CUMULATIVE RISKS TO MARINE MAMMALS, TURTLES, AND SEABIRDS IN THE CALIFORNIA CURRENT

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SUMMARY

In order to better understand species' use of the oceans and maximize effectiveness of marine spatial planning, we need quantitative assessments of animal distributions, human uses, and human threats. The synthesis from the Tagging of Pacific Predators (TOPP) program provided a large biologging dataset of 23 species and over 4,300 tags in the Pacific Ocean, with many species spending significant time in the California Current (Block et al. 2011). In addition, a focused study on cumulative human impacts in the California Current provided spatial layers of threat within the EEZ (Halpern et al. 2009). A recent manuscript, Maxwell et al. (2013), provides a synthetic analysis of marine mammal, turtle, and bird movement data from TOPP (8 species, 685 individuals, Maxwell et al. 2013 Table S3) relative to the 24 anthropogenic stressors previously compiled for the California Current (Figure 1, Halpern et al. 2009, Maxwell et al. 2013 Table S2). In this manuscript, the authors ranked each of the threats by species for 1) frequency of exposure, 2) directness of impact, 3) resistance to the impact, and 4) recovery time of individual, 5) reproductive impacts and 6) population level effects (Maxwell et al. 2013 Table S4). These rankings were then summed for each threat, and the intensity of the threat in each grid cell was multiplied by the ranking to come up with a spatial threat value (see diagram and equation in Figure 1). The species threats were then normalized to 1 and combined to come up with a multi-species threat value (Figure

2a). These cells are the ones with the greatest risk to the suite of examined species. Each species' utilization distribution calculated from a gridded utilization distribution method was summed by grid cell and then normalized to 1 to create a utilization map for each species. These were then summed to come up with a total multi-species utilization distribution (Figure 2b). Finally, these two surfaces (multi-species risk and use) were multiplied together to come up with a cumulative impact score to identify areas that are high use and high risk (Figure 2c).

All three guilds had high use of the U.S. West Coast EEZ, particularly on the shelf (Figure 1a; Maxwell et al. 2013 Figure 1). Seabirds had higher use offshore compared to the marine mammal and turtle guilds and all three guilds had high use in National Marine Sanctuaries (NMS) save the Olympic Coast NMS. This is not to suggest that this NMS has low densities of top predators but instead that most species and populations tagged were centered in central or southern California. Some risks were more ubiquitous throughout the EEZ such as climate change, others were more tied to the coast and river mouths such as pollution, while others were focused in hotspots such as shipping and fishing (Halpern et al. 2009 Figure 1). As part of the ranking of threats to each species, there were those that were similarly ranked across the study species (e.g. ocean acidification, pollution, shipping and invasive species), while others had particular targeted risks such as demersal fishing, coastal engineering, and beach access, which were greater only for pinnipeds that use coastal habitat regularly (Maxwell et al. 2013 Figure S2). The combined threat layers and utilization distributions show areas of overlap between high/low use and high/low risk (Figure 1c). Cumulative risk and use distributions were highest nearshore, within sanctuary boundaries, and particularly along the coast near Point Arena and Monterey Bay. Cumulative impacts and use values for seabirds were highest further north, off the coast of Oregon primarily. Climate stressors had the greatest influence across top predators, potentially due to their widespread and uniform distribution in the EEZ. The NMS were also hotspots of cumulative impact, with particularly high-risk values for climate, coastal pollution, and fishing, and high use from multiple top predator species.

Spatial differences between species use and risk intensity provides opportunities to target management action for the greatest gain. The widespread stressors, such as climate and pollution, will require a long-term effort and international cooperation, increasing the need for minimizing other threats. Mitigation may be the only solution at the local scale for the broad-scale stressors, but increased protection & risk-reduction of critical habitats (spawning habitat, migratory corridors) may be the most successful approach. Given that many of these threats may affect multiple levels of the food web, the cumulative impacts may

compound across trophic levels. At the same time, mitigation for the more widespread stressors will likely have positive impacts across multiple components of the ecosystem.

One of the highest top predator use areas and highest risk areas were the suite of National Marine Sanctuaries along the coast. This pattern held true even when indirect and widespread cumulative impact layers were excluded from the analysis (Maxwell et al. 2013 Table 1 & Supp Fig. S5). Because most of the sanctuaries were key habitat for marine predators, the Sanctuary framework could offer a useful tool for providing greater protection within their boundaries. This could be a traditional closure of key threats year round, or a more targeted approach of reducing threats when top predator numbers are greatest. This dynamic management approach could use top predator data to examine spatial and temporal patterns of use relative to risk layers that may be seasonal or year-round and could restrict potentially harmful activities when critical habitat is present (Hobday et al in press – Law review). Good examples include bycatch of bluefin tuna in the yellowfin fishery in eastern Australia, where fishers without bycatch quota are excluded from high-risk areas based on seasonal and oceanographic changes (Hobday et al. 2009).

This case study compared predator tag data to a re-ranked database of threats, but many other datasets could be used to refine and expand this analysis. Tag data provides a behavioral context to top predator movement, but shipboard sightings or fisheries catch data can provide more holistic transects of biodiversity patterns. In addition, other risk datasets can offer greater temporal and spatial resolution, such as AIS data from shipping vessels or logbook data from fishers, improving the chances of finding grid cells and periods of maximum benefit. This framework of risk / use / cumulative stress can and should be applied to additional components of the ecosystem to minimize overlooked species or ecosystem components from these analyses. The case study provided here along with Maxwell et al. (2013) and Halpern et al. (2009) offers a road map towards combining use and risk calibrated by impact and intensity of perceived threat.
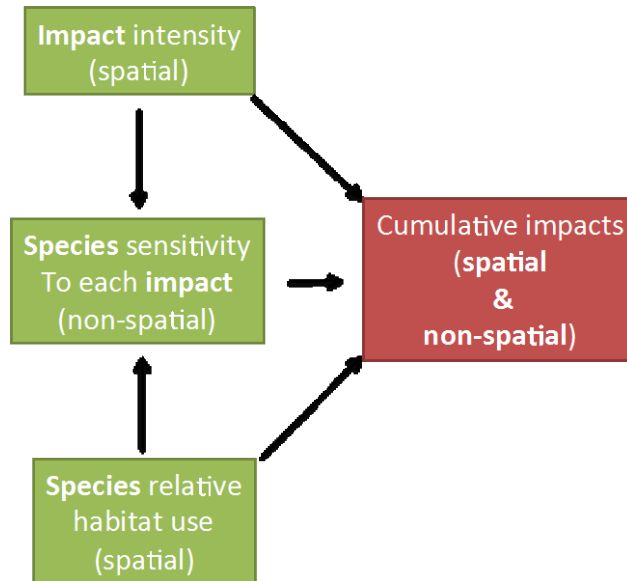
Figure 1. Diagram of cumulative impact calculation, formula shown here $CI = \sum_{i=1}^{n} \sum_{j=1}^{m} D_i + S_j + u_{i,j}$ where D_i = impact intensity, S_j = species sensitivity, and $u_{i,j}$ = relative habitat use. Impact intensity is derived from Halpern et al. 2009, species sensitivity from rankings as part of Maxwell et. al 2013, and species relative use from the TOPP project, Block et al. 2011. The weighted average of the three provide the metric of cumulative impact.

Figure 2. Spatial representations across all species for a) species relative use, b) ranked relative risk, and c) combined cumulative impact products. Each plot is demarcated by color relative to a) use, b) risk, and c) impact (white – low; grey – medium; black - high). The areas of the west coast National Marine Sanctuaries are colored blue.

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Appendix example: Holland, D. and S. Kasperski. 2014. Fishery income diversification and risk for fishermen and fishing communities of the US West Coast and Alaska— updated to 2012. Appendix HD-1 to: Breslow, S., and 20 others. Human Dimensions of the CCIEA. In: Harvey, C.J., N. Garfield, E.L. Hazen and G.D. Williams (eds.). The California Current Integrated Ecosystem Assessment: Phase III Report. Available from http://www.noaa.gov/iea/CCIEA-Report/index.