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REPORT OF ECOSYSTEM STUDIES CONDUCTED DURING THE 2001 OREGON, CALIFORNIA, AND WASHINGTON (ORCAWALE) MARINE MAMMAL SURVEY ON THE RESEARCH VESSELS *DAVID STARR JORDAN* AND *McARTHUR*

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INTRODUCTION

In 2001, the Southwest Fisheries Science Center (SWFSC) conducted a survey to estimate the absolute abundance of dolphin and whale populations in U.S. west coast waters, out to a distance of approximately 300 nautical miles. A similar survey was conducted by the SWFSC in 1996 (Von Saunder 1999).

Two research vessels were used for this survey: the NOAA ships *David Starr Jordan* (hereafter referred to as the *Jordan*) and *McArthur*. The *Jordan* conducted research from July 30 to November 10, while the *McArthur* completed the last three weeks, concluding on December 8, 2001. Approximately the same area and time period were surveyed in 1996.

This report describes the types of ecosystem data collected and sampling techniques used, and summarizes the data collected aboard the *Jordan* and *McArthur* during the 2001 Oregon, California and Washington line-transect expedition (ORCAWALE) survey. The marine mammal data for this cruise, as well as the ecosystem data from the 1996 survey, will be reported in a separate technical memorandum. The 1996 marine mammal data have been published in a preliminary report by Barlow (1997).

OBJECTIVES

The primary objective of this survey was to estimate the abundance, and understand the distribution, of dolphins and whales that are commonly found off of the west coast of the United States. The secondary objective was to collect physical and biological oceanographic data to better characterize their environment. Other objectives include estimation of prey abundance by acoustic sampling, and definition of stocks by biopsy sampling and photo-identification. Oceanographic and other environmental variables, including chlorophyll a, nutrients, temperature, salinity, zooplankton biomass and the occurrence of seabirds and other animals, are sampled concurrently with the mammal sighting survey. Studying oceanographic patterns and variability concurrently with the fauna can help explain year-to-year environmental effects on estimated abundance. Ecosystem data may also help understand the biological basis of dolphin and whale distribution and abundance.

STUDY AREA AND ITINERARY

The principal study area included the U.S. West Coast Exclusive Economic Zone (EEZ): Washington, Oregon, and California waters out to a distance of approximately 300 nautical miles. The ships followed a grid of predetermined tracklines (Figure 1) to uniformly cover this area.

The cruise was conducted in six legs: five on the *Jordan* and one on the *McArthur*. The *Jordan* departed San Diego, California on 30 July 2001, and returned to San Diego on 10 November 2001. The Jordan was plagued with many mechanical breakdowns, which modified the original port schedule (see actual itinerary below). The *McArthur* finished the survey's final leg, from November 15 – December 8, 2001.

The itinerary for each ship was as follows:

	Jordan	**McArthur**
Leg Ia		
Departure	San Diego, California 30 July	
Arrival	Astoria, Oregon 09 August	
Leg Ib		
Departure	Astoria, Oregon 12 August	
Arrival	Newport, Oregon 17 August	
Leg II		
Departure	Portland, Oregon 30 August	
Arrival	Eureka, California 16 September	
Leg III		
Departure	Eureka, California 19 September	
Arrival	San Diego, California 05 October	
Leg IV		
Departure	San Diego, California 08 October	
Arrival	Astoria, Oregon 27 October	
Leg V		
Departure	Astoria, Oregon 01 November	
Arrival	San Diego, California 10 November	
Leg VI		
Departure		San Francisco, California 15 November
Arrival		San Diego, California 08 December

MATERIALS AND METHODS

Oceanography

Temperature and salinity of surface water were measured continuously and recorded in digital form. Seawater was sampled from an intake 3 meters below the surface by a Sea-Bird Electronics (SBE) thermosalinograph (Model SBE-21). A Windows® (Microsoft Corporation) data acquisition program (WinDACS; Holland 1993) recorded the data on a laptop computer with a serial connection to a Sea-Bird junction box. GPS position information was appended to the data stream through the box's NMEA 0183 input port. The ships' Scientific Computing System (SCS) also collected these data, as well as information from other navigational and weather sensors. Discrete bucket temperatures and salinity samples were collected at regular intervals to verify thermosalinograph readings.

Expendable bathythermograph (XBT) drops, to 760 meters depth, were made daily at 0900, 1200, 1500 hours (local ship time), and after sunset. Surface chlorophyll samples were taken after each drop. On the *McArthur*, the Shipboard Environmental (data) Acquisition System (SEAS), developed by NOAA, collected data from the Sippican Deep Blue probes. Low resolution, unprocessed XBT data were transmitted in real-time over the Global Telecommunications System after acquisition by the SEAS. The *Jordan* used Sippican software to acquire data, and conversion to the SEAS format was not possible at sea. The XBT data presented here were processed after the cruise according to guidelines presented in Bailey *et al*. (1994).

Conductivity, temperature and depth (CTD) casts were made each morning before sunrise using a Sea-Bird Electronics 911*plus* CTD and General Oceanics rosette system on the *Jordan*. The *McArthur*'s CTD and rosette were both from Sea-Bird Electronics. The CTD was lowered to 1000 meters and sensors connected to shipboard computers measured conductivity (salinity), temperature and pressure (depth). Water samples were collected from variable depths on all CTD casts for ^{14}C-uptake incubations, salinity calibration, and nutrient and phytoplankton pigment analysis.

CTD cast data were processed using Sea-Bird Electronics' Data Processing software, version 5.27a for Windows[1]. Standard processing following the manufacturers instructions were used with the pre-cruise calibration coefficients and post-cruise calibration adjustments.

Hydrochloric acid (2%) and Micro®-washed General Oceanics Niskin bottles (1.7-liter on the *Jordan* and 5-liter on the *McArthur*) were retrofitted with silicone rubber o-rings in the valves and endcaps. Silicone rubber tubing was used as the closing mechanism. Niskin bottles numbered 1 (surface) to 9 were tripped at 7 variable light depths and 2 additional depths less than 200 m as determined by the "ZEPRED01" program (see below). Two additional bottles were tripped at 500 m and 1000 m (or bottom) for salinity calibration samples.

Ten samples from ≤ 200 m were collected for chlorophyll *a* (275 ml each) and eleven from ≤ 500 m for nutrient (15 ml each) analysis at each station. Chlorophyll *a* and phaeophytin were determined by the fluorometric technique (Holm-Hansen *et al*. 1965) using a Turner Designs Model 10-AU fluorometer calibrated with chlorophyll *a* standards (Turner Designs). These data were entered at sea and processed at the SWFSC following the cruise. Nutrient samples were collected and immediately frozen for analysis following the cruise. Two 150 ml salinity samples per CTD cast (or 6 on every fourth cast) were also collected and analyzed on a Guildline Instruments AutoSal® salinometer (Model 8400) calibrated during each run with IAPSO[1] standard seawater. These data were used at sea to monitor the accuracy of CTD and thermosalinograph conductivity cells.

Water samples for determination of dissolved inorganic carbon uptake were collected from standard light depths. These are depths at which irradiance of PAR (photosynthetically active radiation) is estimated to be a standard fraction (100, 50, 30, 15, 5, 1 and 0.1%) of irradiance just below the sea surface. A program, ZEPRED01, calculated an initial estimate of euphotic zone depth (1% light level) from pigment profiles observed on previous marine mammal cruises (1991, 1993, 1996) according to the spectral model of attenuation by Morel (1988).

Primary productivity samples were drawn into conditioned screw cap "Vitro" glass 150 ml bottles (Wheaton Corporation) rinsed twice with sample water. Radioactively labeled sodium carbonate ($NaH^{14}CO_3$) was added to each sample bottle (10 μCi). The bottles were then incubated in nickel screens (Perforated Products) in an on-deck seawater-cooled Plexiglas® incubator for 24 hours with natural sunlight as the light source. The screens act as neutral density filters, reducing the light intensity to the same level as that occurring at the depth from which the sample was collected. Two extra samples at the 100% and 0.1% light levels were inoculated with radioactive tracer and filtered immediately without incubation to determine abiotic particulate ^{14}C incorporation (Chavez and Barber 1987). For determination of particulate carbon fixation, the water was filtered onto Whatman GF/F filters at <10 psi of vacuum. The filter was acidified with 0.5 N HCl for 12 hours then immersed in 10 mls of scintillation cocktail (CytoScint ES). These vials were counted on a liquid scintillation counter (Beckman LS6000) following the end of the cruise. The total inorganic carbon activity was determined by adding 1.0 ml of incubated sample water (from the 100% and 30% light levels) to a scintillation vial containing 1 ml of β-phenyl-ethylamine in 20 mls of scintillation cocktail. An average of these two values was used as the total amount of added activity for each station in the calculation of carbon uptake for each sample. Primary productivity data were processed after the cruise at the SWFSC.

Net Tows

On each ship, a Bongo net was towed obliquely from 200 meters depth for 15 minutes, starting a minimum of 1 hour after sunset. This is a paired zooplankton net frame with two 505-micrometer (μm) mesh nets, fitted with a flowmeter in the outboard side. A sample was collected only from the outboard net, preserved in 5% buffered formalin, then labeled and stored for post-cruise analysis.

Acoustic Backscatter

On the *Jordan,* acoustic volume backscatter coefficients (sv) were logged continuously from the Simrad EK500 echosounder operating at 38, 120, and 200 kHz. The sv at each frequency were logged for each ping (2 Hz repetition rate) from the surface to 500 m using SonarData's EchoLog_EK software. The multifrequency data were post-processed using

1 The International Association for Physical Science of the Ocean (IAPSO) Standard Seawater is manufactured by Ocean Scientific International.

SonarData's EchoView software. To identify backscatter from fish versus zooplankton, differences in mean volume backscatter strengths ($Sv_{200\ kHz} - Sv_{38\ kHz}$; where Sv=10log(sv)) were used to mask the echograms. The Sv-difference bins for each taxa were determined empirically and confirmed theoretically using physics-based scattering models for fish and euphausiids. The sv from each taxa were integrated from 10 to 500 m and averaged over 1 n.mi. distances (nautical area scattering coefficient or NASC) and plotted as distribution maps (Figures 9 and 10). These NASC are thought to be roughly proportional to the biomass of each taxa. The data collection and processing were similar to the methods described in Hewitt and Demer (1993) and Hewitt *et al*. (2002).

On the *McArthur*, an acoustic data acquisition system (ADA) collected 38 kHz and 200 kHz acoustic backscatter data from the Simrad EQ50 echosounder. Backscatter was digitized and integrated in 5-meter intervals between the surface and a depth of 500 meters (actually 5 m below the transducer, or about 9 m, and 504 m). Nominal ping interval was 5 seconds.

Seabirds

A seabird census was conducted using standard 300-meter strip-transect methods (Appendix A). Bird observers stood shifts of approximately two hours on the flying bridge throughout daylight hours when the ship was underway, weather permitting. Only a single observer was on watch at any time. Actual distance within 300 meters, species identification, number, and behavior of birds were recorded, as well as associations with marine mammals, fish, or flotsam (see Table 4 for a complete list of variables recorded). Distance was estimated with a fixed-interval range finder (Heinemann 1981). Hand-held binoculars were used to confirm species identification.

Contour plots

Data were gridded and contoured using Surfer®(v.7, Golden Software). Gridding was by a kriging algorithm with parameters chosen based on the variogram of the observed data. In general, the data were gridded at 0.5-deg intervals with smoothing scales of 2-5 degrees and an alongshore-offshore anisotropy of 2. Surface chlorophyll, integrated primary productivity, and volume backscatter data (Figures 7 - 10) were log-transformed before gridding.

RESULTS

Oceanography

Figure 1 illustrates cruise tracks for the *Jordan* and *McArthur*. The total number of oceanographic casts, net tows, and samples collected on the *Jordan* and *McArthur* are presented in Table 1.

Figure 2 shows the locations of the 49 *Jordan* and 17 *McArthur* CTD casts. Tables 2 and 3 are CTD cast summaries for each ship, including the number of samples taken and analyzed per station (chlorophyll, productivity, nutrient, and salinity). Stations where samples were not collected due to equipment malfunction or lack of processing time are blank. In general, the CTD water sample salinities on both ships agreed with the CTD sensor values to within ±0.006

PSU (practical salinity units).

Figure 3 shows XBT deployment locations (338 total drops) for both ships.

Sea surface temperature (Figure 4) and thermocline depth (Figure 5) are plotted from both CTD and XBT data. Surface temperature and salinity data from the thermosalinograph are presented in Figure 6.

Surface chlorophyll concentrations from the *Jordan* and *McArthur* are shown in Figure 7.

Nutrient samples (714 total) are in frozen storage, to be analyzed for nitrate, nitrite, silicate and phosphate at a later time.

Primary productivity estimates (integrated over the euphotic zone) are shown in Figure 8.

All CTD, XBT and water sample data (chlorophyll, productivity) will be submitted to NOAA/National Oceanographic Data Center following this publication.

<u>Net Tows</u>

A total of 71 Bongo tows was completed: 54 on the *Jordan* and 17 on the *McArthur*. Samples have not been processed at the time of this publication. Results will be presented in a separate technical memorandum.

<u>Acoustic Backscatter</u>

The EK500 acoustic backscatter provided effective observational ranges in excess of 500 m at 38 kHz, 225 m at 120 kHz and 175 m at 200 kHz. The location of the fish and zooplankton appear to be strongly associated with shallower bathymetry. Highest densities of each taxa were mapped shoreward of the 4000 m contour. Both fish and zooplankton were highest in the Southern California Bight, and in the coastal areas of northern California and Oregon. A diel pattern showing higher NASC during nighttime hours was stronger for fish than zooplankton (analysis not shown). At night, the observed fish occupy the whole water column; during the day they stay closer to the sea-surface.

The EQ50 data processing is incomplete. Results will be presented in another publication.

<u>Seabirds</u>

A total of 88 days was spent on effort for the seabird survey, with the remaining sea days lost to mechanical breakdowns or weather. During this time, a minimum of 55 species was recorded. Total numbers recorded for the entire cruise, and on a per-leg basis are reported in Table 5.

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Table 1. Summary of environmental data collected during the 2001 ORCAWALE survey aboard the NOAA Ships *David Starr Jordan* (legs 1-5) and *McArthur* (leg 6 only).

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	TOTALS
CTD casts	11	11	10	14	3	17	66
CTD chlorophyll samples	110	110	101	140	30	158	649
Surface chlorophyll samples	47	53	54	63	30	88	335
Primary productivity samples	70	70	63	91	21	117	432
Nutrient samples	121	121	111	155	33	173	714
Salinity samples	47	52	64	62	10	72	307
XBT drops	48	56	51	63	28	92	338
Bongo Tows	12	11	14	13	4	17	71

Table 2. *Jordan* 2001 CTD cast summary: station number, date, time, location, depth of cast (m), and numbers of samples for phytoplankton pigments (chl), primary production (prod), nutrients and salinity. Station dates and times are in Greenwich Mean Time. Negative longitude values indicate western (W) positions.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
1	7/31	1150	32.63	-119.53	604	10		11	7
2	8/01	1151	33.27	-122.55	1012	10	7	11	2
3	8/02	1207	33.73	-124.57	1020	10	7	11	6
4	8/03	1216	34.25	-126.99	1014	10	7	11	2
5	8/04	1206	35.77	-126.99	1020	10	7	11	6
6	8/05	1206	38.34	-126.16	1016	10	7	11	2
7	8/06	1150	40.40	-125.42	1018	10	7	11	6
8	8/13	1209	47.20	-126.26	1016	10	7	11	2
9	8/14	1135	46.37	-129.88	1016	10	7	11	6
10	8/15	1205	44.30	-130.65	1020	10	7	11	2
11	8/16	1205	45.05	-128.70	1012	10	7	11	6
12	8/31	1214	45.87	-125.12	1022	10	7	11	2
13	9/01	1223	44.57	-126.23	1022	10	7	11	6
14	9/02	1233	45.19	-128.62	1014	10	7	11	2
15	9/04	1230	47.71	-126.88	1020	10	7	11	6
16	9/05	1217	47.56	-126.15	1014	10	7	11	2
17	9/10	1250	44.01	-129.08	1020	10	7	11	6
18	9/11	1248	42.09	-129.76	1018	10	7	11	2
19	9/12	1249	40.86	-130.20	1020	10	7	11	6
20	9/13	1249	39.32	-129.74	1008	10	7	11	2

Table 2. (*Jordan* 2001 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
21	9/14	1252	38.87	-127.58	1010	10	7	11	6
22	9/15	1252	41.66	-126.64	1022	10		11	12
25	9/23	1252	44.15	-125.76	1020	10	7	11	12
26	9/24	1248	42.05	-126.50	1022	10	7	11	6
27	9/25	1252	40.71	-127.42	1012	10	7	11	2
28	9/26	1247	39.81	-124.90	1018	10	7	11	6
29	9/27	1245	38.24	-124.50	1016	10	7	11	2
30	9/28	1247	38.39	-127.75	1010	10	7	11	6
31	9/29	1257	35.96	-127.90	1022	10	7	11	2
32	10/01	1233	34.64	-121.92	1016	10	7	11	6
33	10/02	1252	33.83	-118.43	204	10	7	11	11
34	10/03	1237	33.47	-117.91	516	10		11	11
35	10/09	1231	32.29	-118.21	832	10	7	11	2
36	10/10	1235	32.97	-121.23	1016	10	7	11	6
37	10/11	1247	33.39	-123.23	1012	10	7	11	2
38	10/12	1309	34.01	-125.92	1012	10	7	11	6
39	10/14	1307	37.15	-126.50	1014	10	7	11	2
40	10/15	1321	37.52	-128.04	1016	10	7	11	6
41	10/16	1321	38.74	-129.29	1012	10	7	11	2
42	10/19	1332	43.18	-130.93	476	10	7	11	6
43	10/20	1334	43.73	-129.61	1014	10	7	11	2
44	10/21	1330	41.90	-128.17	1032	10	7	11	6
45	10/22	1334	40.90	-130.20	1010	10	7	11	2
46	10/24	1333	41.67	-128.28	1020	10	7	11	6
47	10/25	1328	43.84	-127.53	1014	10	7	11	2
48	10/26	1336	44.40	-125.42	1018	10		11	12
49	11/03	1334	41.57	-128.33	1020	10	7	11	2
50	11/04	1336	39.11	-128.40	1020	10	7	11	6
51	11/05	1321	38.54	-126.04	1012	10	7	11	2

Table 3. *McArthur* 2001 CTD cast summary: station number, date, time, location, depth of cast (m), and number of samples for phytoplankton pigments (chl), primary production (prod), nutrients and salinity. Station dates and times are in Greenwich Mean Time. Negative longitude values indicate western (W) positions.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
52	11/16	1402	38.07	-123.68	1012	10	7	11	11
53	11/17	1359	36.14	-125.22	1002	10	7	11	2
54	11/18	1336	34.01	-125.91	1010	10	7	11	6
55	11/19	1331	32.45	-125.61	1010	10	7	11	2
56	11/20	1319	31.93	-123.31	1010	10	7	11	6
57	11/21	1314	31.44	-121.26	1012	10	7	11	2
58	11/22	1305	31.61	-120.05	1012	10	7	11	6
59	11/23	1321	33.45	-121.08	1014	10	7	11	2
60	11/24	1335	34.74	-122.33	1012	10	7	11	6
61	11/25	1334	36.05	-121.76	760	10	7	11	2
62	11/26	1349	37.70	-125.98	1010	10	7	11	6
63	11/27	1350	36.97	-125.53	1012	10	7	11	2
64	11/30	1339	34.02	-122.61	1016	10	7	11	2
65	12/01	1336	34.25	-124.09	1014	10	7	11	2
66	12/02	1335	32.03	-123.32	1010	10	7	11	2
67	12/03	1335	30.66	-124.28	1018	9	6	10	2
68	12/07	1327	31.28	-118.42	508				11

Table 4. Data recorded during the seabird strip transect survey.

VARIABLE NAME	COLUMNS IN DATA FILE
Cruise Number	1 - 4
Greenwich Date (YYMMDD)	6 - 11
Local Date (YYMMDD)	13 - 18
Latitude (decimal degrees)	20 - 26
Longitude (decimal degrees)	28 - 35
Beaufort Sea State	37
Ship's Course	39 - 41
Observation Conditions	43
Side of Ship From Which Observations Made	45
Observer Code	47 - 48
Event Code	50
Greenwich Mean Time (HHMMSS)	52 - 57
Local Mean Time (HHMMSS)	59 - 64
Species Identification	66 - 69
Species Number	71 - 74
Distance from Ship	76
Association with Other Birds	78
Behavior	80
(Sitting, Ship-following, Feeding, Piracy, Directional/Non-directional flight)	
Flight Direction	82 - 84
Age (adult, juvenile, unknown)	86
Sex (male, female, unknown)	88
Comments	90
GMT offset (+ hours)	92 - 93

Table 5. Identity and numbers of seabirds recorded during ORCAWALE 2001. Numbers include some birds recorded outside of 300 m and some off-effort sightings.

Common Name	**Latin Name**	**Leg 1**	**Leg 2**	**Leg 3**	**Leg 4**	**Leg 5**	**Leg 6**	**Total**
Unidentified storm petrel	*Oceanodroma spp.*	7	0	1	3	0	21	32
Sooty Shearwater	*Puffinus griseus*	1631	120	333	1210	108	64	3466
Leach's Storm Petrel (white-rumped)	*Oceanodroma leucorhoa*	574	451	518	332	125	398	2398
Common Murre	*Uria aalge*	425	251	354	180	106	556	1872
California Gull	*Larus californicus*	432	211	518	117	103	148	1529
Red Phalarope	*Phalaropus fulicarius*	366	107	140	77	265	315	1270
Unidentified gull	*Larus spp.*	73	219	158	46	733	28	1257
Northern Fulmar (phase unidentified)	*Fulmarus glacialis*	29	0	0	15	0	1201	1245
Western Gull	*Larus occidentalis*	73	5	856	44	146	119	1243
Terrestrial non-passerines		1	57	22	12	625	74	791
Cassin's Auklet	*Ptychoramphus aleuticus*	5	11	182	52	46	302	598
Pink-footed Shearwater	*Puffinus creatopus*	107	56	196	4	20	27	410
Unidentified phalarope	*Phalaropus spp.*	400	1	0	0	0	0	401
Northern Phalarope	*Phalaropus lobatus*	178	194	8	0	0	1	381
Black-footed Albatross	*Diomedea nigripes*	68	66	65	75	31	61	366
Brown Pelican	*Pelecanus occidentalis*	0	118	181	1	5	47	352
Northern Fulmar (dark phase)	*Fulmarus glacialis*	35	20	10	121	71	80	337
Fork-tailed Storm Petrel	*Oceanodroma furcata*	285	10	5	22	5	2	329

Slender-billed/Sooty Shearwater	*Puffinus tenuirostris/griseus*	3	1	0	207	1	0	212
Rhinoceros Auklet	*Cerorhinca monocerata*	9	23	31	39	36	34	172
Heermann's Gull	*Larus heermanni*	2	0	135	5	6	12	160
New Zealand Shearwater	*Puffinus bulleri*	46	26	41	11	18	15	157
Shorebirds		9	16	102	21	1	1	150
Long-tailed Jaeger	*Stercorarius longicaudus*	56	33	13	5	4	9	120
Herring Gull	*Larus argentatus*	8	0	2	20	38	46	114
Glaucous-winged Gull	*Larus glaucescens*	3	4	2	10	41	41	101
Pomarine Jaeger	*Stercorarius pomarinus*	3	14	27	15	15	26	100
Parasitic Jaeger	*Stercorarius parasiticus*	15	11	41	8	7	4	86
Pacific Loon	*Gavia pacifica*	0	1	3	7	9	64	84
Mottled Petrel	*Pterodroma inexpectata*	0	0	0	7	57	7	71
Black-vented Shearwater	*Puffinus opisthomelas*	0	0	65	0	1	3	69
Arctic Tern	*Sterna paradisaea*	28	16	22	1	0	0	67
Xantus's Murrelet	*Synthliboramphus hypoleuca*	10	6	28	10	7	1	62
Passerines		3	0	47	2	1	0	53
Sabine's Gull	*Larus sabini*	7	24	14	4	0	0	49
Brandt's Cormorant	*Phalacrocorax penicillatus*	0	0	10	10	3	21	44
Northern Fulmar (intermediate phase)	*Fulmarus glacialis*	7	1	1	11	10	10	40
Bonaparte's Gull	*Larus philadelphia*	0	0	0	11	5	24	40
Laysan Albatross	*Diomedea immutabilis*	0	0	0	7	8	21	36
Xantus's/Craveri's Murrelet	*Synthliboramphus hypoleuca/craveri*	1	6	12	0	5	8	32

South Polar Skua	*Catharacta maccormicki*	6	9	10	3	1	1	30
Slender-billed Shearwater	*Puffinus tenuirostris*	0	1	0	14	7	5	27
Common Tern	*Sterna hirundo*	3	0	19	0	0	0	22
Tufted Puffin	*Fratercula cirrhata*	17	0	1	1	0	0	19
Leach's Storm Petrel (intermediate-rumped)	*Oceanodroma leucorhoa*	12	2	1	2	0	1	18
Black-legged Kittiwake	*Rissa tridactyla*	0	1	0	4	5	8	18
Black Storm Petrel	*Oceanodroma melania*	14	0	1	2	0	0	17
Cook's Petrel	*Pterodroma cookii*	9	0	0	2	0	4	15
Northern Fulmar (light phase)	*Fulmarus glacialis*	2	1	0	5	3	3	14
Ashy Storm Petrel	*Oceanodroma homochroa*	1	1	2	0	1	8	13
Red-tailed Tropicbird	*Phaethon rubricauda*	0	0	2	1	0	8	11
Unidentified jaeger	*Stercorarius spp.*	1	4	3	1	1	1	11
Leach's Storm Petrel (unidentified rump color)	*Oceanodroma leucorhoa*	7	2	0	0	0	0	9
Flesh-footed Shearwater	*Puffinus carneipes*	0	0	0	1	3	4	8
Arctic/Common Tern	*Sterna paradisaea/hirundo*	0	8	0	0	0	0	8
Ancient Murrelet	*Synthliboramphus antiquus*	0	0	0	8	0	0	8
Leach's Storm Petrel (dark-rumped)	*Oceanodroma leucorhoa*	4	0	0	2	0	0	6
Red-billed Tropicbird	*Phaethon aethereus*	2	0	1	1	1	1	6
Least Storm Petrel	*Oceanodroma microsoma*	2	0	1	0	0	2	5
Unidentified loon	*Gavia spp.*	0	0	0	1	0	4	5
Ring-billed Gull	*Larus delawarensis*	0	1	0	1	2	1	5

Double-crested Cormorant	*Phalacrocorax auritus*	2	0	2	0	0	0	4
Thayer's Gull	*Larus thayeri*	0	0	0	0	1	3	4
Common Loon	*Gavia immer*	0	2	0	1	0	0	3
Dark-rumped Petrel	*Pterodroma sandwichensis*	1	1	0	0	1	0	3
Unidentified Cookillaria Petrel		0	0	1	1	0	1	3
Least Tern	*Sterna antillarum*	1	0	2	0	0	0	3
Elegant Tern	*Sterna elegans*	0	0	3	0	0	0	3
Raptors		1	2	0	0	0	0	3
Parasitic/Long-tailed Jaeger	*Stercorarius parasiticus/longicauda*	1	0	0	1	0	0	2
Mew Gull	*Larus canus*	0	0	0	1	1	0	2
Marbled Murrelet	*Brachyramphus marmoratus*	0	0	0	2	0	0	2
Craveri's Murrelet	*Synthliboramphus craveri*	0	0	0	0	0	2	2
Unidentified alcid		0	0	0	0	0	2	2
Unidentified shearwater	*Puffinus spp.*	0	0	1	0	0	0	1
Wilson's Storm Petrel	*Oceanites oceanicus*	0	0	0	0	0	1	1
Unidentified dark-rumped storm petrel	*Oceanodroma spp.*	0	0	1	0	0	0	1
Pelagic Cormorant	*Phalacrocorax pelagicus*	0	1	0	0	0	0	1
Unidentified tern	*Sterna spp.*	0	0	1	0	0	0	1
TOTAL		4985	2115	4195	2777	2689	3851	20,612

Figure 1. Cruise tracks, *Jordan* (—) and *McArthur* (━), 30 July - 8 December 2001.

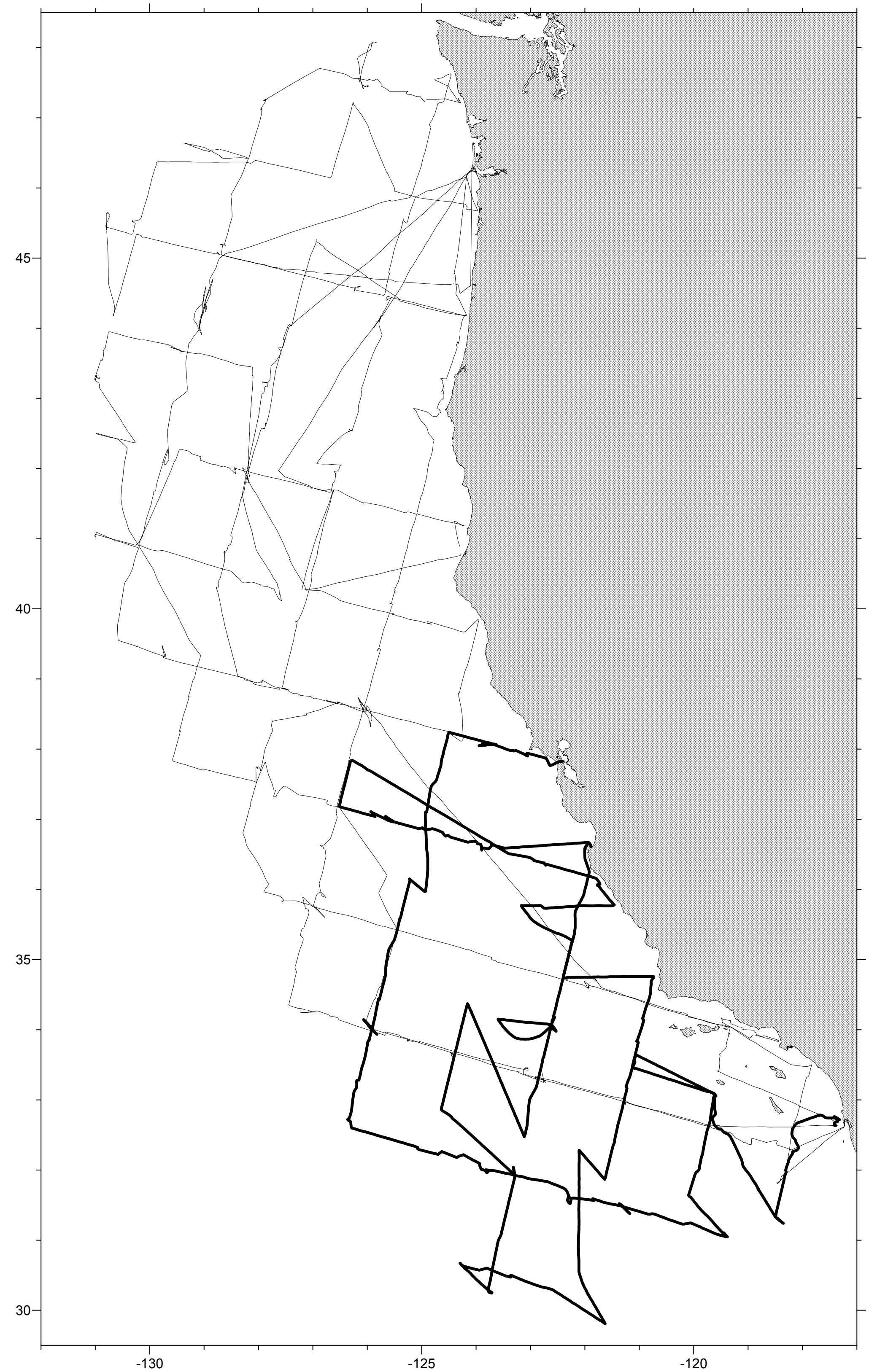


Figure 2. CTD stations, *Jordan* (○) and *McArthur* (x), 30 July - 8 December 2001.

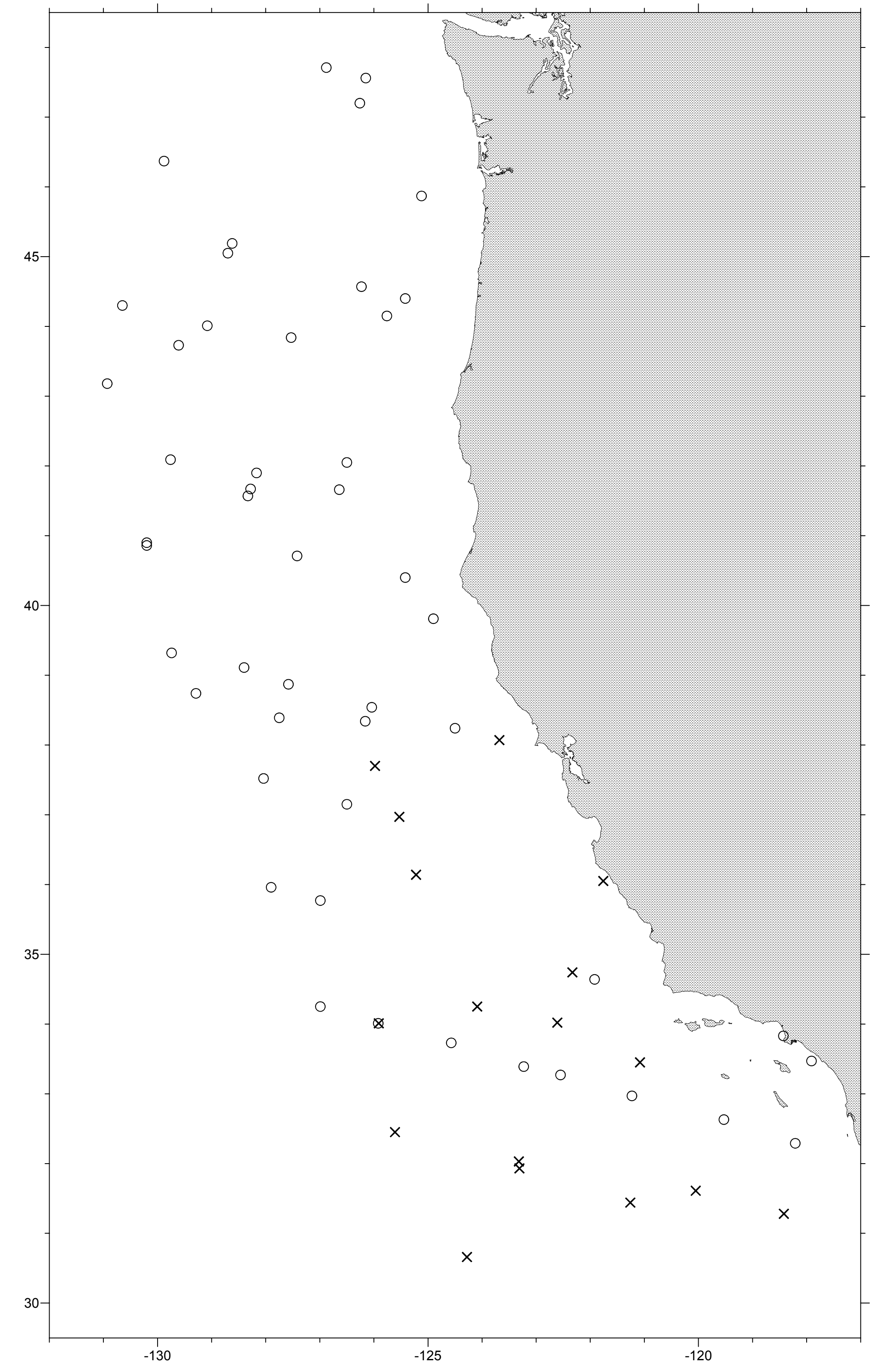


Figure 3. XBT deployments, *Jordan* (○) and *McArthur* (x), 30 July - 8 December 2001.

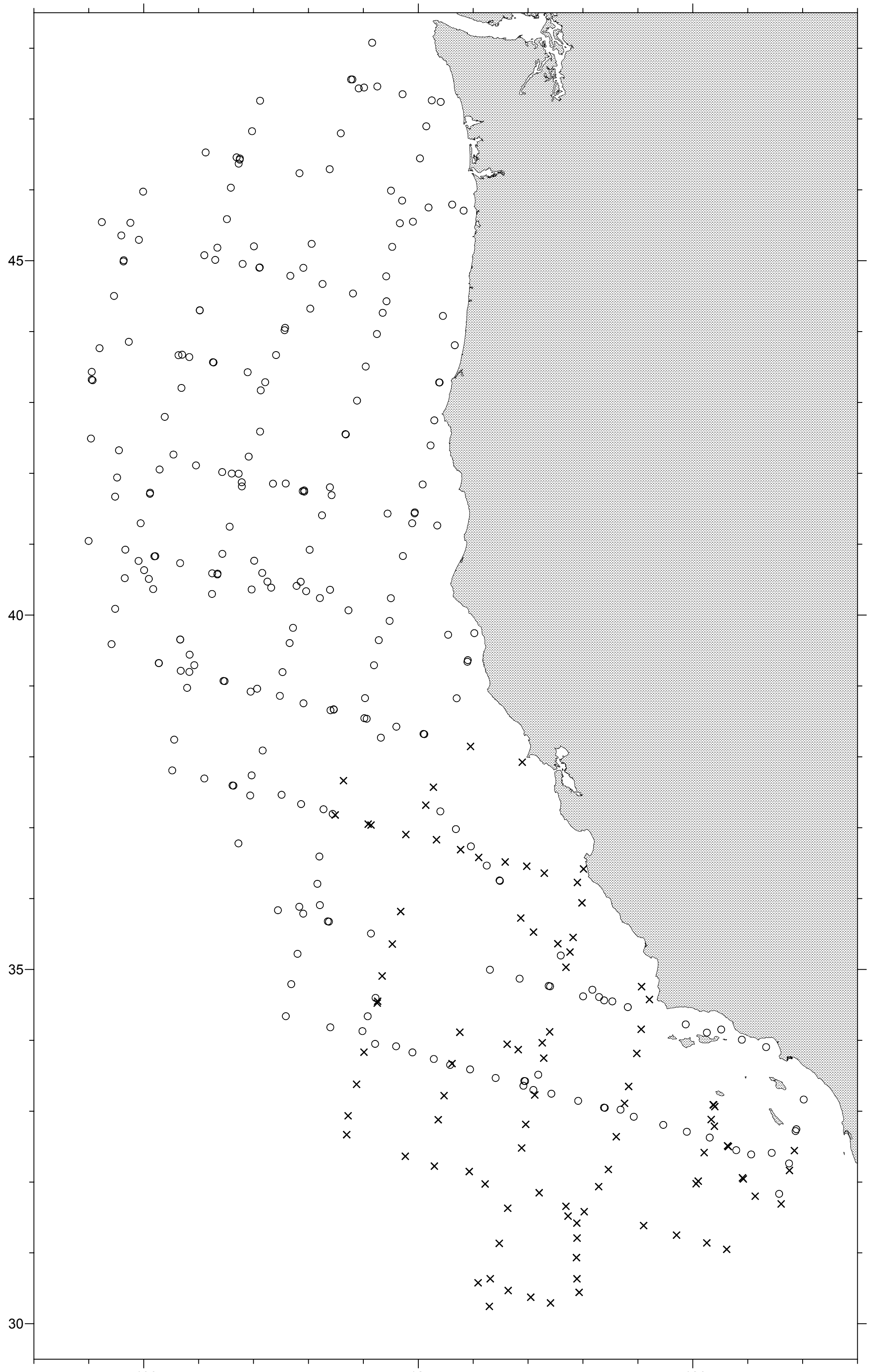


Figure 4. Sea surface temperature (°C) from CTD and XBT profiles (+), 30 July - 8 December 2001.

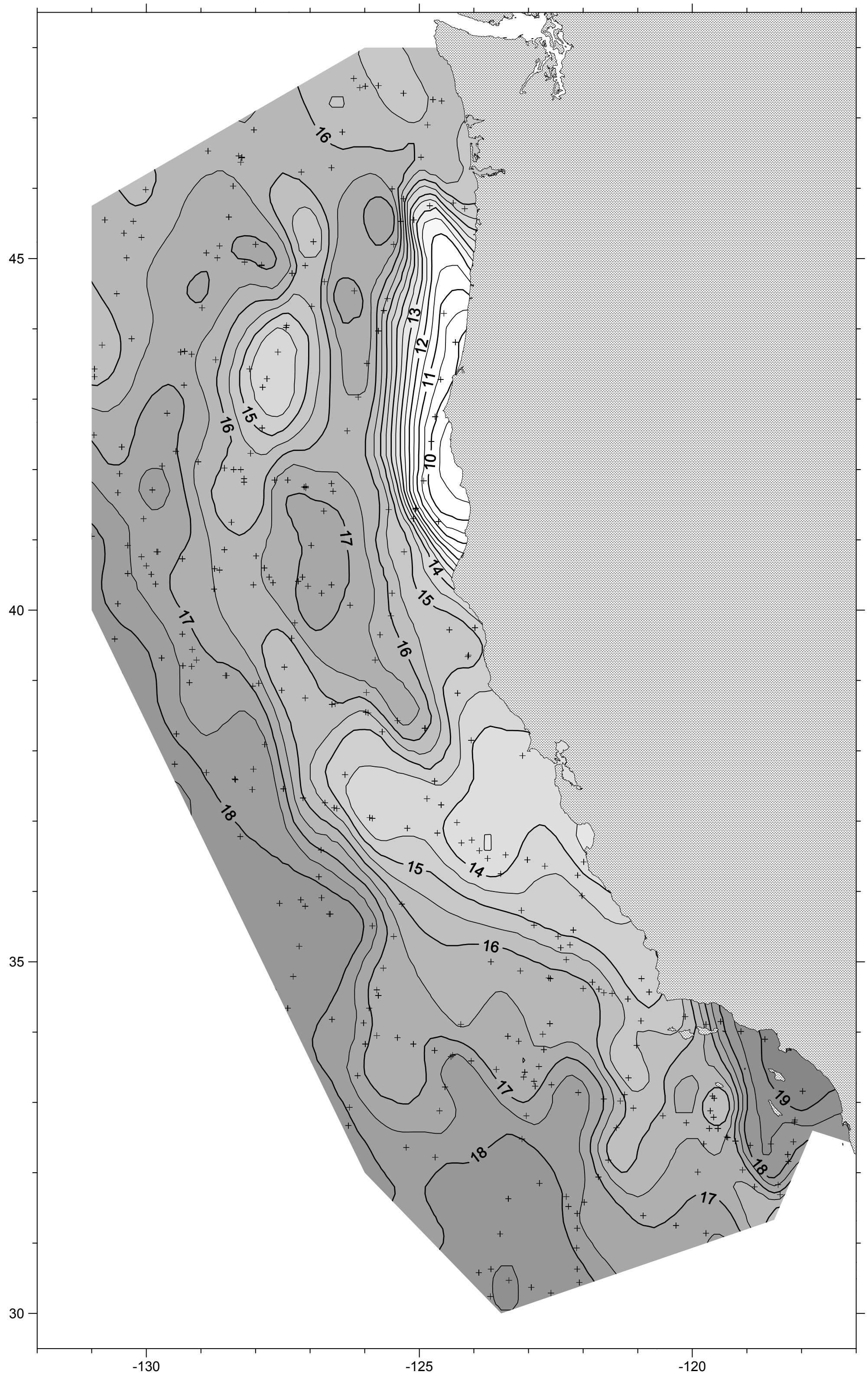
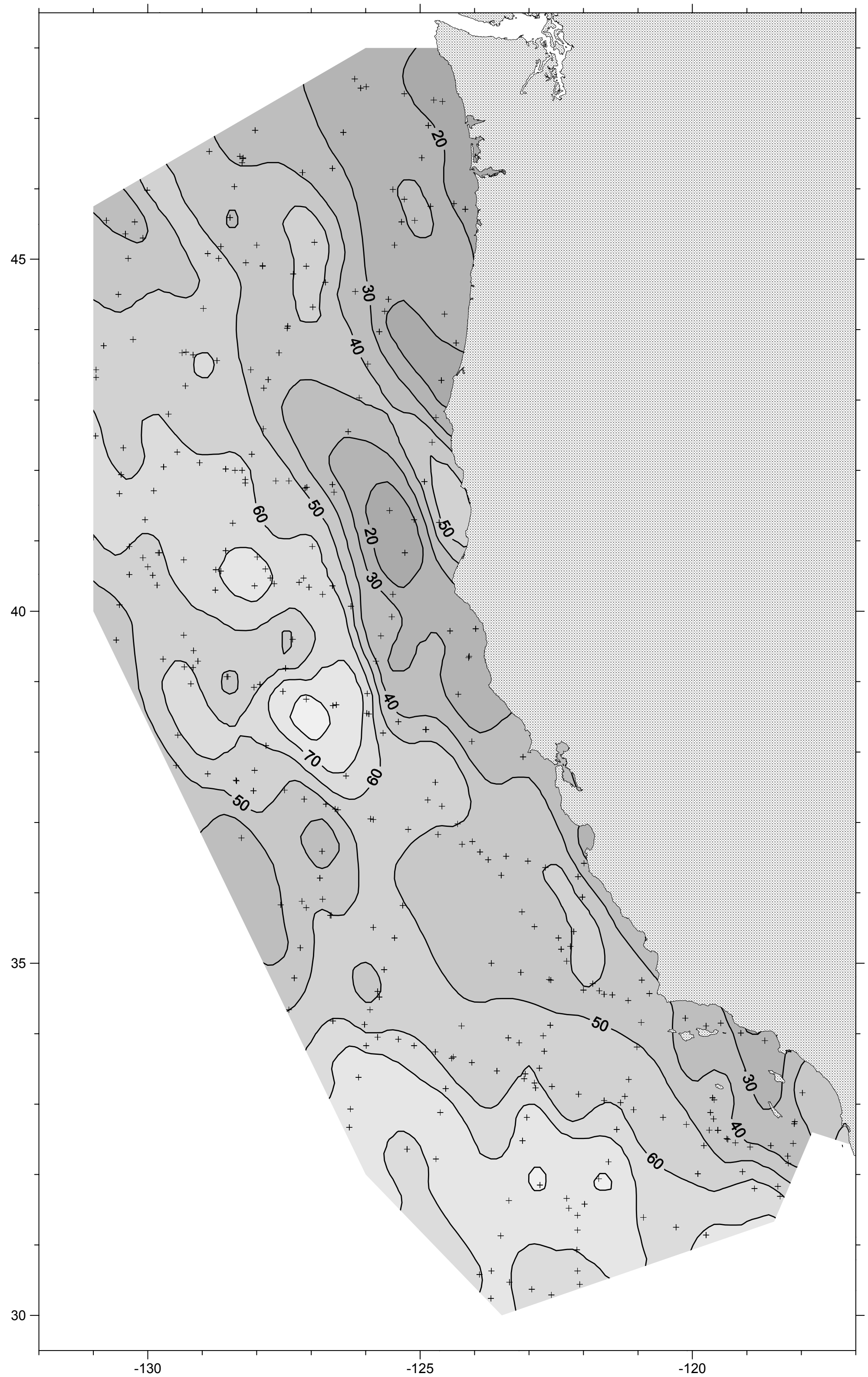


Figure 5. Thermocline depth (m, depth of maximum temperature gradient over an interval of 30 m) from CTD and XBT profiles (+), 30 July - 8 December 2001.



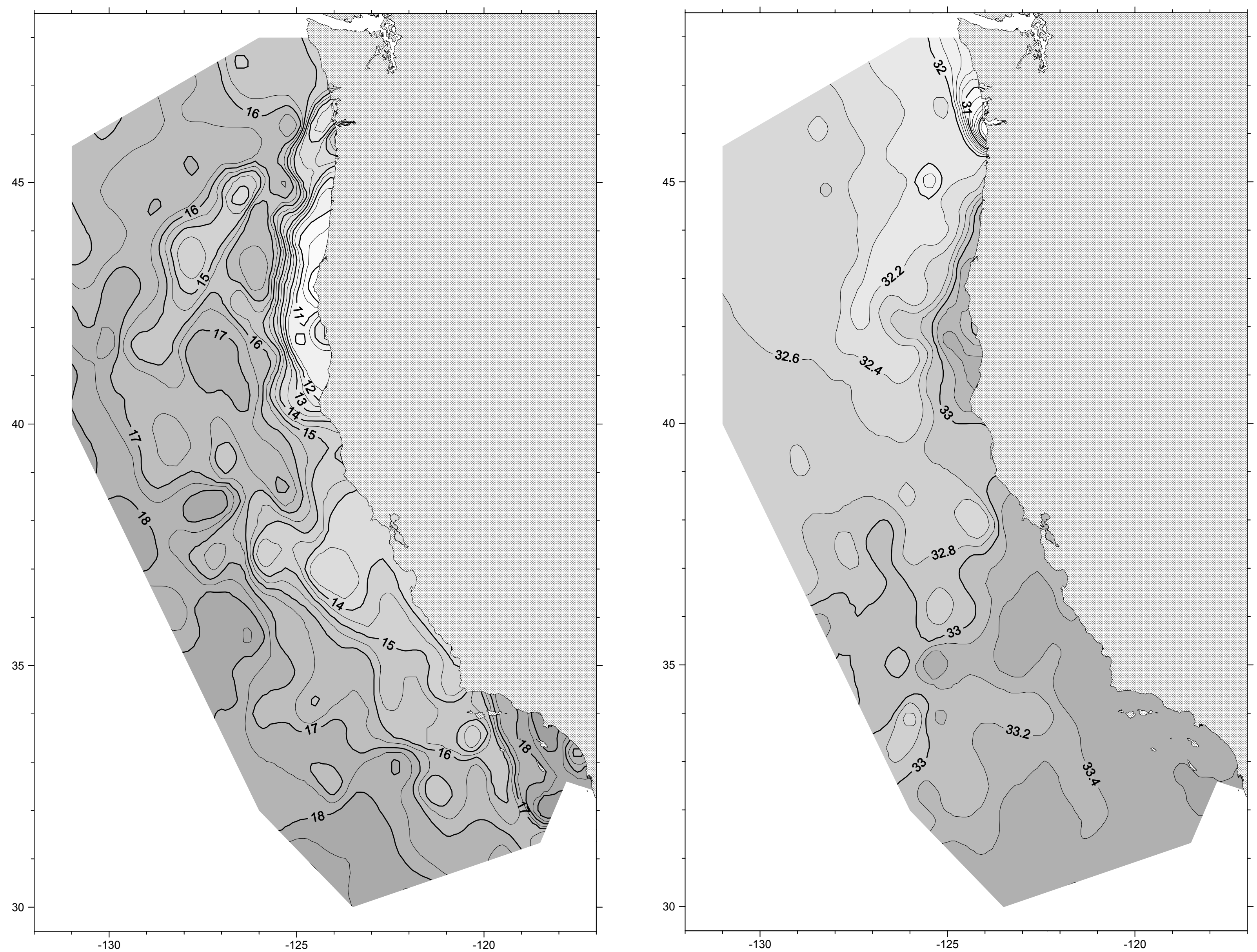


Figure 6. Sea surface temperature (°C, left) and salinity (PSU, right) from thermosalinograph data, 30 July - 8 December 2001.

Figure 7. Surface chlorophyll concentration (mg m^{-3}), from CTD casts and underway samples (+), 30 July - 8 December 2001.

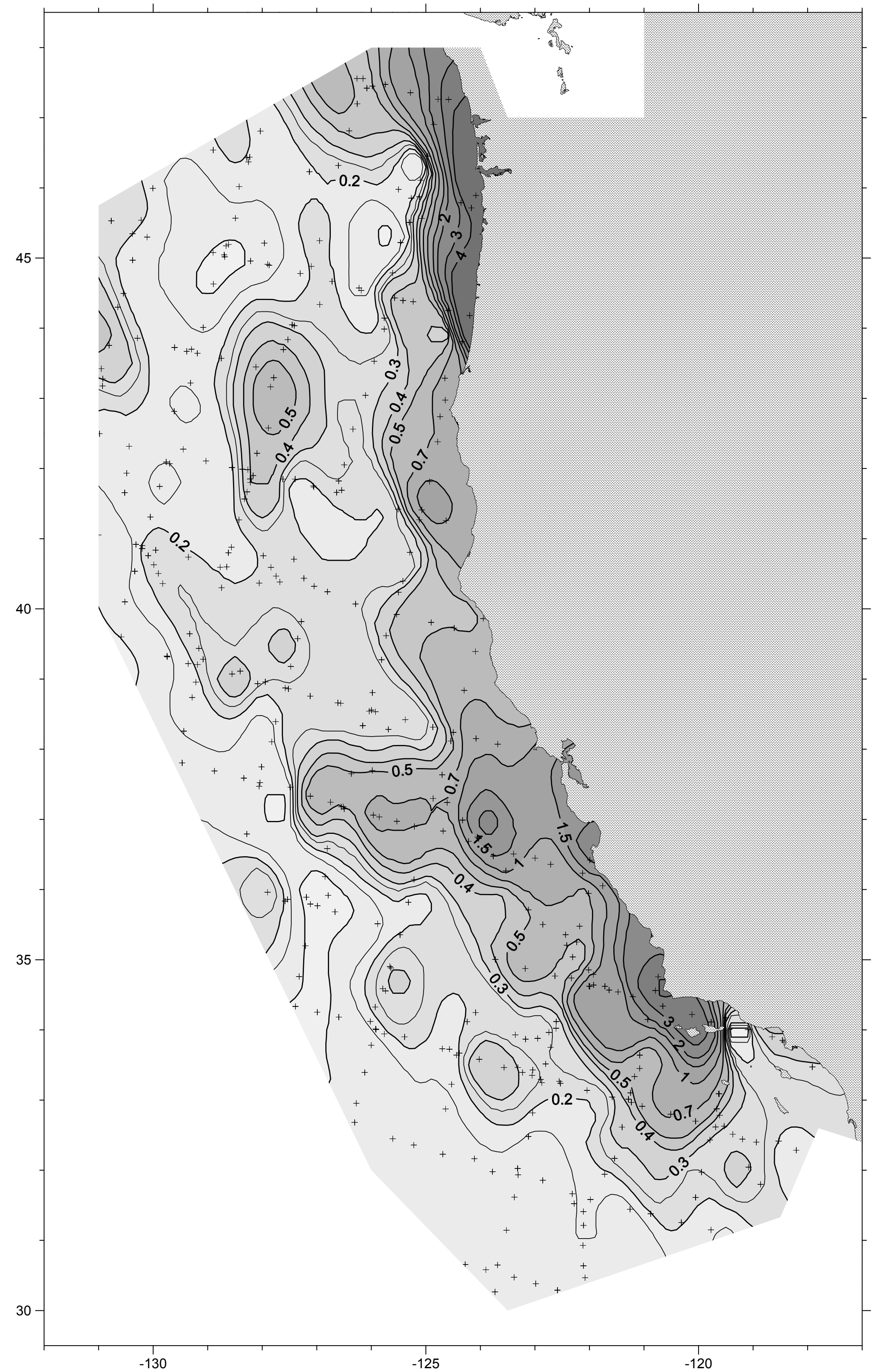


Figure 8. Primary productivity (mg C m^{-2} d^{-1}) in the euphotic zone, from morning CTD casts (+), 30 July - 8 December 2001.

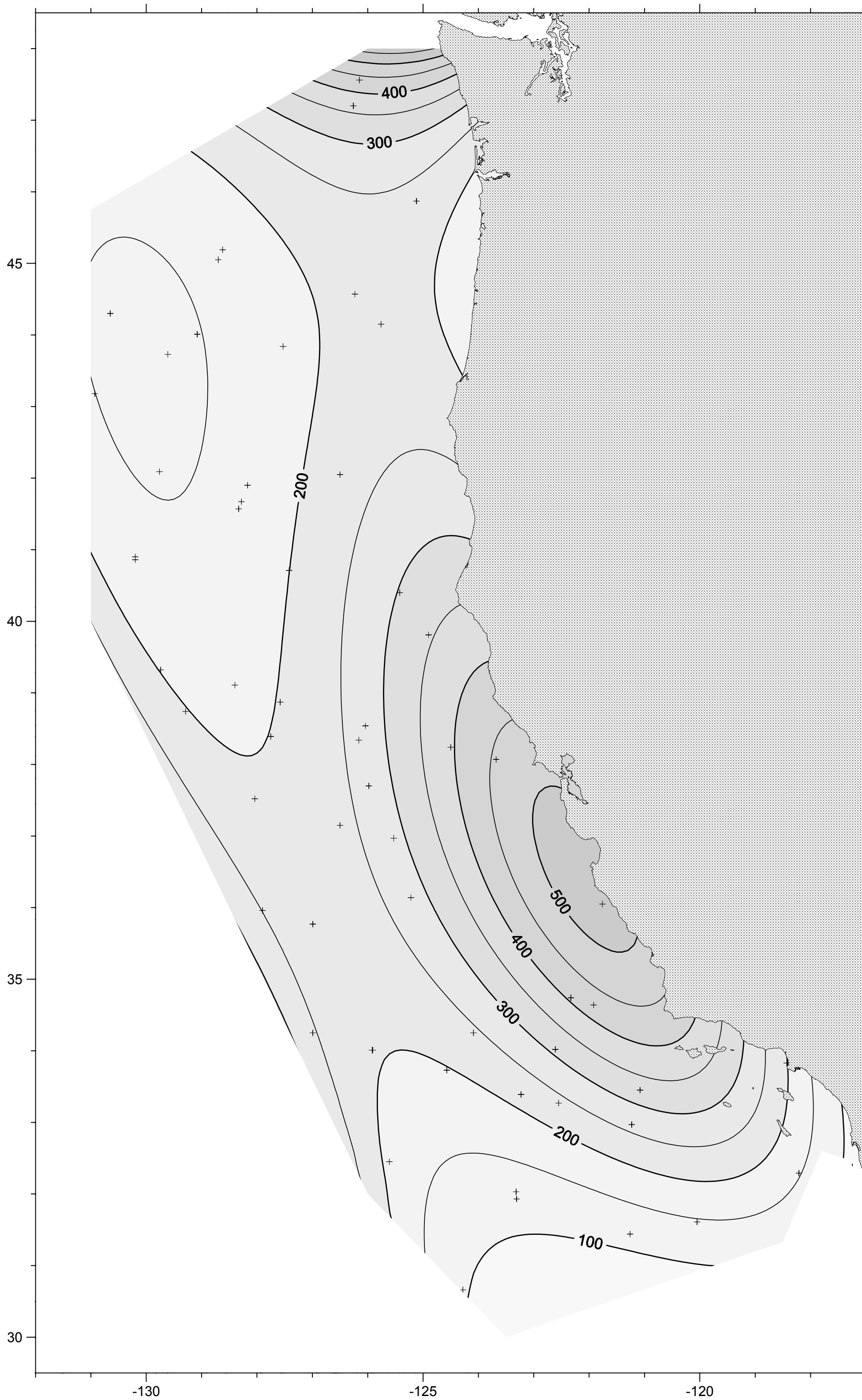


Figure 9. Integrated volume backscattering coefficients (NASC) in m^2/nmi^2, thought to be associated with fish, *Jordan*, 30 July – 10 November 2001.

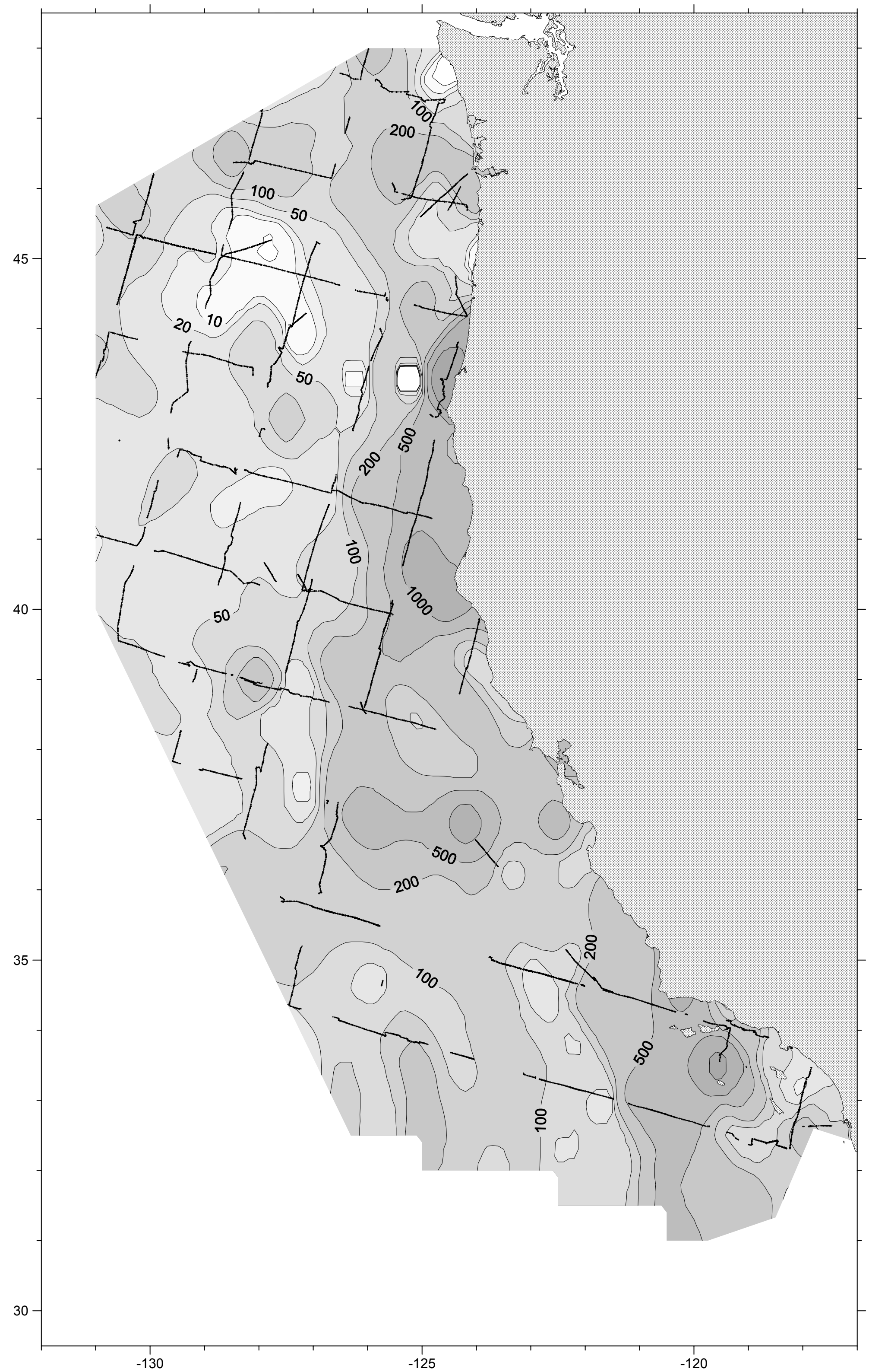
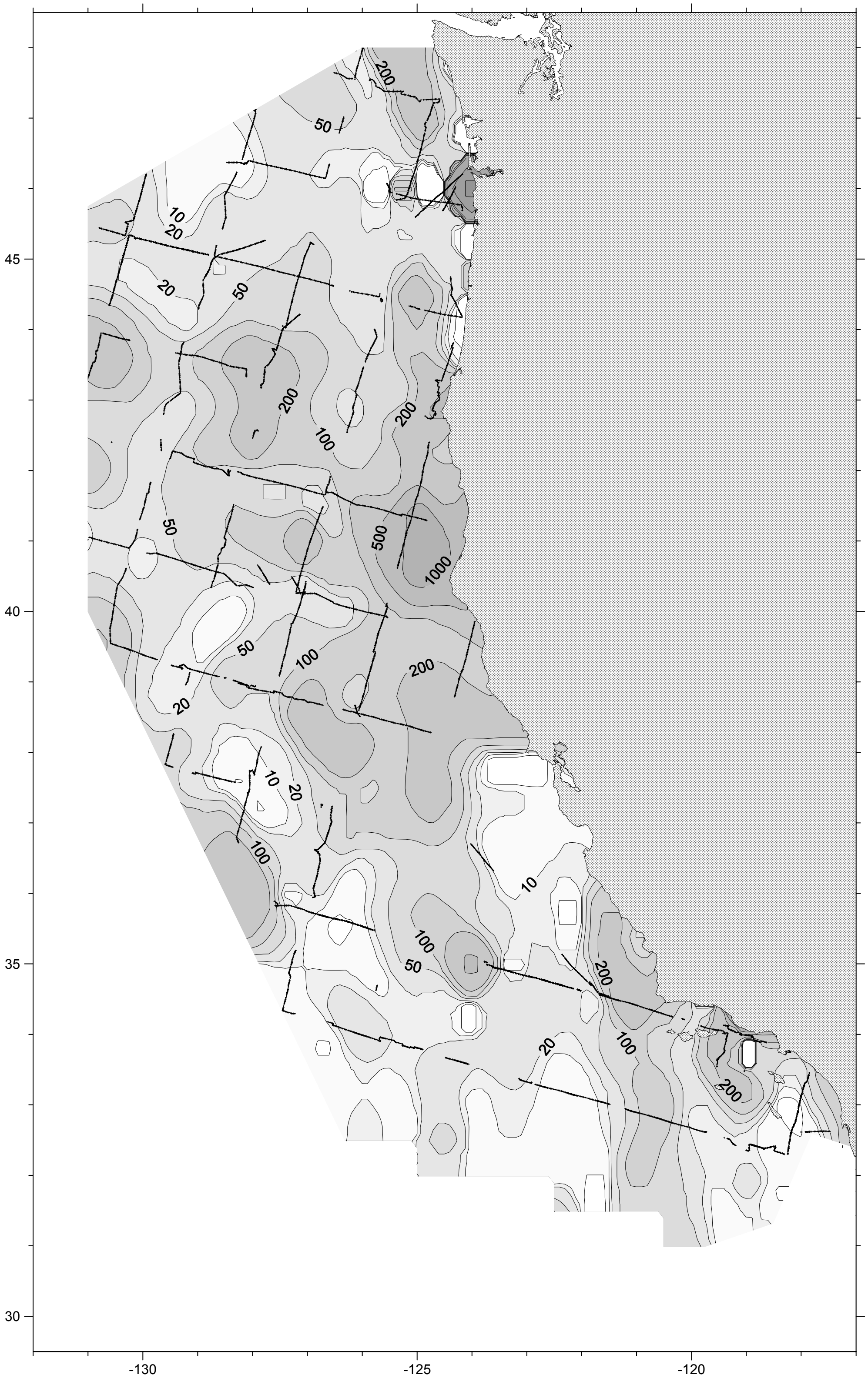


Figure 10. Integrated volume backscattering coefficients (NASC) in m^2/nmi^2, thought to be associated with zooplankton, *Jordan*, 30 July - 10 November 2001.



APPENDIX A

SEABIRD SURVEY INSTRUCTION MANUAL, ORCAWALE 2001

INTRODUCTION

This manual provides complete instructions on data collection procedures in the field for the seabird abundance and distribution surveys conducted by the Ecology Program of Southwest Fisheries Science Center, NOAA, NMFS. If you have any questions after having read this manual, please contact Lisa T. Ballance, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037; 858-546-7173 phone; 858-546-7003 fax; lisa.ballance@noaa.gov

NOTES ON DATA COLLECTION PROCEDURES

Equipment, Data Collection, General Procedures

Data are collected from a station on the flying bridge. There will be a designated chair for the seabird observer to sit in and a makeshift table for the laptop computer, bird books, binoculars, *etc*. We will provide one copy of each of the two Harrison seabird guides: that with painted plates (1983), and that with photographic plates (1987), pencils, paper, and assorted notebooks. There will be binoculars available for general use on the flying bridge, but you should bring your own for use during seabird observations.

A large "Igloo" ice chest will be designated for seabird survey use and should be left on the flying bridge permanently. Use it to store the identification books, pencils, notebooks, and personal items such as sun lotion, *etc*. during the day. It is water resistant but not waterproof. Because of this, make sure you bring water-sensitive equipment below with you every night.

There will be 6 or more marine mammal observers on the ship with you, along with several other scientists, depending upon the particular project needs: oceanographers, photo-identification specialists, *etc*. Of these, the mammal observers will work on the flying bridge as well.

Seabird data are recorded in two forms. 1) The data from the regular survey will be recorded on a small laptop computer on the flying bridge. 2) Any detailed comments you have pertaining to this regular survey will be hand written into a green record book.

Generally we collect data from just after sunrise to just before sundown. We have found that the best way to work is to rotate the responsibility for data collection so that you collect data for 2 hours and then have a 2 hour break while the second bird observer collects data; it is difficult to maintain concentration for more than 2 hours at a time. The mammal observers will generally follow this same schedule.

There will be occasions when you will be unable to observe because of bad weather. Generally, when the mammal observers are unable to work (above Beaufort 5), you should also consider taking some time off. However, because we observe an area of 300 meters alongside the ship as opposed to several km for the mammal observers, it will be possible to collect good bird data under conditions which preclude mammal observations. We have found that bird observations are possible in seas up to (and, sometimes, including) Beaufort 6, in fog, and in light rain. Of course, the final call is up to you. The bottom line is that *we would rather have no data than unreliable data*.

Strip Transect Methods

We will be using a standardized survey method known as the 300 meter strip transect technique. The method requires recording all objects of interest (birds, in this case) that are found within a certain strip width as one proceeds along a pre-determined track. Once this is complete, a density of birds within the sampled area can be calculated, and this density can be applied to that area of ocean that was not sampled.

For our survey, the strip width is 300 m, which means that you should monitor that area of ocean on one side of the ship (that side with the best viewing conditions), that stretches from the bow to the beam, and out to 300 m. You record all birds that you see within this area.

There is one crucial assumption in strip transect methods. The assumption is that you can detect ALL birds within your sampling zone (within 300 meters of the ship in a 90 degree arc, from the bow to the beam, on one side of the ship) at any particular time. It is VERY IMPORTANT that this assumption be met. Accordingly, you must focus your attention on this piece of ocean so that you will be able to detect all birds which should come into this area. We generally try to use one side preferentially over another but should glare or wind become a problem, you should not hesitate to switch your effort to the other side of the ship until viewing conditions improve.

The data from each day will be recorded in the form of "transects". A transect is a period of effort during which all observation conditions are constant. Each time the conditions change, you should end the previous transect and begin a new one. Therefore, there will be many transects each day. You should end the current transect and begin a new one each time one of the following events occurs:

--a shift in seabird observers (this will occur every 2 hours or so)

--a change in the course of the ship with the exception of minor course corrections of less than 10 degrees (at the beginning of the survey, you should make sure the officer on watch will inform you each time this occurs; the mammal observers will need to have this information as well).

--a change in any one of the sighting conditions: sea state, side of ship on which you are viewing, "observation conditions" (see below)

You will only record data using the strip transect method when the ship is "on effort", that is when it is following the pre-determined track which was plotted back in San Diego. During this time the mammal observers will be in their normal search mode. When one of the mammal observers makes a sighting, the ship will either continue on the pre-plotted course for an additional period of time, or the ship will divert to investigate the sighting. You should end your transect when the ship diverts from it's course for this purpose. It will require a period of time ranging from a few minutes to an hour or more for the ship to approach the mammal school close enough for the observers to verify species identity, make school size estimates, and conduct any other data collection procedures (collection of biopsy samples or photos, for example). Once finished with the sighting, the ship will return to the pre-plotted cruise track and you should begin a new transect. The mammal observers will return to their normal search mode at this time also. (NOTE: if there were birds aggregated above the mammal school, you should wait to begin the next transect until the ship is out of this aggregation. A few minutes are generally sufficient.)

Range Finders

Estimating how much of the ocean in front of you is within 300 meters of the ship is one of the most difficult parts of the 300 meter strip transect method, YET ONE OF THE MOST CRUCIAL. We solve this problem with a "range finder," which you will make before the first sailing day. (See Heinemann 1981 for details.) Brief instructions summarizing range finders follow.

Our range finder is a pencil with marks along the length which correspond to distances of 100, 200 and 300 m from the ship. To use the range finder, stand with arm *completely extended horizontally*, and hold the pencil in your hand so that it is oriented vertically. Close one eye and line up the top of the pencil so that it is even with the horizon. In this position, you can use the marks on the pencil to indicate the location of various distances from the ship.

How do you know where to place the marks on the pencil so that they correspond to 100, 200 and 300 m away? You calculate where to place them by using equations based on your height above the water surface, the distance to the horizon at this height, and the distance from your eye to the upper end of the pencil. The equations are given in Heinemann (1981). For an observer between the heights of 5'6" and 5'11" standing aboard the NOAA research vessels *David Starr Jordan* or *McArthur*, the relevant values are:

Height of Observer Standing on Flying Bridge	34 ft =	10.36 m
Distance to Horizon at Flying Bridge Height	5.6 n m =	10,371.2 m
Distance Between Observer's Eye to Pencil Top	0.63 m	
Distance from Pencil Top to Mark Corresponding To:	300 m =	2.11 cm
	200 m =	3.20 cm
	100 m =	6.46 cm

Because the distance to the horizon and the height of the flying bridge are both so much greater than any differences between height of observers, or distance from the eye to the end of the pencil, we have found that a single range finder can be used by all persons between the heights of 5'6" and 5'11". If your height is very much different from this, you should recalculate values for distance between the pencil top to marks corresponding to 300, 200 and 100 m from the ship to check how different they are from the values given above.

Practice with this range finder at the beginning of the cruise and periodically throughout to verify your distance estimates. You should always have the range finder with you (and you should make a spare in case you lose the first).

Some Miscellaneous Comments About Procedures

While you are collecting bird data you will occasionally see an individual or group of marine mammals that are not detected by the mammal observers. Before the cruise begins, you should check with the cruise leader to see how these undetected sightings should be handled.

Most likely, you will occasionally find a wayward terrestrial bird that has been blown onto the ship, and died. These specimens should be placed into a plastic bag with a label noting the date and position, and frozen. If you are in international waters, or those of a country other than the United States, check with the Cruise Leader to see that they can be legally brought into the country.

Should you have any personal problems, problems with the other scientists, or with any of the crew, take them to the cruise leader. One of the main responsibilities of the cruise leader is to be available should such situations arise and to act as a liaison between yourself and other persons on the ship, or on shore.

All of the data collected on the ship are the official property of Southwest Fisheries Science Center. Should you wish to access any part of them for analysis or use of any kind, you will need to discuss your intentions with Lisa Ballance.

TYPES OF DATA AND DATA CODES

We will be collecting two types of data which we refer to as "effort data" and "sighting data". The effort data contain information on the conditions prevailing when the data are recorded: how windy is it?; which side of the ship are you recording data from?; *etc*. The sighting data contain information on the seabirds themselves: which species and how many individuals do you see?; what are the birds doing?; *etc*.

EFFORT DATA

CRUISE NUMBER : ("CRUISE #")

This is a 4-digit number which identifies this vessel and particular cruise. The number is the same for seabird, mammal, and oceanographic portions of the project. It will be assigned at the beginning of the survey and will remain the same throughout the entire cruise.

For the 2001 survey, the cruise number for the *David Starr Jordan* is **1617**; for the *McArthur* **1619**.

DATE : ("GM DATE" AND "LM DATE")

We record the date as a 6-digit number: the last two digits of the year, followed by two digits representing the month, followed by two digits representing the day. For example, March 28, 1997 would be entered as 970328.

The data file will contain two separate dates, one corresponding to local and the other to Greenwich date. Both will automatically be entered by the computer using its internal calendar and a link to the ship's Global Position System (GPS).

POSITION : ("LATITUDE" and "LONGITUDE")

Latitude and longitude will automatically be entered by the computer using a link to the ship's GPS. The units are decimal degrees and are recorded to the nearest 1000^{th} of a degree. Southern latitudes and western longitudes will be recorded as negative numbers.

SEA STATE : ("BEAUFORT")

This is a 1-digit number by which you will estimate the wind velocity based on the visual appearance of the sea. We use the Beaufort scale for this. The mammal observers record this during their survey as well. For the first few weeks of the cruise, or until you become familiar with the Beaufort scale, use their estimate to verify yours.

SHIP'S COURSE : ("SHIP COURSE")

The ship's course will be calculated by the ship's GPS and automatically recorded onto the computer. This course will represent the course made good, *not the ship's heading*, although the difference between these two should be relatively minor. The course will be updated automatically and frequently. Therefore, there could be several minor course changes while on a single transect. For any major course change (> 10 degrees), end the current transect and begin a new one.

OBSERVATION CONDITIONS : ("OBSERVER CONDITION")

This is a 1-digit number which combines all environmental conditions (glare, wind velocity and direction, relative measure of whitecaps, *etc.*) into a single value. This value is used as an overall assessment of the visibility conditions during which data were collected.

Unavoidably, the assignment of an observation condition will be somewhat subjective but you should try to be consistent, at least within your own observations from day to day. Rather than use a set of conditions themselves to define each value, we have developed a scale that is based upon *species* and *distance from the ship*. Use the following as a guideline:

1 - Conditions extremely bad
--Storm-Petrels and Phalaropes cannot reliably be detected to 100 m
--All individuals of all other species cannot reliably be detected to 200 m

2 - Conditions poor
--All Storm-Petrels and Phalaropes visible to 100 m
--All individuals of all other species visible to 200 m

3 - Conditions fair
--All Storm-Petrels and Phalaropes visible to 200 m
--All individuals of all other species visible to 300 m

4 - Conditions good
--All individuals of all species visible out to 300 m

5 - Conditions excellent
--All individuals of all species visible out to 300 m +

Remember that the first, and most important, assumption of strip transect methodology is that you are recording ALL of the seabirds that are in your survey strip. Although we use a 300 m wide strip as a default value, the Observation Condition code essentially allows us to vary the strip widths for different bird taxa as the visibility conditions vary. So, for example, if your data were recorded with an

Observation Condition of "3", we would use a strip width of 200 m to calculate density for storm-petrels and phalaropes, and a strip width of 300 m for all other taxa.

Accordingly, your choice of Observation Conditions for each transect is an extremely important one. The best rule of thumb to use when assigning an observation condition to a transect is to ask yourself "How far away from the ship am I able to detect ALL of the storm-petrels?"

Another important note regarding Observation Condition concerns the distance at which you record birds (see below). When using codes 4 and 5, you will want to record all species out to 300 m. However, when using code 3, you will not want to enter Storm-Petrels and Phalaropes until they come within 200 m of the ship, *even if you detect them farther out than this*. This is because we will be using a strip width of 200 m to calculate densities for these species and those entered at a distance of 300 m will not be used in our calculations. Similar procedures should be used for Observation Conditions 2 and 1. *It is extremely important for our analyses that this procedure be followed*. Please keep this in mind when you are on effort.

OBSERVATION SIDE : ("OBSERVATION SIDE")

This is a 1-digit number which indicates the side of the ship used for surveying. A "1" indicates that you surveyed the area on the port side of the ship. A "2" indicates the survey took place on the starboard side of the ship.

OBSERVER #1 CODE : ("OBSERVER CODE #1")

This is a 2-digit number which identifies the individual currently on effort and recording data on the computer. Use the following codes:

01 – Bob Pitman
17 – Lisa Ballance
21 – Mike Force
31 – Cornelia Oedekoven
99 – Other

You should not need to use this last code. But should it become necessary, for any reason, to use an alternate observer, record "99" as the observer code and be sure to record the identity of this observer in the green record book.

SIGHTING DATA

EVENT CODE : ("EVENT CODE")

An event code is used to indicate the reason for entering the current line of data. There are 6 codes:

0 - Automatic Time/Position Update

This code will automatically be entered by the computer approximately every 10 minutes and a time and position stamp will follow.

1 - Begin Transect

Use this code to indicate the beginning of an on-effort transect. As already noted, you will need to begin a new transect when any of the environmental conditions change, when you change observers, or when the ship makes a major course change for any reason. The data entry program will not allow you to record sightings or change effort data until you enter this "Begin Effort" line.

2 - On Effort Sighting

Use this code to indicate a sighting of any type during the transect. A sighting will include birds, bird flocks, mammals, fish, turtles and flotsam.

3 - End Transect

Use this code to indicate the end of a transect. The most common reasons for ending the effort period will be a major course change for any reason, a change of observers, a change in environmental conditions, deviation from the track to pursue a marine mammal school, or the end of the day. The data entry program will not allow you to resume effort, or exit the program, until the current transect has been ended.

4 - Cumulative Total

You may encounter a situation when the bird abundance is so high that it becomes impossible to count and enter individual birds at the time you sight them. In these situations, it will be necessary to count birds in blocks (as groups of 10's for example) and enter these numbers periodically, at regular intervals (every 5 minutes for example).

Should such a situation arise, you will be recording data only on species identification and species number for each time period. The distance code you record should always be a 3 (you should not count any birds if they are farther than 300 meters from the ship); the behavior code will always be a 6 (this is the code for "other", and you should note in the green record book that for this situation you are using this code to indicate that no data on behavior were recorded); the association, age, and sex codes will all be the codes for "unknown" (3, 1, and 1, respectively); and the flight direction code will be 1 to indicate that no flight direction data were recorded.

Because our project will generally be designed to survey birds in pelagic areas (*i.e.* where bird densities are relatively low) you should rarely need to use this code.

5 - Off-Effort Sighting

As is the case for an on-effort sighting, you should use this code to indicate a sighting of birds, bird flocks, mammals, fish, turtles and flotsam. The difference is that an event code of "5" signifies that you were not on regular transect effort when the sighting was made. In general, we do not have much use for off effort sightings. There are only a few situations in which you will need to record them:

a) when you see a "rare" bird (in other words, one not yet recorded during that day's effort)

b) when you see a pinniped or turtle

c) when you see any other animal or object that is unusual

In general, an off effort sighting allows us to record data for "significant" events, even though we

are not on effort. All off effort sightings, by definition, will occur between the end of one transect and the beginning of another one.
Note that if you are on effort and wish to record birds, or any other unusual events that occur outside the 300 m strip transect, the proper event code is a 2, not a 5, and the distance code is a 4 (see below).

TIME : ("GM TIME" and "LM TIME")

Time corresponds to the time at which the event, recorded in the previous field, occurred. The time will be recorded as a 6-digit number: 2 digits representing the hour, 2 digits representing the minute, and two digits representing the seconds.

Time will be automatically entered by the program using the computer clock. This clock will read according to local time, although each line in the data file will contain both LMT (Local Mean Time) and GMT (Greenwich Mean Time). All times will be based on the 24-hour system (i.e. 3:00 p.m. = 15:00).

Time will be automatically synchronized to the ship's GPS time stamp every time you start the data entry program. Upon starting, the program will prompt you for the local hour. When you enter this, the program will automatically synchronize this hour with the minutes and seconds read from the ship's GPS unit to re-set the computer's internal clock. The program will also automatically calculate the GMT offset. This automatic synchronization process will also be performed with mammal and oceanographic data; in this way, all data sets will correspond to the same time, and it will no longer be necessary to periodically check each computer clock for synchronization.

IMPORTANT - Please make sure the daylight savings time option in the computer's control panel is NOT checked.

SPECIES CODE : ("SPECIES CODE")

This is a 4-letter code which represents the identity of the species you are recording. The list in Appendix 2 gives the codes for all of the birds you will see, as well as codes for mammals, turtles and fish, which you should also record.

You will memorize these codes over time. As a general rule of thumb, the first two letters of the code represent the common name of the taxon at the family level (*i.e*. "BO" for boobies, "GU" for gulls), while the second two letters represent the specific identity (*i.e*. "BOBR" for Brown Booby, "GUWE" for Western Gull). However, note that there are many exceptions to this, so have the species code sheet easily accessible until you have learned all of the codes.

There will be occasions when you will see more than one species simultaneously. In this case you will need to record the code for the first species along with the remaining sighting data on one line. Then, using the same time as was recorded for this line of data (see below), record the code for the second species, along with the remaining sighting data, on the next line.

SPECIES NUMBER : ("SPECIES NUMBER")

This number represents the number of individuals for the species you are recording and should be entered for all sightings. There will be certain cases when you will not know the number of individuals, or be able to estimate that number. These cases are detailed elsewhere in this manual – in these instances, you should enter a “9999" in this field, which will indicate that the species was present, but no number information is available.

DISTANCE : ("DISTANCE")

This single digit number represents the distance from the ship to the bird when you first sight it (or when it first enters your survey strip). Use the following codes:

1 -- 0 - 100 m from the ship
2 -- 100 - 200 m " " "
3 -- 200 - 300 m " " "
4 -- outside of this area

Note that a code of "4" applies to a bird closer than 300 m to the ship, when it is on the opposite side from your survey side.

It is important that you NOT count birds that are flushed into your survey area by the ship. As closely as possible, we want to sample the area of ocean, as though we were not present. Thus, if the ship flushes a bird so that it moves into the survey area (distance codes 1, 2, or 3), you should not count it, as, presumably, it would not have been there had the ship not flushed it into the area. When in doubt, follow the general rule: act as though the ship were not there.

Distance code 4 is included primarily so you can record rare birds, even when they do not enter our 300 m strip. At times, this rare bird information will come from the few mammal observers who are experienced birders and who detect these species with the high-powered binoculars. Although it may be tempting, be careful not to spend too much time scanning for birds in zone 4 – because you may miss birds in the 300 m strip. (*Remember, these are “On Effort” sightings if YOU are currently on effort.*)

ASSOCIATION : ("ASSOCIATION")

This single digit number represents the kind of association (if any) between individuals sighted at the same time. Use the following codes:

1 -- Individual(s) not associated with others at the time the sighting is recorded. This code will be used for a solitary bird.

2 -- Individual(s) associated with other individuals at this same time. This code will be used for birds flying together, sitting in a group on the water, or any other aggregation in which the species involved are "associating" (individuals responding to the same stimulus or to each other).

3 -- Association unknown

BEHAVIOR : ("BEHAVIOR")

This single digit number represents the behavior of the individual(s) at the time of the sighting. Use the following codes:

1 -- Sitting
3 -- Following the ship (see below)
4 -- Feeding
5 -- Piracy
6 -- Other
    (Be sure to explain the meaning of this code each time you use it by writing the explanation in the green record book)
7 -- Unknown
8 -- Directional flight (over 1 km or more)
9 -- Non-directional flight

It may happen that you will see several birds at the same time engaged in more than one type of behavior. In this case you should record the code for the species, the number of individuals engaged in the first category of behavior, and the code for this behavior on one line. Then, using the same time as the previous sighting, record the species code, the number of individuals engaged in the second category of behavior, and the code for this behavior on the next line.

Ship Following

Ship following is a special type of behavior that is important to note. Birds of certain taxa almost always divert their course to approach and follow a ship every time they see one. Such birds are called "ship followers." These are usually, but not always, scavenging species. Classic ship following groups are albatrosses, some petrels and shearwaters, boobies (especially juvenile Red-footed and Brown), and tropicbirds. It is important to note ship following because these birds must be treated differently in density calculations. Because a ship follower will come over to the boat, you will record an artificially high number of these types of birds in the 300 m strip. If we were to use this number in density calculations, the density value would be inflated. Typically, some sort of correction factor is applied to ship followers to account for this artificially high number.

A ship follower is fairly easy to identify, as it will usually circle at least several times before it leaves. Some birds will stay with the ship for several hours, some all day long. It is important to count these individuals only ONCE -- and this is not always easy. Noticing some individual plumage mark or pattern is one way in which you can learn to recognize a particular bird so that it is not counted twice. (Our protocol is to start with a clean slate every morning, even though this means that if a bird stays with the ship all night, it will have been counted once yesterday, and once today.)

Flight Behavior

We record flight behavior, among other reasons, in order to be able to calculate abundance. For this purpose, it is important to distinguish between directional and non- directional flight. It is usually easy to make this distinction. A few notes will help:

1) A behavior code indicating directional flight means that the bird was flying in one direction for a distance of 1 km or more.

2) Many shearwaters and petrels use the wind as an energy source while in flight. Their flight behavior consists of a series of banking movements up and down, left and right of their overall flight direction. Even though they progress in a zigzag direction, this is considered directional flight because their “course made good” is in a single direction.

FLIGHT DIRECTION : ("FLIGHT DIRECTION")

This is a 3-digit number which represents the flight direction of the bird relative to the ship's heading. Record the direction in which the bird is flying in degrees. So, for example, if the bird is flying in the same direction as the ship is traveling, flight direction is 000 (or just 0). If the bird is flying perpendicular to the ship, flight direction is 90 if the bird is flying to the right, 270 if to the left . And if the bird is flying in the opposite direction as the ship's course, flight direction is 180.

We use angle boards to quantify direction. An angle board is a circular surface (made from a board) that is clamped onto the rail in front of you. It is marked with 360 degree ticks around the outside. A movable pointer is attached to the center. When you see a bird in directional flight, keep your eye on it and simply move the pointer in the direction in which that bird is flying. When you begin to enter data for that bird, simply look at the direction of the pointer; this is the 3-digit number you should enter for flight direction.
You will only need to record flight information if the Behavior code is “8,” that is, if the bird is in directional flight. Otherwise, the computer will automatically enter “999" which is the code indicating that flight direction information is not applicable to this sighting.

AGE : ("AGE")

This single digit number represents the estimated age class of the sighted individual. Use the following codes:

1 -- age unknown
2 -- juvenile
3 -- adult

Should you see birds at the same time which comprise 2 or 3 of these age categories, enter the data for each age class on a separate line and record the same time (that of the initial sighting) for each line.

SEX : ("SEX")

This single digit number represents the sex of the sighted individual. Use the following codes:

1 -- sex unknown
2 -- female
3 -- male

Should you see birds at the same time which comprise 2 or 3 of these sex categories, enter the data for each sex on a separate line and record the same time (that of the initial sighting) for each line.

COMMENTS : ("COMMENTS")

This is a 1 digit number which indicates whether further comments on the sighting have been recorded. Use the following codes:

1 -- No Comment

You should enter this value when you have no comment regarding the current line of data.

2 -- Comment

Use this code any time you observe an event which you feel deserves some written comments. For example, if you see a bird which is not expected to be in the general area we are surveying, you might want to record details specifying how you arrived at your species identification. If you see a bird involved in an unusual behavior, you may want to record details of this behavior. The computer will not allow entry of text into the data base file, so, if you have a comment, you should write it in the green record book along with the date and time corresponding to the line of data displayed by the computer.

GENERAL COMMENTS

It is extremely important that you *do not change existing codes or initiate any new ones*. The codes on the previous pages should be adequate to record all events. Should a novel situation arise that you believe requires a change in a code or procedure, be sure to contact us.

SPECIAL TYPES OF DATA

Rare Birds

Not infrequently, the mammal observers (which use 25 power binoculars) will see one or more species which do not fly into the 300 m survey strip. In these cases, we want to have them in the database to show that they were present in the area for a particular day. The best way to accomplish this is to ask the mammal observers (*only the accomplished birders*) to let you know when they see a bird not yet recorded. When this happens, you should enter a line of data that records that species at a particular time in zone 4 (outside of the survey strip). Although it is tempting, be careful not to spend so much time scanning for rare birds outside the 300 m strip that you will run the risk of missing those within the strip. ***Remember that these are "On Effort" sightings, if YOU are on effort, and "Off Effort" sightings if you are off effort***.

Pinniped Data

On this survey, the seabird observers will conduct a dedicated pinniped survey, simultaneous with the seabird survey. We use the same 300 meter strip transect methods, and record all pinnipeds which come into the zone in the same way that seabirds are recorded.

Five behavior codes are specific to pinnipeds and should be used as follows:

A = FINNING (restricted to Otariids)
B = JUG-HANDLING (specific type of finning restricted to fur seals)
C = BOBBING (vertically; will primarily be used for Phocids, but valid for Otariids too)
D = SLOW SWIMMING
E = PORPOISING

Some seabird behavior codes are also applicable here (codes 3, 4, 6 and 7).

REFERENCES

Harrison, P. 1983. Seabirds. An identification guide. Houghton Mifflin Company, Boston.

Harrison, P. 1987. A field guide to seabirds of the world. The Stephen Greene Press, Lexington, Massachusetts.

Heinemann, D. 1981. A range finder for pelagic bird censusing. Journal of Wildlife Management 45(2): 489-493.

APPENDIX B: Four-letter species codes used for the seabird survey.

------SPECIES CODES------ (NUMERIC)	(ALPHA)	COMMON NAME	SCIENTIFIC NAME
1100	PNSP	UNID. PENGUIN	
1101	PNEM	EMPEROR PENGUIN	APTENODYTES FORSTERI
1102	PNKI	KING PENGUIN	APTENODYTES PATAGONICUS
1110	PNAD	ADELIE PENGUIN	PYGOSCELIS ADELIAE
1111	PNCS	CHINSTRAP PENGUIN	PYGOSCELIS ANTARCTICA
1112	PNGE	GENTOO PENGUIN	PYGOSCELIS PAPUA
1120	PNMC	MACARONI PENGUIN	EUDYPTES CHRYSOLOPHUS
1121	PNRH	ROCKHOPPER PENGUIN	EUDYPTES CHRYSOCOME
1122	PNFC	FJORDLAND CRESTED PENGUIN	EUDYPTES PACHYRHYNCHUS
1123	PNSC	SNARES ISLAND PENGUIN	EUDYPTES ROBUSTUS
1124	PNRO	ROYAL PENGUIN	EUDYPTES SCHLEGELI
1125	PNEC	ERECT-CRESTED PENGUIN	EUDYPTES SCLATERI
1130	PNYE	YELLOW-EYED PENGUIN	MEGADYPTES ANTIPODES
1140	PNWF	WHITE-FLIPPERED PENGUIN	EUDYPTULA ALBOSIGNATA
1141	PNLB	LITTLE BLUE PENGUIN	EUDYPTULA MINOR
1150	PNJA	CAPE PENGUIN	SPHENISCUS DEMERSUS
1151	PNHU	HUMBOLDT PENGUIN	SPHENISCUS HUMBOLDTI
1152	PNMG	MAGELLANIC PENGUIN	SPHENISCUS MAGELLANICUS
1153	PNGA	GALAPAGOS PENGUIN	SPHENISCUS MENDICULUS
2000	LOON	UNID. LOON	GAVIA SP.
2001	LORT	RED-THROATED LOON	GAVIA STELLATA
2002	LOAR	ARCTIC LOON	GAVIA ARCTICA
2003	LOCO	COMMON LOON	GAVIA IMMER
2004	LOYB	YELLOW-BILLED LOON	GAVIA ADAMSII
2005	LOPA	PACIFIC LOON	GAVIA PACIFICA
3000	GREB	UNID. GREBE	PODICIPEDIFORM SP.
4100	ALSP	UNID. ALBATROSS	DIOMEDEA SP.
4101	ALST	SHORT-TAILED ALBATROSS	DIOMEDEA ALBATRUS
4102	ALBU	BULLER'S ALBATROSS	DIOMEDEA BULLERI
4103	ALSH	SHY ALBATROSS	DIOMEDEA CAUTA SSP?
4104	ALYN	YELLOW-NOSED ALBATROSS	DIOMEDEA CHLORORHYNCHOS
4105	ALGH	GRAY-HEADED ALBATROSS	DIOMEDEA CHRYSOSTOMA
4106	ALRO	ROYAL ALBATROSS	DIOMEDEA EPOMOPHORA
4107	ALWN	WANDERING ALBATROSS	DIOMEDEA EXULANS
4108	ALLA	LAYSAN ALBATROSS	DIOMEDEA IMMUTABILIS
4109	ALWA	WAVED ALBATROSS	DIOMEDEA IRRORATA
4110	ALBB	BLACK-BROWED ALBATROSS	DIOMEDEA MELANOPHRIS
4111	ALBF	BLACK-FOOTED ALBATROSS	DIOMEDEA NIGRIPES
4112	ALAM	AMSTERDAM ALBATROSS	DIOMEDEA AMSTERDAMENSIS
4113	ALWC	WHITE-CAPPED ALBATROSS	DIOMEDEA CAUTA CAUTA
4114	ALSA	SALVIN'S ALBATROSS	DIOMEDEA CAUTA SALVINI

4115	ALCI	CHATHAM ISLAND ALBATROSS	DIOMEDEA CAUTA EREMITA
4120	ALSO	SOOTY ALBATROSS	PHOEBETRIA FUSCA
4121	ALLS	LIGHT-MANTLED ALBATROSS	PHOEBETRIA PALPEBRATA
4201	PEGI	UNID. GIANT PETREL	MACRONECTES SP.
4202	PENG	NORTHERN GIANT PETREL	MACRONECTES HALLI
4203	PESG	SOUTHERN GIANT PETREL	MACRONECTES GIGANTEUS
	PESL	SOUTHERN GIANT PETREL (LIGHT PHASE)	
	PESD	SOUGHERN GIANT PETREL (DARK PHASE)	
4204	FUNO	NORTHERN FULMAR	FULMARUS GLACIALIS
	FUND	NORTHERN FULMAR DARK MORPH	
	FUNI	NORTHERN FULMAR INTERMEDIATE MORPH	
	FUNL	NORTHERN FULMAR LIGHT MORPH	
4205	FUSO	SOUTHERN FULMAR	FULMARUS GLACIALOIDES
4206	CAPE	CAPE (PINTADO) PETREL	DAPTION CAPENSE
4208	PEBL	BLUE PETREL	HALOBAENA CAERULEA
4210	PRSP	UNID. PRION	PACHYPTILA SP.
4211	PRSB	SLENDER-BILLED PRION	PACHYPTILA BELCHERI
4212	PRFU	FULMAR PRION	PACHYPTILA CRASSIROSTRIS
4213	PRDO	DOVE PRION	PACHYPTILA DESOLATA
4214	PRSA	SALVIN'S PRION	PACHYPTILA SALVINI
4215	PRFA	FAIRY PRION	PACHYPTILA TURTUR
4216	PRBB	BROAD-BILLED PRION	PACHYPTILA VITTATA
4221	PEAN	ANTARCTIC PETREL	THALASSOICA ANTARCTICA
4223	PEDI	GRAY PETREL	PROCELLARIA CINEREA
4224	SHOE	WHITE-CHINNED PETREL (SHOEMAKER)	PROCELLARIA AEQUINOCTIALIS
4225	PEPA	PARKINSON'S PETREL	PROCELLARIA PARKINSONI
4226	PEWE	WESTLAND PETREL	PROCELLARIA WESTLANDICA
4227	PEPS	PARKINSON'S PETREL/SHOEMAKER	
4228	PROC	UNID. BLACK PROCELLARIA	PROCELLARIA SP.
4230	SHSP	UNID. SHEARWATER	PUFFINUS SP.
4231	SHLI	LITTLE SHEARWATER	PUFFINUS ASSIMILIS
4232	SHTO	TOWNSEND'S SHEARWATER	PUFFINUS AURICULARIS
4233	SHNZ	BULLER’S SHEARWATER (NEW ZEALAND SHEARWATER)	PUFFINUS BULLERI
4234	SHFF	FLESH-FOOTED SHEARWATER	PUFFINUS CARNEIPES
4235	SHPF	PINK-FOOTED SHEARWATER	PUFFINUS CREATOPUS
4236	SHCO	CORY'S SHEARWATER	CALONECTRIS DIOMEDEA
4237	SHFL	FLUTTERING SHEARWATER	PUFFINUS GAVIA
4238	SHGR	GREATER SHEARWATER	PUFFINUS GRAVIS
4239	SHSO	SOOTY SHEARWATER	PUFFINUS GRISEUS
4240	SHHE	HEINROTH'S SHEARWATER	PUFFINUS HEINROTHI
4241	SHHU	HUTTON'S SHEARWATER	PUFFINUS HUTTONI
4242	SHBL	BALEARIC/LEVANTINE SHWTR.	P. MAURETANICUS/YELKOUAN
4243	SHST	STREAKED SHEARWATER	CALONECTRIS LEUCOMELAS
4244	SHAU	AUDUBON'S SHEARWATER	PUFFINUS LHERMINIERI
4245	SHCH	CHRISTMAS ISLAND SHWTR.	PUFFINUS NATIVITATUS
4246	SHBV	BLACK-VENTED SHWTR.	PUFFINUS OPISTHOMELAS
4247	SHWT	WEDGE-TAILED SHWTR.	PUFFINUS PACIFICUS
4248	SHNE	NEWELL'S SHEARWATER	PUFFINUS NEWELLI
	SHTN	TOWNSEND’S/NEWELL’S SHEARWATER	
4249	SHMA	MANX SHEARWATER	PUFFINUS PUFFINUS
4250	SHSB	SLENDER-BILLED SHWTR.	PUFFINUS TENUIROSTRIS

4251	SHWD	DARK MORPH W-T SHWTR.	PUFFINUS PACIFICUS
4252	SHWW	LIGHT MORPH W-T SHWTR.	PUFFINUS PACIFICUS
	SHWI	INT. MORPH W-T SHWTR.	
4254	SHMT	"MANX-TYPE" SHEARWATER	PUFFINUS SP.
4255	SHSS	SOOTY/SLENDER-BILLED SHEARWATER	
	SHPE	PERSIAN SHEARWATER	PUFFINUS PERSECUS
4256	PESM	SOLANDER'S/MURPHY'S PETREL	
4257	PESC	STEJNEGERS/COOK'S PETREL	
4258	PESW	STEJNEGER'S/WHITE-WINGED PETREL	
4259	PEKH	KERMADEC/HERALD PETREL	
4260	PTSP	UNID. PTERODROMA	PTERODROMA SP.
4261	PEPH	PHOENIX PETREL	PTERODROMA ALBA
4262	PETR	TRINIDADE PETREL	PTERODROMA ARMINJONIANA
4263	PEMS	MASCARENE BLACK PETREL	PTERODROMA ATERRIMA
4264	PECI	CHATHAM ISLAND PETREL	PTERODROMA AXILLARIS
4265	PEBK	BECK'S PETREL	PTERODROMA BECKI
4266	PECL	COLLARED PETREL	PTERODROMA BREVIPES
4267	PEKR	KERGUELEN PETREL	PTERODROMA BREVIROSTRIS
4268	PECA	BERMUDA PETREL	PTERODROMA CAHOW
4269	PEWN	WHITE-NECKED PETREL	P. EXTERNA CERVICALIS
4270	PECO	COOK'S PETREL	PTERODROMA COOKII
4271	PEJF	JUAN FERNANDEZ PETREL	PTERODROMA EXTERNA
4272	PEBC	BLACK-CAPPED PETREL	PTERODROMA HASITATA
4273	PEHE	HERALD PETREL	PTERODROMA HERALDICA
	PEHN	HENDERSON PETREL	PTERODROMA ATRATA
4274	PEBO	BONIN PETREL	PTERODROMA HYPOLEUCA
4275	PEAT	ATLANTIC PETREL	PTERODROMA INCERTA
4276	PEMO	MOTTLED PETREL	PTERODROMA INEXPECTATA
4277	PEWH	WHITE-HEADED PETREL	PTERODROMA LESSONII
4278	PEWW	WHITE-WINGED PETREL	PTERODROMA LEUCOPTERA
	PECW	COLLARED/WHITE-WINGED PETREL	
4279	PEST	STEJNEGER'S PETREL	PTERODROMA LONGIROSTRIS
4280	PEGW	GREAT-WINGED PETREL	PTERODROMA MACROPTERA
4281	PEBA	BARAU'S PETREL	PTERODROMA BARAUI
4282	PESP	SOFT-PLUMAGED PETREL	PTERODROMA MOLLIS
4283	PEBW	BLACK-WINGED PETREL	PTERODROMA NIGRIPENNIS
4285	PEDR	DARK-RUMPED PETREL	PTERODROMA PHAEOPYGIA/SANWICHENSIS
4286	PEKE	KERMADEC PETREL	PTERODROMA NEGLECTA
	PEKI	KERMADEC PETREL, INTERMEDIATE PHASE	
	PEKD	KERMADEC PETREL, DARK PHASE	
4287	PEPY	PYCROFT'S PETREL	PTERODROMA PYCROFTI
	PECP	COOK’S/PYCROFT’S PETREL	
4288	PETA	TAHITI PETREL	PSEUDOBULWERIA ROSTRATA
4289	PESO	SOLANDER'S PETREL	PTERODROMA SOLANDRI
4290	PEMU	MURPHY'S PETREL	PTERODROMA ULTIMA
4292	PEJW	JUAN FERNANDEZ/WHITE-NECKED PETREL	
4293	COOK	UNID. COOKILARIA	PTERODROMA SP.
4294	PETP	TAHITI/PHOENIX PETREL	PTERODROMA ROSTRATA/ALBA
	JFWT	JUAN FERNANDEZ PETREL/W-T SHEARWATER	
4295	PESN	SNOW PETREL	PAGODROMA NIVEA
4296	BUSP	BULWERIA SP.	
4297	PEBU	BULWER'S PETREL	BULWERIA BULWERII

4298	PEJO	JOUANIN'S PETREL	BULWERIA FALLAX
	BUSP	BULWERIA SPECIES	BULWERIA SP.
4299	PEMA	MACGILLIVRAY'S PETREL	BULWERIA MACGILLIVRAYI
	PEDE	DEFILIPPE'S PETREL	PTERODROMA DEFILIPPIANA
	PEMG	MAGENTA PETREL	PTERODROMA MAGENTAE
4300	SPSP	UNID. STORM-PETREL	OCEANODROMA SP.
4305	SPWR	WHITE-RUMPED STORM PETREL	
4306	SPDR	DARK-RUMPED STORM PETREL	
4310	SPWI	WILSON'S STORM PETREL	OCEANITES OCEANICUS
4311	SPWV	WHITE-VENTED STORM PETREL	OCEANITES GRACILIS
4320	SPWF	WHITE-FACED STORM PETREL	PELAGODROMA MARINA
4330	SPWB	WHITE-BELLIED STORM PETREL	FREGETTA GRALLARIA
4332	SPBB	BLACK-BELLIED STORM PETREL	FREGETTA TROPICA
4333	SPFR	BLACK-BELLIED/WHITE-BELLIED S-P	
4340	SPWT	WHITE-THROATED STORM PETREL	NESOFREGETTA ALBIGULARIS
4350	SPGB	GREY-BACKED STORM PETREL	GARRODIA NEREIS
4360	SPBR	BRITISH STORM PETREL	HYDROBATES PELAGICUS
4370	SPGA	WEDGE-RUMPED STORM PETREL (GALAPAGOS STORM PETREL)	OCEANODROMA TETHYS
4371	SPHA	HARCOURT'S STORM PETREL	OCEANODROMA CASTRO
4372	SPLE	LEACH'S STORM PETREL	OCEANODROMA LEUCORHOA
4373	SPGU	GUADALUPE STORM PETREL	OCEANODROMA MACRODACTYLA
4374	SPMA	MARKHAM'S STORM PETREL	OCEANODROMA MARKHAMI
4375	SPSW	SWINHOE'S STORM PETREL	OCEANODROMA MONORHIS
4376	SPTR	TRISTRAM'S STORM PETREL	OCEANODROMA TRISTRAMI
4377	SPAS	ASHY STORM PETREL	OCEANODROMA HOMOCHROA
4378	SPMT	MATSUDAIRA'S STORM PETREL	OCEANODROMA MATSUDAIRAE
4379	SPHO	HORNBY'S STORM PETREL	OCEANODROMA HORNBYI
4380	SPFT	FORK-TAILED STORM PETREL	OCEANODROMA FURCATA
4381	SPBL	BLACK STORM PETREL	OCEANODROMA MELANIA
4390	SPLS	LEAST STORM PETREL	OCEANODROMA MICROSOMA
4391	SPLW	WHITE-RUMPED LEACH'S S-P	OCEANODROMA LEUCORHOA
4392	SPLD	DARK-RUMPED LEACH'S S-P	OCEANODROMA LEUCORHOA
	SPLI	INTERMEDIATE-RUMPED LEACH’S S-P	OCEANODROMA LEUCORHOA
4393	SPBM	BLACK/MARKHAM'S STORM PETREL	
4394	SPLH	LEACH'S/HARCOURT'S STORM PETREL	
4395	SPWW	WILSON'S/WHITE-VENTED STORM PETREL	
4400	DPSP	UNID. DIVING PETREL	PELECANOIDES SP.
4401	DPPE	PERUVIAN DIVING PETREL	PELECANOIDES GARNOTI
4402	DPMA	MAGELLANIC DIVING PETREL	PELECANOIDES MAGELLANI
4403	DPGE	GEORGIAN DIVING PETREL	PELECANOIDES GEORGICUS
4404	DPCO	COMMON DIVING PETREL	PELECANOIDES URINATRIX
5100	TROP	UNID. TROPICBIRD	PHAETHON SP.
5101	TBRB	RED-BILLED TROPICBIRD	PHAETHON AETHEREUS
5102	TBRT	RED-TAILED TROPICBIRD	PHAETHON RUBRICAUDA
5103	TBWT	WHITE-TAILED TROPICBIRD	PHAETHON LEPTURUS
5200	PEBC	BROWN/CHILEAN PELICAN	PELECANUS OCCIDENTALIS/THAGUS
5201	PEBR	BROWN PELICAN	PELECANUS OCCIDENTALIS

5202	PECH	CHILEAN PELICAN	PELECANUS THAGUS
5303	BOOB	BOOBY SP.	SULA SP.
5301	GANO	NORTHERNGANNET	SULA BASSANUS
5302	GACA	CAPE GANNET	SULA CAPENSIS
5303	GAAU	AUSTRALIAN GANNET	SULA SERRATOR
5310	BOBF	BLUE-FOOTED BOOBY	SULA NEBOUXII
5311	BOPE	PERUVIAN BOOBY	SULA VARIEGATA
5312	BOMA	MASKED/NAZCA BOOBY	SULA DACTYLATRA/GRANTI
5313	BORF	RED-FOOTED BOOBY	SULA SULA
5314	BOBR	BROWN BOOBY	SULA LEUCOGASTER
5315	BOAB	ABBOT'S BOOBY	SULA ABBOTTI
5316	BOMO	NAZCA BOOBY	SULA GRANTI
5317	BOMY	MASKED BOOBY	SULA DACTYLATRA
5400	CORM	UNID. CORMORANT	PHALACROCORAX SP.
5401	CODC	DOUBLE-CRESTED CORM.	PHALACROCORAX AURITUS
5402	COOL	OLIVACEOUS CORMORANT	PHALACROCORAX OLIVACEUS
5410	COBR	BRANDT'S CORMORANT	PHALACROCORAX PENICILLATUS
5412	COPE	PELAGIC CORMORANT	PHALACROCORAX PELAGICUS
5413	CORF	RED-FACED CORMORANT	PHALACROCORAX URILE
5415	COGU	GUANAY CORMORANT	PHALACROCORAX BOUGAINVILLII
5416	COSO	SOCOTRA CORMORANT	PHALACROCORAX NIGROGULARIS
5422	CORL	RED-LEGGED CORMORANT	PHALACROCORAX GAIMARDI
5600	FRIG	UNID. FRIGATEBIRD	FREGATA SP.
5601	FRAS	ASCENSION FRIGATEBIRD	FREGATA AQUILA
5602	FRCH	CHRISTMAS ISLAND F-BIRD	FREGATA ANDREWSI
5603	FRMA	MAGNIFICENT FRIGATEBIRD	FREGATA MAGNIFICENS
5604	FRGR	GREAT FRIGATEBIRD	FREGATA MINOR
5605	FRLE	LESSER FRIGATEBIRD	FREGATA ARIEL
6000	DUCK	UNID. DUCK	ANSERIFORM SP.
7100	PHAL	UNID. PHALAROPE	PHALAROPUS FULICARIUS/LOBATUS
7101	PHRE	RED PHALAROPE	PHALAROPUS FULICARIUS
7102	PHWI	WILSON'S PHALAROPE	STEGANOPUS TRICOLOR
7103	PHNO	RED-NECKED PHALAROPE (NORTHERN PHALAROPE)	PHALAROPUS LOBATUS
7200	SKUA	UNID. SKUA	CATHARACTA SP.
7201	SKSP	SOUTH POLAR SKUA	CATHARACTA MACCORMICKI
7202	SKAN	ANTARCTIC SKUA	CATHARACTA ANTARCTICA
7203	SKGR	GREAT SKUA	CATHARACTA SKUA
7204	SKCH	CHILEAN SKUA	CATHARACTA CHILENSIS
7210	JAEG	UNID. JAEGER	STERCORARIUS SP.
7211	JAPO	POMARINE JAEGER	STERCORARIUS POMARINUS
7212	JAPA	PARASITIC JAEGER	STERCORARIUS PARASITICUS
7213	JALT	LONG-TAILED JAEGER	STERCORARIUS LONGICAUDUS
7214	JAPL	PARASITIC/LONG-TAILED JAEGER	

7300	GULL	UNID. GULL	LARUS SP.
7301	GUPA	PACIFIC GULL	LARUS PACIFICUS
7302	GUDO	DOLPHIN GULL	LARUS SCORESBII
7303	GUIV	IVORY GULL	PAGOPHILA EBURNEA
7304	GULV	LAVA GULL	LARUS FULIGINOSUS
7305	GUGR	GRAY GULL	LARUS MODESTUS
7306	GUHE	HEERMANN'S GULL	LARUS HEERMANNI
7307	GUWH	WHITE-EYED GULL	LARUS LEUCOPHTHALMUS
7308	GUSO	SOOTY GULL	LARUS HEMPRICHII
7309	GUBT	BAND-TAILED GULL	LARUS BELCHERI
7310	GUBL	BLACK-TAILED GULL	LARUS CRASSIROSTRIS
7311	GUAU	AUDOUIN'S GULL	LARUS AUDOUINII
7312	GURB	RING-BILLED GULL	LARUS DELAWARENSIS
7313	GUME	MEW GULL	LARUS CANUS
7314	GUHR	HERRING GULL	LARUS ARGENTATUS
7315	GUTH	THAYER'S GULL	LARUS THAYERI
7316	GUYL	YELLOW-LEGGED GULL	LARUS CACHINNANS
7317	GULB	LESSER BLACK-BACKED GULL	LARUS FUSCUS
7318	GUCA	CALIFORNIA GULL	LARUS CALIFORNICUS
7319	GUWE	WESTERN GULL	LARUS OCCIDENTALIS
7320	GUKE	KELP GULL	LARUS DOMINICANUS
7321	GUSB	SLATY-BACKED GULL	LARUS SCHISTISAGUS
7322	GUGB	GREAT BLACK-BACKED GULL	LARUS MARINUS
7323	GUGW	GLAUCOUS-WINGED GULL	LARUS GLAUCESCENS
7324	GUGL	GLAUCOUS GULL	LARUS HYPERBOREUS
7325	GUIC	ICELAND GULL	LARUS GLAUCOIDES
7326	GUGT	GREAT BLACK-HEADED GULL	LARUS ICHTHYAETUS
7327	GULA	LAUGHING GULL	LARUS ATRICILLA
7328	GUBH	BROWN-HEADED GULL	LARUS BRUNNICEPHALUS
7329	GUGH	GRAY-HEADED GULL	LARUS CIRROCEPHALUS
7330	GUAN	ANDEAN GULL	LARUS SERRANUS
7331	GUFR	FRANKLIN'S GULL	LARUS PIPIXCAN
7332	GUSI	SILVER GULL	LARUS NOVAEHOLLANDIAE
7333	GUMD	MEDITERRANEAN GULL	LARUS MELANOCEPHALUS
7334	GUBB	BLACK-BILLED GULL	LARUS BULLERI
7335	GUBR	BROWN-HOODED GULL	LARUS MACULIPENNIS
7336	GUBD	BLACK-HEADED GULL	LARUS RIDIBUNDUS
7337	GUSL	SLENDER-BILLED GULL	LARUS GENEI
7338	GUBO	BONAPARTE'S GULL	LARUS PHILADELPHIA
7339	GULI	LITTLE GULL	LARUS MINUTUS
7340	GUSU	SAUNDER'S GULL	LARUS SAUNDERSI
7341	GUHA	HARTLAUB'S GULL	LARUS HARTLAUBI
7342	GURO	ROSS' GULL	RHODOSTETHIA ROSEA
7343	KIBL	BLACK-LEGGED KITTIWAKE	RISSA TRIDACTYLA
7344	KIRL	RED-LEGGED KITTIWAKE	RISSA BREVIROSTRIS
7345	GUST	SWALLOW-TAILED GULL	LARUS FURCATUS
7346	GUSA	SABINE'S GULL	LARUS SABINI
7347	GUHT	HERRING/THAYER'S GULL	LARUS ARGENTATUS/THAYERI
7348	GUYF	YELLOW-FOOTED GULL	LARUS LIVENS
7350	TERN	UNID. TERN	STERNA (?) SP.
7351	TEWK	WHISKERED TERN	CHLIDONIAS HYBRIDUS
7352	TEWW	WHITE-WINGED BLACK TERN	CHLIDONIAS LEUCOPTERUS
7353	TEBL	BLACK TERN	CHLIDONIAS NIGER
7354	TELB	LARGE-BILLED TERN	PHAETUSA SIMPLEX

7355	TEGU	GULL-BILLED TERN	STERNA NILOTICA
7356	TECA	CASPIAN TERN	STERNA CASPIA
7357	TEIR	INDIAN RIVER TERN	STERNA AURANTIA
7358	TESA	SOUTH AMERICAN TERN	STERNA HIRUNDINACEA
7359	TECO	COMMON TERN	STERNA HIRUNDO
7360	TEAR	ARCTIC TERN	STERNA PARADISAEA
7361	TEAN	ANTARCTIC TERN	STERNA VITTATA
7362	TEKE	KERGUELEN TERN	STERNA VIRGATA
7363	TEFO	FORSTER'S TERN	STERNA FORSTERI
7364	TETR	TRUDEAU'S TERN	STERNA TRUDEAUI
7365	TERS	ROSEATE TERN	STERNA DOUGALLII
7366	TEWF	WHITE-FRONTED TERN	STERNA STRIATA
7367	TEWC	WHITE-CHEEKED TERN	STERNA REPRESSA
7368	TEBN	BLACK-NAPED TERN	STERNA SUMATRANA
7369	TEBB	BLACK-BELLIED TERN	STERNA MELANOGASTRA
7370	TEAL	ALEUTIAN TERN	STERNA ALEUTICA
7371	TEGB	GRAY-BACKED TERN	STERNA LUNATA
7372	TEBR	BRIDLED TERN	STERNA ANAETHETUS
7373	TESO	SOOTY TERN	STERNA FUSCATA
	TESB	SOOTY/BRIDLED TERN	
7374	TEFA	AUSTRALIAN FAIRY TERN	STERNA NEREIS
7375	TEBF	BLACK-FRONTED TERN	STERNA ALBISTRIATA
7376	TEAM	AMAZON TERN	STERNA SUPERCILIARIS
7377	TEDA	DAMARA TERN	STERNA BALAENARUM
7378	TEPE	PERUVIAN TERN	STERNA LORATA
7379	TELE	LEAST TERN	STERNA ANTILLARUM
7380	TECR	CRESTED TERN	STERNA BERGII
7381	TELC	LESSER CRESTED TERN	STERNA BENGALENSIS
7382	TECC	CHINESE CRESTED TERN	STERNA BERNSTEINI
7383	TERO	ROYAL TERN	STERNA MAXIMA
7384	TECY	CAYENNE TERN	STERNA EURYGNATHA
7385	TEEL	ELEGANT TERN	STERNA ELEGANS
7386	TESN	SANDWICH TERN	STERNA SANDVICENSIS
7387	TEIN	INCA TERN	LAROSTERNA INCA
7388	NOBG	BLUE-GRAY NODDY	PROCELSTERNA CERULEA
7389	NOBR	BROWN NODDY	ANOUS STOLIDUS
7390	NOBL	BLACK NODDY	ANOUS MINUTUS
7391	NOLE	LESSER NODDY	ANOUS TENUIROSTRIS
7392	TEWH	WHITE TERN	GYGIS ALBA
7393	NOSP	UNID. NODDY TERN	ANOUS SP.
7394	TEAC	ARCTIC/COMMON TERN	STERNA PARADISAEA/HIRUNDO
7395	TELI	LITTLE TERN	STERNA ALBIFRONS
7396	TESL	SAUNDER'S TERN	STERNA SAUNDERSI
7401	SKBL	BLACK SKIMMER	RYNCHOPS NIGRA
7402	SKAF	AFRICAN SKIMMER	RYNCHOPS FLAVIROSTRIS
7403	SKIN	INDIAN SKIMMER	RYNCHOPS ALBICOLLIS
7500	ALCD	UNID. ALCID	ALCIDAE SP.
7501	DOVE	DOVEKIE	ALLE ALLE
7502	RAZR	RAZORBILL	ALCA TORDA
7504	MUTB	THICK-BILLED MURRE	URIA LOMVIA
7505	MUCO	COMMON MURRE	URIA AALGE
7510	GUBL	BLACK GUILLEMOT	CEPPHUS GRYLLE
7511	GUPI	PIGEON GUILLEMOT	CEPPHUS COLUMBA
7512	GUSP	SPECTACLED GUILLEMOT	CEPPHUS CARBO

7514	MULB	LONG-BILLED MURRELET	BRACHYRAMPHUS PERDIX
7515	MUMA	MARBLED MURRELET	BRACHYRAMPHUS MARMORATUS
7516	MUKI	KITTLITZ'S MURRELET	BRACHYRAMPHUS BREVIROSTRIS
7517	MUXA	XANTUS' MURRELET	SYNTHLIBORAMPHUS HYPOLEUCA
7518	MUCR	CRAVERI'S MURRELET	SYNTHLIBORAMPHUS CRAVERI
7519	MUXC	XANTUS'/CRAVERI'S MURRELET	
7520	MUAN	ANCIENT MURRELET	SYNTHLIBORAMPHUS ANTIQUUS
7521	MUJA	JAPANESE MURRELET	SYNTHLIBORAMPHUS WUMIZUSUME
7525	AUCA	CASSIN'S AUKLET	PTYCHORAMPHUS ALEUTICUS
7530	AUPA	PARAKEET AUKLET	CYCLORRHYNCHUS PSITTACULA
7535	AUCR	CRESTED AUKLET	AETHIA CRISTATELLA
7536	AULE	LEAST AUKLET	AETHIA PUSILLA
7537	AUWH	WHISKERED AUKLET	AETHIA PYGMAEA
7540	AURH	RHINOCEROS AUKLET	CERORHINCA MONOCERATA
7545	PUAT	COMMON PUFFIN	FRATERCULA ARCTICA
7546	PUHO	HORNED PUFFIN	FRATERCULA CORNICULATA
7547	PUTU	TUFTED PUFFIN	FRATERCULA CIRRHATA
9100	NPSS	UNID. BIRD (NON-MARINE AND NON-PASSERINE)	
9101	UNID	UNID. BIRD	
9102	SHOR	SHORE BIRD	
9103	RAPT	RAPTOR	
9200	PASS	PASSERINES	

Marine Mammal Species Codes

Cetaceans

Balaenoptera sp.	BASP
B. acutorostrata	BAAC
B. borealis	BABO
B. borealis/edeni	BABE
B. edeni	BAED
B. musculus	BAMU
B. physalus	BAPH
Delphinus sp.	DESP
D. delphis	DEDE
D. capensis	DECA
D. tropicalis	DETR
Feresa attenuata	FEAT
Globicephala sp.	GLSP
Globicephala macrorhynchus	GLMA
Globicephala melas	GLME
Grampus griseus	GRGR
Hyperoodon planifrons	HYPL
Kogia breviceps	KOBR
Kogia simus	KOSI
Kogia simus/breviceps	KOSP
Lagenodelphis hosei	LAHO
Lagenorhynchus obliquidens	LAOB
L. cruciger	LACR
Lissodelphus borealis	LIBO
Megaptera novaeangliae	MENO
Mesoplodon carlhubbsi	MECA
M. densirostris	MEDE
M. gingkodens	MEGI
M. grayi	MEGR
M. layardii	MELA
M. stejnegeri	MEST
M. sp.	MESP
Neophocoena phocoenoides	NEPH
Orcinus orca	OROR
Peponocephala electra	PEEL
Peponocephala/Feresa	PEFE
Physeter macrocephalus	PHMA
Pseudorca crassidens	PSCR

Sousa chinensis	SOCH	
Stenella attenuata	STAT	
S. coeruleoalba	STCO	
S. longirostris	STLO	
S. species	STSP	
Steno bredanensis	STBR	
Tursiops truncatus	TUTR	
Ziphiid	ZISP	
Ziphius cavirostris	ZICA	
Unid. dolphin or porpoise	UNDO	
Unid. odontocete	UNOD	
Unid. cetacean	UNCE	
Unid. large whale	UNLW	
Unid. small whale	UNSW	
Unid. whale	UNWH	

Pinnipeds

Arctocephalus townsendi	ARTO	GUADALUPE FUR SEAL
Callorhinus ursinus	CAUR	NORTHERN FUR SEAL
	FSSP	UNIDENTIFIED FUR SEAL
Eumetopias jubatus	EUJU	STELLER SEA LION
Zalophus californicus	ZACA	CALIFORNIA SEA LION
	OTSP	UNIDENTIFIED OTARIID
Mirounga angustirostris	MIAN	NORTHERN ELEPHANT SEAL
Phoca vitulina	PHVI	HARBOR SEAL
	PHSP	UNIDENTIFIED PHOCID
	PINN	UNIDENTIFIED PINNIPED

Fish/Squid Species Codes

Flyingfish

FFUN	UNID. EXOCOETID
FODI	FODIATOR SP.
EXOC	EXOCOETUS SP.
FFFW	UNID. FOUR-WING
FFST	UNID. STRIPE-WING
FFRW	RED WING
HIRU	HIRUNDICHTHYS SP.
HISP	HIRUNDICHTHYS SPEC.

Predatory Fish

FISH	UNID. FISH	
TUNA	UNID. TUNA	FAMILY SCOMBRIDAE
TUSM	SMALL TUNA	
TUYS	YELLOW-FIN/SKIPJACK TUNA	
WAHO	WAHOO	ACANTHOCYBIUM SOLANDRI
TUBU	BULLET TUNA (FRIGATE MACKERAL)	AUXIS THAZARD
TUSJ	SKIPJACK TUNA	KATSUWONUS PELAMIS
TUBS	BLACK SKIPJACK	EUTHYNNUS AFFINIS
TUYF	YELLOW-FIN TUNA	THUNNUS ALBACARES
TUBE	BIG-EYE TUNA	THUNNUS OBESUS
MAHI	MAHI MAHI	CORYPHAENA HIPPURUS (OR SP.)
MOLA	OCEAN SUNFISH	

Squid

SQID	UNID. SQUID

Marine Turtle Species Codes

TURT	UNID. SEA TURTLE	
TULE	LEATHERBACK SEA TURTLE	DERMOCHELYS CORIACEA
TUGR	GREEN SEA TURTLE	CHELONIA MYDAS
TUHA	HAWKSBILL SEA TURTLE	ERETMOCHELYS IMBRICATA
TULO	LOGGERHEAD SEA TURTLE	CARETTA CARETTA
TUKR	KEMP'S RIDLEY SEA TURTLE	LEPIDOCHELYS KEMPII
TUOR	OLIVE RIDLEY SEA TURTLE	LEPIDOCHELYS OLIVACEA

APPENDIX C

SCIENTIFIC PERSONNEL

Cruise Leaders	Ship (Leg #s)
Jay Barlow, SWFSC (Chief scientist)	D.S. Jordan (1)
Lisa Ballance, SWFSC	D.S. Jordan (2)
Barb Taylor, SWFSC	D.S. Jordan (3)
Sarah Mesnick, SWFSC	D.S. Jordan (4)
Robert Pitman, SWFSC	D.S. Jordan (5)
James Carretta, SWFSC	McArthur (6)
Marine Mammal Identification Specialists	
James Cotton, SWFSC	D.S. Jordan (1-3,5) McArthur (6)
Richard Rowlett, SWFSC	D.S. Jordan (1-5) McArthur (6)
Juan Carlos Salinas, SWFSC	D.S. Jordan (4)
Marine Mammal Observers	
Erin LaBrecque, SWFSC	D.S. Jordan (1-5) McArthur (6)
Laura Morse, SWFSC	D.S. Jordan (1-5) McArthur (6)
Juan Carlos Salinas, SWFSC	D.S. Jordan (1-3,5) McArthur (6)
Leigh Torres, SWFSC	D.S. Jordan (1-5)
Christina Fahey, SWFSC	D.S. Jordan (4)
Shannon Rankin, SWFSC	McArthur (6)
Photo Identification Specialists	
Annie Douglas, SWFSC	D.S. Jordan (1,2) McArthur (6)
Todd Chandler, SWFSC	D.S. Jordan (3,4)
Paula Olson, SWFSC	D.S. Jordan (5)
Bird Observers	
Michael Force, SWFSC	D.S. Jordan (1-5) McArthur (6)
Cornelia Oedekoven, SWFSC	D.S. Jordan (1-5) McArthur (6)
Oceanographers	
Valerie Philbrick, SWFSC	D.S. Jordan (1)
Candice Hall, SWFSC	D.S. Jordan (1-5)
Pierre Malan, SWFSC	McArthur (6)
Acoustic Technicians	
Shannon Rankin, SWFSC	D.S. Jordan (1-5)
Megan Ferguson, Scripps Institute of Oceanography	D.S. Jordan (1)
Julie Oswald, SWFSC	D.S. Jordan (2,3)
Tony Martinez, SWFSC	D.S. Jordan (4)
Jessica Burtenshaw, Scripps Institute of Oceanography	D.S. Jordan (5)
Visiting Scientist	
Josh Fluty, SWFSC	D.S. Jordan (2)

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(June 2002)

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Compiled and edited by: T.C. JOHANOS and J.D. BAKER
(August 2002)

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M. LABELLE
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