40.

Other Groundfish: Relevant Literature

Abookire et al. 2007; Agostini et al. 2006, 2008; Anderson and Yoklavich 2007; Andrews and Foy 2009; Andrews et al. 2011; Bailey et al. 2006; Beamish and Sweeting 2009; Beaudreau and Essington 2007, 2009, 2011; Benson and McFarlane 2008; Bizzarro and Vaughn 2009; Bizzarro et al. 2007; Bredeson et al. 2006; Brodeur et al. 2009; Buser et al. 2009; Carlisle and Starr 2009, 2010; Choromanski et al. 2004, 2005; Conners and Monro 2008; Conrath and Foy 2009; Cook et al. 2005; Csepp et al. 2011; Davies et al. 2006; Davis and Ottmar 2009; Dowd et al. 2010; Drazen and Seibel 2007; Ebert and Bizzarro 2007; Ebert and Ebert 2005; Emmett and Krutzikowsky 2008; Farrer 2009; Field et al. 2007; Frid and Marliave 2010; Fulmer and Bollens 2005; Funes–Rodriguez et al. 2009; Gallucci and Langseth 2009; Gertseva 2009; Glaser 2010; Hamilton and Konar 2007; Hart et al. 2010; Harvey 2009; Harvey et al. 2008; Hight and Lowe 2007; Hosack et al. 2006; Hulbert et al. 2005; Hurst et al. 2009; Juan–Jorda et al. 2009; Keller et al. 2005, 2006a, 2006b, 2007, 2008, 2010; King and McFarlane 2010; Laurel et al. 2007, 2009; Litzow and Ciannelli 2007; Logerwell et al. 2005; Love and Schroeder 2007; Love and York 2005, 2006; Love et al. 2006, 2008, 2009; Lowe et al. 2009; Lowry and Motta 2008; Lowry et al. 2007; Lundsten et al. 2009; Maloney and Sigler 2008; McConnaughey and Syrjala 2009; McFarlane and King 2009; McKenzie and Wynne 2008; Miller and Brodeur 2007; Misarti et al. 2009; Orlov 2004; Orr et al. 2004; 2011; Ostrand et al. 2004; Palsson et al. 2008; Parnel et al. 2008; Pearsall and Fargo 2007; Petrie and Ryer 2006; Phillips et al. 2007, 2009; Pondella and Allen 2008; Preti et al. 2004; Reynolds et al. 2010; Robinette et al. 2007; Robinson et al. 2007; Ruiz–Campos et al. 2010; Sakuma et al. 2007; Schirripa and Colbert 2006; Schweigert et al. 2010; Sigler et al. 2008; Starr et al. 2004, 2005; Sturdevant et al. 2009; Taylor et al. 2009; Thedinga et al. 2008; Tolimieri 2007; Tolimieri and Levin 2006; Tolimieri et al. 2009; Vollenweider et al. 2006; Von Szalay et al. 2008, 2010, 2011; Westrheim and Fargo 2005; Wilson et al. 2008; Workman et al. 2008; Yamanaka et al. 2004, 2008; Yang 2004; Yang 2007; Yang et al. 2005, 2006; Yeh and Drazen 2011; Yeung and McConnaughey 2008; Zenger 2004

Appendix G-6: Bibliography of Recent Literature Relevant to EFH for Pacific Coast Groundfishes

Abookire, A.A. and Bailey, K.M. 2007. The distribution of life cycle stages of two deep–water pleuronectids, Dover sole (*Microstomus pacificus*) and rex sole (*Glyptocephalus zachirus*), at the northern extent of their range in the Gulf of Alaska. Journal of Sea Research 57: 198–208.

Abookire, A.A., Duffy–Anderson, J.T. and Jump, C.M. 2007. Habitat associations and diet of young–of–the–year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150: 713–726.

Agostini, V.N., Francis, R.C., Hollowed, A.B., Pierce, S.D., Wilson, C. and Hendrix, A.N. 2006. The relationship between Pacific hake (*Merluccius productus*) distribution and poleward subsurface flow in the California Current System. Canadian Journal of Fisheries and Aquatic Sciences 63: 2648–2659.

Agostini, V.N., Hendrix, A.N., Hollowed, A.B., Wilson, C.D., Pierce, S.D. and Francis, R.C. 2008. Climate–ocean variability and Pacific hake: A geostatistical modeling approach. Journal of Marine Systems 71: 237–248.

Anderson, T.J. and Yoklavich, M.M. 2007. Multiscale habitat associations of deepwater demersal fishes off central California. Fishery Bulletin 105: 168–179.

Andrews, A.G. and Foy, R. J. 2009. Geographical variation in carbon and nitrogen stable isotope ratios of spiny dogfish in the northeastern Pacific Ocean, p. 269–276. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Andrews, K.S., Tolimieri, N., Williams, G.D., Samhouri, J.F., Harvey, C.J. and Levin, P.S. 2011. Comparison of fine–scale acoustic monitoring systems using home range size of a demersal fish. Marine Biology 158: 2377–2387.

Aydin, K. and Mueter, F. 2007. The Bering Sea – a dynamic food web perspective. 2007. Deep Sea Research II 54: 2501–2525.

Bailey, D.M., Ruhl, H.A. and Smith, K.L. 2006. Long–term change in benthopelagic fish abundance in the abyssal northeast Pacific Ocean. Ecology 87: 549–555.

Bailey, K.M., Abookire, A.A. and Duffy–Anderson, J.T. 2008. Ocean transport paths for the early life history stages of offshore–spawning flatfishes: a case study in the Gulf of Alaska. Fish and Fisheries 9: 44–66.

Beamish, R.J. and Sweeting, R.M. 2009. Spiny dogfish in the pelagic waters of the Strait of Georgia and Puget Sound, p.101–118. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Beaudreau, A.H. and Essington, T.E. 2007. Spatial, temporal, and ontogenetic patterns of predation on rockfishes by lingcod. Transactions of the American Fisheries Society 136: 1438–1452.

Beaudreau, A.H. and Essington, T.E. 2009. Development of a new field–based approach for estimating consumption rates of fishes and comparison with a bioenergetics model for lingcod (*Ophiodon elongatus*). Canadian Journal of Fisheries and Aquatic Sciences 66: 565–578.

Appendix G-6:Bibliography of Recent Literature Relevant to EFH for Pacific Coast Groundfishes

Beaudreau, A.H., and Essington, T.E. 2011. Use of pelagic prey subsidies by demersal predators in rocky reefs: insight from movement patterns of lingcod. Marine Biology 158: 471–483.

Benson, A.J. and McFarlane, G.A. 2008. Distribution and biology of grenadiers off the west coast of Canada, p. 81–102. In: Orlov, A.M.I.T. and Iwamoto, T., eds. Grenadiers of the world oceans: biology, stock assessment, and fisheries. American Fisheries Society Symposium 63.

Bizzarro, J.J. and Vaughn, M.T. 2009. Aspects of the biology and species composition of skates (Rajiformes) off southeastern Alaska. Northwestern Naturalist. 90: 247–256.

Bizzarro, J.J., Robison, H.J., Rinewalt, C.S. and Ebert, D.A. 2007. Comparative feeding ecology of four sympatric skate species off central California, USA. Environmental Biology of Fishes. 80: 197–220.

Black, B.A., Boehlert, G.W. and Yoklavich, M.M. 2008. Establishing climate–growth relationships for yelloweye rockfish (*Sebastes ruberrimus*) in the northeast Pacific using a dendrochronological approach. Fisheries Oceanography 17: 368–379.

Blood, D.M., Matarese, A.C. and Busby, M.S. 2007. Spawning, egg development, and early life history dynamics of arrowtooth flounder (*Atheresthes stomias*) in the Gulf of Alaska. NOAA Professional Paper NMFS 7, 28 p.

Boersma, K.S., Ryer, C.H., Hurst, T.P. and Heppell, S.S. 2008. Influences of divergent behavioral strategies upon risk allocation in juvenile flatfishes. Behavioral Ecology and Sociobiology 62: 1959–1968.

Boldt, J.L. and Rooper, C.N. 2009. Abundance, condition, and diet of juvenile Pacific ocean perch (*Sebastes alutus*) in the Aleutian Islands. Fishery Bulletin 107: 278–285.

Bowles, E., Schulte, P.M., Tollit, D.J., Deagle, B.E. and Trites, A.W. 2011. Proportion of prey consumed can be determined from faecal DNA using real–time PCR. Molecular Ecology Resources 11: 530–540.

Bredesen, E.L., Coombs, A.P. and Trites, A.W. 2006. Relationship between Steller sea lion diets and fish distributions in the Eastern North Pacific, p. 131–139. In: Trites, A.W., Atkinson, S.K., DeMaster, D.P., Fritz, L.W., Gelatt, T.S., Rea, L.D. and Wynne, K.M., eds. Sea lions of the world. Alaska Sea Grant. University of Alaska, Fairbanks.

Brodeur, R.D., Fisher, J.P., Emmett, R.L., Morgan, C.A. and Casillas, E. 2005. Species composition and community structure of pelagic nekton off Oregon and Washington under variable oceanographic conditions. Marine Ecology Progress Series 298: 41–57.

Brodeur, R.D., Fleming, I.A., Bennett, J.M. and Campbell, M.A. 2009. Summer distribution and feeding of spiny dogfish off the Washington and Oregon Coasts, p. 39–51. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Brown, J.A. 2006a. Classification of juvenile flatfishes to estuarine and coastal habitats based on the elemental composition of otoliths. Estuarine Coastal and Shelf Science 66: 594–611.

Appendix G-6:Bibliography of Recent Literature Relevant to EFH for Pacific Coast Groundfishes

Brown, J.A. 2006b. Using the chemical composition of otoliths to evaluate the nursery role of estuaries for English sole *Pleuronectes vetulus* populations. Marine Ecology Progress Series 306: 269–291.

Buonaccorsi, V.P., Westerman, M., Stannard, J., Kimbrell, C., Lynn, E. and Vetter, R.D. 2004. Molecular genetic structure suggests limited larval dispersal in grass rockfish, *Sebastes rastrelliger*. Marine Biology 145: 779–788.

Buonaccorsi, V.P., Kimbrell, C.A., Lynn, E.A. and Vetter, R.D. 2005. Limited realized dispersal and introgressive hybridization influence genetic structure and conservation strategies for brown rockfish, *Sebastes auriculatus*. Conservation Genetics 6: 697–713.

Burford, M.O. 2009. Demographic history, geographical distribution and reproductive isolation of distinct lineages of blue rockfish (*Sebastes mystinus*), a marine fish with a high dispersal potential. Journal of Evolutionary Biology 22: 1471–1486.

Burford, M.O., Carr, M.H. and Bernardi, G. 2011. Age–structured genetic analysis reveals temporal and geographic variation within and between two cryptic rockfish species. Marine Ecology Progress Series 442: 201–215.

Buser, T.J., Davis, N.D., Jiménez–Hidalgo, I. and Hauser, L. 2009. Genetic techniques provide evidence of Chinook salmon feeding on walleye pollock offal. North Pacific Anadromous Fish Commission Bulletin 5: 225–229.

Carlisle, A.B. and Starr, R.M. 2009. Habitat use, residency, and seasonal distribution of female leopard sharks *Triakis semifasciata* in Elkhorn Slough, California. Marine Ecology Progress Series 380: 213–228.

Carlisle, A.B. and Starr, R.M. 2010. Tidal movements of female leopard sharks (*Triakis semifasciata*) in Elkhorn Slough, California. Environmental Biology of Fishes 89: 31–45.

Caselle, J.E., Kinlan, B.P. and Warner, R.R. 2010. Temporal and spatial scales of influence on nearshore fish settlement in the Southern California bight. Bulletin of Marine Science 86: 355–385.

Chittaro, P.M., Finley, R.J. and Levin, P.S. 2009. Spatial and temporal patterns in the contribution of fish from their nursery habitats. Oecologia 160: 49–61.

Choromanski, E.M., Fargo, J., Workman, G.D. and Mathias, K. 2004. Multispecies trawl survey of Hecate Strait, F/V Viking Storm, June 10 – 28, 2002. Canadian Data Report of Fisheries and Aquatic Sciences 1124, 81 p.

Choromanski, E.M., Workman, G.D. and Fargo, J. 2005. Hecate Strait multi–species bottom trawl survey, CCGS WE Ricker, May 19 to June 7, 2003. Canadian Data Report of Fisheries and Aquatic Sciences 1169, 85 p.

Clarke, M.E., Tolimieri, N. and Singh, H. 2009. Using the seabed AUV to assess populations of groundfish in untrawlable areas, p. 357–372. In: Beamish, R.J. and Rothschild, B.J., eds. Future of fisheries science in North America. Fish and Fisheries Series 31.

Cloern, J.E., Jassby, A.D., Thompson, J.K. and Hieb, K.A. 2007. A cold phase of the East Pacific triggers new phytoplankton blooms in San Francisco Bay. Proceedings of the National Academy of Sciences 204: 18561–18565.

Coates, J., Gunderson, D.R., LaFrance, L., Miller, B.S., Goetz, B. and Palsson, W.A. 2007. Changes in growth and recruitment of the Puget Sound rockfish (*Sebastes emphaeus*) in northern Puget Sound, p. 223–236. In: Heifetz, J., Dilusino, J., Gharett, A.J., Love, M.S., O'Connell, V.M. and Stanley, R.D., eds. Biology, assessment, and management of North Pacific Rockfishes. Alaska Sea Grant. University of Alaska, Fairbanks.

Conners, M.E. and Munro, P. 2008. Effects of commercial fishing on local abundance of Pacific cod (*Gadus macrocephalus*) in the Bering Sea. Fishery Bulletin 106: 281–292.

Conrath, C.L. and Foy, R.J. 2009. A history of the distribution and abundance of spiny dogfish in Alaska Waters, p. 119–126. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Cook, M.A., Guthrie, K.M., Rust, M.B. and Plesha, P.D. 2005. Effects of salinity and temperature during incubation on hatching and development of lingcod *Ophiodon elongatus* Girard, embryos. Aquaculture Research 36: 1298–1303.

Csepp, D.J., Vollenweider, J.J. and Sigler, M.F. 2011. Seasonal abundance and distribution of pelagic and demersal fishes in southeastern Alaska. Fisheries Research 108: 307–320.

Davies, S., Griffiths, A. and Reimchen, T.E. 2006. Pacific Hagfish, *Eptatretus stoutii*, spotted ratfish, *Hydrolagus colliei*, and scavenger activity on tethered carrion in subtidal benthic communities off Western Vancouver Island. Canadian Field Naturalist 120: 363–366.

Davis, M.W. and Ottmar, M.L. 2009. Vertical distribution of juvenile Pacific cod *Gadus macrocephalus*: potential role of light, temperature, food, and age. Aquatic Biology 8: 29–37.

Dowd, W.W., Harris, B.N., Cech, J.J., Jr. and Kueltz, D. 2010. Proteomic and physiological responses of leopard sharks (*Triakis semifasciata*) to salinity change. Journal of Experimental Biology 213: 210–224.

Drazen, J.C. and Seibel, B.A. 2007. Depth–related trends in metabolism of benthic and benthopelagic deep–sea fishes. Limnology and Oceanography 52: 2306–2316.

Du Preez, C. and Tunnicliffe, V. 2011. Shortspine thornyhead and rockfish (Scorpaenidae) distribution in response to substratum, biogenic structures and trawling. Marine Ecology Progress Series 425: 217–231.

Duffy–Anderson, J.T., Busby, M.S., Mier, K.L., Deliyanides, C.M. and Stabeno, P.J. 2006. Spatial and temporal patterns in summer ichthyoplankton assemblages on the eastern Bering Sea shelf 1996–2000. Fisheries Oceanography 15: 80–94.

Ebert, D.A. and Bizzarro, J.J. 2007. Standardized diet composition and trophic levels of skates. (Chondrichthyes: Rajiformes: Rajoidei). Environmental Biology of Fishes. 80: 221–237.

Ebert, D.A. and Ebert, T.B. 2005. Reproduction, diet and habitat use of leopard sharks, *Triakis semifasciata* (Girard), in Humboldt Bay, California, USA. Marine and Freshwater Research 56: 1089–1098.

Emmett, R. and Krutzikowsky, G. 2008. Nocturnal feeding of Pacific hake and jack mackerel off the mouth of the Columbia River, 1998–2004: implications for juvenile salmon predation. Transactions of the American Fisheries Society 137: 657–676.

Fargo, J. and Westrheim, S. 2007. Final results of the September 1979 Dover sole tagging experiment in northern Hecate Strait, 1979–1999. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2813, 36 p.

Farrer, D.A. 2009. Northern range extension of the Leopard shark, *Triakis semifasciata*. California Fish and Game 95: 62–64.

Field, J.C. and Ralston, S. 2005. Spatial variability in rockfish (*Sebastes* spp.) recruitment events in the California Current System. Canadian Journal of Fisheries and Aquatic Sciences 62: 2199–2210.

Field, J.C., Baltz, K. and Phillips, J.A. 2007. Range expansion and trophic interactions of the jumbo squid, *Dosidicus gigas*, in the California Current. California Cooperative Oceanic Fisheries Investigations 48: 131–146.

Frid, A. and Marliave, J. 2010. Predatory fishes affect trophic cascades and apparent competition in temperate reefs. Biology Letters 6: 533–536.

Fulmer, J.H. and Bollens, S.M. 2005. Responses of the chaetognath, *Sagitta elegans*, and larval Pacific hake, *Merluccius productus*, to spring diatom and copepod blooms in a temperate fjord (Dabob Bay, Washington). Progress In Oceanography 67: 442–461.

Funes–Rodriguez, R., Elorduy–Garay, J.F., Hinojosa–Medina, A. and Zarate–Villafranco, A. 2009. Interannual distribution of Pacific hake *Merluccius productus* larvae in the southern part of the California Current. Journal of Fish Biology 75: 630–646.

Gaichas, S.K. and Francis, R.C. 2008. Network models for ecosystem–based fishery analysis: a review of concepts and application to the Gulf of Alaska marine food web. Canadian Journal of Fisheries and Aquatic Sciences 65: 1965–1982.

Gaichas, S.K., Aydin, K.Y. and Francis, R.C. 2010. Using food web model results to inform stock assessment estimates of mortality and production for ecosystem–based fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 67: 1490–1506.

Gallucci, V.F. and Langseth, B.J. 2009. Interactions between two sharks: spiny dogfish and sixgill shark in the Puget Sound/Georgia Basin ecosystem, northeast Pacific Ocean, p. 277–284. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Gertseva, V.V. 2009. The population dynamics of the longnose skate, *Raja rhina*, in the northeast Pacific Ocean. Fisheries Research 95: 146–153.

Gharrett, A.J., Matala, A.P., Peterson, E.L., Gray, A.K., Li, Z. and Heifetz, J. 2007. Distribution and population genetic structure of sibling rougheye rockfish species. p. 121–140. In: Heifetz, J., Dilusino, J., Gharett, A.J., Love, M.S., O'Connell, V.M. and Stanley, R.D., eds. Biology, assessment, and management of North Pacific Rockfishes. Alaska Sea Grant. University of Alaska, Fairbanks.

Glaser, S. 2010. Interdecadal variability in predator–prey interactions of juvenile North Pacific albacore in the California Current System. Marine Ecology Progress Series 414: 209–221.

Gray, A.K., Kendall, A.W., Wing, B.L., Carls, M.G., Heifetz, J., Li, Z.Z. and Gharrett, A.J. 2006.

Identification and first documentation of larval rockfishes in southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Transactions of the American Fisheries Society 135: 1–11.

Green, K.M. and Starr, R.M. 2011. Movements of small adult black rockfish: implications for the design of MPAs. Marine Ecology–Progress Series 436: 219–230.

Hamilton, J. and Konar, B. 2007. Implications of substrate complexity and kelp variability for south–central Alaskan nearshore fish communities. Fishery Bulletin 105: 189–196.

Hannah, R.W. and Rankin, P.S. 2011. Site fidelity and movement of eight species of Pacific rockfish at a high–relief rocky reef on the Oregon Coast. North American Journal of Fisheries Management 31: 483–494.

Hart, T.D., Clemons, J.E.R., Wakefield, W.W. and Heppell, S.S. 2010. Day and night abundance, distribution, and activity patterns of demersal fishes on Heceta Bank, Oregon. Fishery Bulletin 108: 466–477.

Harvey, C.J. 2009. Effects of temperature change on demersal fishes in the California Current: a bioenergetics approach. Canadian Journal of Fisheries and Aquatic Sciences 66: 1449–1461.

Harvey, C., Gross, K., Simon, V. and Hastie, J. 2008. Trophic and fishery interactions between Pacific hake and rockfish: effect on rockfish population rebuilding times. Marine Ecology Progress Series 365: 165–176.

Hayden–Spear, J. and Gunderson, D.R. 2007. Nearshore habitat associations of young–of–year copper (*Sebastes caurinus*) and quillback (*S. maliger*) rockfish in the San Juan channel, Washington. p. 367–382. In: Heifetz, J., Dilusino, J., Gharett, A.J., Love, M.S., O'Connell, V.M. and Stanley, R.D., eds. Biology, assessment, and management of North Pacific Rockfishes. Alaska Sea Grant. Univeristy of Alaska, Fairbanks.

Hight, B.V. and Lowe, C.G. 2007. Elevated body temperatures of adult female leopard sharks, *Triakis semifasciata*, while aggregating in shallow nearshore embayments: Evidence for behavioral thermoregulation? Journal of Experimental Marine Biology and Ecology 352: 114–128.

Hixon, M.A. and Tissot, B.N. 2007. Comparison of trawled vs. untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. Journal of Experimental Marine Biology and Ecology 34: 23–34.

Hoff, G.R. 2006. Biodiversity as an index of regime shift in the eastern Bering Sea. Fishery Bulletin 104: 226–237.

Hoff, G. and Britt, L. 2005. Results of the 2004 Eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–156, 276 p.

Hoff, G., and Britt, L. 2009. Results of the 2008 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–197, 294 p.

Hoff, G., and Britt, L. 2011. Results of the 2010 Eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–224, 300 p.

Hosack, G.R., Dumbauld, B.R., Ruesink, J.L. and Armstrong, D.A. 2006. Habitat associations of estuarine species: comparisons of intertidal mudflat, seagrass (*Zostera marina*), and oyster (*Crassostrea gigas*) habitats. Estuaries and Coasts 29: 1150–1160.

Hulbert, L.B., Aires–da–Silva, A.M., Gallucci, V.F. and Rice, J.S. 2005. Seasonal foraging movements and migratory patterns of female *Lamna ditropis* tagged in Prince William Sound, Alaska. Journal of Fish Biology 67: 490–509.

Hurst, T.P., Cooper, D.W., Scheingross, J.S., Seale, E.M., Laurel, B.J. and Spencer, M.L. 2009. Effects of ontogeny, temperature, and light on vertical movements of larval Pacific cod (*Gadus macrocephalus*). Fisheries Oceanography 18: 301–311.

Hyde, J.R., Kimbrell, C.A., Budrick, J.E., Lynn, E.A. and Vetter, R.D. 2008. Cryptic speciation in the vermilion rockfish (*Sebastes miniatus*) and the role of bathymetry in the speciation process. Molecular Ecology 17: 1122–1136.

Iverson, S., Springer, A. and Kitaysky, A. 2007. Seabirds as indicators of food web structure and ecosystem variability: qualitative and quantitative diet analyses using fatty acids. Marine Ecology Progress Series 352: 235–244.

Johansson, M.L., Banks, M.A., Glunt, K.D., Hassel–Finnegan, H.M. and Buonaccorsi, V.P. 2008. Influence of habitat discontinuity, geographical distance, and oceanography on fine–scale population genetic structure of copper rockfish (*Sebastes caurinus*). Molecular Ecology 17: 3051–3061.

Johnson, D.W. 2006. Predation, habitat complexity, and variation in density–dependent mortality of temperate reef fishes. Ecology 87: 1179–1188.

Johnson, D.W. 2007. Habitat complexity modifies post–settlement mortality and recruitment dynamics of a marine fish. Ecology 88: 1716–1725.

Jorgensen, S.J., Kaplan, D.M., Klimley, A.P., Morgan, S.G., O'Farrell, M.R. and Botsford, L.W. 2006. Limited movement in blue rockfish *Sebastes mystinus*: internal structure of home range. Marine Ecology Progress Series 327: 157–170.

Juan–Jorda, M.J., Barth, J.A., Clarke, M. and Wakefield, W. 2009. Groundfish species associations with distinct oceanographic habitats in the Northern California Current. Fisheries Oceanography 18: 1–19.

Keller, A.A., Wick, T.L., Fruh, E.L., Bosley, K.L., Kamikawa, D.J., Wallace, J.R. and Horness, B.H. 2005. The 2000 U.S. west coast upper continental slope trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–70, 163 p.

Keller, A.A., Fruh, E.L., Bosley, K.L., Kamikawa, D.J., Wallace, J.R., Horness, B.H., Simon, V.H. and Tuttle, V.J. 2006a. The 2001 U.S. west coast upper continental slope trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–72, 175 p.

Keller, A.A., Horness, B.H., Tuttle, V.J., Wallace, J.R., Simon, V.H., Fruh, E.L., Bosely, K.L. and Kamikawa, D.J. 2006b. The 2002 U.S. west coast upper continental slope trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–75, 189 p.

Keller, A.A., Horness, B.H., Simon, V.H., Tuttle, V.J., Wallace, J.R., Fruh, E.L., Bosley, K.L., Kamikawa, D.J. and Buchanan, J.C. 2007. The 2004 U.S. west coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–87, 134 p.

Keller, A.A, Horness, B.H., Fruh, E.L., Simon, V.H., Tuttle, V.J., Bosley, K.L., Buchanan, J.C., Kamikawa, D.J. and Wallace, J.R. 2008. The 2005 U.S. west coast bottom trawl survey of groundfish resources off Washington, Oregon, and California: estimates of distribution, abundance, and length composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–NWFSC–93, 136 p.

Keller, A.A., Simon, V.H., Chan, F., Wakefield, W.W., Clarke, M.E., Barth, J.A., Kamikawa, D. and Fruh, E.L. 2010. Demersal fish and invertebrate biomass in relation to an offshore hypoxic zone along the US West Coast. Fisheries Oceanography 19: 76–87.

King, J.R. and McFarlane, G.A. 2010. Movement patterns and growth estimates of big skate (*Raja binoculata*) based on tag–recapture data. Fisheries Research 101: 50–59.

Knoth, B.A. and Foy, R.J. 2008. Temporal variability in the food habits of arrowtooth flounder (*Atheresthes stomias*) in the Western Gulf of Alaska. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–184, 30 p.

Krishka, B.A., Starr, P.J. and Choromanski, E.M. 2005. Longspine thornyhead random stratified trawl survey off the west coast of Vancouver Island, September 4–21 2003. Canadian Technical Report of Fisheries and Aquatic Sciences 2577, 93 p.

Laidig, T.E., Chess, J.R. and Howard, D.F. 2007. Relationship between abundance of juvenile rockfishes (*Sebastes* spp.) and environmental variables documented off northern California and potential mechanisms for the covariation. Fishery Bulletin 105: 39–48.

Laidig, T.E., Watters, D.L. and Yoklavich, M.M. 2009. Demersal fish and habitat associations from visual surveys on the central California shelf. Estuarine Coastal and Shelf Science 83: 629–637.

Laurel, B.J., Stoner, A.W., Ryer, C.H., Hurst, T.P. and Abookire, A.A. 2007. Comparative habitat associations in juvenile Pacific cod and other gadids using seines, baited cameras and laboratory techniques. Journal of Experimental Marine Biology and Ecology 351: 42–55.

Laurel, B.J., Ryer, C.H., Knoth, B. and Stoner, A.W. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (*Gadus macrocephalus*). Journal of Experimental Marine Biology and Ecology 377: 28–35.

Lauth, R.R., Wakefield, W.W. and Smith, K. 2004. Estimating the density of thornyheads, *Sebastolobus* spp., using a towed video camera sled. Fisheries Research 70: 39–48.

Lee, J.S.F. and Berejikian, B.A. 2009. Structural complexity in relation to the habitat preferences, territoriality, and hatchery rearing of juvenile China rockfish (*Sebastes nebulosus*). Environmental Biology of Fishes 84: 411–419.

Lee, S.I., Aydin, K.Y., Spencer, P.D., Wilderbuer, T.K., and Zhang, C.I. 2010. The role of flatfishes in the organization and structure of the eastern Bering Sea ecosystem. Fisheries Science 76: 411–434.

Lee, Y.W. and Sampson, D.B. 2009. Dietary variations in three co–occurring rockfish species off the Pacific Northwest during anomalous océanographie events in 1998 and 1999. Fishery Bulletin 107: 510–522.

Litzow, M.A. and Ciannelli, L. 2007. Oscillating trophic control induces community reorganization in a marine ecosystem. Ecology Letters 10: 1124–1134.

Lochead, J.K. and Yamanaka, K.L. 2006. Summary report for the inshore rockfish (*Sebastes* spp.) longline survey conducted in statistical areas 12 and 13, August 24–September 10, 2004. Canadian Technical Report of Fisheries and Aquatic Sciences 2627, 65 p.

Logerwell, E.A., Aydin, K., Barbeaux, S., Brown, E., Conners, M.E., Lowe, S., Orr, J.W., Ortiz, I., Reuter, R. and Spencer, P. 2005. Geographic patterns in the demersal ichthyofauna of the Aleutian Islands. Fisheries Oceanography 14: 93–112.

Love, M.S., and Schroeder, D.M. 2007. A characterization of the fish assemblage of deep photic zone rock outcrops in the Anacapa Passage, Southern California, 1995 to 2004, with evidence of a regime shift. 48: 165–176.

Love, M.S. and Yoklavich, M. 2008. Habitat characteristics of juvenile cowcod, *Sebastes levis* (Scorpaenidae), in Southern California. Environmental Biology of Fishes 82: 195–202.

Love, M.S. and York, A. 2005. A comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, southern California bight. Bulletin of Marine Science 77: 101–117.

Love, M.S. and York, A. 2006. The relationships between fish assemblages and the amount of bottom horizontal beam exposed at California oil platforms: fish habitat preferences at man–made platforms and (by inference) at natural reefs. Fishery Bulletin 104: 542–549.

Love, M.S., Schroeder, D.M. and Lenarz, W.H. 2005. Distribution of bocaccio (*Sebastes paucispinis*) and cowcod (*Sebastes levis*) around oil platforms and natural outcrops off California with implications for larval production. Bulletin of Marine Science 77: 397–408.

Love, M.S., Schroeder, D.M., Lenarz, B. and Cochrane, G.R. 2006. Gimme shelter: The importance of crevices to some fish species inhabiting a deeper–water rocky outcrop in Southern California. California Cooperative Oceanic Fisheries Investigations Reports 47: 119–126.

Love, M.S., Schroeder, D.M., Snook, L., York, A. and Cochrane, G. 2008. All their eggs in one basket: a rocky reef nursery for the longnose skate (*Raja rhina* Jordan and Gilbert, 1880) in the southern California Bight. Fishery Bulletin 106: 471–475.

Love, M.S., Yoklavich, M. and Schroeder, D.M. 2009. Demersal fish assemblages in the Southern California Bight based on visual surveys in deep water. Environmental Biology of Fishes 84: 55–68.

Lowe, C.G., Anthony, K., Jarvis, E.T., Belliquist, L.F., and Love, M.S. 2009. Site fidelity and movement patterns of groundfish associated with offshore petroleum platforms in the Santa Barbara Channel. Marine and Coastal Fisheries 1: 71–89

Lowry, D. and Motta, P.J. 2008. Relative importance of growth and behaviour to elasmobranch suction–feeding performance only early ontogeny. Journal of the Royal Society Interface 5: 641–652.

Lowry, D. Motta, P.J. and Hueter, R.E. 2007. The ontogeny of feeding behavior and cranial morphology in the leopard shark *Triakis semifasciata* (Girard 1854): a longitudinal perspective. Journal of Experimental Marine Biology and Ecology 341: 153–167.

Lundsten, L., McClain, C.R., Barry, J.P., Cailliet, G.M., Clague, D.A. and DeVogelaere, A.P. 2009. Ichthyofauna on three seamounts off southern and central California, USA. Marine Ecology Progress Series 389: 223–232.

Maloney, N.E. and Sigler, M.F. 2008. Age–specific movement patterns of sablefish (*Anoplopoma fimbria*) in Alaska. Fishery Bulletin 106: 305–316.

Marliave, J. and Challenger, W. 2009. Monitoring and evaluating rockfish conservation areas in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 66: 995–1006.

Marliave, J.B., Conway, K.W., Gibbs, D.M., Lamb, A. and Gibbs, C. 2009. Biodiversity and rockfish recruitment in sponge gardens and bioherms of southern British Columbia, Canada. Marine Biology 156: 2247–2254.

Martin, J.C. and Yamanaka, K.L. 2004. A visual survey of inshore rockfish abundance and habitat in the Southern Strait of Georgia using a shallow–water towed video system. Canadian Technical Report of Fisheries and Aquatic Sciences 2566, 52 p.

McConnaughey, R.A. and Syrjala, S.E. 2009. Statistical relationships between the distributions of groundfish and crabs in the eastern Bering Sea and processed returns from a single–beam echosounder. ICES Journal of Marine Science 66: 1425–1432.

McFarlane, G.A. and King, J.R. 2009. Movement patterns of spiny dogfish within the Strait of Georgia, p. 77–87. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

McKenzie, J. and Wynne, K. 2008. Spatial and temporal variation in the diet of Steller sea lions in the Kodiak Archipelago, 1999 to 2005. Marine Ecology Progress Series 360: 265–283.

Miller, J.A. and Shanks, A.L. 2004. Evidence for limited larval dispersal in black rockfish (*Sebastes melanops*): implications for population structure and marine–reserve design. Canadian Journal of Fisheries and Aquatic Sciences 61: 1723–1735.

Miller, T.W. and Brodeur, R.D. 2007. Diets of and trophic relationships among dominant marine nekton within the northern California Current ecosystem. Fishery Bulletin 105: 548–559.

Misarti, N., Bruce, F., Herbert, M., and Wooler, M.J. 2009. Changes in northeast Pacific marine ecosystems over the last 4500 years: evidence from stable isotope analysis of bone collagen from archeological middens. Holocene 19: 1139–1151.

Orlov, A.M. 2004. Migrations of various fish species between Asian and American waters in the North Pacific Ocean. Aqua: Journal of Ichthyology and Aquatic Biology 8: 109–124.

Orr, A.J., Banks, A.S., and Melman, S. 2004. Examination of the foraging habits of Pacific harbor seal (*Phoca vitulina richardsi*) to describe their use of the Umpqua River, Oregon, and their predation on salmonids. Fishery Bulletin 102: 108–117.

Orr, A.J., VanBlaricom, G.R., DeLong, R.L., Cruz–Escalona, V.H. and Newsome, S.D. 2011. Intraspecific comparison of diet of California sea lions (*Zalophus californianus*) assessed using fecal and stable isotope analyses. Canadian Journal of Zoology 89: 109–122.

Ostrand, W.D., Howlin, S. and Gotthardt, T.A. 2004. Fish school selection by marbled murrelets in Prince William Sound, Alaska: responses to changes in availability. Marine Ornithology 32: 69–76.

Palsson, W.A., Pacunski, R.E., Parra, T.R. and Beam, J. 2008. The effects of hypoxia on marine fish populations in southern Hood Canal, Washington. American Fisheries Society Symposium Series 64: 255–280.

Parker, S.J., Rankin, P.S., Olson, J.M. and Hannah, R.W. 2007. Movement patterns of black rockfish (*Sebastes melanops*) in Oregon coastal waters, p. 39–57. In: Heifetz, J., Dilusino, J., Gharett, A.J., Love, M.S., O'Connell, V.M. and Stanley, R.D., eds. Biology, assessment, and management of North Pacific Rockfishes. Alaska Sea Grant. Univeristy of Alaska, Fairbanks.

Parnel, M.M., Emmett, R.L. and Brodeur, R.D. 2008. Ichthyoplankton community in the Columbia River plume off Oregon: effects of fluctuating oceanographic conditions. Fishery Bulletin 106: 161–173.

Pearsall, I.A. and Fargo, J.J. 2007. Diet composition and habitat fidelity for groundfish assemblages in Hecate Strait, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 2692, 141 p.

Petrie, M.E. and Ryer, C.H. 2006. Laboratory and field evidence for structural habitat affinity of young–of–the–year lingcod. Transactions of the American Fisheries Society 135: 1622–1630.

Phillips, A.J., Ralston, S., Brodeur, R.D., Auth, T.D., Emmett, R.L., Johnson, C. and Wespestad, V.G. 2007. Recent pre–recruit Pacific hake (*Merluccius productus*) occurrences in the northern California Current suggest a northward expansion of their spawning area. California Cooperative Oceanic Fisheries Investigations Reports 48: 215–229.

Phillips, A.J., Brodeur, R.D. and Suntsov, A.V. 2009. Micronekton community structure in the epipelagic one of the northern California Current upwelling system. Progress in Oceanography 80: 74–92.

Pondella, D.J., II and Allen, L.G. 2008. The decline and recovery of four predatory fishes from the Southern California Bight. Marine Biology 154: 307–313.

Porter, S.M. 2005. Temporal and spatial distribution and abundance of flathead sole (*Hippoglossoides elassodon*) eggs and larvae in the western Gulf of Alaska. Fishery Bulletin 103: 648–658.

Preti, A., Smith, S.E. and Ramon, D.A. 2004. Diet differences in the thresher shark (*Alopias vulpinus*) during transition from a warm–water regime to a cool–water regime off California–Oregon, 1998–2000. California Cooperative Oceanic and Fishery Reports 45: 118–125.

Reilly, C.R.L. and Thompson, S.H. 2007. Temperature effects on low–light vision in juvenile rockfish (*Genus Sebastes*) and consequences for habitat utilization. Journal of Comparative Physiology A: Neuroethology Sensory Neural and Behavioral Physiology 193: 943–953.

Reum, J.C.P. and Essington, T.E. 2011. Season– and depth–dependent variability of a demersal fish assemblage in a large fjord estuary (Puget Sound, Washington). Fishery Bulletin 109: 186–197.

Reuter, R.F. and Spencer, P.D. 2007. Characterizing aspects of rockfish (*Sebastes* spp.) assemblages in the Aleutian islands, Alaska, p. 383–409. In: Heifetz, J., Dilusino, J., Gharett, A.J., Love, M.S., O'Connell, V.M. and Stanley, R.D., eds. Biology, assessment, and management of North Pacific Rockfishes. Alaska Sea Grant. Univeristy of Alaska, Fairbanks.

Reynolds, B.F., Powers, S.P. and Bishop, M.A. 2010. Application of acoustic telemetry to assess residency and movements of rockfish and lingcod at created and natural habitats in Prince William Sound. PLoS ONE 5: e12130.

Riemer, S.D. and Mikus, R. 2006. Aging fish otoliths recovered from Pacific harbor seal (*Phoca vitulina*) fecal samples. Fishery Bulletin 104: 626–630.

Robinette, D.P., Howar, J., Sydeman, W.J. and Nur, N. 2007. Spatial patterns of recruitment in a demersal fish as revealed by seabird diet. Marine Ecology Progress Series 352: 259–268.

Robinson, H.J., Cailliet, G.M. and Ebert, D.A. 2007. Food habits of the longnose skate, *Raja rhina* (Jordan and Gilbert, 1880), in central California waters. Environmental Biology of Fishes 80: 165–179.

Rodriguez–Romero, J., Palacios–Salgado, D.S., Lopez–Martinez, J., Hernandez–Vazquez, S. and Ponce–Diaz, G. 2008. Taxonomic composition and zoogeographic relations of demersal in the western coast of Baja California Sur, Mexico. Revista De Biologia Tropical 56: 1765–1783.

Rooper, C. 2008. Data report: 2006 Aleutian Islands bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–179, 239 p.

Rooper, C., and Wilkins, M. 2008. Data report: 2004 Aleutian Islands bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–185, 207 p.

Rooper, C.N., Gunderson, D.R. and Armstrong, D.A. 2004. Application of the concentration hypothesis to English sole in nursery estuaries and potential contribution to coastal fisheries. Estuaries 27: 102–111.

Rooper, C.N., Zimmerman, M. and Spencer, P.D. 2005. Using ecologically based relationships to predict distribution of flathead sole *Hippoglossoides elassodon* in the eastern Bering Sea. Marine Ecology Progress Series 290: 251–262.

Rooper, C.N., Gunderson, D.R. and Armstrong, D.A. 2006. Evidence for resource partitioning and competition in nursery estuaries by juvenile flatfish in Oregon and Washington. Fishery Bulletin 104: 616–622.

Rooper, C.N., Boldt, J.L. and Zimmermann, M. 2007. An assessment of juvenile Pacific Ocean perch

(*Sebastes alutus*) habitat use in a deepwater nursery. Estuarine Coastal and Shelf Science 75: 371–380.

Rooper, C.N., Hoff, G.R. and De Robertis, A. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Canadian Journal of Fisheries and Aquatic Sciences 67: 1658–1670.

Ruiz–Campos, G., Castro–Aguirre, J.L., Balart, E.F., Campos–Dávila, L., and Vélez–Marín, R. 2010. New specimens and records of chondrichthyan fishes (Vertebrata: Chondrichthyes) off the Mexican Pacific coast. Revista Mexicana de Biodiversidad 81: 363–171.

Sakuma, K.M., Ralston, S. and Wespestad, V.G. 2006. Interannual and spatial variation in the distribution of young–of–the–year rockfish (*Sebastes* spp): expanding and coordinating a survey sampling frame. California Cooperative Oceanic Fisheries Investigations Reports 47: 127–139.

Sakuma, K.M., Ralston, S. and Roberts, D.A. 2007. High–frequency patterns in abundance of larval Pacific hake, *Merluccius productus*, and rockfish, *Sebastes* spp., at a single fixed station off central California. Fisheries Oceanography 16: 383–394.

Schirripa, M.J. and Colbert, J.J. 2006. Interannual changes in sablefish (*Anoplopoma fimbria*) recruitment in relation to oceanographic conditions within the California Current System. Fisheries Oceanography 15: 25–36.

Schweigert, J.F., Boldt, J.L., Flostrand, L., and Cleary, J.S. 2010. A review of factors limiting recovery of Pacific herring stocks in Canada. ICES Journal of Marine Science 67: 1903–1913.

Sigler, M.F., Lunsford, C.R., Straley, J.M. and Liddle, J.B. 2008. Sperm whale depredation of sablefish longline gear in the northeast Pacific Ocean. Marine Mammal Science 24: 16–27.

Sivasundar, A. and Palumbi, S.R. 2010. Life history, ecology and the biogeography of strong genetic breaks among 15 species of Pacific rockfish, *Sebastes*. Marine Biology 157: 1433–1452.

Speckman, S.G., Piatt, J.F., Minte–Vera, C., and Parrish, J.K. 2005. Parallel structure among environmental gradients and three trophic levels in a subarctic estuary. Progress in Oceanography 66: 25–65.

Standish, J.D., White, J.W. and Warner, R.R. 2011. Spatial pattern of natal signatures in the otoliths of juvenile kelp rockfish along the Californian coast. Marine Ecology Progress Series 437: 279–290.

Starr, P.J., Krishka, B.A. and Choromanski, E.M. 2004. Longspine thornyhead random stratified trawl survey off the West Coast of Vancouver Island, September 6–23, 2002. Canadian Technical Report of Fisheries and Aquatic Sciences 2558, 81 p.

Starr, R.M., O'Connell, V. and Ralston, S. 2004. Movements of lingcod (*Ophiodon elongatus*) in southeast Alaska: potential for increased conservation and yield from marine reserves. Canadian Journal of Fisheries and Aquatic Sciences 61: 1083–1094.

Starr, R.M., O'Connell, V., Ralston, S. and Breaker, L. 2005. Use of acoustic tags to estimate natural mortality, spillover, and movements of lingcod (*Ophiodon elongatus*) in a marine reserve. Marine Technology Society Journal 39: 19–30.

Stewart, I.J. 2007. Defining plausible migration rates based on historical tagging data: a Bayesian mark–recapture model applied to English sole (*Parophrys vetulus*). Fishery Bulletin 105: 470–484.

Studebaker, R.S. and Mulligan, T.J. 2008. Temporal variation and feeding ecology of juvenile *Sebastes* in rocky intertidal tidepools of northern California, with emphasis on *Sebastes melanops* Girard. Journal of Fish Biology 72: 1393–1405.

Studebaker, R.S. and Mulligan, T.J. 2009. Feeding habits of young–of–the–year black and copper rockfish in eelgrass habitats of Humboldt Bay, California. Northwestern Naturalist 90: 17–23.

Studebaker, R.S., Cox, K.N. and Mulligan, T.J. 2009. Recent and historical spatial distributions of juvenile rockfish species in rocky intertidal tide pools, with emphasis on black rockfish. Transactions of the American Fisheries Society 138: 645–651.

Sturdevant, M.V., Sigler, M.F. and Orsi, J.A. 2009. Sablefish predation on juvenile Pacific salmon in the coastal marine waters of Southeast Alaska in 1999. Transactions of the American Fisheries Society 138: 675–691.

Taylor, I.G., Lippert, G.R., Gallucci, V.F. and Borgmann, G.G. 2009. Movement patterns of spiny dogfish from historical tagging experiments in Washington State, p. 67–76. In: Gallucci, V.F., McFarlane, G.A. and Bargmann, G.G., eds. Biology and management of dogfish sharks. American Fisheries Society. Bethesda, MD.

Thedinga, J.F., Johnson, S.W., Neff, A.D. and Lindeberg, M.R. 2008. Fish assemblages in shallow, nearshore habitats of the Bering Sea. Transactions of the American Fisheries Society 137: 1157–1164.

Tissot, B.N., Hixon, M.A. and Stein, D.L. 2007. Habitat–based submersible assessment of macro–invertebrate and groundfish assemblages at Heceta Bank, Oregon, from 1988 to 1990. Journal of Experimental Marine Biology and Ecology 352: 50–64.

Tolimieri, N. 2007. Patterns in species richness, species density, and evenness in groundfish assemblages on the continental slope of the US Pacific coast. Environmental Biology of Fishes 78: 241–256.

Tolimieri, N. and Levin, P.S. 2006. Assemblage structure of eastern Pacific groundfishes on the US continental slope in relation to physical and environmental variables. Transactions of the American Fisheries Society 135: 317–332.

Tolimieri, N., Andrews, K., Williams, G., Katz, S. and Levin, P.S. 2009. Home range size and patterns of space use by lingcod, copper rockfish and quillback rockfish in relation to diel and tidal cycles. Marine Ecology Progress Series 380: 229–243.

Toole, C.L., Brodeur, R.D., Donohoe, C.J., and Markle, D.F. 2011. Seasonal and interannual variability in the community structure of small demersal fishes off the central Oregon coast. Marine Ecology Progress Series 428: 201–217.

Trites, A.W. and Calkins, D.G. 2007. Diets of Steller sea lions (*Eumetopias jubatus*) in Southeast Alaska, 1993−1999. Fishery Bulletin 105: 234–248.

Vigilant, V.L. and Silver, M.W. 2007. Domoic acid in benthic flatfish on the continental shelf of Monterey Bay, California, USA. Marine Biology 151: 2053–2062.

Vollenweider, J.J., Womble, J. and Heintz, R.A. 2006. Estimation of seasonal energy content of Steller sea lion (*Eumetopias jubatus*) diet, p. 155–176. In: Trites, A.W., Atkinson, S.K., DeMaster, D.P., Fritz, L.W., Gelatt, T.S., Rea, L.D. and Wynne, K.M., eds. Sea lions of the world. Alaska Sea Grant. University of Alaska, Fairbanks.

Von Szalay, P., Wilkins, M. and Martin, M. 2008. Data report: 2007 Gulf of Alaska bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–189, 249 p.

Von Szalay, P., Raring, N., Shaw, F., Wilkins, M. and Martin, M. 2010. Data report: 2009 Gulf of Alaska bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–208, 247 p.

Von Szalay, P., Rooper, C., Rarin, N. and Martin, M.H. 2011. Data report: 2010 Aleutian Islands bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–215, 155 p.

Wada, T., Aritaki, M., Yamashita, Y. and Tanaka, M. 2007. Comparison of low–salinity adaptability and morphological development during the early life history of five pleuronectid flatfishes, and implications for migration and recruitment to their nurseries. Journal of Sea Research 58: 241–257.

Watson, J.R., Mitarai, S., Siegel, D.A., Caselle, J.E., Dong, C. and McWilliams, J.C. 2010. Realized and potential larval connectivity in the Southern California Bight. Marine Ecology–Progress Series 401: 31–48.

Weise, M. and Harvey, J. 2008. Temporal variability in ocean climate and California sea lion diet and biomass consumption: implications for fisheries management. Marine Ecology Progress Series 373: 157–172.

Westrheim, S.J. and Fargo, J. 2005. Bathymetric relationships of principal groundfish shelf cohabitants off West Vancouver Island and in Queen Charlotte Sound, based on demersal–trawl landing records. Canadian Technical Report of Fisheries and Aquatic Sciences 2504, 139 p.

Westrheim, S.J. and Stanley, R.D. 2006. Bathymetric distributions of Pacific Ocean perch (*Sebastes alutus*) off British Columbia. II. Size compositions, by sex and sex, ratios, for specimens caught by off–bottom and on–bottom trawl in Hecate Strait Queen, Charlotte Sound and off West Vancouver, Island, 1969–89. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2763, 104 p.

Wilson, J.R., Broitman, B.R., Caselle, J.E. and Wendt, D.E. 2008. Recruitment of coastal fishes and oceanographic variability in central California. Estuarine Coastal and Shelf Science 79: 483–490.

Womble, J.N. and Siegler. 2006. Temporal variation in Stellar sea lion diet at a seasonal haul–out in Southeast Alaska, p. 141–154. In: Trites, A.W., Atkinson, S.K., DeMaster, D.P., Fritz, L.W., Gelatt, T.S., Rea, L.D. and Wynne, K.M., eds. Sea lions of the world. Alaska Sea Grant. University of Alaska, Fairbanks.

Workman, G.D., Olsen, N., Fargo, J. and Stanley, R.D. 2008. West Coast Vancouver Island groundfish bottom trawl survey, R/V WE RICKER, May 23rd to June 19th, 2006. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2841, 83 p.

Yamanaka, K.L., Lochead, J.K. and Dykstra, C. 2004. Summary of non–halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 27 to August 11, 2003. Canadian Technical Report of Fisheries and Aquatic Sciences 2535, 83 p.

Yamanaka, K.L., Obradovichl, S.G., Cooke, K., Lackol, L.C. and Dykstra, C. 2008. Summary of non–halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from May 29 to July 22, 2006. Canadian Technical Report of Fisheries and Aquatic Sciences 2796, 58 p.

Yang, M.S. 2004. Diet changes of Pacific cod (*Gadus macrocephalus*) in Pavlof Bay associated with climate changes in the Gulf of Alaska between 1980 and 1995. Fishery Bulletin 102, 400–405.

Yang, M.S. 2007. Food habits and diet overlap of seven skate species in the Aleutian Islands. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–177, 46 p.

Yang, M.S., Aydin, K.Y., Greig, A., Lang, G. and Livingston, P. 2005. Historical review of Capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and Eastern Bering Sea. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–155, 89 p.

Yang, M.S., Dodd, K., Hibpshman, R. and Whitehouse, A. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–164, 199 p.

Yeh, J. and Drazen, J.C. 2011. Baited–camera observations of deep–sea megafaunal scavenger ecology on the California slope. Marine Ecology Progress Series 424: 145–156.

Yeung, C. and McConnaughey, R.A. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. Ices Journal of Marine Science 65: 242–254.

Zador, S., Aydin, K., and Cope, J. 2011. Fine–scale analysis of arrowtooth flounder *Atherestes stomias* catch rates reveals spatial trends in abundance. Marine Ecology Progress Series 438: 229–239.

Zenger, H.H., Jr. 2004. Data report: 2002 Aleutian Islands bottom trawl survey. U.S. Department of Commerce, NOAA Technical Memorandum NMFS–AFSC–143, 248 p.

APPENDIX H DESCRIPTION OF AVAILABLE HABITAT MODELS

1. Introduction

A model is a simplified, sometimes theoretical, representation of a real–world situation. Models, by design and circumstance, lack the complexity necessary to precisely replicate ecological systems. However, models can be useful because the empirical data required to elucidate ecosystem processes are often lacking and cannot be obtained without significant expenditures over long time periods, if at all. Models typically consist of a series of linked mathematical equations or statistical functions that are either computationally analyzed or simulated. Data (e.g., species occurrence, physical and environmental variables) are entered into a model, and model outputs (e.g., predicted habitat suitability, fluctuations in biomass and species composition) are used to improve our understanding of ecosystem processes and to evaluate or formulate management decisions. In any modeling effort, there is a trade–off between simplicity and complexity that is typically contingent on the question of interest and the amount and quality of the input data. A simple model that captures the essential features of a study system is often preferable to a more complex model that uses generalized or assumed input data. To understand the utility of a model, it is important to acknowledge that a model will not fully describe the study system correctly, no matter the degree of complexity, and to accept the possibility that many presumed interactions may not represent reality (Field 2004). Consequently, model estimates are best treated in a general sense to pinpoint major findings, key processes, points, or drivers in study systems, and to direct future research needs and priorities. It is, however, important to assess the accuracy and uncertainty of model outputs whenever possible through a variety of available methods that constitute “model validation and groundtruthing.”

This section of the report summarizes the recent contributions of three general categories of models (spatially explicit, trophodynamic, and integrated ecosystem) that are relevant to the determination and designation of EFH for West Coast groundfishes. Modeling efforts off the West Coast are mainly focused on the development and application of spatially explicit models. This emphasis reflects the creation of spatial closures, such as marine protected areas (MPAs), as a primary regulatory approach by regional managers. Management efforts in Alaskan waters are instead focused on trophic interactions and fishery harvests, and therefore trophodynamic modeling is emphasized. This difference is largely attributable to variable ecological characteristics of the primary groundfish targets between the West Coast (rockfishes) and Alaskan waters (gadids, flatfishes), and the more specific habitat–associations of the targeted West Coast fauna. In addition, ecosystem–based fishery management is much more advanced in Alaskan waters, where sections and appendices on ecosystem considerations are included in management documents (SAFE reports and FMPs) and the results of mass–balance models are used in the determination of fishery quotas. Comparable efforts are at a nascent stage off the West Coast, but are advancing rapidly through the activities of the Integrated Ecosystem Assessment and Ecosystem Planning and Development teams, as directed by the PFMC.

2. Examples of Spatially Explicit Models

2.1. Habitat Suitability Probability Model

A habitat suitability probability (HSP) model, termed the "EFH Model" (PFMC 2008), was developed in 2004 by NMFS and outside contractors in order to quantitatively evaluate EFH for West Coast groundfishes (MRAG Americas Inc. et al. 2004). The model incorporates three basic variables (benthic habitat, depth, and location) to describe and identify EFH for each life stage of federally–managed groundfishes and presents this information graphically as an HSP profile (PFMC 2005). Based on the observed distribution of a groundfish species/life–stage in relation to the input variables, each location is assigned a suitability value between 0–100% in the creation of the profile. These scores and their differences among locations are then used to develop a proxy for the areas that can be regarded as "essential" (the higher the HSP score, the more likely the location is suitable habitat for a given groundfish species/life stage). HSP profiles of each groundfish species/life stages can subsequently be combined within GIS and used to predict total groundfish EFH along the West Coast (PFMC 2005). Initial EFH Modeling efforts were incorporated into the 2008 Pacific Coast Groundfish Fishery Management Plan (FMP) (PFMC 2008), and serve as the primary basis for discussion in this section.

Input data for the model are derived mainly from NMFS fishery–independent surveys and the Habitat Use Database (HUD). NMFS surveys provide a valuable source of data on the occurrence and relative density (measured as catch per area swept by the net) of groundfishes at sampled locations (i.e., stations). Depth and latitude are routinely recorded at sampling stations, but habitat information is not collected. It was therefore decided to use NMFS survey data to develop models that incorporate depth and latitude, and to add in the effect of habitat separately, based on habitat preference information recorded in the HUD, the life history appendix of the West Coast Groundfish FMP, and from consultation with scientific experts (PFMC 2005). Several GIS layers were created to facilitate modeling efforts. One such layer (termed "physical substrate") depicts lithographic and physiographic features throughout the study region using a hierarchical system that incorporates megahabitat, seafloor induration, meso/macrohabitat, and modifier(s) (Greene et al. 1999). Another layer distinguishes biogenic habitats (e.g., canopy kelp, seagrass, structure–forming invertebrates), where data were available. Estuaries were also included as a separate "benthic habitat" layer. A single West Coast bathymetry layer was synthesized from an amalgam of sources and contoured to 10 m. Latitude was grouped into 10–minute zones for analysis. Data quality layers were created for bathymetry and physical substrate to account for uncertainty in the source data (PFMC 2005).

A Bayesian Belief Network (BBN) was chosen as an appropriate analytical tool to evaluate the probability of suitable habitat for groundfish species/life stages throughout the West Coast (PFMC 2005). A BBN is a probabilistic graphical model that represents a set of random variables (e.g., benthic habitat, depth, latitude) and their conditional dependencies (e.g., fish occurrence) via a directed graphical representation. The overall HSP is calculated from separate probabilities for each variable, which can be derived from various sources. When enough survey data are available, depth and latitude information are analyzed using a General Additive Model (GAM) with binomial (presence/absence) fish occurrence data and a logit link. Because most species/life stages lack suitable survey information, depth and latitude information are alternatively approximated from the HUD index as follows: $HUD_{index} = Depth_{index} * Latitude_{index}$, where depth and latitude indices incorporate values for absolute minimum, preferred minimum, optimum, preferred maximum, and absolute maximum (PFMC 2005). Minor differences between the substrate classification system used in the HUD and the GIS physical substrate layer were reconciled prior to analysis. In order to incorporate information about substrate preferences from the HUD into the BBN model, the following substrate suitability probability scale was used: unknown = 0.33[6], weak = 0.33, medium = 0.66, and strong = 1.00 (PFMC 2005). Habitat suitability probabilities are then calculated for substrate, depth, and latitude nodes for each polygon in the GIS. Finally, the overall suitability node calculates the estimated joint HSP value of a polygon by multiplying the benthic habitat and combined latitude/depth HSPs. Polygons are uniquely identified by their habitat type, depth range (every 10 m), and latitude range (every 10 minutes). HSP values are calculated for a given species/life stage for all the habitat polygons in the GIS, stored in a database, and plotted to form a contour plot along the entire coast (PFMC 2005).

The EFH Model provided spatially explicit HSP estimates for 160 of 328 groundfish species/life stage combinations, including the adults of all federal management unit (FMU) species (PFMC 2005, 2008). The remaining 168 species/life stages were not completed because of insufficient data. All adult, and most juvenile, stages were accounted for either by the survey data or by the information in the HUD. Of the remaining life stages to be analyzed, 84% represent eggs (n = 69), 80% represent larvae (n = 66) and 40% represent juveniles (n = 33). Among the 160 completed profiles, it was only possible to produce 36 profiles from the NMFS trawl survey data (PFMC 2005). When the HSPs of all species/life stages were combined, all waters and bottom areas at depths < 3,500 m were determined to be groundfish EFH. This designation represents a precautionary approach encompassing the maximum range of all groundfishes within the management area, based on the best scientific information (PFMC 2005). In addition to describing and identifying EFH for individual species and life stages, the EFH Model and resulting HSP values can be used to support future habitat–related management decisions. Such decisions may involve considering tradeoffs between management effects on different habitats. HSP profiles for individual species/life stages also can be combined by GIS analyses into ecosystem–level fish assemblages to investigate and predict environmental consequences of proposed projects (PFMC 2008).

Designation of West Coast EFH from the combined suite of FMU species/life stages is considered precautionary because uncertainty exists about the relative value of different habitats to individual groundfish species/life stages, and thus the actual extent of overall groundfish EFH (PFMC 2005). For example, there were insufficient data to derive habitat suitability probability (HSP) values for approximately half of the FMU species/life stages. Furthermore, the data used to determine HSP values exhibit some biases and limitations, and are subject to continued refinement.

Among the primary concerns regarding the validity of model outputs are the use of disparate data sets and data of variable quality. For example, location information was grouped into 10–minute latitudinal zones because species distributions generally exhibit only gradual changes with latitude. However, this designation is rather arbitrary and may not hold true for all species and life stages, especially in regions where input variables are heterogeneous at small spatial scales.

In addition, there are a number of FMU species and life stages that occur in the water column, and have limited association with benthic habitats. Because determining pelagic habitat associations was not feasible, HSP profiles for these species and life stages were determined solely on the basis of latitude and depth variables. Using presence/absence information to infer the location of EFH habitat is also a potential limitation of the model. A species may, for instance, have a broad depth or geographic distribution, but may only reach high densities in a limited area. Interactions between variables also were not considered, but may be significant. For example, depth distributions of groundfishes are known to vary by latitude, largely as a consequence of correlated latitudinal differences in depth–specific temperature. Although data quality layers were created to account for uncertainty in depth and physical substrate information, they have yet to be applied. In addition, probabilities derived from these layers were based on expert opinion rather than empirical information. In future modeling efforts, the sensitivity of model parameters to the assumed substrate preference probability levels should be investigated, along with the possibility of including a measure of uncertainty into the model.

A particular source of concern regarding the accuracy of EFH Model outputs is the effect of bias in survey data resulting from the nonrandom coverage of substrates (PFMC 2008). Unconsolidated substrates are preferentially sampled because trawl surveys are limited in their capability to sample rocky substrates. Species and life stages that specifically associate with such substrates are therefore likely to be under–represented in the survey data that are used to model the effects of latitude and depth. Data from alternative sources that do not exhibit similar biases, such as visual surveys conducted with submersibles, should be incorporated to more accurately model EFH for FMU species and life stages. The EFH Model and its outputs would also benefit from additional focused interaction with experts for validation of model results (PFMC 2005).

It is important to remember that although the outputs of HSP maps appear similar, the type, accuracy, and precision of the input information for each species/life stage are highly variable (PFMC 2005). HSP maps for different species and life stages should therefore not be treated with the same level of confidence. For example, the GAM models using empirical data on depth and latitude estimated true probabilities of habitat suitability for species/life stages. However, the profiles based on the HUD, which comprises far less, generalized data, provide only a relative scale of likelihood at best. The data sources for each HSP profile are provided in Appendix B, Part 1 of the 2008 Pacific Coast Groundfish FMP and should be referenced to determine the type and quality of input data (PFMC 2005). For the benthic habitat component of the model, habitat association inputs were derived entirely from the HUD and are based on index values, as previously described. Because these habitat association data are combined with the depth and latitude data in the EFH Model, the HSP profiles (whether or not the depth and latitude data were derived from the survey or the HUD) cannot be regarded as true probabilities (PFMC 2005). A future expansion of the current HSP model is necessary to better quantify uncertainty associated with variable data inputs and to display this uncertainty directly in the HSP profiles.

The EFH Model has remained static since its original construction, and no additional HSP profiles have been created or updated since the completion of the 2008 West Coast Groundfish FMP. However, modification of the model is currently underway by personnel at Oregon State University's Active Tectonics and Seafloor Mapping Laboratory, Parametrix, Robust Decisions, and Aquaterra through support of the Bureau of Ocean Energy Management (C. Goldfinger, Oregon State University, pers. comm.). The updates pertain to the Bayesian portion of the model and consist of a modified system called Bayesian Analysis for Spatial Siting (BASS). BASS incorporates the Bayesian portion of the EFH Model as an element of "ecosystem services." It combines the best available scientific, economic, and social information to produce outputs that are quantified and defensible, as well as being integrated with ecosystem components that are typically difficult to quantify, such as stakeholder engagement. BASS updates to the EFH Model are likely to be completed in early 2013. In addition, updates to the HUD (see section 3.5.4 of this report) and significant amounts of new spatial and trophic information associated with West Coast groundfish species and life stages (see section 3.3 of this report) also can be used to improve the predictive capabilities of the EFH Model.

2.2. Fish–Habitat Association Models

Accurate estimates of groundfish distributions are critical for effective spatial management through improved stock assessments and the design of MPAs. Strong, consistent benthic habitat associations of many groundfishes, in conjunction with recent advances in acoustic seafloor mapping techniques, suggest that habitat determination may serve as a proxy for predicting groundfish distribution and abundance at broad regional scales (Anderson et al. 2009). Therefore, it should be possible to model and predict these spatial patterns using habitat maps and quantified habitat relationships (Iampietro et al. 2008; Young et al. 2010). The previously described EFH Model represents one such effort to model groundfish distributions based on selected habitat variables. Some additional modeling efforts that attempt to explain or predict groundfish distributions off the West Coast recently have been published.

Most recent fish–habitat association modeling efforts off the West Coast were conducted in continental shelf waters of central California using presence/absence data. On shale beds in Monterey Bay, researchers used high–resolution multibeam bathymetry and precisely geolocated ROV observations of fish distribution to produce a preliminary genus–specific habitat suitability model for eight locally abundant rockfishes (*Sebastes* spp.) (Iampietro et al. 2005). In a follow–up study, Generalized Linear Models (GLMs) incorporating rugosity, slope, aspect, depth, and topographic position index were created for two of these species (rosy rockfish, *S. rosaceous*, yellowtail rockfish, *S. flavidus*) and used to evaluate the predictability of model estimates among locations (Iampietro et al. 2008). Additional fish–habitat studies also were conducted on groundfishes of Cordell Bank, as a result of ample data inputs and the importance of the location as a National Marine Sanctuary. Anderson et al. (2009) used canonical correlation analysis to examine relationships between a suite of groundfishes and benthic habitat variables (e.g., depth, substrate type, patch size) at multiple scales based on transect data obtained from manned submersible dives. Additionally, distribution and abundance patterns of three rockfishes (rosy rockfish; yellowtail rockfish; greenstriped rockfish, *S. elongatus*) were modeled with GLMs using georeferenced submersible transect data and seafloor variables (e.g., slope, topographic position, vertical relief) obtained from autoclassification of multibeam bathymetry (Young et al. 2010). In a more expansive study, Tolimieri and Levin (2006) used canonical analysis of principal coordinates and other associated multivariate techniques (i.e., discriminant function analysis, cluster analysis) to examine composition and variation in West Coat groundfish assemblage structure on the continental slope (200–1200 m) in relation to temperature, year, depth, latitude, and longitude. Model validation was performed for all predictive studies

(Iampietro et al. 2005, 2008; Young et al. 2010), but was not directly pertinent or incorporated for explanatory studies (Tolimieri and Levin 2006; Anderson et al. 2009).

Results of recent fish–habitat modeling efforts were generally promising in their potential application to current management efforts and for the development of future studies. On a coastwide scale, assemblage structure was strongly correlated with depth and latitude, with shallower regions exhibiting more variation in assemblage structure with latitude than deeper regions (Tolimieri and Levin 2006). The accuracy of predicted rockfish distribution in Monterey Bay was generally high (~80%) at the generic level (Iampietro et al. 2005). This result is especially interesting because the habitat suitability model included only a single data type (topographic position index) and occurrence data were pooled for eight rockfish species (Iampietro et al. 2005). A model for yellowtail rockfish generated using Cordell Bank data was comparably efficient at predicting the distribution of this species on the Monterey Bay shale beds, but a companion model for rosy rockfish proved to be unreliable (Iampietro et al. 2008). The predictive models generated by Young et al. (2010) for Cordell Bank, by contrast, were extremely accurate at predicting the distributions of all study species (model accuracy: rosy rockfish (96%), yellowtail rockfish (92%), greenstriped rockfish (92%)). The probability of occurrence of yellowtail and rosy rockfish was highest in high–relief rocky areas and lowest in low–relief, soft sediment areas, whereas the model for greenstriped rockfish exhibited the opposite pattern (Young et al. 2010). Anderson et al. (2009) determined that groundfish distribution patterns on Cordell Bank were strongly correlated with spatial location and habitat composition. At broad scales, Cordell Bank (in totality) contained the highest diversity of habitats and fishes, whereas at intermediate scales, transition zones (10–100s of m wide) between the Bank and unconsolidated regions supported a diverse and characteristic suite of fish species (Anderson et al. 2009). Fish–habitat responses were taxon–specific, and often contingent on the spatial configuration of fine scale habitats (1–10s of m) within the broader–scale landscape (Anderson et al. 2009). The results of these studies indicate that site– and species–specific habitat associations and high–resolution bathymetry data can be used to accurately extrapolate results of in situ video surveys of groundfishes across broad regions.

Although recently constructed fish–habitat models generally performed well, there are several model aspects that can be improved and some caveats to consider in their usage. It is important to recognize that predictive distribution models estimate potential rather than realized habitat suitability, which represents a more limited spatial area. The difference between potential and realized habitats may be especially pronounced for species whose populations have been greatly reduced (e.g., rockfishes) and are therefore unlikely to be habitat–limited (Iampietro et al. 2005; 2008). The discrepancy between potential and realized habitat occurs because most models rely on indirect predictor variables that are derived from bathymetric data and have no direct physiological relevance to a species' fitness (Young et al. 2010). The gap between potential and realized habitats could be narrowed if more direct physical variables (e.g., substrate type, temperature, currents) were included in the models.

The portability of models is directly contingent on accounting for all variables that may drive distribution. Otherwise, fitting a model in one location and applying it in another may produce a poor result because one or more important habitat variables were not considered. In addition, an effective model should reliably predict the absence of a species as well as its presence. Models that are overly inclusive with respect to potential explanatory variables may not accurately predict absences (Iampietro et al. 2005). The spatial and temporal scales used in modeling efforts also play a major role in the accuracy of model results. For many species, the landscape setting is an important predictor of distribution and assemblage structure in addition to fine–scale habitat associations (Anderson et al. 2009). Additionally, if habitat maps are used as surrogates of species diversity and abundance, it is crucial that the scale and type of fish responses to habitat variables are reconciled with the scale of map resolution (Anderson et al. 2009).

Finally, mention also should be made of the efforts underway by NOAAs Biogeography Branch for Oregon's Territorial Sea Project and for The Nature Conservancy to model spatial distribution of groundfishes. These efforts incorporate NMFS longterm trawl survey dataset and various variables (e.g., bathymetry, distance to shore and shelf break, location, temperature) into models of predicted biomass distribution for various groundfish species. These models are still very much under development and have yet to receive any scientific review or input. One associated bias will be the limitations of the input data set from trawl surveys, which will not adequately reflect those species primarily living in untrawlable habitats.

2.3. Biogenic Habitat Modeling

Biogenic habitat modeling techniques were developed for more data–rich, terrestrial systems, but recent increases in the quality and quantity of seafloor data have supported development and application of these models in marine benthic systems. Off the West Coast, biogenic habitat modeling recently has been used to predict distribution and abundance patterns of structure–forming marine invertebrates (e.g., corals, kelps, sponges). Structure–forming marine invertebrates (SFMI) have received considerable scientific attention because of their potential role as EFH for groundfishes and general vulnerability to human impacts.

Biogenic habitat modeling efforts relevant to the West Coast are less than 10 years old, but interest is growing and the field is rapidly advancing. Most research efforts have focused on modeling predicted coral distributions on a coastwide or global scale, using coarse taxonomic categories and presence (only) data; however, regional studies incorporating presence–absence data and more specific taxonomic categories recently have been conducted (Table 1).

Table 1. Summary of biogenic habitat modeling research conducted along the West Coast of the contiguous United States, including global studies with a West Coast component. Taxonomy = level of taxonomic distinction (common name); Method = general modeling method; Validation = model validation conducted (yes or no); Abbreviations: Chl a = chlorophyll a concentration at surface, GLM = Generalized Linear Model, ENFA = Ecological Niche Factor Analysis, Maxent = Maximum Entropy Modeling, RBNM = Regression-Based Niche Model.

Biogenic Habitat(s)	Taxonomy	Study Region	Data Type	Variables	Method	Validation	Source
Stony corals	Order	Global	Presence	Several (chemical, biological, physical)	ENFA	Yes	Clark et al. 2006
Gorgonian corals	Family	West Coast	Presence	Chl a, current velocity, depth/slope, temperature	ENFA	Yes	Bryan and Metaxas 2007
White cup coral	Species	Global	Presence	Several (chemical, biological, physical)	ENFA	Yes	Davies et al. 2008
Stony corals	Order	Global	Presence	Several (chemical, biological, physical)	ENFA, maxent	Yes	Tittensor et al. 2009
Stony corals	Order, species	Global	Presence	Several (chemical, biological, physical)	Maxent	Yes	Davies and Guinotte 2011
Black corals, stony corals	Order, suborder	West Coast	Presence	Several (chemical, biological, physical)	Maxent	Yes	Guinotte and Davies, in press
Giant kelp	Species	Southern California	Presence/absence	Several (geomorphology/glacial forcing, kelp ecophysiology, oceanography)	RBNM	No	Graham et al. 2010
Hydrocorals, gorgonian corals	Genus	Cordell Bank	Presence/absence	Aspect, depth, topographic position, rugosity, substrate, slope	GLM	No	Etherington et al. 2011
Brittle stars, stony corals, hydroids, sea pens	Class, order	Santa Barbara Channel	Presence/absence	Depth, region, substrate	GLM	Yes	Krigsman et al., in press

Presence–only data have been used to model coral distributions throughout the West Coast, primarily in deep–water (> 200 m), including seamounts. The primary objectives of modeling efforts were to determine the relative importance of environmental factors on coral distributions, create habitat suitability maps, and fill sampling gaps in distribution patterns through model predictions. The overall goal of these efforts was to provide information for the assessment of potential impacts and the development of conservation measures. Two global studies have focused on predicting distributions of stony coral (Order: Scleractinia) on seamounts (Clark et al. 2006; Tittensor et al. 2009). Similar global studies were conducted at species (i.e., *Lophelia pertusa*) and ordinal (e.g., Scleratinia) levels (Davies et al. 2008; Davies and Guinotte 2011). Several studies modeled distributions of corals at regional scales that included the entire West Coast at a variety of taxonomic levels (Table 1). In these studies, physical (e.g., depth, temperature), chemical (e.g., dissolved oxygen, salinity), and biological (e.g., primary productivity, export primary productivity) oceanographic data were combined from a variety of sources. Early modeling efforts used Environmental Niche Factor Analysis (ENFA), which compares the observed distribution of a species or taxon to the background distribution of a variety of environmental factors. This type of analysis estimates the environmental niche of a taxonomic group, identifies the relative difference between the niche and the mean background environment, and reveals the environmental variables that are most important in determining distribution (Clark et al. 2006). More recent efforts, however, have used maximum entropy modeling (Maxent), because it generally outperforms ENFA and other presence–only techniques (Davies and Guinotte 2011). Maxent is derived from the principle that the best approach to approximating an unknown probability distribution is to maximize entropy, subject to constraints (e.g., presence data for the organism andassociated environmental data) representing incomplete information (Tittensor et al. 2009).

Suitable habitat for stony corals has been predicted between 750–1250 m on seamounts in the North Pacific in highly oxygenated areas with high levels of aragonite saturation (used for skeletal formation) and low levels of dissolved inorganic carbon, nitrate, phosphate and silicate (Clark et al. 2006; Tittensor et al. 2009). Although many records exist from the North Pacific, no occurrences of *L. pertusa* were predicted from modeled distribution of this species (Davies et al. 2008), probably because the great majority of occurrence records were located in the North Atlantic. Similarly, patterns of habitat suitability of stony corals on seamounts largely reflected current biogeographical knowledge (Tittensor et al. 2009). Using global data gridded at ~1 km^2, Davies and Guinotte (2011) determined that the most important factors influencing stony coral habitat suitability were depth, temperature, aragonite saturation, and salinity. The North Pacific was found to have little scleratinian coral habitat outside of seamounts (Davies and Guinotte 2011). Between British Columbia and California, depth and chlorophyll–a concentration were the best predictors of Primnoidea distribution whereas depth, temperature, slope, and water currents best predicted Paragorgiidae distribution (Bryan and Metaxas 2007). Both families were expected to occur in areas of complex topography, mainly along the shelf break and on seamounts. Slope, temperature, salinity, and depth were important predictors for most modeled distributions of antipatharian and scleratinian corals (Guinotte and Davies, 2012). All studies performed model validation (typically cross validation techniques) of habitat suitability maps, with all models reported to perform well.

Modeling efforts that used presence–only data estimated regions of greatest habitat suitability and defined important, related variables; however, results may merely represent correlations. Furthermore, such efforts are biased by a variable amount of input data among regions and the aforementioned lumping of taxa that have diverse habitat requirements. Model validation does not address these biases or the accuracy of predictions; it simply determines if the model is a good predictor given the input data. Field studies and independent data sets are necessary to groundtruth model predictions, but were not conducted for any of the referenced studies. Until results are groundtruthed through field studies, they should be interpreted cautiously, especially when used as a basis for policy decisions.

Presence–absence data of a variety of SFMI and giant kelp in California waters have been used to develop potentially more reliable biogenic habitat modeling efforts compared to those based on presence–only information. Graham et al. (2010) used a niche–based model to predict millennial–scale variability in the distribution and productivity of southern California giant kelp forests since the last glacial maximum. Etherington et al. (2011) and Krigsman et al. (2012) developed predictive models using presence/absence of corals and other SFMI on Cordell Bank and in Santa Barbara Channel, respectively, and mapped distributions of these organisms. Input data ranged in quantity and type from a relatively small number of physical variables (depth, location, and substratum type; Krigsman et al. 2012) to myriad physical, oceanographic, and physiological variables. All studies used some form of regression analysis to link independent and explanatory variables, which provided much more robust results than the previously described correlative methods. Graham et al. (2010) determined that late Quaternary climate change probably caused high millennial variability in the distribution and productivity of kelp forests. Examination of the occurrence of coral species by habitat and spatial distribution on Cordell Bank indicated that hydrocorals (*Stylaster* spp.) and gorgonians (*Swiftia* spp.) occupied different niches (Etherington et al. 2010). More specifically, hydrocorals were associated with shallow, hard substrate, high sloping habitats, whereas the more broadly distributed gorgonians had affinity to deeper, low sloping habitats and a diversity of substrate types. In the Santa Barbara Channel, cup corals (Scleratinia) and hydroids had high probabilities of occurrence in areas of hard substrate, whereas short and tall sea pens were predicted to occur on unconsolidated and mixed sediment (Krigsman et al. 2012). Brittle stars were predicted to occur throughout the Channel on a variety of substrates.

Model predictions were highly accurate for most studies based on presence–absence data, although results were not typically validated or groundtruthed. The predicted size and distribution of contemporary giant kelp forests closely matched known distributions based on remote sensing surveys (86% agreement at 10 m resolution), providing support for the accuracy of the model, although no specific validation tests were conducted (Graham et al. 2010). Although kelp forests are much more dynamic than most SFMI, this model could have applications in predicting future kelp forest distributions if accurate data inputs can be provided. Predictive accuracy and model validation were not conducted for deep–sea corals on Cordell Bank, as preference was given to creating a more robust model given data limitation in this preliminary study (Etheridge et al. 2010). The lack of these procedures does, however, mitigate the reliability of predictive results. Predictive accuracy was high (75–89%) for SFMI in Santa Barbara Channel and model performance, estimating area under the characteristic curve (AUC), ranged from acceptable (0.76) to excellent (0.91) (Krigsman et al. 2012). Results of this study should be useful for marine spatial planning and ecosystem–based management, as the authors suggest, and for assessing the effectiveness of EFH closures and other MPAs. Although presence–absence data are certainly preferred, model validation and groundtruthing of results are critical to the interpretation of these models. Where possible, model validation and groundtruthing can be accomplished by retaining some data from a particular time period or region and then comparing predicted with observed distributions.

Modeling techniques may provide the best available estimates of distribution, abundance, and habitat characteristics for SFMI. However, many limitations and challenges exist that may impact the accuracy of model results. For instance, although environmental variables are often highly correlated (e.g., temperature and depth) no method currently exists for incorporating the effects of spatial autocorrelation for presence–only models (Tittensor et al 2009). Another problem inherent to presence–only models is that occurrence data may not accurately capture the complete environmental range of the taxon being modeled. Several methods have been developed to evaluate the predictive capabilities of presence–absence models, but techniques to gauge the performance of presence–only models are largely unavailable. Presence–absence data are preferred but absence data is often unreliable because: 1) the majority of research expeditions target areas of known SFMI abundance, 2) sampling methodologies often vary between expeditions, and 3) the patchiness of deep–sea habitats limits confidence for assessing the absence of SFMI (Davies et al. 2008). In addition, the geographical coverage and resolution of taxonomic occurrence are primary constraints to both presence–only and presence–absence models.

The selection of appropriate spatial and temporal resolutions for environmental data sets is also an important factor when constructing habitat suitability models (Davies and Guinotte 2011). Coarse–resolution models can miss important features (e.g., seamounts, canyons) that may be important to SFMI, but data necessary for high–resolution models are typically unavailable. Some studies use interpolation to fill in data gaps for high–resolution models, but this process introduces an unquantifiable source of error. Different types of environmental data also typically span multiple temporal and spatial scales and are collected with varying, usually unknown, levels of accuracy (Guinotte and Davies 2012). Even when high–resolution data exist, predictive maps cannot be viewed as distribution maps since the actual presence of modeled taxa is not known and potentially important variables (e.g., substrate) may not be incorporated (Guinotte and Davies 2012). Habitat suitability models therefore generally over–predict distributions of SFMI. Groundtruthing of predictive maps through field validation is necessary to: 1) assess the accuracy of model predictions, 2) refine models by identifying false positives, and 3) gauge the utility of models for identifying SFMI in unsurveyed areas for management actions (Davies and Guinotte 2011).

Because of the noted biases, concerns, and limitations, care should be taken when using modeling results for management and conservation purposes. Presence–only models could be useful as predictive tools to plan future research, but too much uncertainty exists to rely solely on presence–only model estimates for EFH designation. Results obtained from validated presence–absence models are more useful for planning and management purposes because they provide a measure of variability and can inform decisions based on different levels of acceptable risk (Etheridge et al. 2010). Presence–only data necessitate broad–scale investigations. By contrast, model efforts that use presence–absence data are typically conducted at scales of 1s to 10s of meters (Graham et al. 2010; Etheridge et al. 2010; Krigsman et al. 2012). Therefore, although presence–absence models are more useful for planning and management purposes, such applications will be limited to specific regions until more robust, widespread data are available. Where applied, however, there are several ways that presence–absence biogenic habitat models can aid our ability to make informed management decisions. Model estimates can (and have) been used: 1) to choose a target location for the placement of an oceanographic instrument mooring that would minimize the impact to sensitive benthic communities, 2) to determine appropriate locations for monitoring or experimental work, and 3) to evaluate the importance of existing EFH conservation zones for SFMI (Etheridge et al. 2010).

3. Examples of Trophodynamic Models

3.1. Ecopath with Ecosim

Ecopath, typically coupled with the dynamic companion model Ecosim, has become the standard for trophodynamic modeling not only off the West Coast but also throughout the world's marine and freshwater regions. The initial model was developed by Polovina (1984), then expanded and provided as a software application by scientists at the University of British Columbia (Christensen and Pauly 1992). Ecopath is a static (typically steady–state) mass balance model of trophic structure that integrates information from diet composition studies, bioenergetics models, fisheries statistics, biomass surveys, and stock–assessments (Field 2004). It represents the initial or reference state of a food web. Ecosim is a dynamic model in which biomass pools and vital rates change through time in response to simulated perturbations. Different species or functional groups are represented in Ecopath as biomass pools with their relative sizes regulated by gains (consumption, production, immigration) and losses (mortality, emigration). Biomass pools are typically linked by predation, though in some cases reproduction and maturation information also is included. In this model, fisheries act as super–predators, removing biomass from the system. In terms of model structure, Ecopath is composed of a series of linear equations that describe biomass flow into and out of discrete biomass pools. In Ecosim, the biomass pools are dynamic and controlled by coupled, differential equations that stem from the general linear equations used by Ecopath. The Ecopath model framework allows investigators to evaluate how well conventional wisdom about a system of interest holds when basic bookkeeping tools are applied, to pool together species and into a coherent food web, and to evaluate trophic interactions (Field 2004). The combined model allows users to simulate ecological or management scenarios, such as the response of the system to changes in primary productivity, habitat availability, climate change, or fishing intensity (Harvey et al. 2010). Ruzicka et al. (2007), Harvey et al. (2010), and Field (2004) provided examples of the application of this model to the West Coast.

Seasonal food web models were developed within the Ecopath framework (Ruzicka et al. 2007), to investigate the trophic role of large jellyfish in the Oregon inner–shelf ecosystem. Determining the trophic role of large jellyfish within the Northern California Current (NCC) upwelling ecosystem is important because increases in jellyfish biomass have been documented in many other marine ecosystems with a typical corresponding decrease in fish biomass. Off Oregon, upwelling–favorable winds typically persist from early spring to early fall. The seasonal models therefore represented spring (April–June) and summer (July–September) during a composite time period from 2000–2002. The model domain extended from 46.0° N to 41.8° N (excluding the mouth of the Columbia River) and from the shoreline to 125 m. Information about fish and jellyfish biomass, distribution, and diet was derived from a variety of pelagic trawl surveys and the NMFS bottom–trawl survey, whereas information about lower–trophic level production was obtained from zooplankton survey data. Benthic food web information was modified from preexisting, annual–scale models of the NCC (Field 2004; Field and Francis

2005; Field et al. 2006). The pelagic food web was developed from a variety of quantitative and qualitative sources (e.g., fish and plankton surveys, fishery records, literature). Each model consisted of 48 consumer groups, two egg groups, and three detritus groups.

Model results indicated that pelagic organisms dominate energetics in the NCC system but the trophic impacts of large jellyfish appear to be slight. From spring to summer, ecosystem biomass doubles in size and total energy flow nearly triples in size. Zooplankton (e.g., copepods, euphausiids, pelagic amphipods) and benthic invertebrates (e.g., pandalid and benthic shrimp, Dungeness crab) dominate the system and account for 88% of the energy flow during both seasons. However, the pelagic subsystem was estimated to be five times larger than the benthic subsystem in terms of biomass. In the spring, jellyfish are modest consumers of zooplankton (16%) and forage fishes (e.g., anchovies, herring) dominate in terms of biomass and consumption (64%). By late summer, jellyfish become the primary zooplankton consumer (39%) with forage fishes relatively less important (27%). Jellyfish are the primary consumers of euphausiid eggs and larvae and small jellyfish, whereas fishes are the primary consumers of adult euphausiids, macro–zoolplankton, and pelagic amphipods. Jellyfish appear to divert zooplankton production away from upper trophic levels because they have few predators. However, zooplankton does not appear to be a limiting resource in this region, with approximately 40–44% of total biomass unconsumed and lost to detritus. Impacts of jellyfish predation and competition therefore appear to be slight and are probably limited to local areas of high jellyfish abundance and low zooplankton abundance. Moreover, jellyfish may provide a substantial nutrient input to the benthic food web when medusa die and sink to the benthos.

A dynamic mass–balance model was recently constructed to evaluate food web structure in the central basin of Puget Sound (Harvey et al. 2010). The model is ultimately intended to identify meaningful indicators that can be used to monitor the efficacy of management decisions, quantify risk, and generate alternative ecosystem management scenarios. The Ecopath model comprised 65 functional groups, including: primary producers, invertebrates, vertebrates, detrital groups, and fisheries. Data necessary to generate Ecopath equations for each functional group were derived from the primary literature, stock assessments, technical reports, unpublished data, and consultation with experts through a series of workshops. Data inputs were restricted to 1990–2010 so that results reflected contemporary conditions. Parameter estimates were developed for biomass, production, consumption, fishery losses, and diet composition and modified iteratively in Ecopath to achieve mass–balance. The Ecopath model provided general, descriptive information on biomass allocation, functional group diversity, energy flow, and mortality. The basic model was then evaluated on the basis of a series of scenarios using Ecosim to examine model responses to changes in the biomass of key functional groups (phytoplankton, Bald Eagles) and to changes in fishing mortality.

Model outputs indicated that the Puget Sound system is dominated by species and guilds associated with benthic habitats. Approximately 70% of standing biomass is associated with benthic regions, with benthic invertebrates (55%) and groundfishes (13%) dominant. Zooplankton functional groups represent the largest contribution to total pelagic biomass (29%), and less than 2% of total biomass is composed of species and guilds that are considered to make extensive use of benthic and pelagic regions (e.g., pinnipeds, seabirds, squids). Most (68%) living biomass is present in just seven functional groups: infaunal bivalves, soft infauna, geoducks, phytoplankton, small crustaceans, ratfish, and copepods. Throughput, the sum of all biomass or energy flows that enter and exit a functional group during a unit of time, was dominated by phytoplankton and detritus (67%). High–energy throughput in the pelagic community therefore compensates for its lower biomass. Bottom–up dynamics strongly influence trophic flows. However, there are some examples of top–down control, and bald eagles appear capable of eliciting trophic cascades by regulating populations of other upper–trophic level seabirds. Current levels of fishing mortality seem to be sustainable, in part because of contemporary declines in commercial catches. However, poor accounting of recreational harvests resulted in underestimates of fishing mortality, at least for some groups. In addition, the present composition of the Puget Sound system may have been impacted by past fishing pressure that was unaccounted for in the contemporary model.

Field (2004) developed the most comprehensive and extensive food web model off the West Coast (see also Field and Francis (2005) and Field et al. (2006)). The modeled area includes the entire region between Cape Mendocino to Vancouver Island, from 55–1280 m. Two Ecopath models of the NCC were developed, one representing a period prior to the most intensive levels of regional fishery exploitation (1960s), and the other representing a period following substantial growth in fishery effort and landings, as well as substantial environmental changes (1990s). The final Ecopath models included 63 organismal functional groups, of which 33 were commercially important fishes and invertebrates, 11 were seabirds or mammals, 4 were phytoplankton or detritus, and 15 represented broad aggregations of zooplankton, benthic fauna, and non–commercial fishes. Seven fisheries also were included. Biological and fishery model parameters were derived from a variety of groundfish, pelagic nekton, zooplankton, and benthic invertebrate surveys, peer–reviewed and grey literature, unpublished data, monitoring and prior modeling results, stock assessments, and existing biomass surplus models. Oceanographic and climate data were obtained from research surveys and monitoring programs, including GLOBEC data. Static Ecopath models were projected forward in time using Ecosim with variable estimates of fisheries effort, fishing mortality and climate characteristics, and model fitting to stock assessment results and survey information. This approach is particularly relevant to the evaluation of consistency between observed trends and results from single species assessments and commonly held notions of ecosystem abundance, productivity, interactions and behavior (Field 2004).

A variety of insights and interesting findings resulted from balancing the NCC Ecopath models and subsequent dynamic simulations. Ecopath model results suggested a shift in major sources of predation for long–lived and slow–growing fishes (e.g., rockfishes) from piscivorous fishes (e.g., sablefish, lingcod, large rockfishes) in the 1960s to fisheries (and moderate increases in marine mammal predation) in the 1990s. Much of the observed variability in existing single–species models and dynamics were replicated in Ecosim simulations, which lent validity to both efforts. Model performance was significantly improved when climate was introduced as a driving force, indicating that NCC system dynamics are mainly driven by bottom–up processes. With regard to component species, Pacific hake were determined to be of great significance as both a predator and competitor of other ecosystem components. For example, Pacific hake and salmon (combined groups) displayed highly competitive interactions with both preying heavily on euphausiids and forage fishes, although the biomass and landings of Pacific hake dwarfed those of salmon. Consequently, throughout the modeled period, there was a slight increase in salmon populations when Pacific hake fishery mortality was included. Pacific hake were determined to be the main source of mortality of the pink shrimp, accounting for ~40% of total shrimp mortality even during periods of peak Pacific hake harvests. By contrast, fisheries accounted for ~20% of pink shrimp mortality. The observation that thornyheads (esp. longspine thornyhead) are a key prey item of sablefish, as suggested by several food habit studies, was found to be inconsistent with the estimated abundance, consumption, and production data for both species and appears to be largely a consequence of net feeding and biases inherent to available dietary studies. Ecopath and Ecosim models suggested that strong interspecific interactions have not played a large role in determining the dynamics of many NCC food web components. This is to be expected in a system that is historically dominated, in part, by long–lived groundfishes that have low natural mortality rates indicative of low predation rates and weak trophic interactions (e.g., generalist diets) (Field 2004).

Although each modeling effort provided important information for an improved understanding of ecosystem dynamics, there are some significant limitations to food web modeling in general, and to these studies in particular, that must be considered. The most pervasive shortcoming of food web models is a lack of adequate data. There simply is not enough known about most ecosystems to accurately parameterize Ecopath with Ecosim models (Field 2004). Unknown parameters are fitted based on known parameters to balance equations, but this process is possible when only a single parameter is unknown. Myriad assumptions must be made simply to estimate "known" parameters in most cases because input data are often either unavailable or of variable type and quality. For example, in the Ruzicka et al. (2007) study: 1) numerical diet information was used as a proxy for weight information, which is required in Ecopath; 2) gelatinous zooplankton were underrepresented in input diet studies because they digest rapidly; 3) the nutritional value of jellyfish was assumed to be comparable to that of fishes, crustaceans, and other organisms when it is known to be substantially less; 4) catchability estimates were assumed for each functional group from survey data; 5) best guess estimates were made for several biomass, population growth, and immigration/emigration estimates; and 6) production export by Ekman transport was neglected in the model although it is known to be considerable in upwelling regions. Major data gaps in the Harvey et al. (2010) study include: lack of robust biomass estimates for most functional groups, poor evidence for interaction strengths among food web components, empirical estimates of recreational fishing mortality, and a lack of diet information for a representative range of seasons, sizes, depths, and habitats. The specified limitations are not unique to these studies but are rather typical in food web model construction. In addition, because there is no spatially explicit component to the Ecopath/Ecosim model, data are integrated across the chosen study region. The consequence of this limitation is that organisms that may not co–occur are linked in the model. Food habit information is intended to be the main source of resolution for this issue. It is therefore important that dietary information is robust. However, incongruous spatial and temporal coverage coupled with uneven and often inadequate sample sizes are common limitations of diet information. For example biases in food habitat sampling were demonstrated to overemphasize tight coupling in sablefish and thornyhead populations (Field 2004). A spatially explicit companion module, Ecospace (Christensen et al. 200), is available but has rarely been applied because adequate data are largely unavailable to accommodate this model component. In addition, ontogenetic changes in diet are almost universal in fishes and therefore different life stages should be used in modeling efforts when appropriate data are available.

<u>3.2 Other Predator–Prey Modeling Efforts</u>

There have been a few directed, recent modeling efforts on predator–prey interactions that are relevant to an improved understanding of Pacific groundfish EFH. As previously stated, one of the primary limitations to current fish–habitat models is a lack of ecological information that may be of considerable importance in determining distribution patterns. Predation and competition are two such processes that warrant consideration. For instance, a model including predatory and competitive interactions predicted two alternative stable states for overfished rockfishes: one in which the overfished species (in this case, yelloweye rockfish, *S. ruberrimus*) dominated, and one in which the prey (pygmy rockfish, *S. wilsoni*) dominated (Baskett et al. 2006). The model predicted that a much larger fishing closure (marine reserve) was necessary for the overfished species to recover and dominate when predatory and competitive interactions were included than when these interactions were ignored.

An evaluation of the relative magnitude of predation and habitat effects on the distribution of a common prey type, dwarf rockfishes (e.g., Pygmy Rockfish, *S. wilsoni*; Halfbanded Rockfish, *S. semcinctus*), did not show a marked predator effect (O'Farrell et al. 2009). However, this result was influenced by the contribution of southern California MPAs that had not fully recovered the biomass of predator species. A *de facto* MPA off central California exhibited high densities of large, predatory rockfishes and a paucity of dwarf species, but sample size limitations precluded a direct, quantitative assessment (O'Farrell et al. 2009).

4. An Example of an Integrated Ecosystem Model

<u>4.1. Atlantis Model</u>

The primary tool used in integrated ecosystem modeling (especially in Australia and the United States) is the Atlantis Model, developed by Elizabeth Fulton at Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) (Fulton et al. 2004). Although it was originally focused on biophysical and fisheries aspects of an ecosystem, Atlantis has been further developed to consider all parts of marine ecosystems (i.e., biophysical, economic and social). All integrated ecosystem models require massive data inputs and must therefore strike a balance between simplicity and complexity, or tractability and realism. The systematic exploration of the optimum level of model complexity is one of the key strengths of the Atlantis Model, and it has been consistently evaluated as the best available integrated ecosystem model (e.g., Plagányi 2007). It can be used to identify which aspects of spatial and temporal resolution, functional group aggregation, and representation of ecological processes are vital to model performance. The modeling approach primarily has been used to address fisheries management questions (e.g. appropriate strategic management options for regional fisheries), but increasingly is being implemented to consider other facets of marine ecosystem use and function (CSIRO 2011).

In terms of structure, the Atlantis Model is composed of a series of linked sub–model, or modules. It contains a deterministic biophysical sub–model, coarsely spatially–resolved in three dimensions, which tracks nutrient flows through the main biological groups in the system. The primary ecological model components are: consumption, production, waste production, migration, predation, recruitment, habitat dependency, and mortality. Trophic resolution is typically set at the functional group level. Invertebrates are usually represented as biomass pools, whereas vertebrates are represented using an explicit age–structured formulation. The physical environment is also represented explicitly, via a set of polygons matched to the major geographical and bioregional features of the simulated marine system Biological model components are replicated in each depth layer of each of these polygons. Movement between polygons is represented by advective transfer or by directed movements depending on the variable in question. Atlantis also includes a detailed industry (or exploitation) sub–model. This module addresses the impact of pollution, coastal development and broad–scale environmental change, and is also focused on the dynamics of multiple fishing fleets. Atlantis is also capable of including explicit handling of economics, compliance decisions, exploratory fishing and other complicated real world concerns such as quota trading. The exploitation model interacts with the biotic part of the ecosystem, but also supplies ‘simulated data’ to the sampling and assessment sub–model. This module is designed to generate sector dependent and independent data with realistic levels of measurement uncertainty evaluated as bias and variance. These simulated data are based on the outputs from the biophysical and exploitation sub–models, using a manually–specified monitoring scheme. The data are then incorporated into the same assessment models used in the real world, and the output is fed into a management sub–model. This last sub–model is typically a set of decision rules and management actions that can be drawn from an extensive list of fishery management instruments (e.g., gear restrictions, quotas, spatial and temporal zoning, bycatch mitigation) (CSIRO 2011).

The Atlantis framework was recently used to construct a preliminary spatially explicit ecosystem model of the NCC (Horne et al. 2010), and is a fundamental tool in use by the Integrated Ecosystem Assessment Team to meet the goals of the Ecosystem Plan Development Team. Field’s (2004) food web model was incorporated as the foundation for model creation, building on prior results and parameterization. The addition of a spatially explicit component will allow users to test hypotheses concerning migrations, movement behavior, and spatial management options that are not possible with the original food web model. The study domain extended from the US/Canadian border to Point Conception and from nearshore waters to the 1200 m isobath. Trophic dynamics of 54 functional groups (i.e., habitat–forming species (e.g., kelp, corals, sponges), phytoplankton, detritus, zooplankton, invertebrates, and fishes) were included, using nitrogen as a common currency between groups. The model was divided into 62 three–dimensional spatial zones, with $\leq$ 7 depth layers per zone. Data for model parameters were derived from a variety of sources in addition to Field (2004), with vertebrate life history parameters drawn from the literature, fish biomass estimates taken from stock assessments and NMFS trawl surveys, and marine mammal biomass estimates incorporated from stock assessments. Initial model conditions were based on data from approximately 1995–2005. A 42–year period without fishing was then simulated forward to reach a quasi–equilibrium unfished state. The unfished scenario was used to compare predictions of the Atlantis Model with those generated by existing single–species stock assessments. The model was driven with hydrodynamic flows, salinity, and temperature outputs from a high–resolution regional ocean sub–model to allow the investigation of impacts that climate–driven changes in upwelling or coastal currents have on nutrients and primary production. Later versions of the model will incorporate fisheries and other anthropogenic effects and fitting to historical time series, and will ultimately be used to evaluate management strategies and decisions (Horne et al. 2010).

The Atlantis Model was able to recreate expected growth, abundance, and seasonal parameters for most functional groups in the NCC (Horne et al. 2010). Abundance of large and small phytoplankton fluctuated seasonally as expected, based on light intensity and nutrient availability from advection. However, seasonal mean phytoplankton abundance increased to unrealistic levels, signaling that some nutrient availability was overstated in the model. Most zooplankton groups showed similar seasonal trends, tracking fluctuations in primary production. By contrast, benthic invertebrate populations were less affected by seasonal variation in phytoplankton abundance. Amphipods, bivalves, and barnacles went extinct and shrimp and octopus declined to low levels as their predators (e.g., finfish) increased. These results were overly extreme and cannot be considered to effectively replicate the natural dynamics of these groups. Vertebrates exhibited strong seasonal changes in biomass due to annual recruitment, growth, and migration. Most vertebrate groups reached equilibrium by the end of the 42–year model run, with the exception of mid-water rockfish, which experienced an increase in predation after 25 years. A lack of fishing mortality resulted in increased biomass of vertebrates and especially rockfishes, flatfishes, and marine mammals. Recovery of depleted large rockfish was rapid (< 10 years) relative to expectations, probably as a result of excessively optimistic recruitment parameters. Trophic effects were evident for some fishes. Small planktivores (e.g., anchovies), deep vertical migrators (e.g., myctophids), and nearshore demersal fishes (e.g., white croaker) declined as a result of increasing predator populations. Large demersal fishes (e.g., lingcod) showed an increasing trend like species recovering from depletion.

The efforts of Horne et al. (2010) represent an initial effort to produce an integrated ecosystem model for the NCC. The model is currently being refined and expanded by the Integrated Ecosystem Assessment Team to address limitations and enable its use in management strategy evaluation. Ongoing work is focused several model components. Biomass of primary producers and invertebrates was difficult to regulate because good calibration targets were lacking. Macroalgae, benthic filter feeders, and benthic grazers were particularly sensitive and went extinct within a few years of simulation. Attempts to resolve these problems resulted in extinction of alternate groups. Large phytoplankton, microzooplankton, large carnivorous zooplankton, and shrimp showed large but bounded fluctuations, whereas other functional groups (e.g., large megazoobenthos) continued to increase indefinitely. Difficulties in calibrating primary producer and invertebrate biomass reflect the relative lack of data for these groups compared to the fish, mammal, and bird species that are the focus of the model and may be problematic until such data deficiencies are resolved. Large and small planktivorous fishes also were difficult to model, as their historical fluctuations likely reflect responses to large–scale climactic variation rather than fishing or direct trophic effects. Recruitment responses to climate drivers are difficult to model in Atlantis with the recruitment routines currently in use (e.g., Beverton–Holt stock recruitment relationship). Future simulations using the suite of spawning and recruitment options already implemented for Australian Atlantis models could enable a linkage between recruitment and climate and thereby model these groups more effectively. Other groups such as large demersal predators and hake did not effectively track historical fishing pressure. For large demersal predators, the very strong declines projected in the historical Atlantis Model may be tied to slight underestimates of the productivity of this stock whereas the difficulties with hake most likely stem from the large amount of time they spend outside of the model domain.

Regardless of these limitations, the Atlantis Model has considerable promise to help characterize the efficacy of management actions within the NCC ecosystem. Although no model will ever perfectly replicate ecosystem processes in nature, the NCC Atlantis Model has been calibrated and tested under a wide variety of conditions, and is believed to produce an adequate representation of ecosystem dynamics (Horne et al. 2010). Addressing the specified model limitations should considerably improve the reliability of the model. Once refined, the NCC Atlantis Model is expected to be a powerful management tool, providing a platform to address important hypotheses relating to the effects of perturbations (e.g., fisheries exploitation), characterize the potential trade–offs of alternate management actions, and test the utility of ecosystem indicators for long–term monitoring programs (Horne et al. 2010). Ultimately, the model should have substantial utility in identifying which policies and methods have the most potential to inform ecosystem–based management on the U.S. West Coast.

5. Discussion

Modeling efforts are being developed to meet NOAA's overall management goals and to specifically inform policy decisions regarding the determination and designation of EFH. These efforts have advanced substantially since the last West Coast groundfish FMP. Although the construction and application of spatially–explicit, trophodynamic, and integrated ecosystem models mainly have been prompted by management needs, recent modeling studies have been facilitated by a considerable increase in the amount of available input data. Long–term NMFS surveys are an important source of biological data on species occurrence, biomass, and population changes. However, rapid advances in the collection and quality of seafloor acoustic data are the main drivers of contemporary modeling efforts in the marine demersal environment.

Considerable progress has been made in modeling ecosystem dynamics off the West Coast, but improvements in model performance are necessary for more accurate outputs. The EFH Model that was developed for the last West Coast Groundfish FMP represents a considerable upgrade over previous qualitative evaluation efforts, but has many flaws and limitations that should be addressed prior to future modeling efforts. Incorporating the BASS system should improve some aspects of model performance. Fish–habitat association models show great promise, especially in continental shelf and upper slope regions where many submersible, ROV, and AUV studies have been conducted and widespread coverage of multibeam bathymetry and other seafloor data now exist. Biogenic habitat models lag somewhat behind fish–habitat association models, largely as a result of greater data limitations. This situation has resulted in a proliferation of modeling efforts using presence–only data and coarse taxonomic resolutions. Using low–resolution taxonomic categories theoretically enables greater predictability than results generated with smaller, high–resolution data sets. However, this is only true if habitat associations are consistent among grouped taxa; otherwise, coarse taxonomic groupings can result in the generation of an "average condition" that isn't representative for any particular taxon. The results of such modeling efforts therefore must be considered skeptically and should be groundtruthed before being used for monitoring or policy formation. Trophodymanic models have been used effectively to evaluate important processes and functional groups across multiple scales and regions but are highly contingent on the quality of diet composition data and the appropriate designation of functional groups. Future efforts should incorporate a measure of uncertainty with regard to data quality, and should consider distinct life stages to account for ontogenetic dietary differences. The development of an integrated ecosystem assessment model using the Atlantis platform has considerable promise for management strategy evaluation and policy formation; however, current model limitations must be addressed and the model must be expanded before it can be effectively used in this capacity.

The greatest limitation to the success of current and future modeling efforts is the quantity and quality of input data for the West Coast marine region. The accuracy and consistency of model outputs are directly contingent on the input data that are used. When input data are sparse, generalized, or interpolated, model results should be considered skeptically. Biogenic models using presence–only data and coarse taxonomic categories are the typical example used here, but this problem is relevant to all model types. A good example of the problematic nature of using poor data inputs is provided by a recent study that attempted to determine dietary overlap of California Current species (DuFault et al. 2009). Accurate calculations of dietary overlap are only possible it diet composition data are of adequate sample size to precisely reflect the diet of a particular species, if temporal, spatial, and ontogenetic differences in diet are accounted for, and if species being compared overlap in geographical and depth distributions. All of these qualifications were violated in the DuFault et al. (2009) study. The results are therefore unreliable at best, and highly problematic if used in future modeling efforts or to provide advice regarding trophic effects within the California Current food web, as advocated by the authors. Data limitation is an unfortunate consequence of modeling in marine environments, but its effects can be mitigated. A key element when dealing with limited data inputs is to formulate appropriate objectives and hypotheses. This practice will produce more reliable results even if the scope of the study must be limited. In addition, model construction can serve as a gap analysis to identify data limitations and inform future research needs and priorities. As data gaps are identified and filled, model results will become more robust and have increased utility for ecosystem understanding, management strategy evaluation, and policy formation.

Literature Cited

Anderson, T.J., Syms, C., Roberts, D.A., and Howard, D.F. 2009. Multi–scale fish–habitat associations and the use of habitat surrogates to predict the organization and abundance of deep–water fish assemblages. Journal of Experimental Marine Biology and Ecology 379: 34–42.

PFMC. 2005. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery. Appendix B, Part 1. Assessment methodology for groundfish essential fish habitat. Pacific Fishery Management Council. Portland, OR.

PFMC. 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery as amended through Amendment 19 (including Amendment 15). Pacific Fishery Management Council. Portland, OR.

Baskett, M.L., Yoklavich, M.M., and Love, M.S. 2006. Predation, competition, and the recovery of overexploited fish stocks in marine reserves. Canadian Journal of Fisheries and Aquatic Science 63: 1214–1229.

Brand, E.J., Kaplan, I.C., Harvey, C.J., Levin, P.S., Fulton, E.A., Hermann, A.J., and Field, J.C. 2007. A spatially explicit ecosystem model of the California Current's food web and oceanography. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–84.

Bryan, T.L., and Metaxas, A. 2007. Predicting suitable habitat for deep–water gorgonian corals on the Atlantic and Pacific continental margins of North America. Marine Ecology Progress Series 330: 113–126.

Christensen, V. and D. Pauly. 1992. Ecopath II – a software for balancing steady–state ecosystem models and calculating network characteristics. Ecological Modeling 61: 169–185.

Clark, M.R., Tittensor, D., Rogers, A.D., Brewin, P., Schlacher, T., Rowden, A., Stocks, K., and Consalvey, M. 2006. Seamounts, deep–sea corals and fisheries: vulnerability of deep–sea corals to fishing on seamounts beyond areas of national jurisdiction. UNEP–WCMC. Cambridge, UK.

CSIRO. 2011. Atlantis – Ecosystem Model. http://atlantis.cmar.csiro.au/

Davies, A.J., and Guinotte, J.M. 2011. Global habitat suitability for framework–forming cold–water corals. PLoS One e18483.

Davies, A.J., Wisshak, M., Orr, J.C., and Roberts, J.M. 2008. Predicting suitable habitat for cold–water *Lophelia pertusa* (Scleractinia). Deep–Sea Research I 55: 1048–1062.

Dufault, A.M., Marshall, K., and Kaplan, I.C. 2009. A synthesis of diets and trophic overlap of marine species in the California Current. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–103.

Etherington, L.L., van der Leeden, P., Graiff, K., Roberts, D., and Nickel, B. 2011. Summary of deep sea coral patterns and habitat modeling results from Cordell Bank, CA. Technical Report. NOAA–Cordell Bank Marine Sanctuary. Olema, CA.

Field, J.C. 2004. Application of ecosystem–based fishery management approaches in the northern California Current. Ph.D. Dissertation. University of Washington. School of Aquatic and Fishery Sciences.

Field, J.C., and Francis, R.C. 2005. Mass balance models of the Northern California Current. UBC Fisheries Centre Research Reports 13: 207–216.

Field, J.C., Francis, R.C., and Aydin, K. 2006. Top–down modeling and bottom–up dynamics: Linking a fisheries–based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68: 238–270.

Fulton, E.A., Smith, A.D.M, and Johnson, C.R. 2004. Effects of spatial resolution on the performance and interpretation of marine ecosystem models. Ecological Modeling 176: 27–42.

Graham, M.H., Kinlan, B.P., and Grosberg, R.K. 2010. Post–glacial redistribution and shifts in productivity of giant kelp forests. Proceedings of the Royal Society of B 277: 399–406.

Greene, H.G., Yoklavich, M.M., Starr, R.M., O'Connell, V.M., Wakefield, W.W., Sullivan, D.E., McRea Jr., J.E., and Cailliet, G.M. 1999. A classification scheme for deep seafloor habitats. Oceanologica ACTA 22: 663–678.

Guinotte, J.M., and Davies, A.J. 2012. Predicted deep–sea coral habitat suitability for the U.S. West Coast. Report to NOAA Deepsea Coral Program.

Harvey, C.J., Bartz, K.K., Davies, J., Francis, T.B., Good, T.P., Guerry, A.D., Hanson, B., Holsman, K.K., Miller, J., Plummer, M.L., Reum, J.C.P., Rhodes, L.D., Rice, C.A., Samhouri, J.F., Williams, G.D., Yoder, N., Levin, P., and Ruckelshaus, M.H. 2010. A mass–balance model for evaluating food web structure and community–scale indicators in the central basin of Puget Sound. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–106.

Horne, P.J., Kaplan, I.C., Marshall, K.N., Levin, P.S., Harvey, C.J., Hermann, A.J., and Fulton, E.A. 2010. Design and parameterization of a spatially explicit ecosystem model of the Central California Current. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS–NWFSC–104.

Iampietro, P.J., Kvitek, R.G., and Morris, E. 2005. Recent advances in automated genus–specific marine habitat mapping enabled by high–resolution multibeam bathymetry. Marine Technology Society Series 39(3): 83–93.

Iampietro, P.J., Young, M.A., and Kvitek, R.G. 2008. Multivariate prediction of rockfish habitat suitability in Cordell Bank National Marine Sanctuary and Del Monte Shalebeds, California, USA. Marine Geodesy 31: 359–371.

Krigsman, L.M., Yoklavich, M.M., Dick, E.J., and Cochrane, G.R. 2012. Models and maps: predicting the distribution of corals and other benthic macro–invertebrates in shelf habitats. Ecosphere 3(article3): 1–16.

Millar, R.B., and Methot, R.D. 2002. Age–structured meta–analysis of U.S. West Coast rockfish (Scorpaenidae) populations and hierarchical modeling of trawl survey catchabilities. Canadian Journal of Fisheries and Aquatic Science 59: 383–392.

MRAG Americas Inc., TerraLogic GIS Inc., NMFS Northwest Fisheries Science Center FRAM Division, and NMFS Northwest Region. 2004. Risk assessment for the Pacific Groundfish FMP. Pacific States Marine Fisheries Commission. Portland, OR.

O'Farrell, M.R., Yoklavich, M.M., and Love, M.S. 2009. Assessment of habitat and predator effects on dwarf rockfishes (*Sebastes* spp.) using multi model inference. Environmental Biology of Fishes 85: 239–250.

Plagányi, E.E. 2007. Models for an ecosystem approach to fisheries. Food and Agriculture Organization of the United Nations. FAO Fisheries Technical Paper 477.

Polovina, J.J. 1984. Model of a coral reef ecosystem I. The Ecopath model and its application to French Frigate Shoals. Coral Reefs 3: 1–10.

Ruzicka, J.J., Brodeur, R.D., and Wainwright, T.C. 2007. Seasonal food web models for the Oregon inner–shelf ecosystem: investigating the role of large jellyfish. CalCOFI Reports. Volume 48.

Tittensor, D.P., Baco, A.R., Brewin, P.E., Clark, M.R., Consalvey, M., Hall–Spencer, J.H., Rowden, A.A., Schlacher, T., Stocks, K.I., and Rogers, A.D. 2009. Predicting global habitat suitability for stony corals and seamounts. Journal of Biogeography 36: 111–1128.

Tolimieri, N., and Levin, P.S. 2006. Assemblage structure of eastern Pacific groundfishes on the U.S. continental slope in relation to physical and environmental variables. Transactions of the American Fisheries Society 135: 317–332.

Young, M.A., Iampietro, P.J., Kvitek, R.G., and Garza, C.D. 2010. Multivariate bathymetry–derived generalized linear model accurately predicts rockfish distribution on Cordell Bank, California, USA. Marine Ecology Progress Series 415: 247–261.

APPENDIX I HABITAT USE DATABASE

This section provides a review of the Habitat Use Database (HUD) used to inform EFH designations contained in Amendment 19, comparing the extent of information contained in the HUD in 2005 with its current state at the end of 2011.

Appendix I-1 Entity Relationship Diagrams

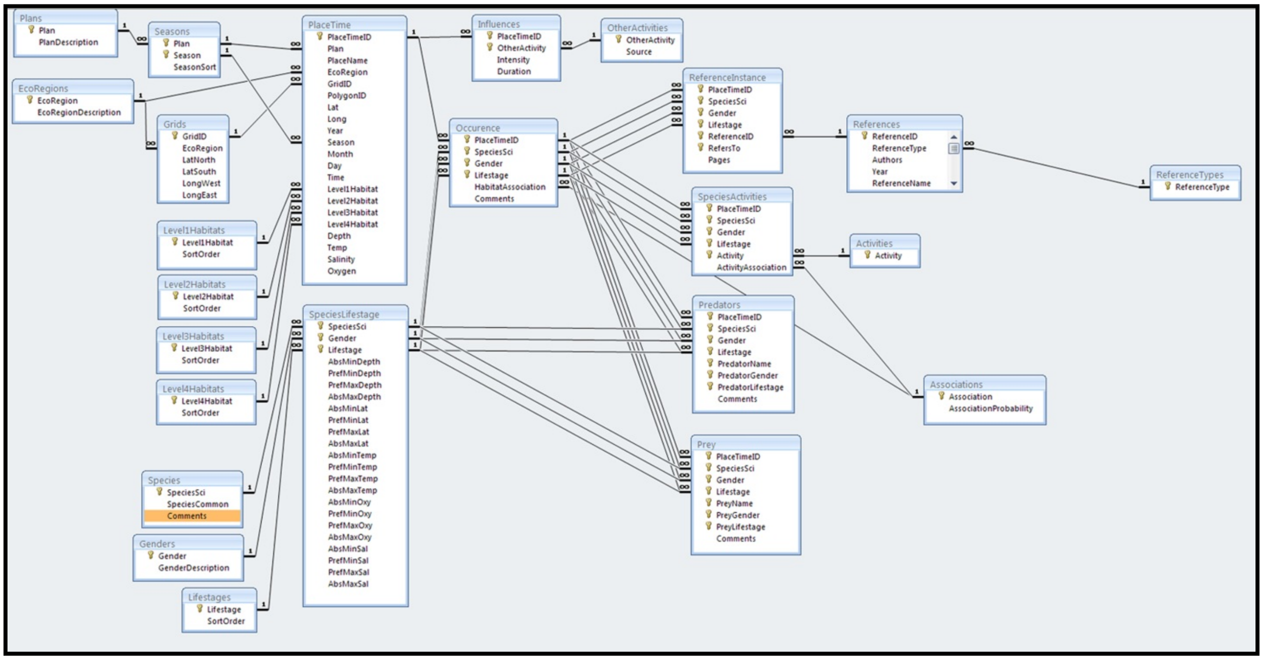


Figure I-1.1. 2005 MS Access® Habitat Use Database Entity Relationship Diagram.

Appendix I-1: Habitat Use Database-Entity Relationship Diagrams

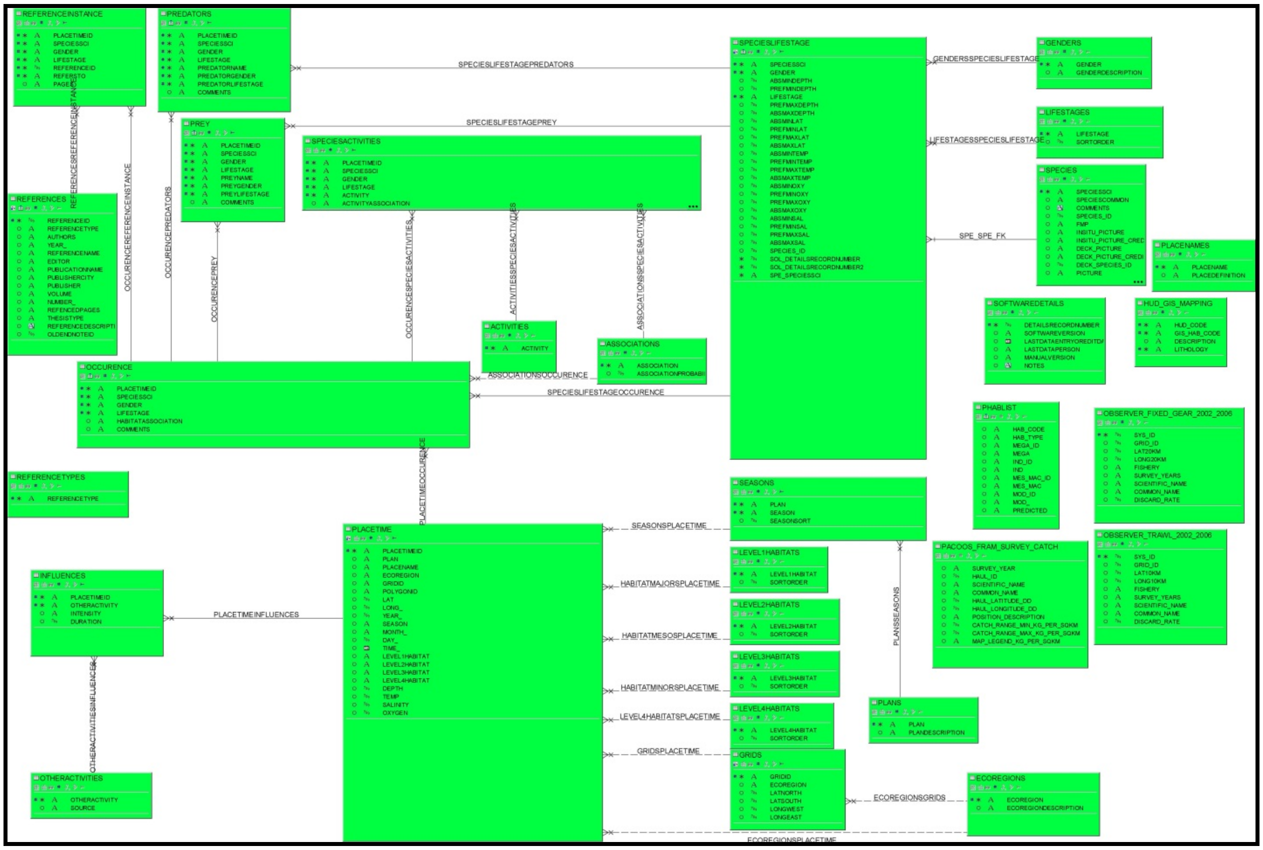


Figure I-1.2. 2011 Oracle® Habitat Use Database Entity Relationship Diagram.

Appendix I-1: Habitat Use Database-Entity Relationship Diagrams

Table I-1.1 HUD tables and a brief description of their contents.

Table Name	Contents
1. PLANS	- Management Plans (FMP, OR Nearshore Strategy, etc)
2. ECOREGIONS	- 7 West Coast Ecoregions
3. SEASONS	- 4 Seasons + All Year and Unknown
4. GRIDS	- No Description Available (appears to reference Ecoregions)
5. LEVEL1HABITATS	- Aquatic Sector
6. LEVEL2HABITATS	- Aquatic Sub Sector
7. LEVEL3HABITATS	- Sub Sector Zone
8. LEVEL4HABITATS	- General Composition
9. SPECIES	- Species (or group)
10. GENDERS	- Male, Female, Both, Unknown
11. LIFESTAGES	- Adult, Juveniles, Larvae, Eggs, Unknown
12. PLACETIME	- Unique and observed combinations of L1 – L4 Habitat including season
13. ASSOCIATIONS	- Relative strength or level of habitat preference
14. SPECIESLIFESTAGE	- Depth, Latitude, Temperature, Oxygen requirements and preferences
15. OCCURRENCE	- Record of Species & life stage by PLACETIME and Association Level
16. INFLUENCES	- No description Available
17. OTHERACTIVITIES	- Notable non-fishing activities
18. REFERENCEINSTANCE	- Relates reference to instance of species-lifestage habitat association
19. ACTIVITIES	- Activity: Spawning, breeding, feeding, or growth-to-maturity
20. SPECIESACTIVITIES	- Activity by PlaceTime, Species, Gender, Lifestage, and Association
21. PREDATORS	- Pairs a HUD species with its predator (by lifestage and gender)
22. PREY	- Pairs a HUD species with its prey (by lifestage and gender)
23. REFERENCES	- Citations
24. REFRENCETYPE	- Accounting of citation medium (book, journal, report, etc.)

In addition to the original 24 tables 4 new tables were created in the Oracle HUD instance:

1. PLACENAMES -no description available
2. PHABLIST -no description available
3. HUD_GIS_MAPPING -one-to-one crosswalk table
4. SOFTWARE_DETAILS -system metadata

Appendix I-2. 2005 & 2011 HUD Scope and Extent

Table I-2.1. Pacific Coast groundfish in the 2005 HUD.

Species Group	Species Count
Flatfishes	4
Other Flatfishes	8
Rockfishes	15
Other Rockfishes	45*
Other Groundfish	15
Total Groundfish Count	87
Predator Species/Groups	24
Prey Species/Groups	73
Predator & Prey Species/Groups	2
Ungrouped Species	7
Total 2005 HUD Species Count	193

*Other Rockfishes include 40 2005 FMP Groundfish and 5 non-FMP Groundfish (Freckled rockfish, Halfbanded rockfish, Pinkrose rockfish, Pygmy rockfish, Swordspine rockfish).

Table I-2.2. Pacific coast groundfish with habitat associations coded in the 2005 HUD.

Species Group	Species Count
Flatfishes	4
Other Flatfishes	8
Rockfishes	15
Other Rockfishes	40
Other Groundfish	14**
Total 2005 HUD Species with Habitat Associations	81

**No habitat association information was included for *Antimora microlepis* (Finescale Codling or Pacific flatnose) in the 2005 HUD.

Table I-2.3. Groundfish Prey.

Table B.3.a Adult Groundfish Prey

Prey Item	Freq.Occ.	%	cum%
Shrimp	68	9.40525588	9.405255878
Fish	49	6.77731674	16.18257261
Crabs	47	6.50069156	22.68326418
Euphausiids	41	5.67081604	28.35408022
Molluscs	38	5.25587828	33.60995851
polychaetes	37	5.1175657	38.7275242
Amphipods	33	4.56431535	43.29183956
Clupeids	32	4.42600277	47.71784232
Squids	31	4.28769018	52.0055325
Octopi	26	3.59612725	55.60165975
Small fishes	22	3.0428769	58.64453665
Copepods	20	2.76625173	61.41078838
fish juveniles	17	2.35131397	63.76210235
Mysids	16	2.21300138	65.97510373
Invertebrates	16	2.21300138	68.18810512
tunicates	16	2.21300138	70.4011065
Crustaceans	11	1.52143845	71.92254495
Pelagic fishes	11	1.52143845	73.4439834
Juvenile rockfish	10	1.38312586	74.82710927
krill	10	1.38312586	76.21023513
Brittle Stars	8	1.10650069	77.31673582
salps	8	1.10650069	78.42323651
Merluccius productus	8	1.10650069	79.52973721
Rockfish	8	1.10650069	80.6362379
Cephalopods	7	0.96818811	81.604426
Snails	6	0.82987552	82.43430152
Theragra chalcogramma	6	0.82987552	83.26417704
Fish eggs	6	0.82987552	84.09405256
Crab larvae	6	0.82987552	84.92392808
Cumaceans	5	0.69156293	85.61549101
Decapod crustaceans	5	0.69156293	86.30705394
Gadids	5	0.69156293	86.99861687
isopods	5	0.69156293	87.69017981
Nudibranchs	4	0.55325035	88.24343015
echinoderms	4	0.55325035	88.7966805
Sandlance	4	0.55325035	89.34993084
juvenile crab	4	0.55325035	89.90318119
Ophiuroids	4	0.55325035	90.45643154
Clams	3	0.41493776	90.87136929
Worms	3	0.41493776	91.28630705
Sea stars	3	0.41493776	91.70124481
Larvacea	3	0.41493776	92.11618257
Demersal fish	3	0.41493776	92.53112033
Lobsters	3	0.41493776	92.94605809
Cottids	3	0.41493776	93.36099585
algae	3	0.41493776	93.77593361
Sea Urchin	3	0.41493776	94.19087137
Echiurans	3	0.41493776	94.60580913
Urechis caupo	3	0.41493776	95.02074689
Sebastolobus alascanus	2	0.27662517	95.29737206
gastropod	2	0.27662517	95.57399723
Small Crustacea	2	0.27662517	95.85062241
Bathylagids	2	0.27662517	96.12724758
Echiurid proboscises	2	0.27662517	96.40387275
Myctophids	2	0.27662517	96.68049793
Sebastolobus altivelis	2	0.27662517	96.9571231
Crustacean eggs	2	0.27662517	97.23374827
Annelids	2	0.27662517	97.51037344
Eopsetta jordani	2	0.27662517	97.78699862
gelatinous plankton	2	0.27662517	98.06362379
Hydrolagus colliei	2	0.27662517	98.34024896
Opisthobranchs	2	0.27662517	98.61687414
Ostracods	2	0.27662517	98.89349931
Scorpaenichthys marmoratus	1	0.13831259	99.03181189
fish larvae	1	0.13831259	99.17012448
hydroids	1	0.13831259	99.30843707
Chitons	1	0.13831259	99.44674965
Salmon	1	0.13831259	99.58506224
Ophiodon elongatus	1	0.13831259	99.72337483
crab	1	0.13831259	99.86168741
jellyfish	1	0.13831259	100

Table B.3.j JuvenileGroundfish

Prey Item	Freq.Occ.	%	cum%
Copepods	54	12.8571	12.8571
Amphipods	49	11.6667	24.5238
Euphausiids	41	9.7619	34.2857
Shrimp	33	7.85714	42.1429
polychaetes	17	4.04762	46.1905
Mysids	16	3.80952	50
Crabs	13	3.09524	53.0952
Squids	12	2.85714	55.9524
Molluscs	11	2.61905	58.5714
barnacle cypriots	11	2.61905	61.1905
Small fishes	11	2.61905	63.8095
tunicates	11	2.61905	66.4286
Fish	9	2.14286	68.5714
fish larvae	9	2.14286	70.7143
krill	8	1.90476	72.619
Copepod nauplii	7	1.66667	74.2857
Small Crustacea	6	1.42857	75.7143
Cumaceans	6	1.42857	77.1429
fish juveniles	6	1.42857	78.5714
Clupeids	5	1.19048	79.7619
Brittle Stars	5	1.19048	80.9524
Copepod eggs	5	1.19048	82.1429
crustacean zoea	5	1.19048	83.3333
Pelagic fishes	4	0.95238	84.2857
Ostracods	4	0.95238	85.2381
algae	4	0.95238	86.1905
Brachyuran	4	0.95238	87.1429
Crab larvae	3	0.71429	87.8571
Ophiuroids	3	0.71429	88.5714
Octopi	3	0.71429	89.2857
Juvenile flatfish	3	0.71429	90
Invertebrates	3	0.71429	90.7143
Sculpins	3	0.71429	91.4286
salps	3	0.71429	92.1429
Crustaceans	3	0.71429	92.8571
Cladocerans	3	0.71429	93.5714
Annelids	2	0.47619	94.0476
Opisthobranchs	2	0.47619	94.5238
crab	2	0.47619	95
Hydrolagus colliei	2	0.47619	95.4762
hydroids	2	0.47619	95.9524
Theragra chalcogramma	2	0.47619	96.4286
Euphausiid eggs	2	0.47619	96.9048
Demersal fish	2	0.47619	97.381
Nudibranchs	2	0.47619	97.8571
Larvacea	2	0.47619	98.3333
Zooplankton	2	0.47619	98.8095
Gadids	2	0.47619	99.2857
Cephalopods	1	0.2381	99.5238
Juvenile rockfish	1	0.2381	99.7619
gelatinous plankton	1	0.2381	100

Table B.3.l Larval Groundfish

Prey Item	Freq.Occ.	%	cum%
Copepods	55	26.8293	26.8293
Copepod nauplii	34	16.5854	43.4146
Copepod eggs	30	14.6341	58.0488
invertebrate eggs	12	5.85366	63.9024
Invertebrate nauplii	11	5.36585	69.2683
Euphausiids	10	4.87805	74.1463
fish larvae	8	3.90244	78.0488
Amphipods	7	3.41463	81.4634
Diatoms	6	2.92683	84.3902
Barnacles	4	1.95122	86.3415
Scorpaenichthys marmoratus	4	1.95122	88.2927
Fish eggs	4	1.95122	90.2439
decapod larvae	3	1.46341	91.7073
tintinnids	3	1.46341	93.1707
barnacle cypriots	3	1.46341	94.6341
Dinoflagellates	3	1.46341	96.0976
Cladocerans	3	1.46341	97.561
Brachyuran	3	1.46341	99.0244
Zooplankton	1	0.4878	99.5122
Molluscs	1	0.4878	100

Table I-2.4. Pacific coast groundfishes and other species in the 2005 and 2011 HUD

Species Group	2005 HUD Species Count	2011 HUD Species Count
FMP Coastal Pleagics	0	4
FMP Groundfish	82 + 5 Non-FMP	91
OR Nearshore Strategy	0	35
OR Nearshore Watch	0	18
OR Nearshore Commonly Assoc.	0	73
Predator Species/Groups	24	20***
Prey Species/Groups	73	73
Predator & Prey Species/Groups	2	2
Ungrouped Species	7	7
Total HUD Species Counts	193	323

***Four predator species were removed from the 2011 HUD (Rhacochilus vacca, Lamna ditropis, Artedius harringtoni, Embiotoca lateralis).

Table I-2.5a. Pacific coast groundfish adults with habitat associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	4	0
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	49	0
-Other Groundfish	15	0
Oregon Nearshore		
-Strategy	28	7
-Watch	17	1
-Commonly Associated	72	1
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	212	111

Table I-2.5b. Pacific coast groundfish juveniles with habitat associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	39	10
-Other Groundfish	14	1
Oregon Nearshore		
-Strategy	0	35
-Watch	0	18
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	80	243

Table I-2.5c. Pacific coast groundfish larvae with habitat associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	31	18
-Other Groundfish	7	8
Oregon Nearshore		
-Strategy	0	35
-Watch	0	18
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	65	258

Table I-2.5d. Pacific coast groundfish eggs with habitat associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	2	13
-Other Rockfishes	1	48
-Other Groundfish	11	4
Oregon Nearshore		
-Strategy	0	35
-Watch	0	18
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	26	297

Table I-2.6a. Pacific coast groundfish adults with Y (Latitude) & Z(Depth) associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	4	0
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	49	0
-Other Groundfish	15	0
Oregon Nearshore		
-Strategy	35	0
-Watch	18	0
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	148	175

Table I-2.6b. Pacific coast groundfish juveniles with Y & Z associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	39	10
-Other Groundfish	14	1
Oregon Nearshore		
-Strategy	0	35
-Watch	0	18
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	80	243

Table I-2.6c. Pacific coast groundfish larvae with Y & Z associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	15	0
-Other Rockfishes	31	18
-Other Groundfish	7	8
Oregon Nearshore		
-Strategy	0	35
-Watch	0	18
-Commonly Associated	0	73
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	65	258

Table I-2.6d. Pacific coast groundfish eggs with Y & Z associations coded in the 2011 HUD.

Species Group	Species Count	Species Missing
FMP Coastal Pelagics	0	4
FMP Groundfish		
-Flatfishes	4	0
-Other Flatfishes	8	0
-Rockfishes	2	13
-Other Rockfishes	1	48
-Other Groundfish	11	4
Oregon Nearshore		
-Strategy	0	35
-Watch	0	17
-Commonly Associated	0	74
Predator Species/Groups	0	20
Prey Species/Groups	0	73
Predator & Prey Species/Groups	0	2
Ungrouped Species	0	7
Total	26	297

Appendix I-3 ODFW Nearshore Plan Species Included in the 2011 HUD

Strategy List Species

	Scientific Name	Common Name	Comments
1.	*Acipenser medirostris*	Green sturgeon	
2.	*Acipenser transmontanus*	White sturgeon	
3.	*Amphistichus rhodoterus*	Redtail surfperch	
4.	*Anarrhichthys ocellatus*	Wolf-eel	
5.	*Atherinops affinis*	Topsmelt	
6.	*Cancer magister*	Dungeness crab	
7.	*Cymatogaster aggregate*	Shiner perch	
8.	*Embiotoca lateralis*	Striped perch	
9.	*Eschrichtius robustus*	Gray whale	(No Life History Information)
10.	*Eumetopias jubatus*	Steller sea lion	(No Life History Information)
11.	*Haliotis rufescens*	Red abalone	
12.	*Haliotis walallensis*	Flat abalone	
13.	*Hexagrammos lagocephalus*	Rock greenling	
14.	*Hinnites giganteus*	Rock scallop	
15.	*Hypomesus pretiosus*	Surf smelt	
16.	*Mirounga angustirostris*	Northern elephant seal	
17.	*Mytilus californianus*	California mussel	
18.	*Nereocystis luetkeana*	Bull kelp	
19.	*Octopus dofleini*	Giant octopus	
20.	*Phoca vitulina*	Pacific harbor seal	(No Life History Information)
21.	*Phocoena phocoena*	Harbour porpoise	(No Life History Information)
22.	*Phyllospadix spp.*	Surf grass	
23.	*Pisaster ochraceus*	Ochre sea star	
24.	*Postelsia palmaeformis*	Sea palm	
25.	*Rhacochilus vacca*	Pile perch	
26.	*Siliqua patula*	Razor clam	
27.	*Strongylocentrotus franciscanus*	Red sea urchin	
28.	*Strongylocentrotus purpuratus*	Purple sea urchin	
29.	*Thaleichthys pacificus*	Eulachon	
30.	*Zalophus califonianus*	California sea lion	(No Life History Information)
31.	*Haliotis cracherodii*	Black abalone	
32.	*Prionace glauca*	Blue Shark	
33.	*Mustelus henlei*	Brown smoothhound	
34.	*Enophrys bison*	Buffalo sculpin	
35.	*Hemilepidotus spinosus*	Brown Irish Lord	

Appendix I-3: Habitat Use Database-ODFW Nearshore Plan Species

Watch List Species

	Scientific Name	Common Name	Comments
1.	*Alopias vulpinus*	Common thresher	
2.	*Ammodytes hexapterus*	Pacific sand lance	
3.	*Cancer productus*	Red rock crab	
4.	*Carcharodon carcharias*	White shark	
5.	*Cebidichthys violaceus*	Monkeyface prickleback	
6.	*Delolepis gigantean*	Giant wrymouth	
7.	*Emerita analoga*	Sand (Mole) crab	
8.	*Fusitriton oregonensis*	Oregon triton	
9.	*Hemilepidotus hemilepidotus*	Red Irish Lord	
10.	*Isurus oxyrinchus*	Shortfin mako shark (Bonito shark)	
11.	*Leptocottus armatus*	Pacific staghorn sculpin	
12.	*Pandalus danae*	Coonstripe or Dock shrimp	
13.	*Paralichthys californicus*	California halibut	
14.	*Parastichopus californicus*	California Sea Cucumber	
15.	*Penitella penita*	Flap-tipped piddock	
16.	*Squatina californica*	Pacific angel shark	
17.	*Trichodon trichodon*	Pacific sandfish	
18.	Lamna ditropis	Salmon Shark	

Commonly Associated Species

	Scientific Name	Common Name	Comments
1.	*Agonomalus mozinoi*	Kelp poacher	
2.	*Alaria marginata*	Winged kelp	
3.	*Allosmerus elongatus*	Whitebait smelt	
4.	*Amphistichus koelzi*	Calico surfperch	
5.	*Anoplagonus inermis*	Smooth alligatorfish	
6.	*Anoplarchus insignis*	Slender cockscomb	
7.	*Anoplarchus pupurescens*	High cockscomb	
8.	*Anthopleura elegantissima*	Aggregating anemone	
9.	*Apodichthys flavidus*	Penpoint gunnel	
10.	*Artediellus pacificus*	Pacific hookhorn sculpin	
11.	*Artedius corallinus*	Coralline sculpin	
12.	*Artedius fenestralis*	Padded sculpin	
13.	*Artedius harringtoni*	Scalyhead Sculpin	
14.	*Artedius lateralis*	Smoothhead sculpin	
15.	*Artedius notospilotus*	Bonehead sculpin	
16.	*Ascelichthys rhodorus*	Rosylip sculpin	
17.	*Atherinopsis californiensis*	Jacksmelt	
18.	*Aulorhyncus flavidus*	Tubesnout	
19.	*Balanus nubilis*	Giant acorn barnacle	
20.	*Blepsias cirrhosus*	Silverspotted sculpin	
21.	*Bothragonus swanii*	Rockhead	
22.	*Brachyistius frenatus*	Kelp surfperch	(No Life History Information)
23.	*Brosmophycis marginata*	Red brotula	
24.	*Cancer antennarius*	Brown rock crab	
25.	*Chirolophis decoratus*	Decorated warbonnet	
26.	*Chirolophis nugator*	Mosshead warbonnet	
27.	*Chitonotus pugetensis*	Roughback sculpin	
28.	*Citharichthys stigmaeus*	Speckled sanddab	
29.	*Clinocardium nuttallii*	Cockle clam	
30.	*Clinocottus acuticeps*	Sharpnose sculpin	

31.	*Clinocottus embryum*	Calico sculpin	
32.	*Clinocottus globiceps*	Mosshead sculpin	
33.	*Clinocottus recalvus*	Bald sculpin	
34.	*Cryptochiton stelleri*	Gumboot chiton	
35.	*Dendraster excentricus*	Sand dollar	
36.	*Egregia menziesii*	Egregia	
37.	*Fucus distichus*	Rockweed	
38.	*Gobiesox maeandricus*	Northern clingfish	
39.	*Haliotis kamtschatkana*	Pinto (Northern) abalone	
40.	*Hyperprosopon anale*	Spotfin surfperch	
41.	*Hyperprosopon argenteum*	Walleye surfperch	
42.	*Hyperprosopon ellipticum*	Silver surfperch	
43.	*Jordania zonope*	Longfin sculpin	
44.	*Lumpenopsis hypochroma*	Y-prickleback	
45.	*Lumpenus sagitta*	Snake prickleback	
46.	*Macrocystis pyrifera*	Giant kelp	
47.	*Myliobatis californica*	Bat ray	
48.	*Nautichthys oculofasciatus*	Sailfin sculpin	
49.	*Odontopyxis trispinosa*	Pygmy poacher	
50.	*Oligocottus maculosus*	Tidepool sculpin	
51.	*Oligocottus rimensis*	Saddleback sculpin	
52.	*Oligocottus snyderi*	Fluffy sculpin	
53.	*Oxylebius pictus*	Painted greenling	
54.	*Pallasina barbata*	Tubenose poacher	
55.	*Pandalus platyceros*	Spot prawn	
56.	*Phanerodon furcatus*	White surfperch	
57.	*Pholis clemensi*	Longfin gunnel	
58.	*Pholis laeta*	Cresent gunnel	
59.	*Pholis* ornata	Saddleback gunnel	
60.	*Pholis schultzi*	Red gunnel	(No Life History Information)
61.	*Phytichthys chirus*	Ribbon prickleback	
62.	*Podothecus accipenserinus*	Sturgeon poacher	
63.	*Prionotus stephanophrys*	Lumptail searobin	
64.	*Pugettia producta*	Kelp crab	
65.	*Rhamphocottus richardsonii*	Grunt sculpin	
66.	*Ruscarius meanyi*	Puget Sound sculpin	
67.	*Spirinchus starksi*	Night smelt	
68.	*Spirinchus thaleichthys*	Longfin smelt	
69.	*Stellerina xyosterna*	Pricklebreast poacher	
70.	*Synchirus gilli*	Manacled sculpin	
71.	*Torpedo californica*	Pacific electric ray	
72.	*Xiphister atropurpureus*	Black prickleback	
73.	*Xiphister mucosus*	Rock prickleback	

Appendix I-4 2005 Crosswalk Table

GIS hab_code	Description	Lithology	HUD Code
Ahc	Rocky Apron Canyon Wall	Any	Fshn
Ahe	Rocky Apron	Any	Fbhn
As_u	Sedimentary Apron	Any	Fbun
Asc/f	Sedimentary Apron Canyon Floor	Any	Fsun
Asc_u	Sedimentary Apron Canyon Wall	Any	Fsun
Asg	Sedimentary Apron Gully	Any	Fbun
Asl	Sedimentary Apron Landslide	Any	Fbun
Bhe	Rocky Basin	Any	Fahn
Bs_u	Sedimentary Basin	Any	Faun
Bsc/f_u	Sedimentary Basin Canyon Floor	Any	Fsun
Bsc_u	Sedimentary Basin Canyon Wall	Any	Fsun
Bsg	Sedimentary Basin Gully	Any	Faun
Bsg/f_u	Sedimentary Basin Gully Floor	Any	Faun
Fhc	Rocky Slope Canyon Wall	Any	Fshn
Fhc/f	Rocky Slope Canyon Floor	Any	Fshn
Fhe	Rocky Slope	Any	Fbhn
Fhg	Rocky Slope Gully	Any	Fbhn
Fhl	Rocky Slope Landslide	Any	Fbhn
Fhl	Rocky Slope Landslide	ROCK	Fbhn
Fs_u	Sedimentary Slope	Unknown	Fbun
Fs_u	Sedimentary Slope	CLAY	Fbuv
Fs_u	Sedimentary Slope	MUD	Fbum
Fs_u	Sedimentary Slope	SAND	Fbus
Fs_u	Sedimentary Slope	SAND/MUD	Fbub
Fsc/f_u	Sedimentary Slope Canyon Floor	Any	Fsun
Fsc_u	Sedimentary Slope Canyon Wall	Any	Fsun
Fsg	Sedimentary Slope Gully	Unknown	Fbun
Fsg	Sedimentary Slope Gully	MUD	Fbum
Fsg/f	Sedimentary Slope Gully Floor	Any	Fbun
Fsl	Sedimentary Slope Landslide	Unknown	Fbun
Fsl	Sedimentary Slope Landslide	MUD	Fbum
Rhe	Rocky Ridge	Any	Fbhn
Rs_u	Sedimentary Ridge	Unknown	Fbun
Rs_u	Sedimentary Ridge	CLAY	Fbuv
Rs_u	Sedimentary Ridge	MUD	Fbum
Rs_u	Sedimentary Ridge	SAND	Fbus
Shc	Rocky Shelf Canyon Wall	Any	Sshn
She	Rocky Shelf	Any	Sbhn
Shi_b/p	Rocky Glacial Shelf Deposit	Any	Sbhn
Ss_u	Sedimentary Shelf	Unknown	Sbun

Appendix I-4: Habitat Use Database-2005 Crosswalk Table

GIS hab_code	Description	Lithology	HUD Code
Ss_u	Sedimentary Shelf	CLAY	Sbuv
Ss_u	Sedimentary Shelf	GRAVEL	Sbuh
Ss_u	Sedimentary Shelf	MIX SAND/GRAVEL	Sbcs
Ss_u	Sedimentary Shelf	MUD	Sbum
Ss_u	Sedimentary Shelf	ROCK/SAND	Sbcw
Ss_u	Sedimentary Shelf	SAND	Sbus
Ss_u	Sedimentary Shelf	SAND/MUD	Sbub
Ssc/f_u	Sedimentary Shelf Canyon Floor	Any	Ssun
Ssc_u	Sedimentary Shelf Canyon Wall	Any	Ssun
Ssg	Sedimentary Shelf Gully	Unknown	Sbun
Ssg	Sedimentary Shelf Gully	MUD	Sbum
Ssg	Sedimentary Shelf Gully	SAND	Sbus
Ssg/f	Sedimentary Shelf Gully Floor	Any	Sbun
Ssi_o	Sedimentary Glacial Shelf Deposit	GRAVEL	Sbuh
Ssi_o	Sedimentary Glacial Shelf Deposit	MUD	Sbum
Ssi_o	Sedimentary Glacial Shelf Deposit	SAND	Sbus
Estuary	Estuary	Unknown	Ennn
Estuary	Estuary	SAND	Ebun
Estuary	Estuary	ROCK	Ebhn

Appendix I-5. 2011 HUD Crosswalk Table, one SGH (habitat code) to many HUD Codes.

(yellow)	=	shelf codes, shouldn't find these in Apron, Basin or Slope habitats
(orange)	=	slope codes, shouldn't find these in Shelf or Nearshore habitats

			HUD Wildcard Codes				HUD Codes													
Mega_Habitat	**SGH_Prefix**	**Lith_Combo**	**Slope***	**Shelf***	**Nearsh***	**Estuary***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Apron	Ah	hard	**Fnnn**	x	x	x	**Fbhb**	**Fbhg**	**Fbhn**	**Fbhq**	**Fbhr**	**Fbnn**								
Apron	As	soft	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbuh**	**Fbuh_w**	**Fbum**	**Fbun**	**Fbus**	**Fbut**						
Basin	Bh	hard	**Fnnn**	x	x	x	**Fann**	**Fbnn**	**Fahr**											
Basin	Bh	ROCK	**Fnnn**	x	x	x	**Fann**	**Fbhn**	**Fbhr**	**Fbnn**	**Fahr**									
Basin	Bm	MUD/ROCK	**Fnnn**	x	x	x	**Facx**	**Fann**	**Fbcr**	**Fbcu**	**Fbcx**	**Fbnn**								
Basin	Bm	ROCK/MUD	**Fnnn**	x	x	x	**Facx**	**Fann**	**Fbcr**	**Fbcu**	**Fbcx**	**Fbnn**								
Basin	Bs	MUD	**Fnnn**	x	x	x	**Fann**	**Faum**	**Faun**	**Fbcu**	**Fbnn**	**Fbub**	**Fbum**	**Fbun**	**Fbut**					
Basin	Bs	soft	**Fnnn**	x	x	x	**Fann**	**Faum**	**Faun**	**Faus**										
Canyon	Ch	BOULDER	**Fnnn**	**Snnn**	x	x	**Fshb**	**Fsnn**	**Ssnn**	**Sshb**										
Canyon	Ch	hard	**Fnnn**	**Snnn**	x	x	**Fshb**	**Fshg**	**Fshn**	**Fshr**	**Fsnn**	**Ssnn**	**Sshb**	**Sshg**	**Sshn**	**Sshr**	**Nshr**			
Canyon	Ch	ROCK	**Fnnn**	**Snnn**	x	x	**Fshn**	**Fshr**	**Fsnn**	**Sshr**	**Ssnn**	**Nshr**								
Canyon	Cm	boulder/sand	**Fnnn**	**Snnn**	x	x	**Fsnn**	**Fsun**	**Fshb**	**Fshn**	**Sscy**	**Ssnn**	**Ssun**							
Canyon	Cm	SAND/MUD	**Fnnn**	**Snnn**	x	x	**Fsnn**	**Ssnn**	**Ssun**											
Canyon	Cs	MUD	**Fnnn**	**Snnn**	x	x	**Fsnn**	**Fsum**	**Fsun**	**Fsut**	**Ssum**	**Ssut**	**Ssun**	**Ssnn**						
Canyon	Cs	SAND	**Fnnn**	**Snnn**	x	x	**Fsun**	**Fsnn**	**Ssnn**	**Ssun**										
Canyon	Cs	soft	**Fnnn**	**Snnn**	x	x	**Fsnn**	**Fsum**	**Fsun**	**Fsut**	**Ssnn**	**Ssum**	**Ssun**	**Ssut**						
Estuary	Eb_i	Algal	x	x	x		Eivk													
Estuary	Eb_i	Seagrass		**Ennn** x	x	x	Eivr													
Estuary	Eb_s	Algal		**Ennn** x	x	x	Ebvk													
Estuary	Eb_s	Seagrass		**Ennn** x	x	x	Ebvr													
Estuary	Eh_i			**Ennn** x	x	x	Eihb													
Estuary	Eh_i	hard	x	x	x	**Ennn**	Eihr	Eihb	Eihq	Eihg	Eihn									
Estuary	Eh_i	ROCK	x	x	x	**Ennn**	Eihr													
Estuary	Eh_s	BOULDER	x	x	x	**Ennn**	Ebhb													
Estuary	Eh_s	hard	x	x	x	**Ennn**	Ebhr_a	Ebhr_p	Ebhr_s	Ebhr_w	Ebhb	Ebhn								
Estuary	Eh_s	ROCK	x	x	x	**Ennn**	Ebhr_a	Ebhr_p	Ebhr_s	Ebhr_w										
Estuary	Es_i	COBBLE/GRAVEL	x	x	x	**Ennn**	Eiuh													
Estuary	Es_i	MUD	x	x	x	**Ennn**	Eium													
Estuary	Es_i	soft	x	x	x	**Ennn**	Eiuh	Eium	Eiun	Einn										
Estuary	Es_s	COBBLE/GRAVEL	x	x	x	**Ennn**	Ebhg_a	Ebhg_p	Ebhg_s	Ebhg_w	Ebhq	Ebuh								
Estuary	Es_s	MUD	x	x	x	**Ennn**	Ebum	Ebum_a	Ebum_p	Ebum_s	Ebum_w									
Estuary	Es_s	SAND	x	x	x	**Ennn**	Ebus													
Estuary	Es_s	soft	x	x	x	**Ennn**	Ebhg_a	Ebhg_p	Ebhg_s	Ebhg_w	Ebhq	Ebuh	Ebum	Ebum_a	Ebum_p	Ebum_s	Ebum_w	Ebus	Ebut	Ebun
Flank (Slope)	Fh	hard	**Fnnn**	x	x	x	**Fbhb**	**Fbhg**	**Fbhn**	**Fbhq**	**Fbhr**	**Fbnn**								
Flank (Slope)	Fh	ROCK	**Fnnn**	x	x	x	**Fbhn**	**Fbhr**	**Fbnn**											
Flank (Slope)	Fm	GRAVEL/ROCK	**Fnnn**	x	x	x	**Fbcr**	**Fbcu**	**Fbch**	**Fbhg**	**Fbnn**									
Flank (Slope)	Fm	MUD/ROCK	**Fnnn**	x	x	x	**Fbcr**	**Fbcu**	**Fbcx**	**Fbnn**										
Flank (Slope)	Fm	ROCK/MUD	**Fnnn**	x	x	x	**Fbcr**	**Fbcu**	**Fbcx**	**Fbnn**										
Flank (Slope)	Fm	rock/sand	**Fnnn**	x	x	x	**Fbcw**	**Fbcu**	**Fbnn**											
Flank (Slope)	Fm	SAND/MUD	**Fnnn**	x	x	x	**Fbcu**	**Fbnn**												
Flank (Slope)	Fs	MUD	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbum**	**Fbun**	**Fbut**									
Flank (Slope)	Fs	SAND	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbun**	**Fbus**										
Flank (Slope)	Fs	soft	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbuh**	**Fbuh_w**	**Fbum**	**Fbun**	**Fbus**	**Fbut**						
Ridge	Rh	hard	**Fnnn**	x	x	x	**Fbhn**	**Fbhr**	**Fbnn**	**Fbhb**	**Fbhg**	**Fbhq**	**Fbhr**							
Ridge	Rh	ROCK	**Fnnn**	x	x	x	**Fbhn**	**Fbhr**	**Fbnn**											
Ridge	Rm	ROCK/MUD	**Fnnn**	x	x	x	**Fbcr**	**Fbcu**	**Fbcx**	**Fbnn**										
Ridge	Rm	ROCK/SAND	**Fnnn**	x	x	x	**Fbcr**	**Fbcu**	**Fbcw**	**Fbnn**										
Ridge	Rs	MUD	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbum**	**Fbun**	**Fbut**									
Ridge	Rs	sand	**Fnnn**	x	x	x	**Fbus**	**Fbun**												
Ridge	Rs	soft	**Fnnn**	x	x	x	**Fbnn**	**Fbub**	**Fbuh**	**Fbuh_w**	**Fbum**	**Fbun**	**Fbus**	**Fbut**						
Shelf	Sh	boulder	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbhn**	**Sbhb**	**Nbhn**	**Nbhb**									
Shelf	Sh	hard	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbhn**	**Sbhb**	**Sbhq**	**Sbhr**	**Sbhr_a**	**Sbhr_s**	**Nbhn**	**Nbhr**					
Shelf	Sh	ROCK	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbhn**	**Sbhr_a**	**Sbhr_s**	**Sbhr**	**Nbhn**	**Nbhr**							
Shelf	Sm	boulder/cobble	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbcu**	**Nbun**											
Shelf	Sm	boulder/gravel	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbcu**	**Nbun**											
Shelf	Sm	boulder/mud	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbcu**	**Sbcy**	**Nbun**										
Shelf	Sm	boulder/rock	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Nbun**												
Shelf	Sm	boulder/sand	x	**Snnn**	**Nnnn**	x	**Sbnn**	**Sbcu**	**Sbcl**	**Nbun**										

Appendix I-5: Habitat Use Database-2011 HUD Crosswalk Table

			HUD Wildcard Codes				HUD Codes													
Mega_Habitat	SGH_Prefix	Lith_Combo	Slope*	Shelf*	Nearsh*	Estuary*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Shelf	Sm	boulder/sand/gravel	x	Snnn	Nnnn	x	Sbnn	Sbcs	Sbcu	Sbcl	Nbun									
Shelf	Sm	boulder/shell	x	Snnn	Nnnn	x	Sbnn	Sbcu	Nbun											
Shelf	Sm	cobble/boulder	x	Snnn	Nnnn	x	Sbnn	Sbcu	Nbhq	Nbun										
Shelf	Sm	cobble/gravel	x	Snnn	Nnnn	x	Sbnn	Sbhg	Sbhg_a	Sbhg_s	Nbhq	Nbun								
Shelf	Sm	cobble/mud	x	Snnn	Nnnn	x	Sbnn	Sbcz	Nbhq	Nbun										
Shelf	Sm	cobble/rock	x	Snnn	Nnnn	x	Sbnn	Sbcr	Nbhq	Nbhr	Nbun									
Shelf	Sm	cobble/sand	x	Snnn	Nnnn	x	Sbnn	Sbci	Nbhq	Nbun										
Shelf	Sm	cobble/shell	x	Snnn	Nnnn	x	Sbnn	Nbhq	Nbun											
Shelf	Sm	gravel/boulder	x	Snnn	Nnnn	x	Sbnn	Sbcu	Nbun											
Shelf	Sm	gravel/cobble	x	Snnn	Nnnn	x	Sbnn	Sbhg	Sbhg_a	Sbhg_s	Nbun									
Shelf	Sm	gravel/mud	x	Snnn	Nnnn	x	Sbnn	Sbcg	Nbun											
Shelf	Sm	GRAVEL/ROCK	x	Snnn	Nnnn	x	Sbnn	Sbch	Sbcr	Nbun										
Shelf	Sm	GRAVEL/SAND	x	Snnn	Nnnn	x	Sbnn	Sbcs	Nbun											
Shelf	Sm	gravel/sand/mud	x	Snnn	Nnnn	x	Sbcg	Sbcs	Sbnn	Nbun										
Shelf	Sm	gravel/shell	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	mud/boulder	x	Snnn	Nnnn	x	Sbnn	Sbcy	Sbcu	Nbun										
Shelf	Sm	mud/cobble	x	Snnn	Nnnn	x	Sbnn	Sbcz	Nbun											
Shelf	Sm	mud/gravel	x	Snnn	Nnnn	x	Sbnn	Sbcg	Nbun											
Shelf	Sm	mud/rock	x	Snnn	Nnnn	x	Sbnn	Sbcx	Sbcr	Nbcx	Nbun									
Shelf	Sm	MUD/SAND	x	Snnn	Nnnn	x	Sbnn	Sbub	Sbct	Nbun	Nbub									
Shelf	Sm	mud/shell	x	Snnn	Nnnn	x	Sbnn	Sbub	Nbun											
Shelf	Sm	rock/boulder	x	Snnn	Nnnn	x	Sbnn	Sbhb	Sbhr	Sbhr_a	Sbhr_s	Nbun								
Shelf	Sm	rock/boulder/sand	x	Snnn	Nnnn	x	Sbnn	Sbcl	Sbcr	Sbcu	Sbcw	Nbun								
Shelf	Sm	rock/cobble	x	Snnn	Nnnn	x	Sbnn	Sbcr	Nbun											
Shelf	Sm	ROCK/GRAVEL	x	Snnn	Nnnn	x	Sbnn	Sbch	Sbcr	Nbun										
Shelf	Sm	ROCK/MUD	x	Snnn	Nnnn	x	Sbnn	Sbcr	Sbcx	Nbcx	Nbun									
Shelf	Sm	rock/mud/sand	x	Snnn	Nnnn	x	Sbnn	Sbcr	Sbcw	Sbcx	Nbun									
Shelf	Sm	ROCK/SAND	x	Snnn	Nnnn	x	Sbnn	Sbcr	Sbcw	Nbcw	Nbun									
Shelf	Sm	ROCK/SAND/MUD	x	Snnn	Nnnn	x	Sbnn	Sbcr	Sbcw	Sbcx	Nbun									
Shelf	Sm	rock/shell	x	Snnn	Nnnn	x	Sbnn	Sbcr	Nbun											
Shelf	Sm		x	Snnn	Nnnn	x	Sbnn	Sbch	Sbcr	Nbun										
Shelf	Sm	ROCK/SILT/SAND	x	Snnn	Nnnn	x	Sbnn	Sbcr	Nbun											
Shelf	Sm	sand/boulder	x	Snnn	Nnnn	x	Sbnn	Sbcl	Nbun	Sbcu										
Shelf	Sm	sand/cobble	x	Snnn	Nnnn	x	Sbnn	Sbci	Nbun											
Shelf	Sm	SAND/GRAVEL	x	Snnn	Nnnn	x	Sbnn	Sbcs	Nbun											
Shelf	Sm	SAND/MUD	x	Snnn	Nnnn	x	Sbnn	Sbub	Nbun	Nbub	Sbct									
Shelf	Sm	SAND/MUD/SHELL	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	sand/rock	x	Snnn	Nnnn	x	Sbnn	Sbcr	Sbcw	Nbcw	Nbun									
Shelf	Sm	SAND/SHELL	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	shell/boulder	x	Snnn	Nnnn	x	Sbnn	Sbcu	Nbun											
Shelf	Sm	shell/cobble	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	SHELL/GRAVEL	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	shell/mud	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Sm	shell/rock	x	Snnn	Nnnn	x	Sbnn	Sbcr	Nbun											
Shelf	Sm	shell/sand	x	Snnn	Nnnn	x	Sbnn	Nbun												
Shelf	Ss	cobble	x	Snnn	Nnnn	x	Sbnn	Sbhn	Sbhq	Nbhq	Nbun									
Shelf	Ss	GRAVEL	x	Snnn	Nnnn	x	Sbnn	Sbun	Sbuh	Nbun										
Shelf	Ss	MUD	x	Snnn	Nnnn	x	Sbnn	Sbun	Sbum	Sbum_a	Sbum_s	Sbut	Nbun	Nbum						
Shelf	Ss	SAND	x	Snnn	Nnnn	x	Sbnn	Sbun	Sbus	Nbun	Nbus									
Shelf	Ss	SHELL	x	Snnn	Nnnn	x	Sbnn	Sbun	Nbun											
Shelf	Ss	soft	x	Snnn	Nnnn	x	Sbnn	Sbun	Sbuh	Sbum	Sbum_a	Sbum_s	Sbub	Sbus	Sbut	Nbun	Nbus	Nbum		

APPENDIX I-6 INVERTEBRATE UPDATES

HUD Workshop: Species to add
Alan Shanks & Brian Tissot
(1/6/2010)

*Indicators
&Structure-forming
% Ecologically important
@Economically important

Need depth range, preferred depth range (if available), and geographic range.

Cnidarians
*Stylaster**californicus* (high relief hard substrate)
Subtidal zone to 55m. Northern California to Southern California

Sea pens:
Sea Whip (*Halipterus willeomoesi)* spp. **& (soft sediments)*
Subtidal, below 20m. Southern Alaska to northern Washington, perhaps southern California.

Orange sea pen *(Ptilosarcus gurneyi)*& (soft sediments)*
Subtidal to 135m. On sand bottoms/soft sediments. Northern Alaska to northern Mexico.

Stylatula elongata *& (soft sediments)
Subtidal to below 10m. On sandy or mud bottoms. Southern Alaska to California.

Sea pansies *(Renilla koellikeri)**& (soft sediments)
On sand, in shallow waters. Southern California to Cedros Island, Baja California.

Gorgonians %&*

- Purple (heavily branched) Gorgonian *(Eugorgia rubens)*
Found in depths of 24 to 30m. Attached to rocks. Southern California to Baja. Common around the San Benito Islands off Baja.

- Red (branching) Gorgonian *(Lophogorgia chilensis)*
Depths of about 15 to 60m. Monterey bay to Isla Cedros, Baja California.

-Short Red (branching) Gorgonian *(Swiftia spauldingi)*
Subtidal to below 15m. Northern Washington to southern California. (Prefers habitat with strong current and ocean surge).

Anemones
Pink-Tipped Anemone (*Anthropleura elegantissima)*
Intertidal to about 18m. Abundant on rock faces or boulders, in tidepools or crevices, on wharf pilings. Alaska to central Baja.

Green Surf Anemone *(Anthropleura anthogrammacus)*
Low intertidal to about 30m. On rocks in tidepools and deep channels on exposed rocky shores, and on concrete pilings in open bays and harbors. Alaska to Panama.

Swimming Anemone *(Stomphia coccinea)*

Subtidal, below 10m. In very deep water on rocks. Circumpolar on this coast from northern Alaska to southern California.

Short Plumose anemone (*Metridium senile)*

Intertidal to 300m. On rocks warf pilings and other man-made structures, particularly in bays. Circumpolar; on our coast, from northern Alaska to Southern California.

Giant Plumose Anemone *(M. giganteum) (Metridium farcimen)*

Subtidal to 300m. On reefs, wrecks, and other structures. Northern Alaska to northern Mexico.

(*Utricina* spp.)

- Fish-eating Urticina (*Urticina piscivora*)

  From low intertidal to about 48m. On sides of rocks. Northern Alaska to southern California.

- Stubby rose anemone (*Urticina coriacea*)

  Intertidal to 45m. Attached to rocks, but usually buried partially in sand or shell debris. Alaska to southern California.

- Sand-rose anemone (*Urticina columbiana*)

  Subtidal, from 3 to 45m. Buried in sand and mud bottoms. Southern British Columbia to northern Mexico.

Orange cup coral (*Balanophyllia)* (high relief hard substrate)

Low intertidal to at least 48m. Attached to rocks. Southern Alaska to northern Mexico.

Pom-Pom Anemone (*Liponema brevicornis)*

Habitat: Deep sea. Range: soft, muddy seafloor at depths of 100-1,000m. <montereybayaquarium.org>

Dog-Toy Anemone (*Anthomastus ritteri*) (deep soft sediments)

Habitat: Deep sea. Range: on rocky surfaces at depths of 213-1,243m. <montereybayaquarium.org>

<u>Mollusks</u>

Purple Olivella (*Olivella biplicata*)

Low intertidal to shallow subtidal (preferred) to 50 m. Sandy bottoms in lagoons, bays and the open coast. British Columbia to Baja.

Black Turban snails (*Tegula funebralis)*

Intertidal rocks in protected coastal areas. British Columbia to Baja.

Brown Turban Snail (*T. brunnea*)*

Low intertidal & kelp forest. On blades and stipes of brown algae. Channel Islands to Cape Arage (rare).

Moon snail (*Polinices lewisii*)*& (shallow sand & mud, top predators)

Low intertidal to subtidal 150 m. Soft substrata off open coast. British Columbia to Baja.

Rock Scallop (*Hinnites giganteus*)

Low intertidal to 50 m. Cemeted to rocks. British Columbia to Baja California.
Geoduck

(*Panope generosa)*
Low intertidal to subtidal (no depth range given) in sandy mud of protected waters and bays. Common Alaska to Baja.

Northern Razor clam (*Siliqua patul)*
Common in sand on open flat beaches (dissipative beaches) receiving strong wave action. Low intertidal to shallow subtidal. Alaska to Pismo beach.

Native oyster (*Ostrea lurida*)@
Attached to rocks and shells in low intertidal in quite bays and estuaries. Alaska to Baja California

Swimming scallop (*Chlamys hastata*)@
On rocks, sand, or mud, from low-tide line to 152 m deep. Southern Alaska to Santa Barbara, California.

Giant Pacific Octopus (*Octopus dofleini*)%
Smaller individuals in low intertidal on rocky shores, Larger individuals subtidal to 100 m. Found around the north Pacific rim from Northern Asia to California. There is a subspecies (*O. dofleini martinis*) off British Columbia.

Humboldt squid@ (*Dosidicus gigas*)
Epipelagic to several hundred meters, common South America to Baja, in some years abundant off California and Oregon.

Gumboot chiton (*Crytochiton stelleri*)* (intertidal)
Intertidal rocky shores. Subtidal in kelp beds. Aleutian Islands to San Nicolas in southern California.

<u>Branchiopods</u>
Terebratalia transversa (no common name)
Low intertidal (rare) more common subtidal to at least 1,800 m. On hard surfaces. Alaska to Baja.
<u>Arthropods</u>
Sand Crab (*Emerita analoga*)
On sandy beaches in the intertidal. Chile to Oregon. Populations in Oregon are dependent on larvae carried from California by currents.

Blueband, Grainyhand, Hairy Hermit crabs* (*Pagurus samuelis, P. granosimanus,* and *P. hirsutiusculus*)
Common intertidal, rare subtidal to 30m. Alaska to central California or Baja.

Blackeyed and Alaskan hermits (*Pagurus armatus* and *P. ochotensi*)
P. armatus – low intertidal to 146 m. On sandy bottoms in sheltered areas. Common in sea pen beds. Alaska to Southern California
P. ochotensis – low intertidal to 400 m. Sand or muddy sand. Alaska to Pt. Arena, California.

Brown Box crabs (*Lopholithodes foraminatus*)@
Low intertidal to 550 m Typically on muddy bottoms below 18 m. Alaska to San Diego.

Appendix I-6: Habitat Use Database-Invertebrate Updates

Flat Porcelain crab (*Petrolisthes cinctipes and P. eriomerus*)
Intertidal on rocky shores. British Columbia to Santa Barbara

Flattop Porcelain crab (*Petrolisthes eriomerus*)
Under rocks low intertidal to 85 m. Alaska to San Diego.

Snow/tanner crab (*Chinoecetes bairdi*)@
Open mud or sand bottoms from 6 to 500 m. Juveniles at shallower depths, adults deeper. Bering Sea to Winchester Bay, Oregon.

Oregon cancer crab (*Cancer oregoensis*)@
Intertidal to 436 m depth. On rocky substrates. Alaska to Southern California Bight.

Red rock crab (*Cancer productus*)
Intertidal to 79 m. Younger crabs in shallow, older deeper. Occurs on a wide range of substrates, but most common in gravelly areas and on well-protected boulder beaches. Common in estuaries. Alaska to Baja.

Northern Kelp Crab (*Pugettia producta*)
Juveniles in the intertidal zone under rocks or in algae. Adults in kelp beds often in canopy. Alaska to Baja.

Bay ghost shrimp (*Neotrypea californiensis*)*
Sand and muddy sand in bays and estuaries. Alaska to Baja

Blue mud shrimp (*Upogebia pugettensis*)*
In estuarine mud in low intertidal. Alaska to Morro Bay, California.

Shore crabs (*Hemigrapsus nuda* & *H. oregonensis*)* (intertidal)
(*H. nuda*) Intertidal on rocky shores. Mostly open coast. Alaska to Baja.
(*H. oregonensis*) Intertidal under rocks on muddy or gravel beaches. Common in estuaries. Alaska to Baja.

Striped shore crabs (*Pachygrapsus crassipes*)* (El Nino in Oregon)
Rocky intertidal. Ecola State Park, Oregon to Baja. Present following El Ninos then slowly dies out.

Giant acorn barnacle (*Balanus nubilus*)
On hard surfaces low intertidal to 90 m. Alaska to La Jolla.

Gooseneck barnacles (Pollicipes polymerus)
Middle intertidal on rocks. British Columbia to Baja.

Smooth Bay Shrimp. (*Lissocrangon stylirostris*)
Common. Found intertidally on high energy sandy beaches and subtidally to 80 m. Alaska to central California.

Pink shrimp (*Pandalus jordani*)*@ (soft sediments)
Depth 45 to 370 m. Important commercial species. Alaska to Baja.

Sidestriped shrimp (*Pandalopsis dispar*)
Found on soft bottoms in deep water from 46 to 650 m. Fished commercially. Alaska to Manhattan beach, Oregon.

Spot prawn (*Pandalus platyceros*)*@

On rocky bottoms and vertical rock faces from very low intertidal to 500 m. Commercial and sport fishery. Alaska to Baja.

Echinoderms

Feather Star Crinoid (*Florometra serritissima*)&

Shallow subtidal to 1252m. On soft and hard bottoms. Alaska to Baja.

Sunflower star (*Pycnopodia/Rathbunaster*)%& (top predator)

Low intertidal to about 435m. On rocky as well as soft bottoms. Northern Alaska to northern Mexico.

Leather star (*Dermastaerias imbricata*) (rock)

Very low intertidal to 91m. On rocks, occasionally on sand. Central Alaska to northern Mexico.

Sand star (*Luidia foliolata*)* (deep mud/sand)

Intertidal to 613m. On soft bottoms. Central Alaska to Nicaragua, Galapagos Islands.

Pisaster spp. (giganteus) brevispinus)& (top predators)

-Giant Spined Star (Pisaster giganteus)& (top predators)

Very low intertidal to about 90m. On rocky as well as sand bottoms. Vancouver Island, British Columbia to Isla Cedros, Baja California.

-Short Spined Sea Star (Pisaster brevispinus)& (top predators)

Low intertidal to 182m. On rocky and soft bottoms. Southern Alaska to southern California.

Fragile Pink Urchin *(Allocentrotus fragilis)** (deep mud)

Found at depths of 50-1260m. On soft as well as rocky substrate. Queen Charlotte Islands to Baja California.

White sea urchin (*Lytechinus anamesus*)* (mid-depth sand)

Shallow subtidal to about 300m. On soft as well as rocky bottoms. Channel Islands, California to Gulf of California.

Sand dollar (*Dendraster excentricus*)* (nearshore sand)

Low intertidal to 90m. Soft substrate. Alaska to the central west coast of Baja California.

Burrowing sea cucumbers (*Psolus* spp). * (soft mud)

-Creeping Pedal Sea Cucumber or Slipper Sea Cucumber *(Psolus chitonoides)* * (soft mud)

Intertidal to 250m. Common in shallow subtidal areas. On rocks. Northern Alaska to northern Mexico.

-White Creeping Pedal Sea Cucumber *(Psolus squamatus)* * (soft mud)

Subtidal, between 37-1,061m. Northern Alaska to southern Chile.

Basketstar (*Gorgonocephalus eucnemis*)%& (high relief hard substrate)

Subtidal, between 10-1,850m. Typically from 15-150m. Sometimes abundant on rocky bottoms with moderate to strong water currents, or on mud and sand bottoms with projecting boulders, sea fans, and sea pens. Circumpolar; On our coast, from the Bering Sea (Northern Alaska) to southern California.

Appendix I-6: Habitat Use Database-Invertebrate Updates

Fishes
Intertidal fish
High Cockscomb (*Anoplarchus purperescens*)
Rocky intertidal. Alaska to southern California
Rock prickleback (*Xiphister mucosus*)
Rocky intertidal and subtidal to 18m. Alaska to southern California
Penpoint Gunnel (*Apodicththys flavidus*)
Rocky intertidal. Alaska to southern California
Tidepool sculpin (*Oligocottus maculosus*)
Tidepools on rocky shores. Bering sea to northern California.

Calico and mosshead sculpins (*Clinocottus embryum* and *C. globiceps*)
Intertidal rocky shores. In tidepools and under rocks. Alaska to southern California

Buffalo sculpin (*Enophrys bison*)
Intertidal to shallow subtidal (0 to 20 m) on rocky and sandy substrates. Alaska to central California.

Northern Clingfish (*Gobiesox maeandricus*)
Intertidal rocky shores. Alaska to southern California.

Surf smelt (*Hypomesus pretiosus pretiosus*)
Adults in nearshore waters. Spawn in course sand or fine gravel beaches in the high intertidal. Popular recreational fishery.

References:

Gotshall, Daniel W. Guide to Marine Invertebrates: Alaska to Baja California. Monterey, CA: Sea Challengers, 1994.
Hart J (1973) Pacific Fishes of Canada, Vol Bulletin 180. Fisheries Research Board of Canada, Ottawa
Jensen GC (1995) Pacific Coast Crabs and Shrimps. Sea Challengers, Monterey, California
Lamb, Andy and Bernard P. Hanby. Marine Life of the Pacific Northwest: A Photographic Encyclopedia of Invertebrates, Seaweeds and Selected Fishes. Madeira Park, BC: Harbour Publishing, 2005.

Lambert, Philip. Sea cucumbers of British Columbia, Southeast Alaska and Puget Sound. Vancouver, BC: Royal British Columbia Museum, 1997.

Lambert, Philip and William C. Austin. Brittle Stars, Sea Urchins and Feather Stars of British Columbia, Southeast Alaska and Puget Sound. Victoria, BC: Royal British Columbia Museum, 2007.
Love MS (1991) Probably more than you wanted to know about the fishes of the Pacific coast. Really Big Press, Santa Barbara
Monterey Bay Aquarium.Website Accessed: 5 January 2010. http://www.montereybayaquarium.org/animals/AnimalList.aspx?a=Invertebrates

Morris RH, Abbott DP, Haderlie EC (1980) Intertidal Invertebrates of California. Stanford University Press, Stanford, California
Shanks AL (ed) (2001) An Identification Guide to the Larval Marine Invertebrates of the Pacific Northwest. Oregon State University Press, Corvallis

APPENDIX J: FISHING GEAR IMPACTS FINDINGS FROM AMENDMENT 19 (EFH) TO THE GROUNDFISH FMP AS COMPARED TO CURRENT INFORMATION

2005 Findings Summary

As part of the initial EFH process, the Council issued an Impacts Model for Groundfish Essential Fish Habitat in 2005, which was adapted from the *Risk Assessment for the Pacific Groundfish FMP*. The Risk Assessment describes the EFH Model used to identify and describe EFH, an Impacts Model developed to evaluate anthropogenic impacts to EFH, and a data gaps analysis.

In 2005, there were several literature reviews on the effects of fishing gears on habitat, containing some studies specific to the West Coast. Only two studies from the Pacific were found that had useful information for the analysis. In order to develop a more complete picture of potential impacts, and following the recommendations of the NRC 2002 report on the Effects of Trawling and Dredging on Seafloor Habitat, the review relied on studies from the global literature. It was determined reasonable to infer impacts from studies in other areas so long as they are based on similar gear x habitat combinations, so the analysis was limited to only studies that involved gear types used on the west coast and the major habitat types that occur there. Hence, research from areas other than the Pacific coast provided most of the information on which the analysis was based.

In an effort to provide a quantitative measure of the degree of habitat modification resulting from a unit of fishing effort, two notional indices were developed: the Sensitivity Index and the Recovery Index. The Sensitivity Index provided a relative measure of the sensitivity of habitats to the action of fishing gears. The Recovery Index provided a measure of the time taken for a habitat to recover to a pre-impacted state.

The analysis suggested the following relative rankings of gear from highest to lowest impact: dredges > bottom trawls > pots & traps (no empirical data available for nets and hook & line gears). Although relatively less research existed on fixed gears, the various types of nets (gillnets, seines) were generally considered to have much less impact on the seabed than dredges and trawls, and hook & line methods had the least impact. Hence, the derived values reflect this relative ranking of impacts: dredges > trawls > nets > pots and traps > hook and line. These relative rankings corroborated those provided in Chuenpagdee et al.'s (2003) evaluation of U.S. fishing gears on seafloor habitat.

In addition to the relative gear rankings, the analysis of empirical research also showed a nearly consistent sensitivity ranking by substrate/macrohabitat type almost regardless of gear type from most adversely impacted to least: biogenic > hard bottom > soft sediment.

The 2005 analysis emphasized they only had a preliminary understanding of how fishing gear impacts biogenic habitats. Recovery times ranged mainly from zero to five years, although these were thought to be much longer for slow growing biogenic habitat such as corals and sponges, and the overall trends by gear and habitat types were similar to the trends indicated by sensitivity levels.

The general trends shown by the analysis when organizing habitats from most to least sensitive, and gears from most to least impacting, were similar to previous assessments. In terms of major habitats, biogenic habitats were found to be more sensitive than hard bottoms (although the former may occur on the latter) and these were found to be much more sensitive than soft bottoms.

There was very little research useful for the analysis on gear impacts in water depths exceeding 200 m. It should be noted, however, that there are theoretical bases for adjusting values from these deeper habitats. Benthic communities in deeper waters where wind and waves do not disturb the seabed were found to be probably less adapted to resisting and recovering from physical disturbances generally (Watling and Norse 1998). No such adjustments, however, were attempted for the analysis. Hence, the analysis should not be interpreted as a direct quantification of gear impacts that can be used to infer, for example, functional habitat characteristics related to EFH.

A related topic that was not considered in the analysis was the issue of fishing intensity, or frequency of disturbance of the bottom by fishing gear. In particular, if the period between successive trawl tows in a specific habitat is less than the recovery time, the habitat will remain in a chronically impacted state.

There was very little quantitative information describing the relationship between habitat type, structure, and function and the productivity of managed fish species. In particular, the level of information for most species x habitat associations remained at Level 1 as defined in the NMFS EFH Final Rule Guidance (i.e., presence-absence only), requiring a precautionary approach to the determination of potential adverse impacts.

Summary of Changes since the 2005 Findings

Since 2005, there are been several new publications including peer-reviewed literature, white papers and technical memorandums relevant to West Coast groundfish fisheries that have studied: 1) the effects of fishing gear on benthic habitats; 2) the status of biogenic habitat (corals and sponges); 3) predictive modeling of biogenic habitats; and 4) the effects of fishing gear-related marine debris on habitats.

The Effects of Fishing Gear on Benthic Habitats

The recent studies on the effects of fishing gear on benthic habitats are primarily focused on the effects of trawling. However, there is at least one publication that discusses the effects of bottom longlines. There have been several new studies the west coast of the contiguous US, Canada and Alaska that have focused on otter trawls in unconsolidated substrate including sand and mud that contain biogenic habitat on the seafloor. Additionally since 2005, general effects of fishing with mobile, bottom-contact fishing gear (such as otter trawls) are increasingly well established through studies worldwide. Relative to the information available in 2005, the new studies including those performed on the U.S. west coast, found significant impacts of trawling on soft sediment habitats. The following are summaries of the most recent and relevant findings that highlight new information to be considered when determining if there is a need to alter current EFH designations:

- Kaiser et al. (2006) conducted a meta-analysis of 101 different fishing impact manipulations and found that the direct effects of different types of fishing gear were strongly habitat-specific. The biota of soft-sediment habitats, in particular muddy sands, were surprisingly vulnerable, with predicted recovery times measured in years. Slow-growing large-biomass biota such as sponges and soft corals took much longer to recover (up to 8 yr) than biota with shorter life-spans such as polychaetes (<1 yr). Otter Trawls had a significant initial effect on muddy-sand and mud habitats and this could reflect the great depth to which otter doors penetrate this soft sediment habitat, but on the latter these effects were short-lived with an apparent long-term, positive, post-trawl, disturbance response (there were no recovery data for muddy-sand). This positive response may represent an increase in the abundance of smaller-bodied fauna, but a possible overall decrease in biomass in response to trawling. In muddy sand, crustaceans appear more strongly impacted by otter trawls than annelids and mollusks. The effect of otter trawls in biogenic habitats was less severe than for scallop dredges, but there was insufficient data to deduce an accurate recovery time based on published experimental manipulations.
- Baer et al. (2010) found that bottom longlines can cause significant damage to sensitive habitats through entanglement and concluded that management of areas to be fished appear to be the main mitigative strategy for this problem.
- Brown et al. (2005) studied the effects of commercial otter trawling on benthic communities in

the southeastern Bering Sea and documented that mobile invertebrate scavengers were more abundant in chronically trawled areas.

- De Marignac et al. (2008) conducted an analysis of videographic data on unconsolidated substrates in areas opened and closed to trawling on the central California coast and found that significant differences existed between an actively trawled area and an area that had been recovering from trawling impacts for three years at the time of sampling. Findings indicated that biogenic mound and biogenic depression microhabitats were significantly less abundant at trawled sites. Epifaunal macro-invertebrates were sparsely distributed and occurred in low numbers in both treatments. However, their total abundance was significantly different between treatments, which was attributable to lower densities at trawled sites. These differences were manifest in the micro-topographic structure that fish utilize for protection from predation and as refugia from currents, as well as in invertebrate epifaunal and infaunal communities. Each of the differences was found to be consistent with the literature dealing with gear impacts to seafloor communities.
- Lindholm et al. (2008) studied Patterns in the distribution of the sea whip in an area impacted by mobile fishing gear off the central California coast and found that the marked difference in the occurrence of upright sea whips among video transects was un-anticipated and may be attributable to two primary factors: water depth and/or impacts from otter trawling.
- Hixon and Tissot (2007) compared trawled versus untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon and concluded that the observed differences between trawled and untrawled demersal fish and epibenthic macroinvertebrate communities on deep mud seafloors adjacent to Coquille Bank were the result of gear impacts of groundfishing activities, particularly trawling, rather than local environmental differences. These differences suggest that the effects of bottom trawling along the west coast of North America are similar to those documented on deep soft-sediment seafloors elsewhere in the world. Furthermore they point out that it seems prudent to consider the adverse impacts of bottom trawling on mud-seafloor ecosystems of the continental shelf and slope and that their results are best examined in the context of the many rigorous studies worldwide demonstrating that bottom trawling clearly alters communities of seafloor species.
- Interpretation of the Hixon and Tissot study is complicated by the fact that the sites they compared had nonoverlapping depth ranges, confounding depth and trawling-related effects on the biota (Hannah et al. 2010). However, Hannah et al. 2010 studied the effects of trawling for ocean shrimp on macroinvertebrate abundance and diversity near Nehalem Bank, Oregon at shallower depths and found comparable results: that densities of the sea whip, the flat mud star, unidentified Asteroidea, and squat lobsters were lower at heavily trawled sites, as was invertebrate diversity based on the Shannon-Wiener index. Sea cucumbers and unidentified corals were observed at lightly trawled sites but not at heavily trawled sites.

Several papers have underscored the fact that little has been written about recovery of seafloor habitat from the effects of fishing and that there is a lack of long-term studies, control sites or research closures, which hinder the ability to fully evaluate impacts. ODFW Marine Resources Program Staff also highlighted this issue during a technical review and discussion of the Hixon and Tissot paper where concerns were raised about the designated ‘untrawled’ area as an area that was part of historical shrimp and groundfish trawling grounds, which could hinder an accurate evaluation of impacts and recovery. They stated: "This is an analysis of data collected during a 1990 survey in response to proposals for oil drilling off of the west coast. The result was a comparison that was not adequately controlled for differences between sites. In addition MRP data shows that both sites had been trawled by bottom trawl gear." In response to this critique and other concerns raised, the authors responded that these critiques did not affect the general result of documented trawl impacts to soft sediment.

Predictive Modeling of Biogenic Habitats

Subsequent to the EFH Final Action in 2005, Fujioka (2006) documented the impacts model used in the

Alaska EFH process. This model offered several advantages over the impacts model used in the West Coast EFH process. In particular the model addressed:
Spatial heterogeneity in trawl effort and habitat types;

- Trawl intensity, using empirical trawl effort data from the region;
- More realistic estimates of recovery time for hard corals on the order of 100 years;
- Development of a Long-term Effect Index (LEI), which calculated an estimate of the proportion of each habitat type in each cell impacted over the long-term under current levels of effort.

Key outcomes of the analysis were that the LEI results for hard corals were typically greater than 50% even under low levels of trawl effort and that substantial long-term impacts could occur to soft sediment habitats depending on trawl intensity. While this approach employs a model with several underlying assumptions, it provides for quantitative estimates of fishing impacts in a spatially explicit manner, which is a significant improvement over the qualitative nature of the impacts model used in the west coast Pacific EFH process that concluded in 2005.

The Effects of Marine Debris on Benthic Habitats

Watters et al (2010). provided the first quantitative assessment of marine debris and its impacts to the seafloor in deep submarine canyons and continental shelf locations off California and the US. They discerned only a few negative impacts to benthic organisms. Two incidents of ghost fishing by derelict gear were observed over 189 km of surveyed seafloor and a variety of habitats; however, several gear items could not be evaluated for ghost fishing due to limited viewing from the videotape. Entanglement of fishes in other types of debris was not witnessed. Some physical disturbance to habitats (including common structure-forming macroinvertebrates) was observed, which was caused by debris. It is possible that there was limited ability to see disturbance from the videotape, especially when caused by monofilament line. However, from scuba surveys conducted in shallow reefs (which provide direct viewing of marine debris), Chiappone et al. (2005) found that less than 0.2% of the available invertebrates were affected by lost hook-and-line fishing gear, even though this gear caused 84% of the documented impacts (primarily tissue abrasion) to sponges and cnidarians. Debris was found to alter the seafloor, by providing artificial habitat to demersal organisms. The majority of the debris was colonized, sometimes quite heavily, by encrusting invertebrates.

Literature Cited

Baer et al. 2010. Canadian Science Advisory Secretariat, Research Document 2010/012, Impacts of Longline and Gillnet Fisheries on Aquatic Biodiversity and Vulnerable Marine Ecosystems.

Brown, E.J., Finney, B., Hills, S., and Dommisse, M. 2005. Effects of commercial otter trawling on benthic communities in the southeastern Bering Sea. Am. Fish. Soc. Symp. 41, 439–460.

Chiappone, M., Dienes, H., Swanson, D.W., Miller, S.L., 2005. Impacts of lost fishing gear on coral reef sessile invertebrates in the Florida Keys National Marine Sanctuary. Biological Conservation 121, 221–230.

Chuenpagdee et al. 2003. Shifting gears: assessing collateral impacts of fishing methods in US waters. Front Ecol Environ 2003; 1(10): 517–524

de Marignac, J., Hyland, J. Lindholm, A. DeVogelaere, W.L. Balthis, and D. Kline. 2008. a comparison of seafloor habitats and associated benthic fauna in areas open and closed to bottom trawling along the central California continental shelf. Marine Sanctuaries Conservation Series ONMS-09-02, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries. Silver Spring, MD. 44 pp.

Fujioka, J. T. 2006. A model for evaluating fishing impacts on habitat and comparing fishing closure strategies. Canadian Journal of Fisheries and Aquatic Sciences 63:(10) 2330-2342,.

Guinotte, J.M. and A.J. Davies. 2012. Predicted deep-sea coral habitat suitability for the U.S. West Coast. Report to NOAA-NMFS. 85 pp.

Hannah, R.H., S.A. Jones, W. Miller, and J.S. Knight. 2010. Effects of trawling for ocean shrimp (*Pandalus jordani*) on macroinvertebrate abundance and diversity at four sites near Nehalem Bank, Oregon. Fishery Bulletin 108:30–38.

Hixon, M.A and B.N. Tissot. 2007. Comparison of trawled vs. untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. J. Exp. Mar. Biol. Ecol. 344: 23-34.

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J., Karakassis, I. 2006. Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series 311: 1-14.

Lindholm, J., M. Kelly, D. Kline, and J. deMarignac. 2008. Patterns in the local distribution of the sea whip, *Halipteris willemrnoesi*, in an area impacted by mobile fishing gear. Marine Technology Society Journal 42: 64-68.

Watters, Diana L., Mary M. Yoklavich, Milton S. Love, and Donna M. Schroeder . 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60 (2010) 131–138.

Whitmire, C.E. and Clarke M.E. 2007. State of deep coral ecosystems of the U.S. Pacific Coast: California to Washington. pp. 109-154. In: S.E. Lumsden, T.F. Hourigan, A.W Bruckner. and G. Dorr (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Tech. Memo., CRCP3. Silver Spring, MD. 365 pp.

APPENDIX K COMMERCIAL FISHING EFFORT

Appendix K-1 Bottom Trawl Effort

Appendix K-2 Mid-Water Trawl Effort

Appendix K-3 Fixed Gear Effort

Appendix K-1 Bottom Trawl Effort

Figures in Appendix K-1 depict the spatial distribution of commercial bottom trawl effort within two time periods: "Before" (1 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Each of the three coastal states administers a commercial logbook program, for which records are uploaded to the PacFIN regional database. Database records were utilized for commercial trips using bottom trawl gear types (e.g., "small" footrope, "large" footrope, flatfish, selective flatfish, and roller trawl) regardless of fishery sector (e.g., limited entry, open access). Records from the majority of state-managed trawl fisheries (e.g., pink shrimp, ridgeback prawn, sea urchin) are not included in PacFIN and thus are not represented in the figures. Tows targeting one state-managed trawl fishery – California halibut – are submitted to PacFIN and thus are included in the bottom trawl effort summaries.

In order to analyze the effort data spatially, a straight line connecting the start and end points was used to represent each tow event. Towlines intersecting land, outside the U.S. EEZ, deeper than 2,000 m, or with a calculated straight-line speed greater than five knots were removed from the spatial analysis. Two complimentary data products were created with these records: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than three vessels were operating, and 2) an extent polygon that shows the gross spatial extent of effort.

The first data product, intensity, was calculated as the total length of all towlines intersecting a standardized area. To calculate this metric, a line density algorithm in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) was used. The line density algorithm calculates density within a circular search area (radius = 3 km) centered at a grid cell (size 500 m x 500 m). The value (units: km/km^2) for each grid cell is the quotient of total towline portions intersecting the circular area per grid cell area. Since density outputs are highly sensitive to the specified radius and cell size, the absolute values are less important than the relative nature of them. The benefit of this output over depicting towlines themselves is that the density output better identifies areas where fishing effort is concentrated, while still ensuring confidentiality of individual fishing locations. The initial density output was more spatially extensive than the one shown in Appendix K-1, because it included cells with density values calculated from tows made by less than three vessels. Those "confidential" cells were removed for the final published data product. Density parameters were chosen in order to minimize data exclusion (due to confidentiality mandates) while still providing a fairly high spatial resolution (500 x 500 m). For the bottom trawl effort maps, only 1.1 and 1.8 percent of all effort (i.e., length of towlines) was excluded within a given time period, although the proportion varies considerably in certain areas along the coast.

The second data product, the extent polygon, was created using an algorithm known as a convex hull. Convex hulls are a type of minimum extent polygon that forms an "envelope" around a group of points, or in this case, straight lines representing tows. The algorithm can be applied at various spatial scales. In this case, we grouped towlines into 0.5° latitude x 0.5° longitude blocks. The algorithm was then applied to each set of towlines within each block. Finally, all convex hull polygons were merged together for each time period. The resulting polygon encloses all towlines within each time period (e.g., Figure 15). The best way to interpret this data product is that no bottom trawling occurred outside of the extent polygon within a particular time period. In order to ensure that each extent polygon encompasses towlines from at least three vessels, the result is an overestimation of the areas of seafloor actually contacted by trawl gear. In fact, there are many areas within the extent polygon where no trawling occurred; hence this product is only intended to represent the gross "footprint" of trawling for each time period. However, there are several alternative approaches to determining the "footprint" of fishing effort resulting in very different spatial extents and interpretations, such as identifying the minimum area encompassing a certain percentage of all tows (e.g., Ban and Vincent 2009).

Appendix K-1: Bottom Trawl Effort

These spatial summaries of bottom trawl effort were developed from data represented only by start and end points of tows. It is recognized that tows rarely follow straight-line paths; however, this was the best information available on the spatial distribution of effort for vessels using bottom trawl gears. Because of this limitation and due to prohibitions of trawling within state waters, representatives of the states of Washington and California requested that any portions of the spatial summaries that intersect prohibited state waters be removed. In addition, Washington requested that effort occurring within both state and federal waters of the Salish Sea be removed since they felt that this information was incomplete and may not be representative of fishing effort within those areas. However, NMFS General Counsel has advised the EFHRC that there is not justification to limit access/display of these data from state waters so they are included in the map products.

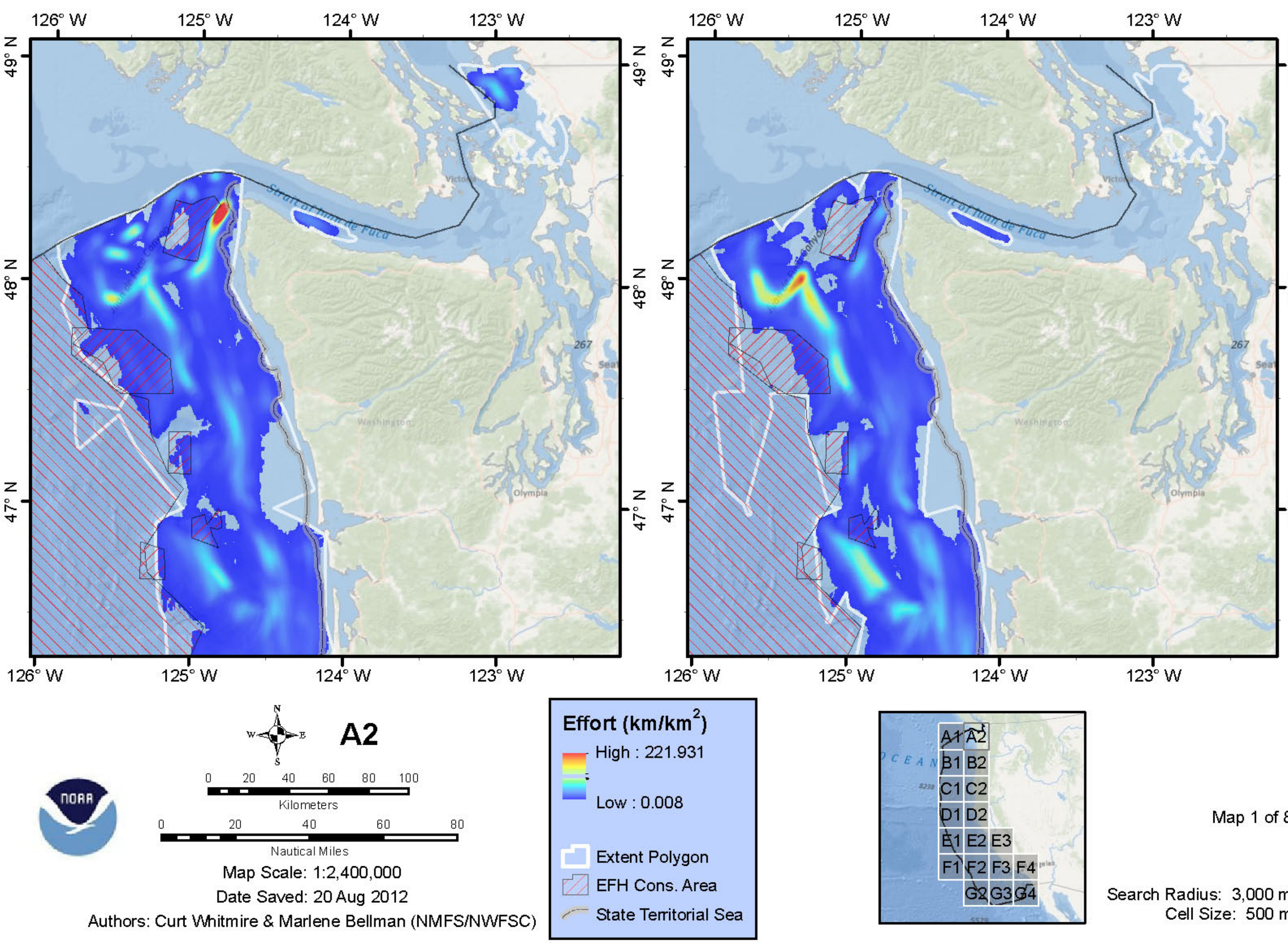
In order to evaluate how fishing effort has changed between the two time periods, the color ramps for the intensity layers are scaled to the same range of values in each panel (see Appendix K-1 figures). Blue- (red-) shaded areas represent the lowest (highest) relative effort in both time periods. The upper value in the map legends is the lowest "high" value between the time periods. It was necessary to set the color ramp to the lowest "high" value in order for the colors in each panel to perfectly match and therefore be comparative.

Areas of high relative effort in the former time period are apparent off northern Washington (Plate A2), in Monterey Bay, CA (Plate E3) and south of Los Angeles, CA (Plate F4). In the recent time period, only one area in deeper waters off northern Washington (Plate A2) shows up with relatively high bottom trawl effort. There are a number of areas of medium to medium-high relative effort that show up in the map panels for both time periods. They are distributed throughout the region over both the shelf and slope, often showing some persistence between the two time periods.

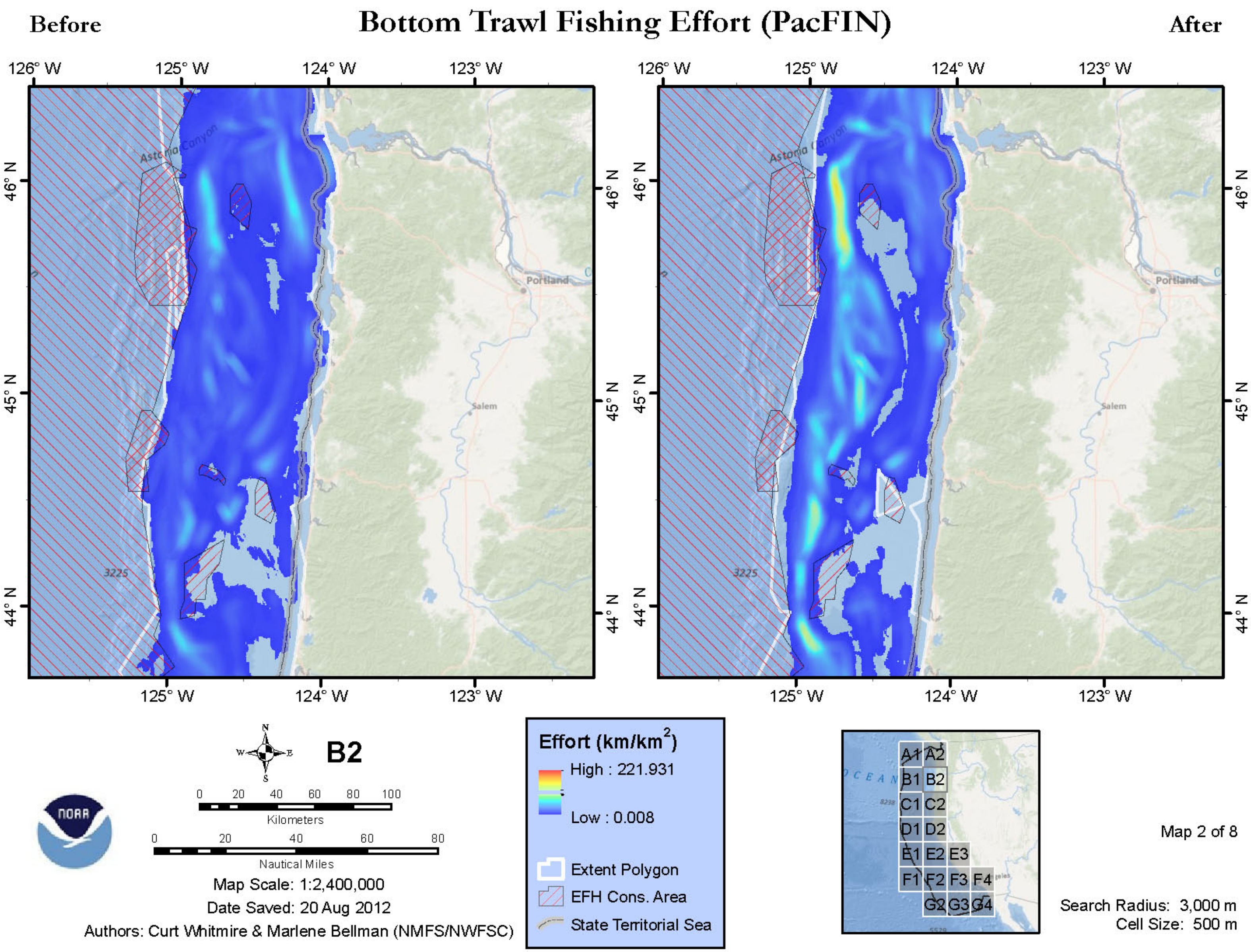
To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
A GIS project was constructed in ArcGIS™ geographical information system software (Environmental System Research Institute, Incorporated, Redlands, California) in order to archive and display the collected data files, and to create the map layouts from which the comparative maps were derived. This project is currently available online at: http://efh-catalog.coas.oregonstate.edu/overview/.

Bottom Trawl Fishing Effort (PacFIN)

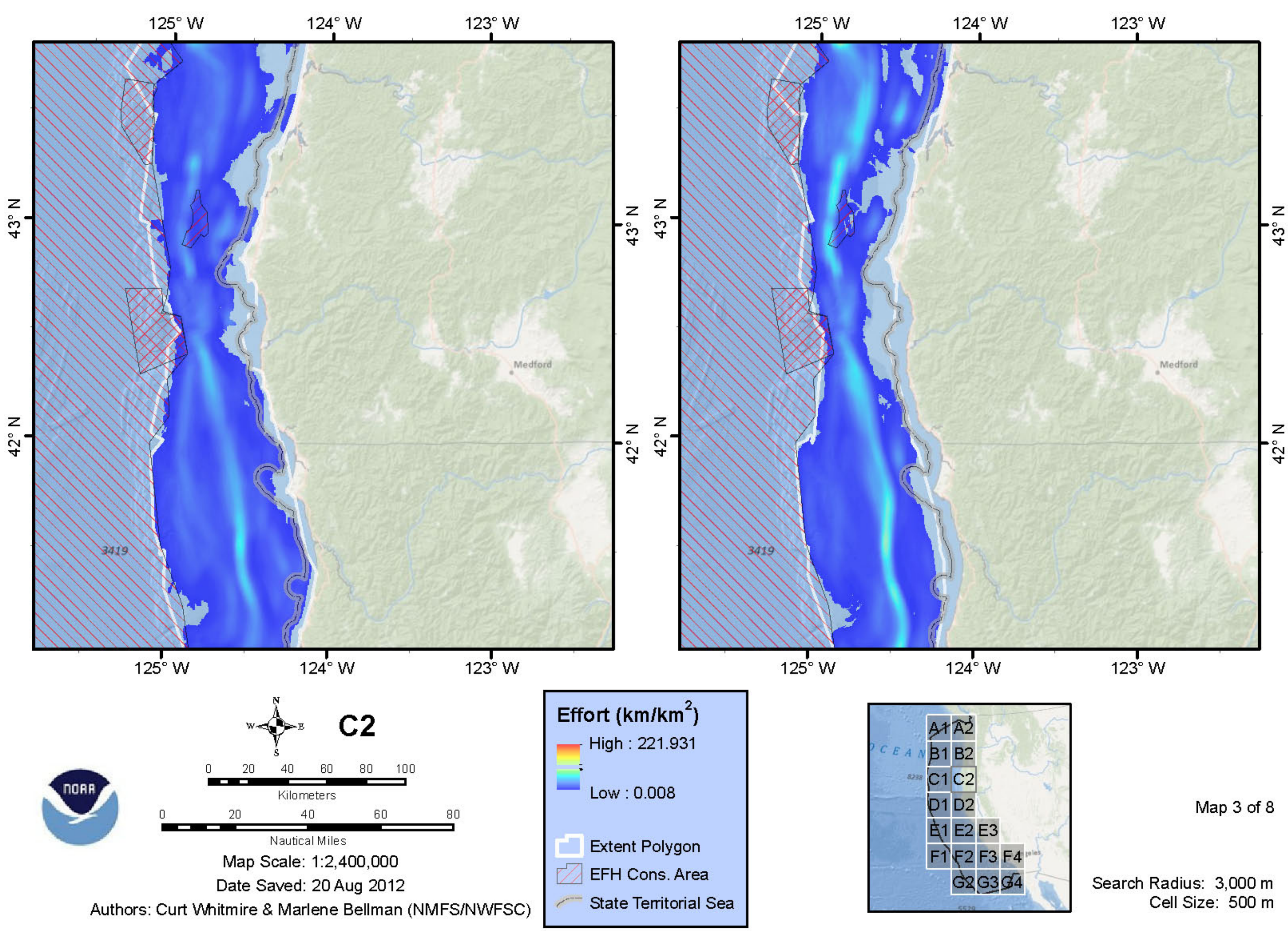
Before | After

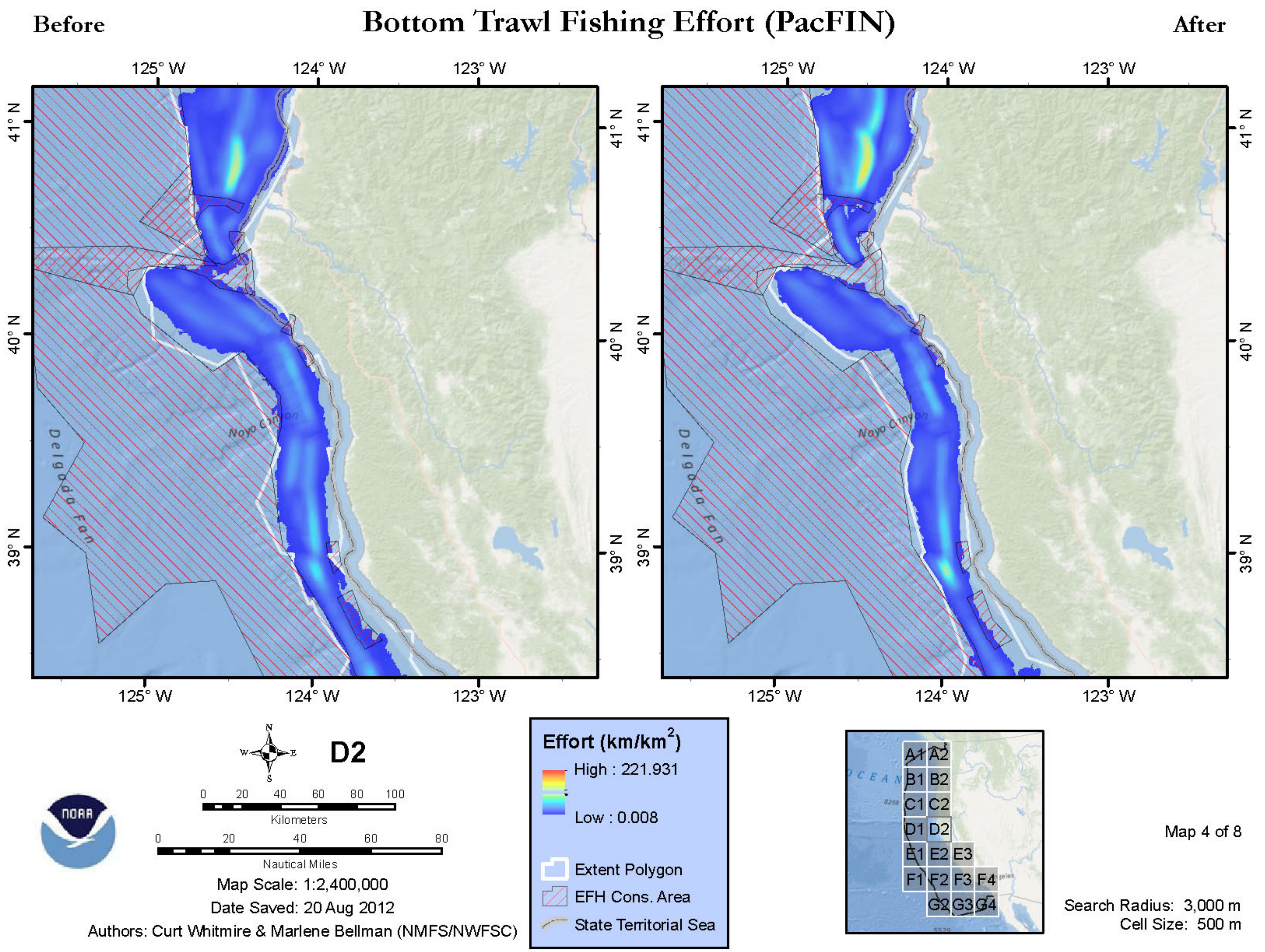


Bottom Trawl Fishing Effort (PacFIN)

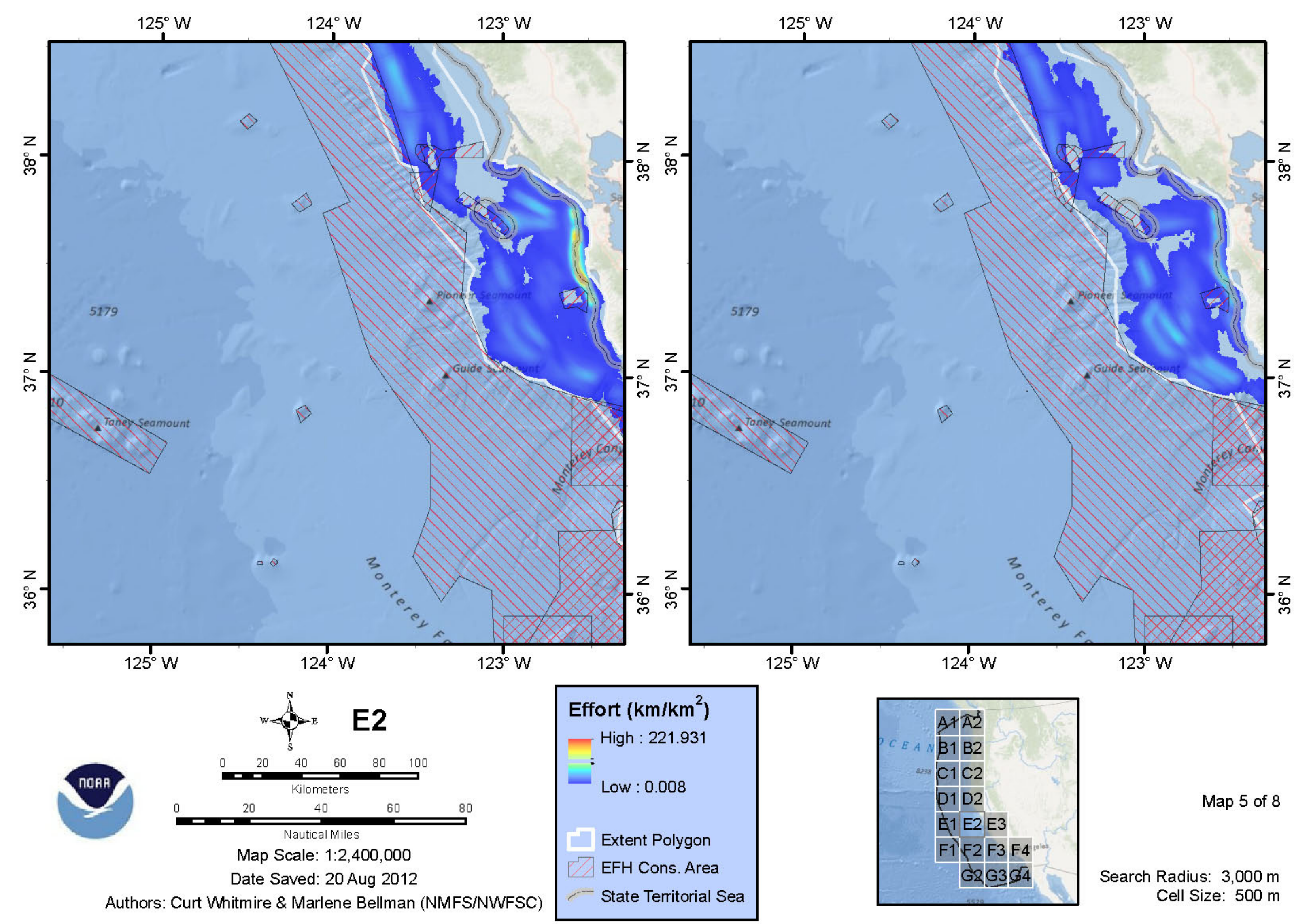


Bottom Trawl Fishing Effort (PacFIN)

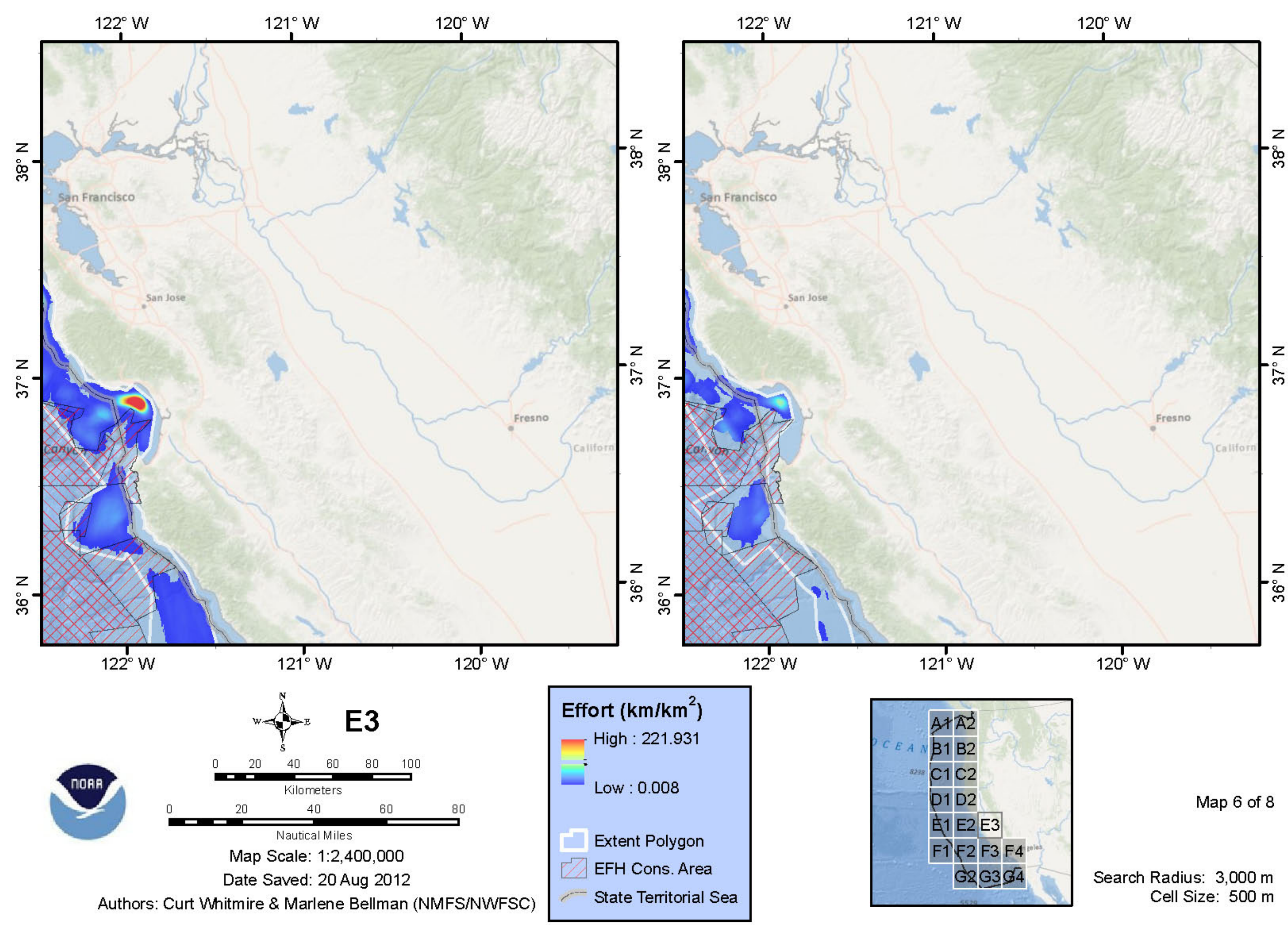


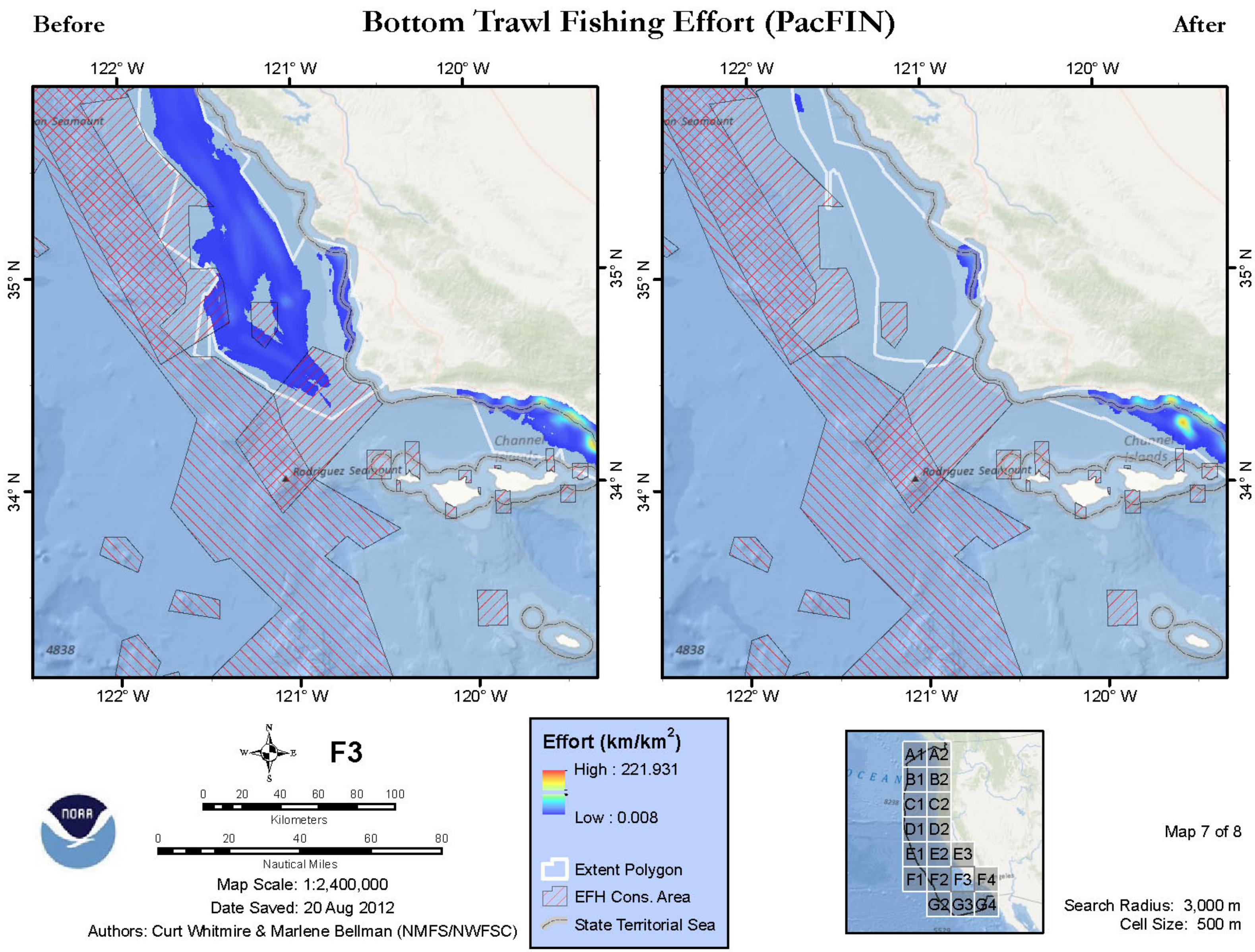

Before
Bottom Trawl Fishing Effort (PacFIN)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km²)
High : 221.931
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 8
Search Radius: 3,000 m
Cell Size: 500 m

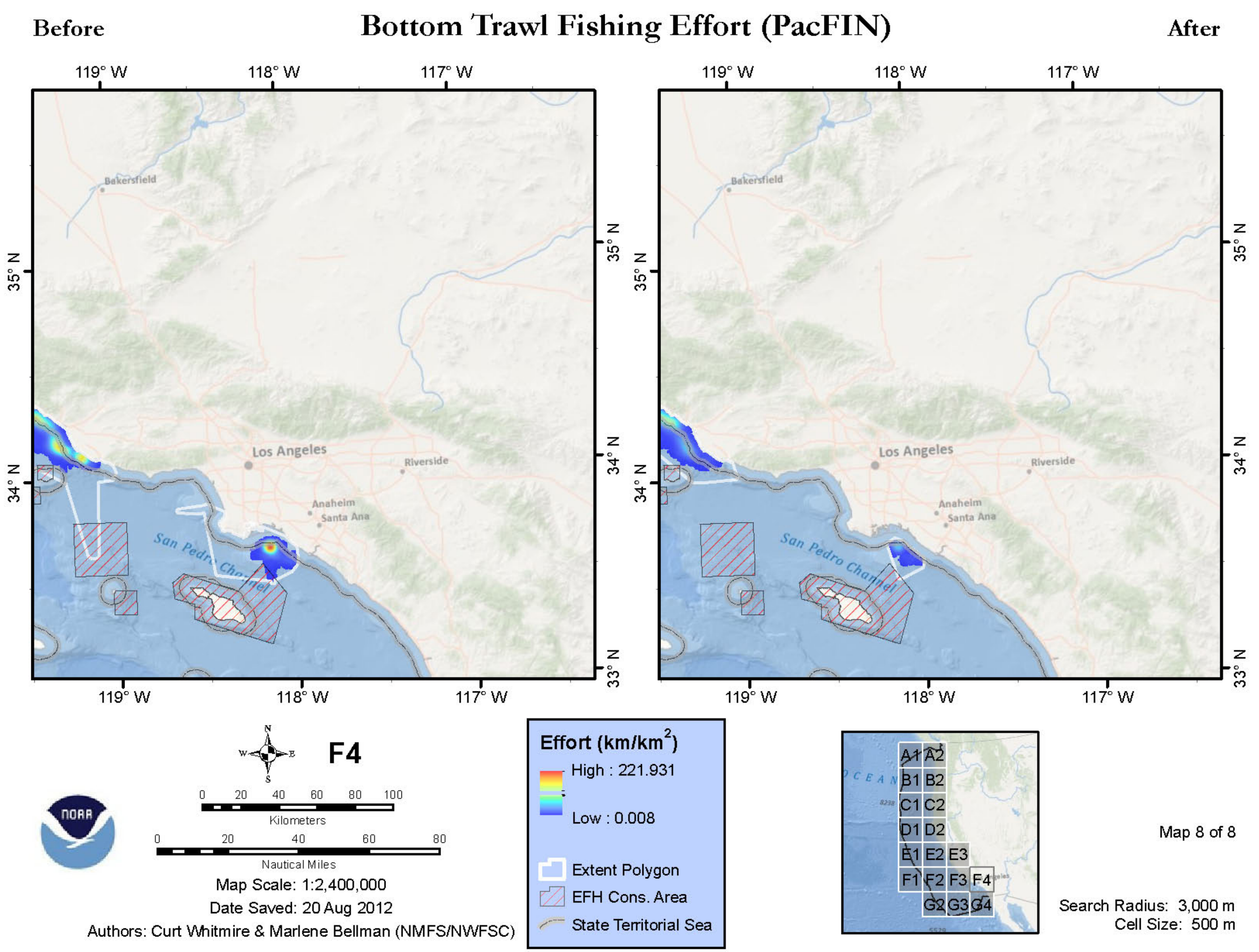
Bottom Trawl Fishing Effort (PacFIN)



Before **Bottom Trawl Fishing Effort (PacFIN)** After




Before
Bottom Trawl Fishing Effort (PacFIN)
After
122° W
121° W
120° W
35° N
34° N
Rodriguez Seamount
Channel Islands
4838
F3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km²)
High : 221.931
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 7 of 8
Search Radius: 3,000 m
Cell Size: 500 m



Before
Bottom Trawl Fishing Effort (PacFIN)
After
119° W
118° W
117° W
35° N
34° N
33° N
Bakersfield
Los Angeles
Riverside
Anaheim
Santa Ana
San Pedro Channel
F4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km²)
High : 221.931
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 8 of 8
Search Radius: 3,000 m
Cell Size: 500 m

Appendix K-2 Mid-Water Trawl Effort

Appendix K-2 Plates depict the spatial distribution of mid-water trawl effort within two time periods: "Before" (1 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of mid-water trawl tows were compiled from two data sources: 1) Logbook data originating from the state logbook programs and uploaded to the PacFIN regional database, and 2) observer records from the ASHOP. These two data sources represent the shoreside and at-sea hake fleets, respectively. Included in the ASHOP data are observations of tribal fishing in the at-sea hake sector.

In order to analyze the effort data spatially, a straight line connecting the start and end points was used to represent each tow event. Towlines intersecting land, outside the EEZ, deeper than 2,000 m, or with a calculated straight-line distance greater than 20 km were removed from the spatial analysis. Because of their patchy spatial distributions, towlines for mid-water trawls occurring south of Cape Mendocino were removed from the analysis at the request of the state of California. Similar to the bottom trawl effort maps, two complimentary data products were created with these towlines: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than three vessels were operating, and 2) an extent polygon that shows the gross extent of effort. Please refer to the description of methods used to create the bottom trawl effort plates (see Appendix K-1 above), as they were very similar to the methods used for the mid-water trawl plates. The initial density output was more spatially extensive than the one shown in the plates because it included cells with density values calculated from tows made by less than three vessels. For the published layer, grid cells were removed where tows from less than three vessels intersected the circular search area. These "confidential" cells only represent 1.6 and 3.1 percent of all towlines within a given time period, although the proportion varies considerably in certain areas along the coast.

Similar to the bottom trawl effort figures, these spatial summaries of mid-water trawl effort were developed from data represented only by start and end points of tows. It is recognized that tows rarely follow straight-line paths; however, this was the best information available on the spatial distribution of effort for vessels using mid-water trawl gears. Because of their patchy spatial distributions, towlines for mid-water trawls occurring south of Cape Mendocino were removed from the analysis at the request of the state of California.

AppendixK-2 Plates show areas of high relative effort in the before time period are apparent off northern Washington and central and southern Oregon. In the after time period, areas of high relative effort show up again off northern Washington, off south-central Oregon, and near the Oregon-California maritime border (Plate A2). There are a number of areas of medium to medium-high relative effort that show up in the map plates for both time periods, but appear more widespread in the recent period. Those areas show little spatial consistency between the two time periods, possibly due to the migratory nature of the target species.

To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
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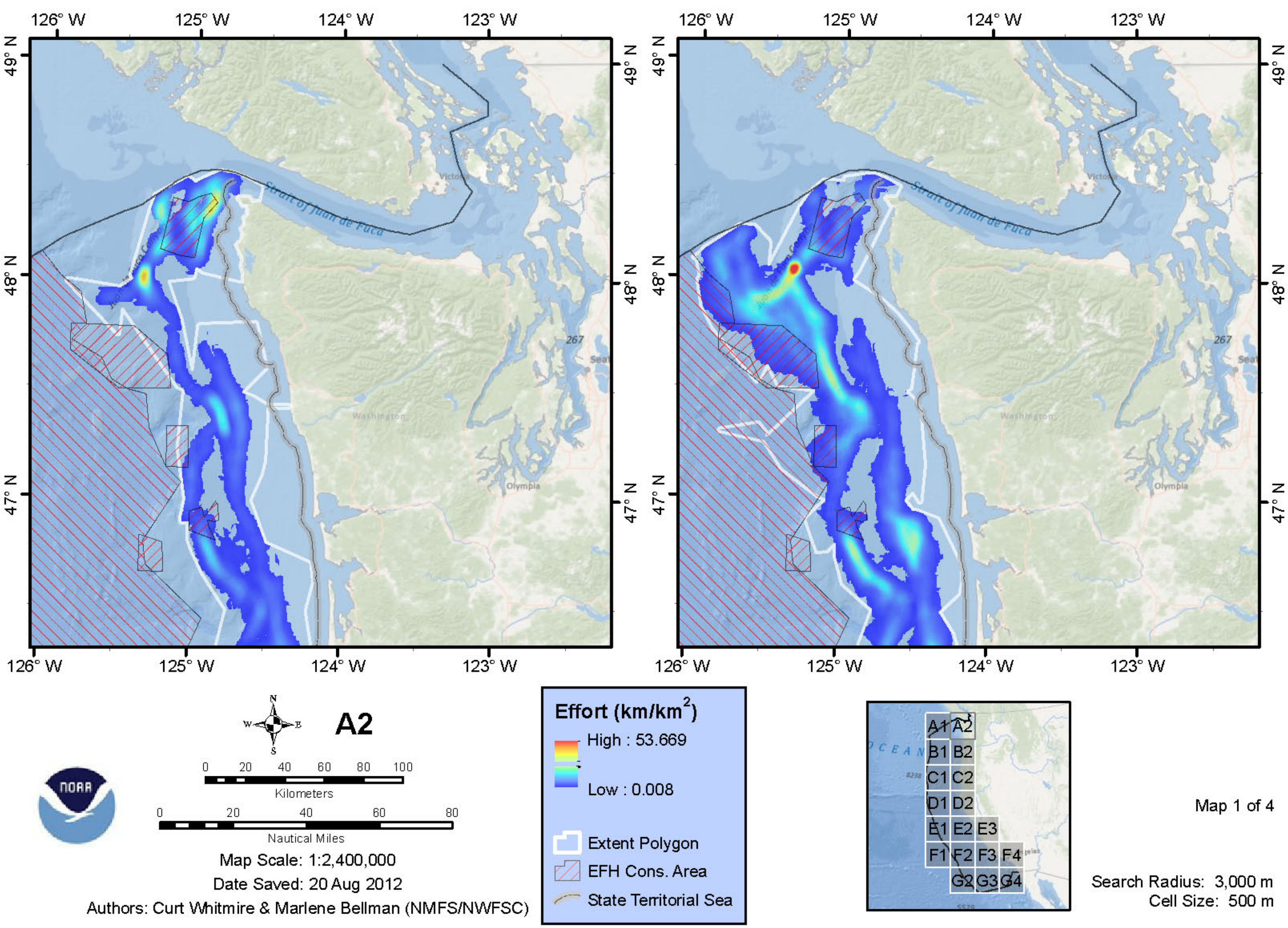
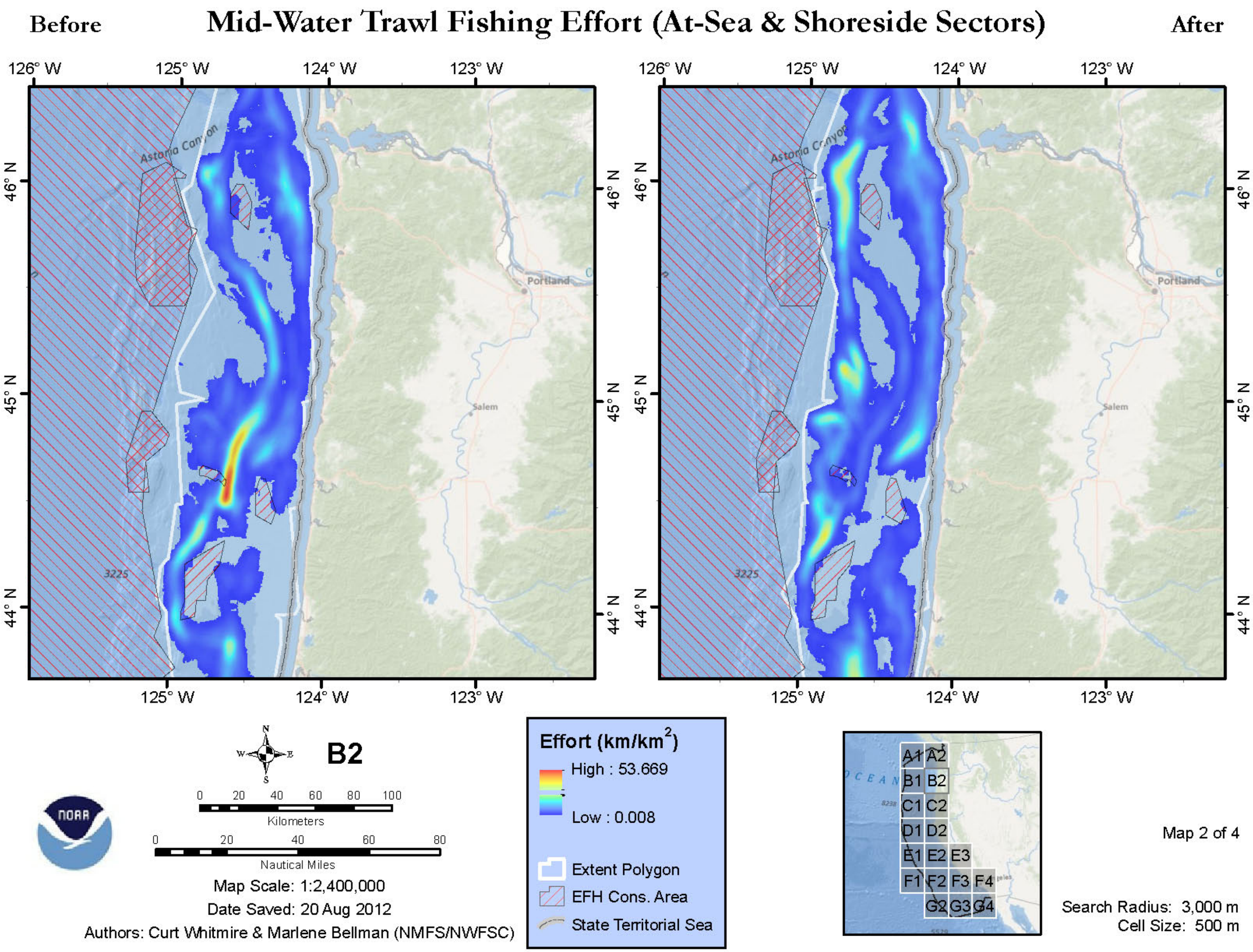
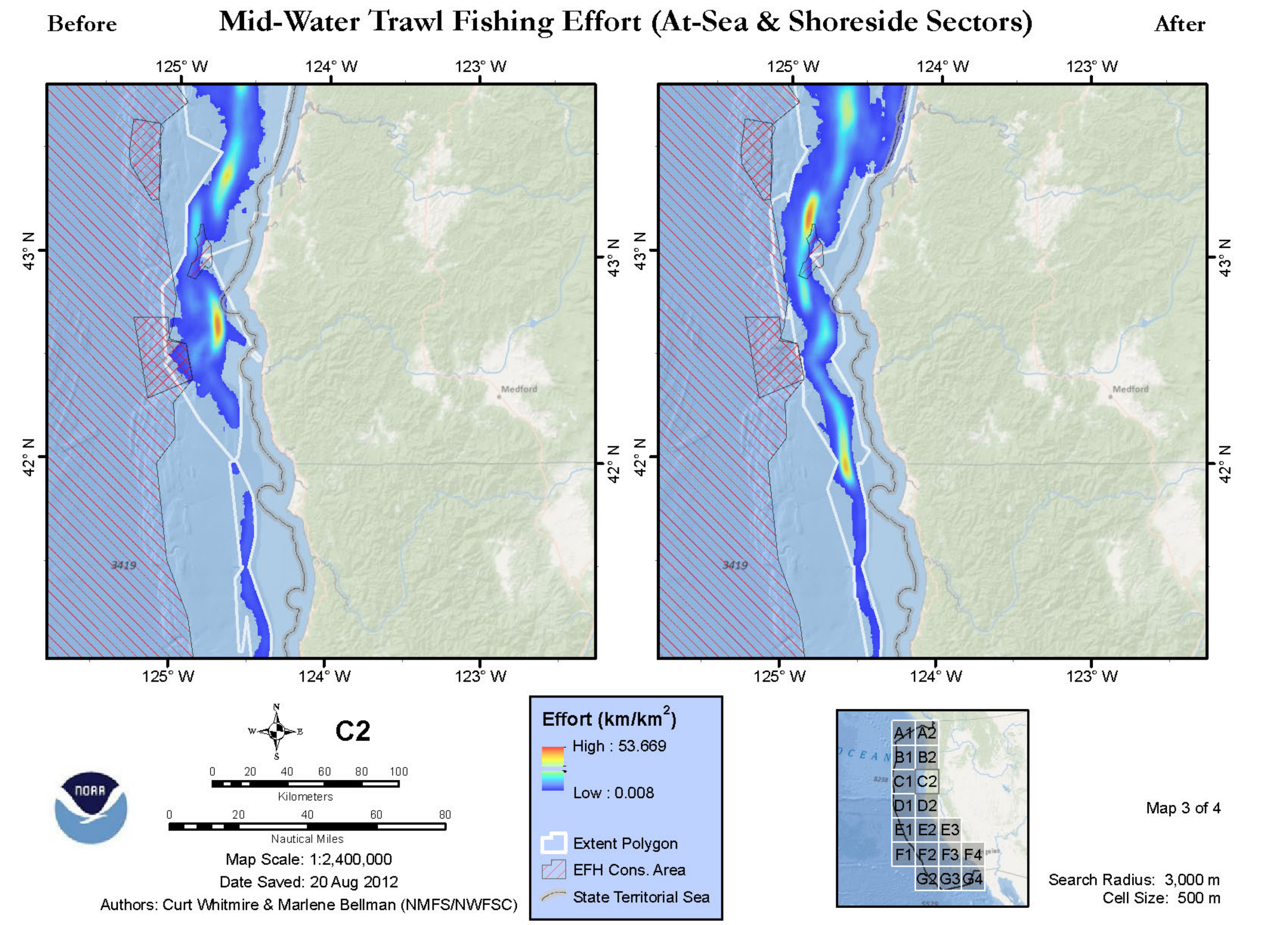
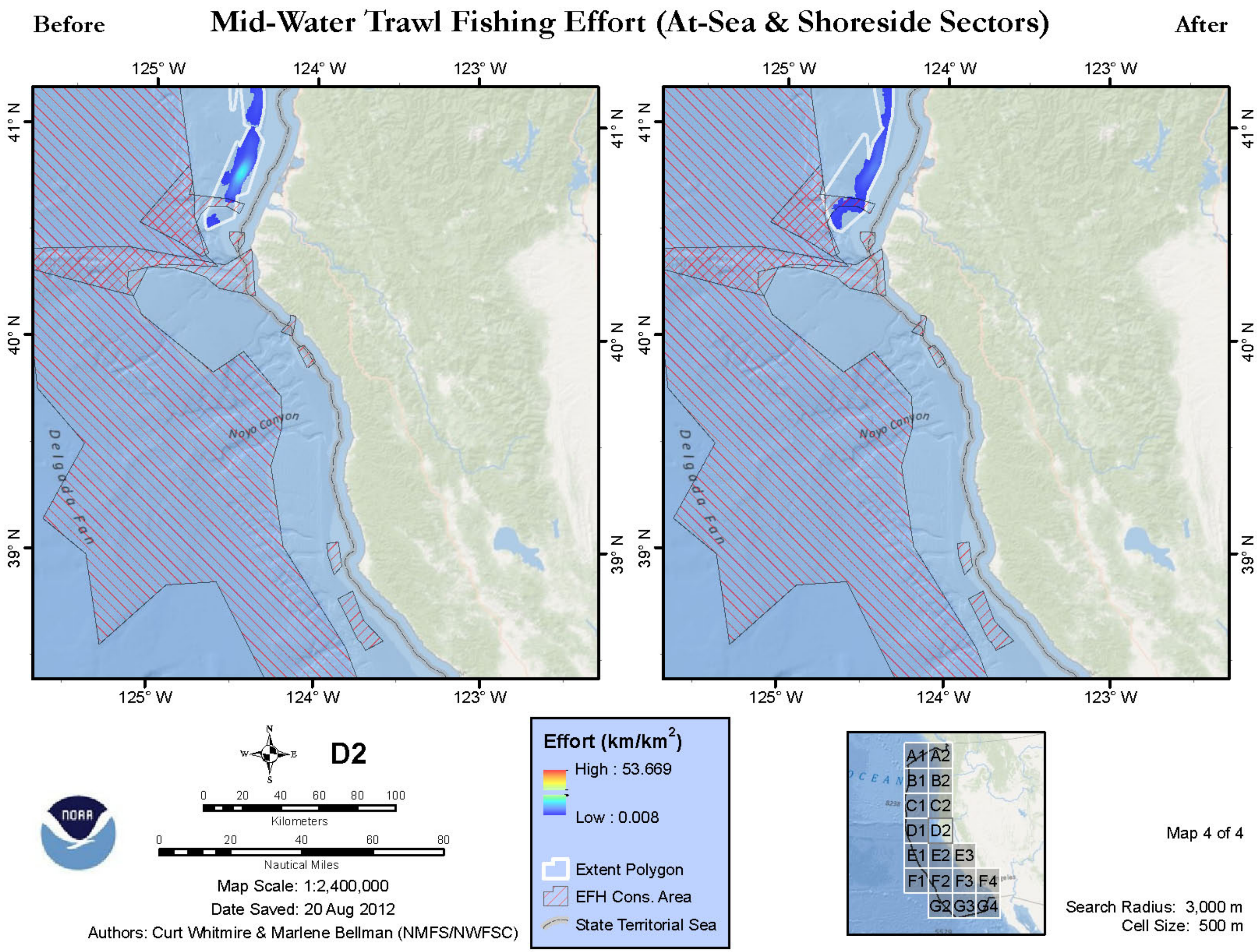
Before **Mid-Water Trawl Fishing Effort (At-Sea & Shoreside Sectors)** **After**





Before
Mid-Water Trawl Fishing Effort (At-Sea & Shoreside Sectors)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
B2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km2)
High : 53.669
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 4
Search Radius: 3,000 m
Cell Size: 500 m


Before
Mid-Water Trawl Fishing Effort (At-Sea & Shoreside Sectors)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km²)
High : 53.669
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 4
Search Radius: 3,000 m
Cell Size: 500 m


Before
Mid-Water Trawl Fishing Effort (At-Sea & Shoreside Sectors)
After
125° W
124° W
123° W
41° N
40° N
39° N
Noyo Canyon
Delgada Fan
D2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (km/km²)
High : 53.669
Low : 0.008
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 4 of 4
Search Radius: 3,000 m
Cell Size: 500 m

Appendix K-3 Fixed Gear Effort

Appendix K-3 figures depict the spatial distribution of observed fixed gear effort within two time periods: "Before" (1 Jan 2002 – 11 Jun 2006) and "After" (12 Jun 2006 – 31 Dec 2010) implementation of Amendment 19 regulations. Records of fixed gear fishing locations were compiled from one source: observer records from the West Coast Groundfish Observer Program (WCGOP) database. The WCGOP database includes records of trips for vessels participating in the following sectors: limited entry sablefish-endorsed primary season, limited entry non-sablefish endorsed, open access fixed gear, Oregon and California nearshore. Annual WCGOP coverage of fixed gear sectors can be found online at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/sector_products.cfm. Since all fishing operations are not observed, neither the maps nor the data can be used to characterize the fishery completely. We urge caution when utilizing these data due to the complexity of groundfish management and fleet harvest dynamics.

Since fishing does not occur continuously between set and haul points for fixed gears, the WCGOP fixed gear data products are based on spatial locations of both set and haul coordinates (referred to as "fishing locations"). This is in contrast to the trawl effort data products, where a straight line connecting the start and end points was used to represent each tow event. Fishing locations where either set or haul points were either on land, outside the EEZ, or deeper than 2,000 m were removed from the spatial analysis. Similar to the bottom trawl effort maps, two complimentary data products were created with these fishing locations: 1) an effort density layer that depicts the relative intensity of fishing effort within each time period, except areas where less than 3 vessels were operating, and 2) an extent polygon that shows the gross extent of effort. Please refer to the description of methods used to create the bottom trawl effort maps, as they were very similar to the methods used for the bottom trawl and mid-water trawl figures. The main difference for the fixed gear data is that a point density, rather than a line density, algorithm was used to quantify density of effort (units: locations/km^2). The density parameters used for calculating standardized effort for observed fixed gear fishing locations was a 5-km search radius and a 1,000x1,000 m cell size. As with the two trawl data products, the initial density output was more spatially extensive than the one shown in the figures, because it included cells with density values calculated from fishing locations of less than three vessels. For the published layer, we removed those grid cells where fishing locations from less than 3 vessels intersected the circular search area. These "confidential" cells represent 15.3 and 22.4 percent of all fishing locations within a given time period, although the proportion varies considerably in certain areas along the coast.

As with the two trawl effort maps, the color ramps for the intensity layers are scaled to the same range of values in each panel

Appendix K-3 map plates show areas of high relative effort in the before time period are apparent off northern Washington, Cape Blanco, OR, and Crescent City, CA. In the after time period, areas of high relative effort show up again off northern Washington, off the Columbia River mouth, and off Cape Blanco, OR (Plates B2 and C2). There are a number of areas of medium to medium-high relative effort that show up in the map plates for both time periods; however, compared to the two sets of trawl figures, there appear to be little spatial consistency between the two periods.

Another stark contrast between the fixed gear figures and the two trawl figures is the characteristic of the extent polygons. The extent polygons for fixed gear effort extend greater distances from the intensity layers than trawl effort. There are a couple probable explanations for this phenomenon. First, the fixed gear data comes from observers who are present only on a subset of all fixed gear trips, in contrast to the bottom trawl and mid-water trawl data sources which are a mostly complete record of all trips using those gear types. Second, due to a more patchy nature of the spatial distribution of effort, the fixed gear intensity layer represents a smaller portion of locations within the extent polygon. In other words, a higher proportion of density cells were considered confidential because the values for those cells were calculated from only one or two vessels. The overall objective of the fixed gear intensity layer development was to ensure adequate coastwide representation (in which over 80 percent or more of the data are represented). Compared to the bottom and mid-water trawl summaries, the extent polygon for observed fixed gear effort encompasses a large majority of observed fishing locations; however, some points were excluded due to confidentiality considerations.

To access full resolution images, follow this link: http://efh-catalog.coas.oregonstate.edu/overview/
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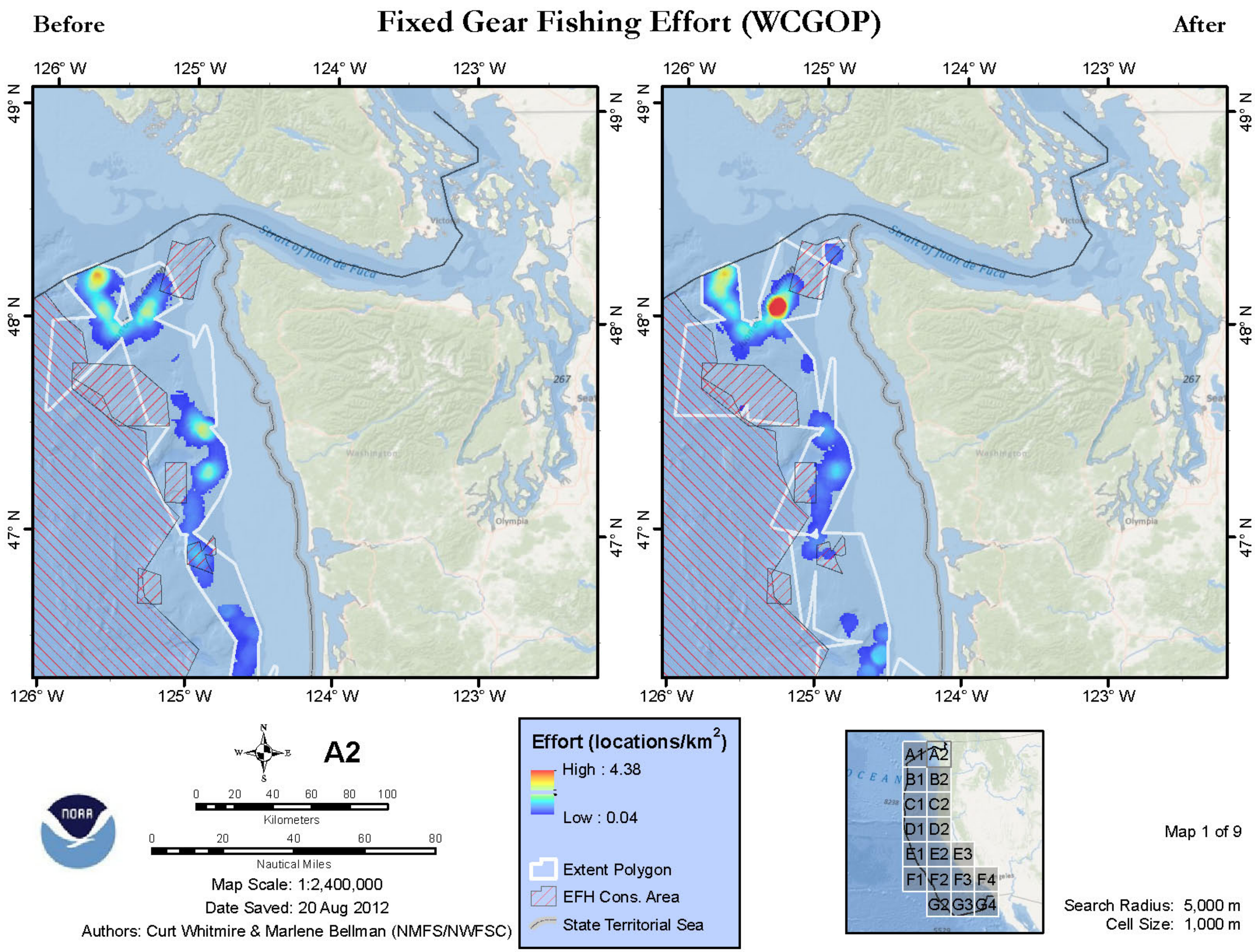
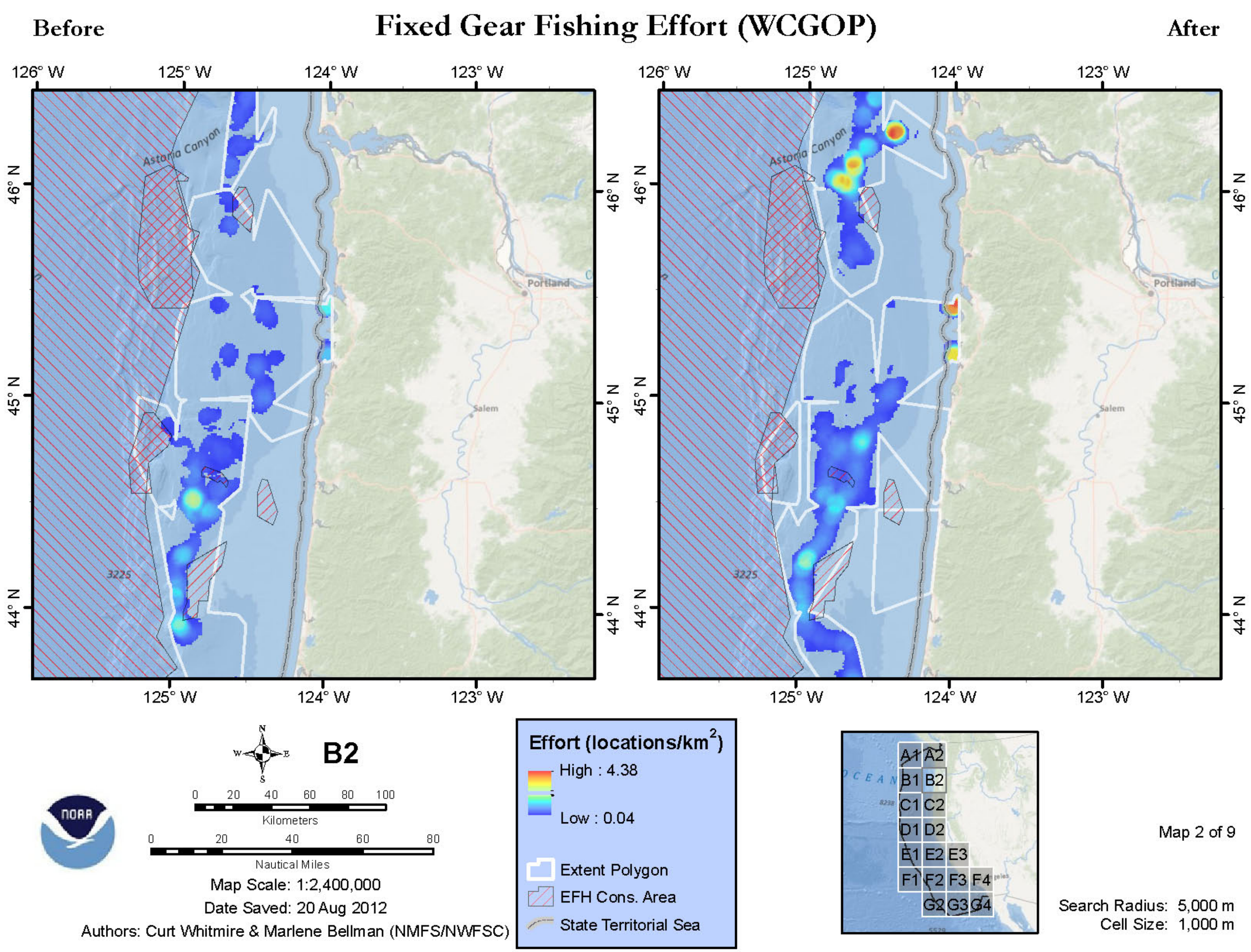
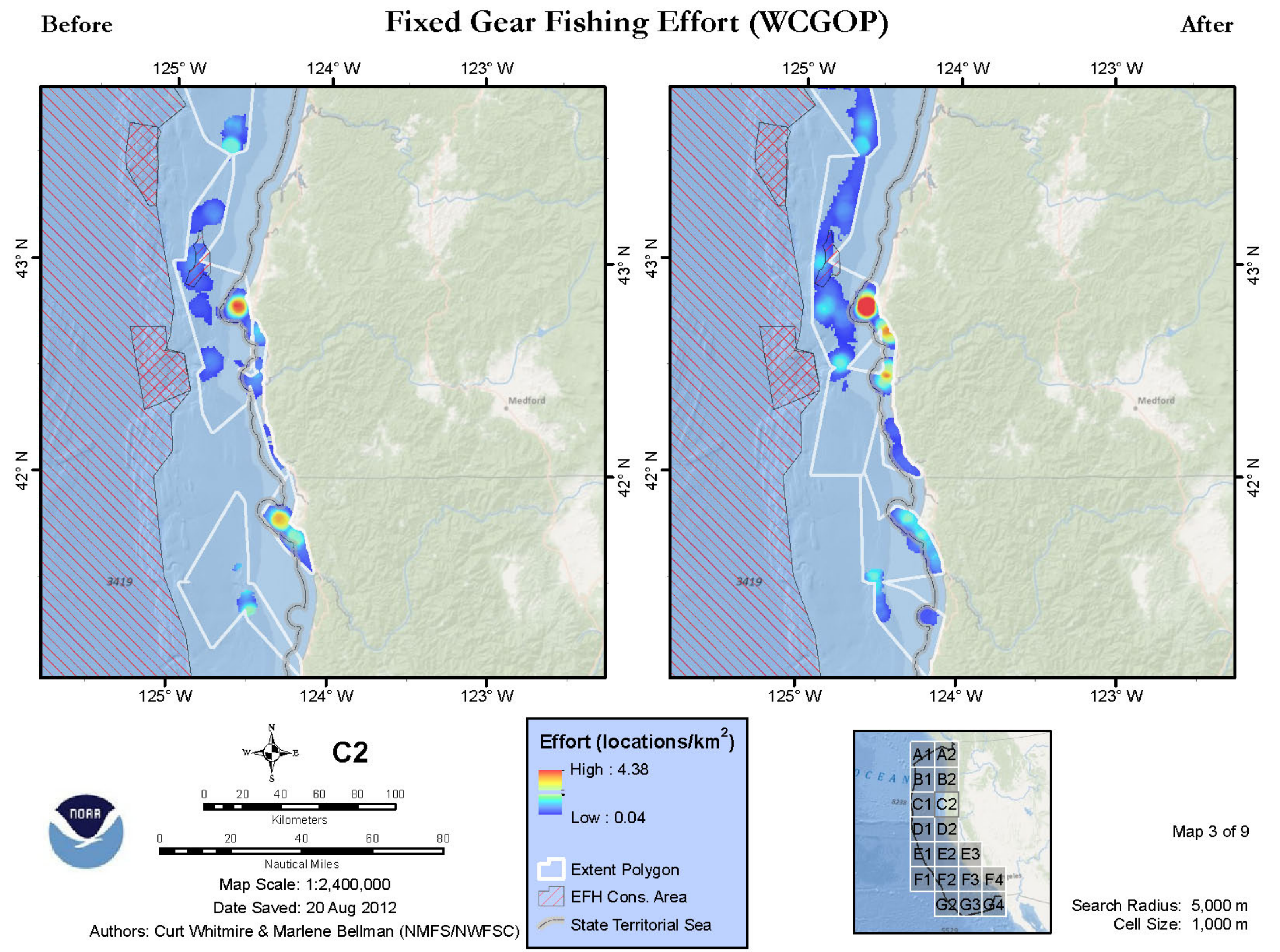
Appendix K-3: Fixed Gear Effort

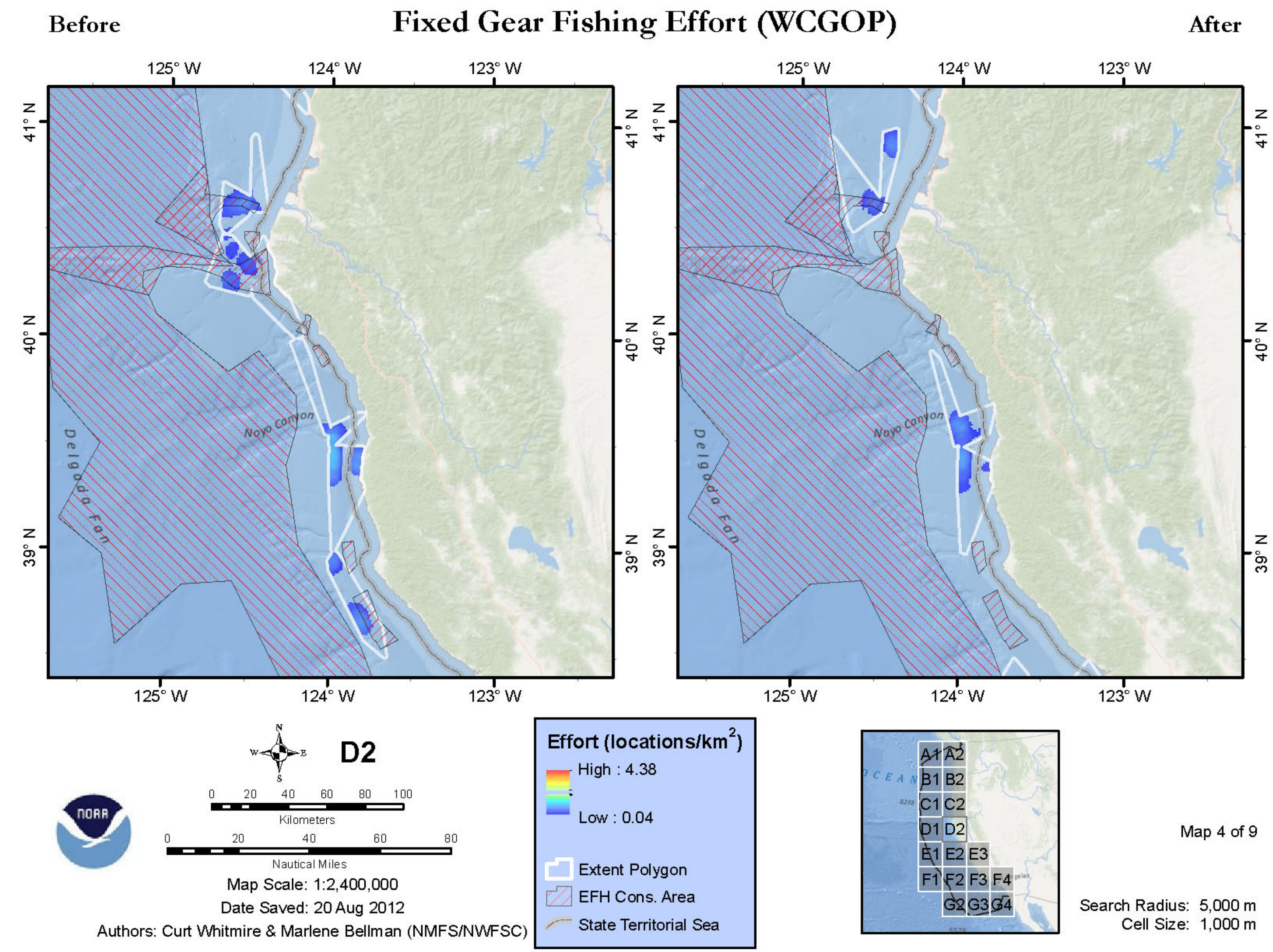


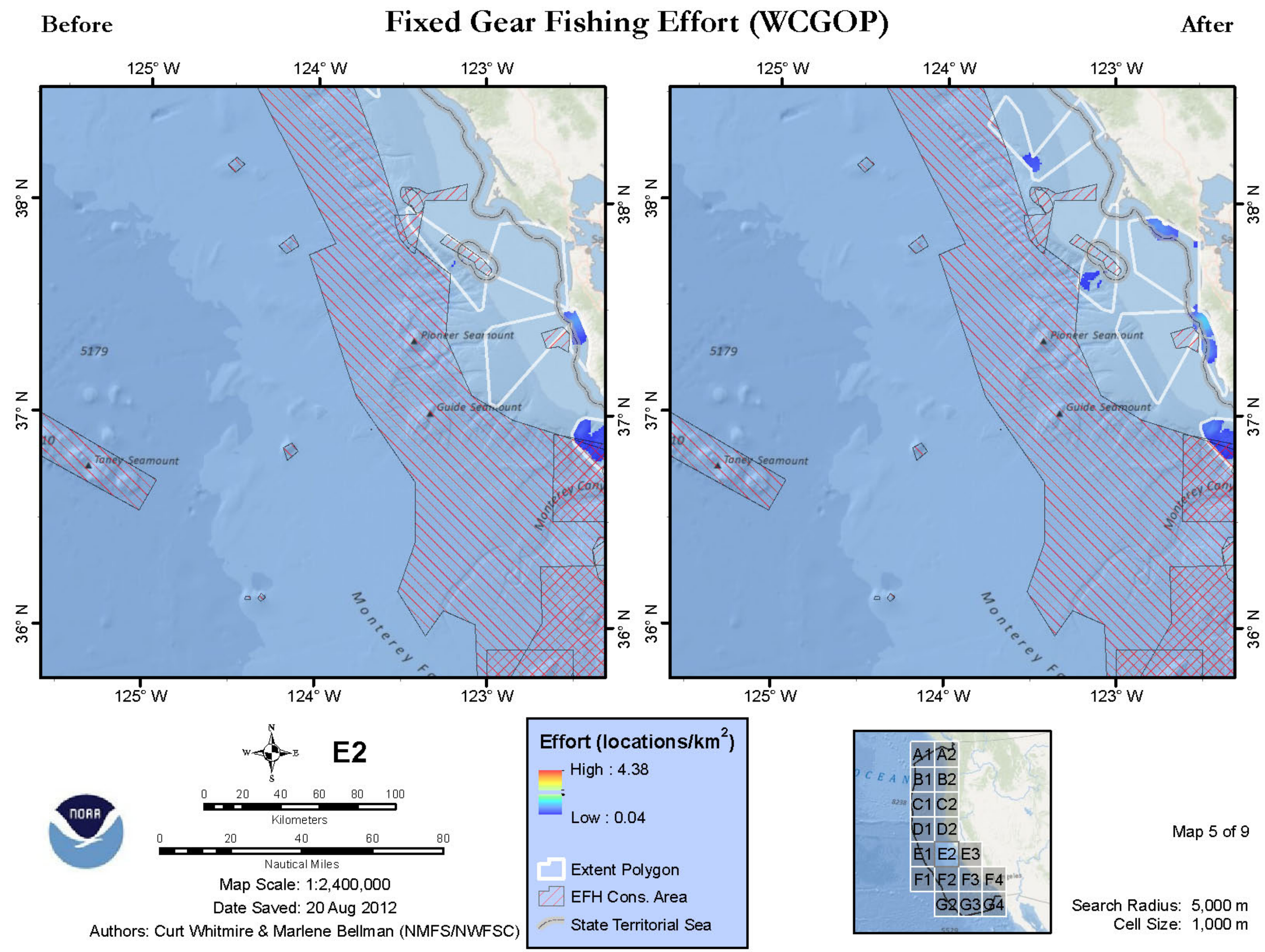


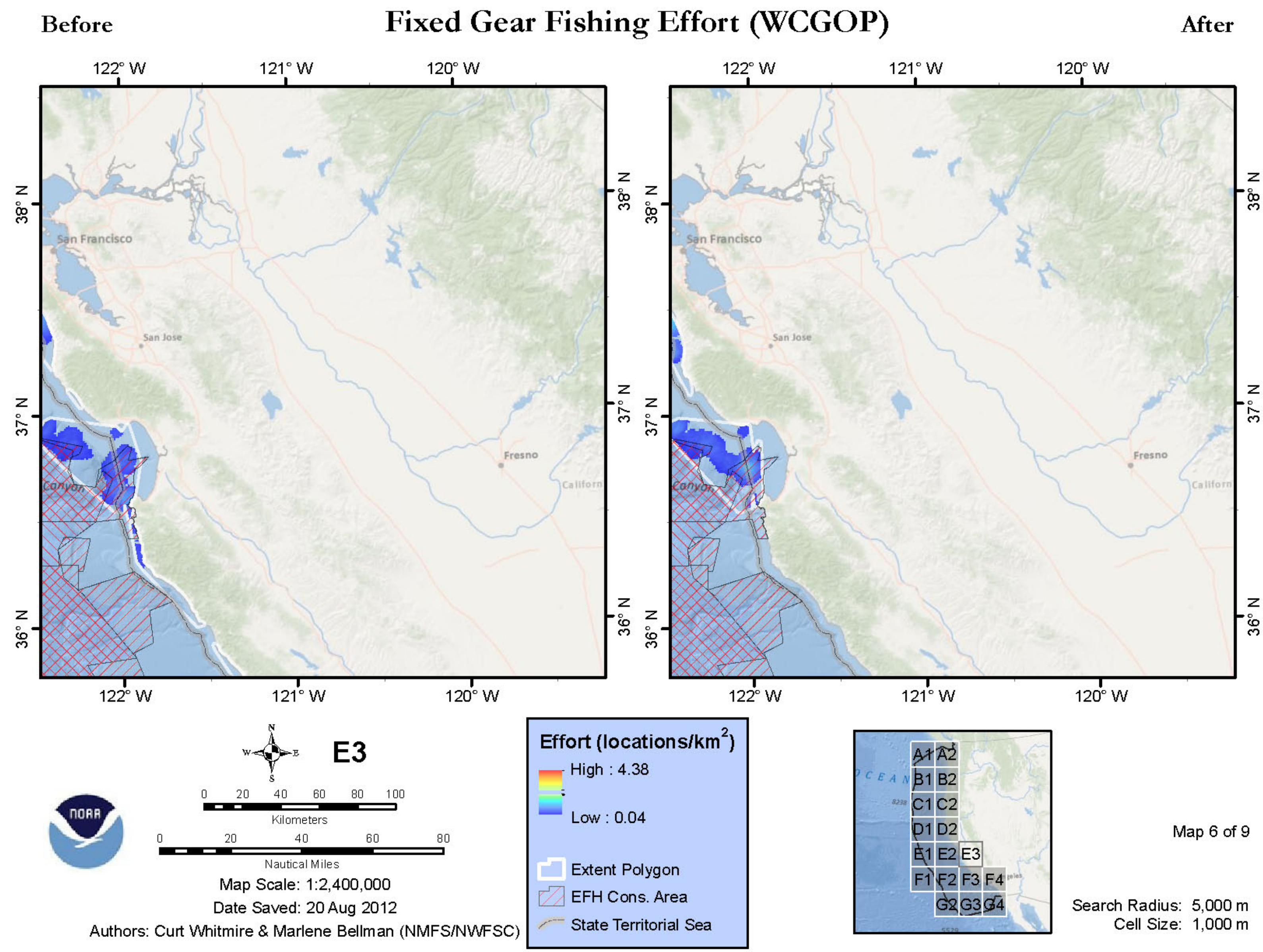
Before
Fixed Gear Fishing Effort (WCGOP)
After
126° W
125° W
124° W
123° W
46° N
45° N
44° N
Astoria Canyon
Portland
Salem
3225
B2
Kilometers
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km2)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 2 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m


Before
Fixed Gear Fishing Effort (WCGOP)
After
125° W
124° W
123° W
43° N
42° N
Medford
3419
C2
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km²)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 3 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m

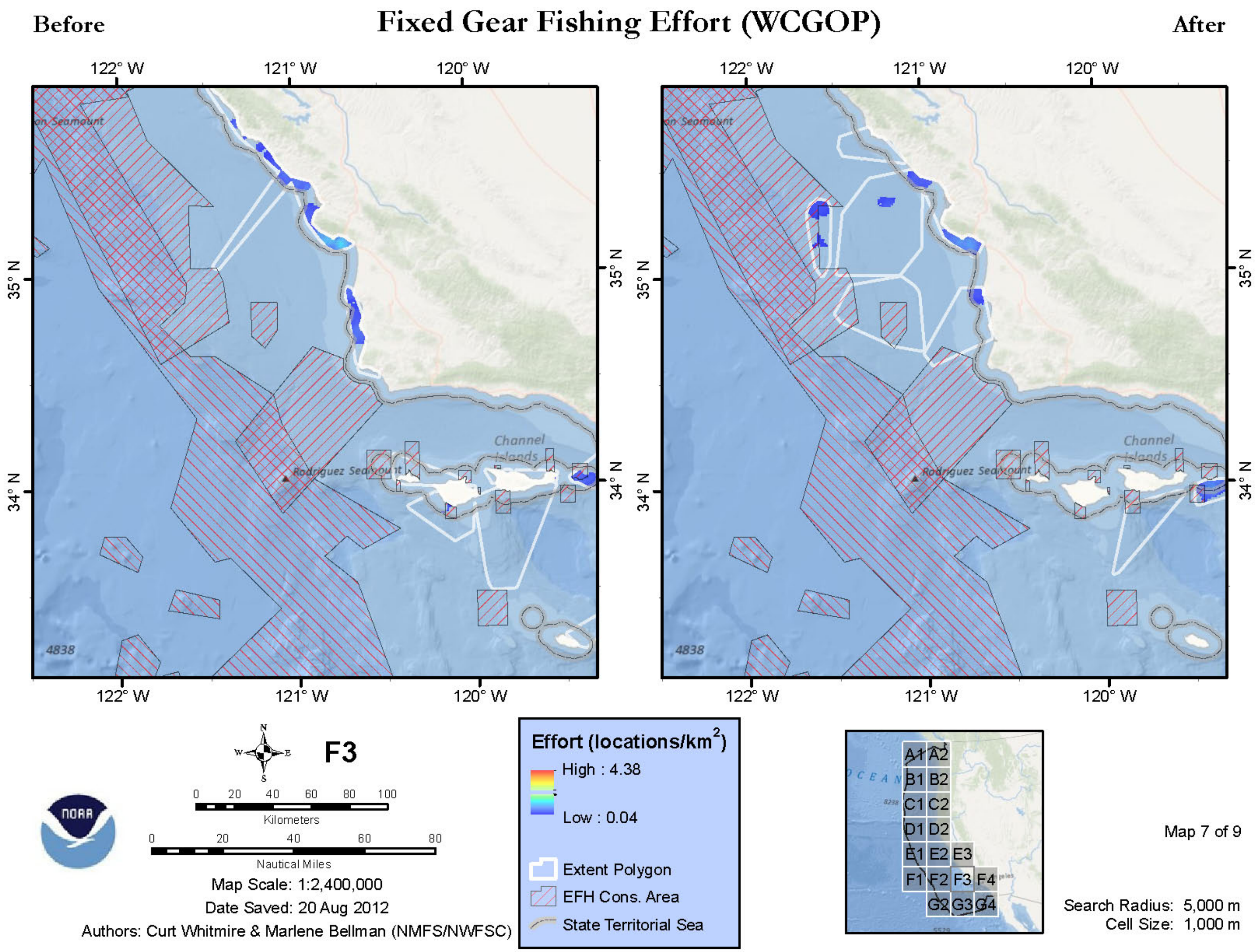
Appendix K-3: Fixed Gear Effort

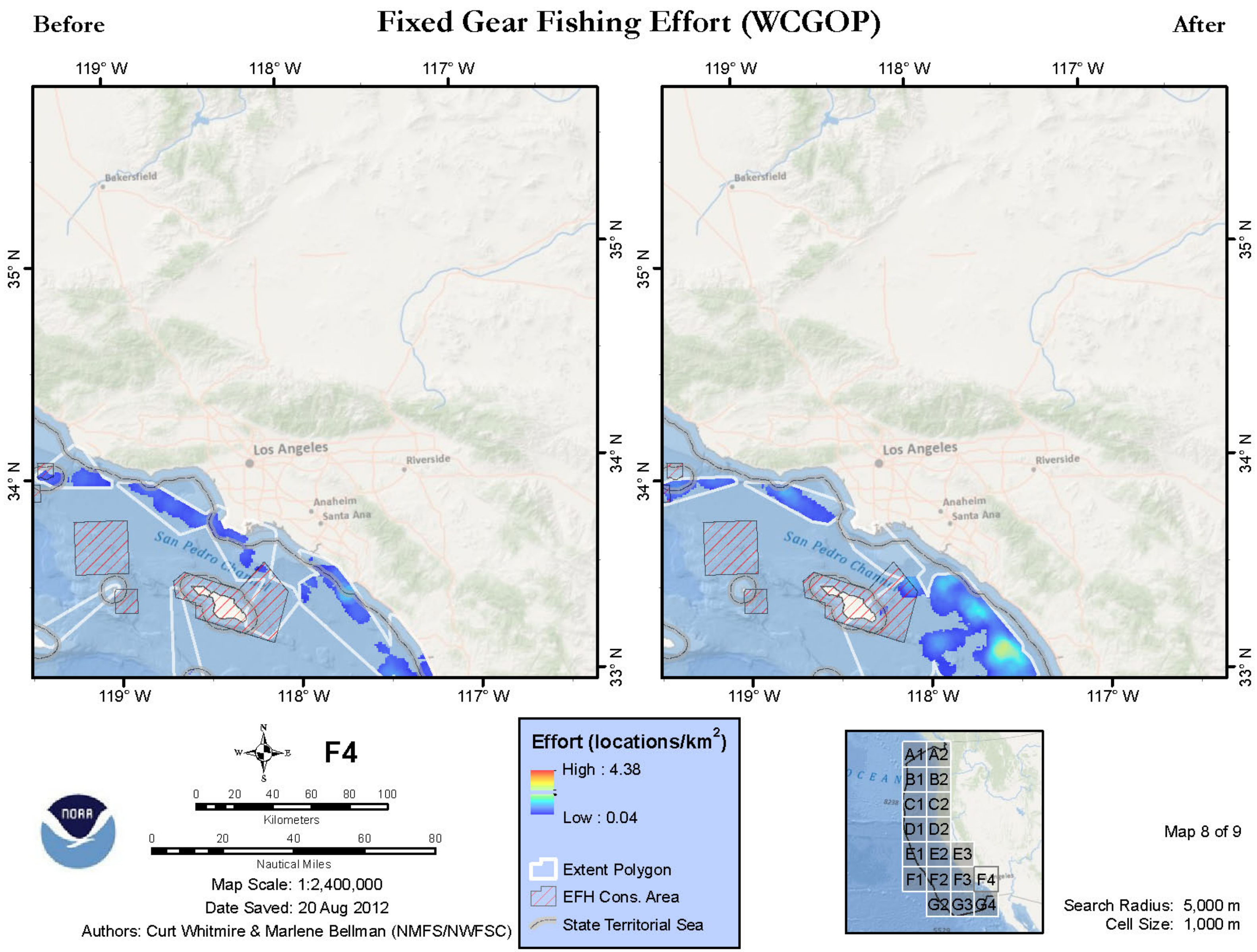


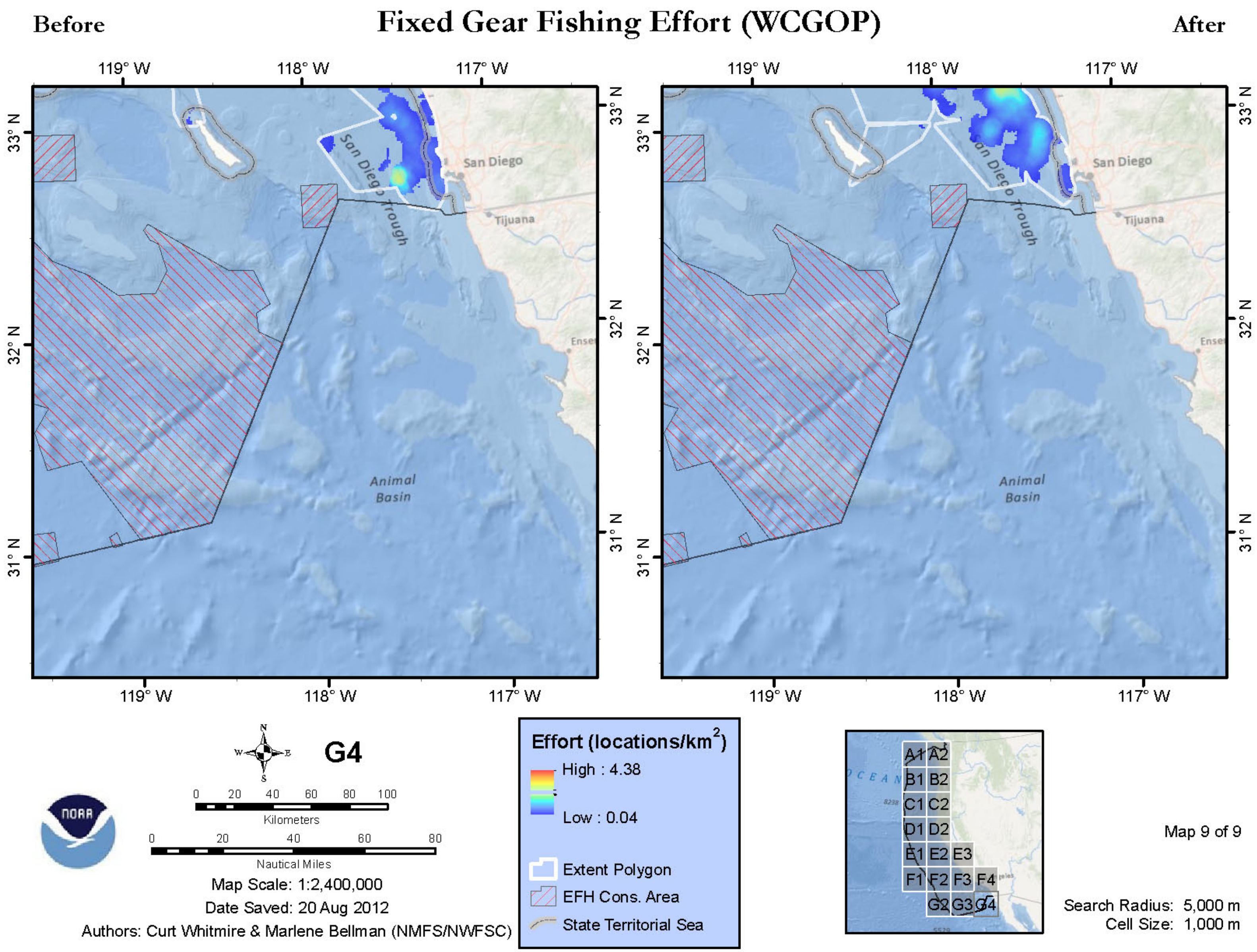

Before
Fixed Gear Fishing Effort (WCGOP)
After
125° W
124° W
123° W
38° N
37° N
36° N
5179
Pioneer Seamount
Guide Seamount
Taney Seamount
Monterey Canyon
Monterey Fan
E2
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km2)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 5 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m


Before
Fixed Gear Fishing Effort (WCGOP)
After
122° W
121° W
120° W
38° N
37° N
36° N
San Francisco
San Jose
Fresno
Canyon
E3
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km^2)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 6 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m

Appendix K-3: Fixed Gear Effort




Before
Fixed Gear Fishing Effort (WCGOP)
After
119° W
118° W
117° W
35° N
34° N
33° N
Bakersfield
Los Angeles
Riverside
Anaheim
Santa Ana
San Pedro Channel
F4
0 20 40 60 80 100
Kilometers
0 20 40 60 80
Nautical Miles
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km^2)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 8 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m


Before
Fixed Gear Fishing Effort (WCGOP)
After
119° W
118° W
117° W
33° N
32° N
31° N
San Diego
Tijuana
San Diego Trough
Animal Basin
G4
Kilometers
0 20 40 60 80 100
Nautical Miles
0 20 40 60 80
Map Scale: 1:2,400,000
Date Saved: 20 Aug 2012
Authors: Curt Whitmire & Marlene Bellman (NMFS/NWFSC)
Effort (locations/km2)
High : 4.38
Low : 0.04
Extent Polygon
EFH Cons. Area
State Territorial Sea
A1 A2
B1 B2
C1 C2
D1 D2
E1 E2 E3
F1 F2 F3 F4
G2 G3 G4
Map 9 of 9
Search Radius: 5,000 m
Cell Size: 1,000 m