Presentation Abstracts
Module 2: Thursday, August 27th | 9:00 am – 1:00 pm

West Coast Entanglement Science Workshop, August – September 2020
https://www.opc.ca.gov/west-coast-entanglement-science-workshop/

Session: Forecasting and monitoring marine species dynamics | Part 2: Modeling

Changes in abundance and timing of migration of whales in central California.

Kaytlin Ingman[1,2], Ellen Hines[1], Piero Mazzini[1], Nadav Nur[2], Cotton Rockwood[2], and Jaime Jahncke[2]

[1] Estuary & Ocean Science Center, SFSU
[2] Point Blue Conservation Science

We document changes in the annual sightings and timing of humpback (*Megaptera novaeangliae*) and blue whale (*Balaenoptera musculus*) migration around the Farallon Islands, California. We hypothesized that changes in the timing of migration off central California were driven by local oceanography, regional upwelling, and basin-scale climate conditions. Using 24 years of daily whale counts collected from Southeast Farallon Island, we developed negative binomial regression models to evaluate trends in local whale sightings over time. We used linear models to assess trends in the timing of migration, and to identify potential environmental drivers. Wind-driven upwelling and overall productivity in the

California Current System is driven by atmospheric circulation that is influenced by basin scale climate patterns: the El Niño Southern Oscillation, the Pacific Decadal Oscillation, and the North Pacific Gyre Oscillation. We used the timing model to predict entanglement risk. Humpback whale sightings significantly increased over the study period, but blue whale counts did not though there was variability across the time series. Breeding migration (departure time) for all species showed little to no change, whereas migration towards feeding areas (arrival time) occurred earlier for humpback and blue whales. Timing was significantly influenced by both local variables (upwelling, temperature) and a basin wide climate index (El Niño). Earlier arrival time without concomitant earlier departure results in longer periods when blue and humpback whales are present in the Gulf of the Farallones. We maintain that these changes have increased whale exposure to pot and trap fishery gear off the central California coast during Spring, elevating the risk of entanglements. Humpback entanglement rates were correlated with increased counts and early arrival in central California. Actions to decrease the temporal overlap between whales and pot/trap fishing gear, particularly when whales arrive earlier in warm or El Niño years, would likely decrease the risk of entanglements.

Fine-scale spatial models capture changes in humpback whale distribution associated with the 2014-2016 marine heat wave along the U.S. West Coast

Karin A. Forney[1], Jessica V. Redfern, Samuel M. Woodman, Elizabeth A. Becker, Jarrod A. Santora, Isaac Schroeder.

[1]Marine Mammal & Turtle Division, Southwest Fisheries Science Center, NOAA

As our understanding of climate impacts on the marine environment has grown, so has our recognition that approaches to managing anthropogenic impacts on marine species must explicitly take into account shifts in species distributions associated with episodic and longterm climate changes. For marine mammals, species distribution models (SDMs) that include dynamic habitat predictors have become an essential tool for managing impacts of naval activities, fisheries, vessel traffic, and underwater sound. Off the U.S. West Coast, a 2014-2016 marine heatwave led to pronounced shifts in the distribution of marine species, which in turn caused a dramatic increase in entanglements of humpback whales, *Megaptera novaeangliae*, in nearshore fixed-gear fisheries. Robust humpback whale SDMs have been extensively developed and validated for the broader California Current Ecosystem, but the resolution of these models (10 km) was too coarse to provide reliable distribution data in the nearshore regions, where fixed-gear fisheries operate. We have, therefore, adapted the previous SDMs that examined broad-scale interannual cetacean distributions to create a dynamic finer-scale (3 km) model that captures seasonal patterns of whale occurrence in nearshore habitats across 15 years from 2005-2019. Using independent data sets to validate the model, we demonstrate its ability to capture seasonal and interannual whale distribution shifts, particularly associated with the 2014-2016 marine heatwave. This model provides a foundation for two separate studies that examine whale entanglement risk (Redfern et al., in prep) and socio-economic tradeoffs associated with entanglement risk reduction (Samhouri et al., in prep) for various potential management approaches to reduce whale entanglements along the U.S. West Coast.

WhaleWatch 2.0: a dynamic ensemble model to predict daily blue whale distributions along the West Coast in near real-time

Briana Abrahms, Heather Welch, Stephanie Brodie, Michael Jacox, Elizabeth Becker, Steven J. Bograd, Ladd Irvine, Daniel Palacios, Bruce Mate, Elliott L. Hazen

In this presentation I introduce WhaleWatch 2.0, a predictive spatial management tool that helps scientists and managers evaluate the most likely times and places that blue whales will be present along the U.S. West Coast in order to mitigate risk of interaction with human activities. We integrated a long-term satellite tracking dataset on 104 blue whales with data-assimilative ocean model output to predict daily, year-round habitat suitability for blue whales at 10x10 km resolution along the U.S. West Coast. We evaluated candidate models using multiple metrics and training/testing datasets, including the largest compilation of independent blue whale sightings data to date. The final model had strong predictive skill, resulting in daily, year-round predictions of blue whale habitat suitability in the CCE that accurately captured the whales' migratory behavior and shifts due to anomalous environmental conditions. Daily, coastwide blue whale predictions are publicly available and operational in near-real time, and can be found at https://coastwatch.pfeg.noaa.gov/projects/whalewatch2/about_whalewatch2.html.

Dynamic, high-resolution species distribution models with strong predictive performance such as this are valuable for targeting management needs in near real-time. After introducing the WhaleWatch 2.0 tool, I present a brief case study on its application to management of ship strikes to blue whales in the Southern California Bight, where metrics derived from this tool for ship strike risk assessment are currently operational. Our aim is to expand its application for entanglement risk assessments by providing blue whale distribution information for the entire coast at daily, monthly, or seasonal timescales as needed. Since whale distributions are dynamic and have been shown to shift in response to changing environmental conditions, integration of this information into management is valuable.

Advancing development of regional management strategies that incorporate ecosystem oceanography to mitigate whale entanglements along the U.S. West Coast

Jarrod A. Santora, NOAA Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division; University of California Santa Cruz

We will present an overview of a new website that describes the development and of an ecosystem oceanography toolbox for understanding and communicating attributes underlying whale entanglements along the U.S. West Coast. The website provides information describing the process for conducting seasonal assessment and contains data on relevant indicators for monitoring ecosystem conditions (dynamic time series and maps). Monitoring forage species (krill, anchovy) distribution and the area of cool surface temperatures provides supporting information for understanding upwelling ecosystem conditions and monitoring impacts from warming events (e.g., marine heatwaves). Specifically, we developed the habitat compression index (HCI) to inform regional ecosystem dynamics along the U.S. West Coast. The HCI is a spatial time series that tracks the area of coastal upwelling habitat and is relevant for retroactive and ongoing risk assessments involving whale entanglement. Larger values (e.g., >1SD) indicate expansion of cool habitat and values less than the mean indicate periods when habitat compressed onshore. Under periods of strong habitat compression (low values) there is an apparent increased risk of increased whale entanglement due to the shrinkage of the coastal upwelling ecosystem, coinciding with the lack of forage used by whales. Our presentation will provide an overview of the HCI and discuss examples on how the index may be integrated with other habitat metrics, especially with respect to bathymetry since fishery management and conservation decisions may be based on setting crab fishing depth restrictions. Additionally, we will discuss how the HCI can be classified according to thresholds (e.g., low, medium and high) to monitor potential entanglement risk. These thresholds will be provided to federal and state resource managers to develop regional management strategies to mitigate whale entanglement risk.

Session: Understanding fishing dynamics

Using landings and vessel monitoring system (VMS) data to model fixed-gear fishing activity and its relationship to whale entanglements off the US west coast

Blake Feist[1], Jameal Samhouri[1], Owen Liu[1], Mary Fisher[1,2] Lauren Saez[3], Karin Forney[4] and Dan Lawson[3]

[1]Northwest Fisheries Science Center
[2]University of Washington
[3]West Coast Regional Office
[4]Southwest Fisheries Science Center

Bycatch of whales in commercial fishing gear poses a global threat to populations and is of particular concern for endangered or threatened whale species. In order for resource managers to effectively minimize the risk of entanglement while ensuring economic well-being in associated fisheries, they need to be able to integrate the dynamics of fishing activity, whale distributions and environmental conditions. Further, the geographic extent over which whales are exposed to commercial fishing gear can be vast, and yet, decisions must often be made at a more local extent. Therefore, we need to develop tools that incorporate the factors that drive entanglements and can be used at relevant spatio-temporal scales for fisheries management in the context of whale entanglements.

In this presentation we describe new, spatially-explicit indices of fishing activity off the US west coast from 2009-2016 for four major pot- and trap-fisheries most commonly implicated in entanglements, and relate that activity to modelled humpback whale species distributions and reported entanglements across the same spatial domain. We use vessel monitoring system (VMS) data informed by port-level landings data to delineate fishing activity hotspots and examine overlap patterns with predicted humpback whale density. Over the full study period for the four fisheries we analyzed, we did not detect marked increases in fishing activity in general or changes in fisheries footprints within areas with historically high mean annual whale densities. However, we observed a clear signal of higher Dungeness crab fishing activity in California in spring of 2016 that is consistent with a high rate of entanglement in that year. Together, our results add to a growing body of work related to bycatch of protected species in otherwise sustainable fisheries and highlight the potential value of novel, spatio-temporal data sources and analyses for reducing human-wildlife conflict in the ocean. Outputs from these models are currently in the next phase of development in order to improve their accuracy at identifying fishing hotspots. These next generation fishing activity models, coupled with dynamic ocean whale density models are

being used to simulate various scenarios that can be used by resource managers to test a variety of fisheries management strategies aimed at reducing the risk of entanglements.

A Vertical Line Model for the West Coast Dungeness Fishery

Owen R. Liu, National Research Council Postdoctoral Fellow, Northwest Fisheries Science Center

Entanglement of large whales in fishing gear is a complex environmental problem. Managing entanglement risk requires an understanding of both the biological and economic dynamics of whales and fisheries. Much recent research has focused on the environmental drivers of whale distributions over space and time, but substantially less attention has been paid to the spatial dynamics of fisheries. Focusing on the Dungeness crab fishery in California, this research attempts to address the need to better understand the distribution of fishing effort over time. Specifically, using satellite-derived vessel positions combined with fishery landings data, we developed a model of the number of fishing lines in the water over space and time, which we term a vertical line model.

While not a replacement for current approaches to understanding and managing whale entanglements, results from the vertical line model can be used as an additional source of information when assessing the potential impacts of alternative management approaches to reduce entanglement risk. For example, the model provides a spatial view of hotspots of fishing line density, as well as an assessment of how these hotspots change over time. When combined with predictive models of whale distributions, the model can be used to help assess relative entanglement risk across space. In the future, extensions from this model could be used in predictive models of how fishing pressure might change in response to management measures.

Preliminary analysis on "Co-occurrence of whales and Dungeness crab-pot fishing gear in the north-central California National Marine Sanctuaries."

Cotton Rockwood[1] and co-authors

[1]Point Blue Conservation Science

One of the primary remaining human impacts on large whales is entanglements with fishing gear. In recent years the number of entangled whales has increased along the U.S. West Coast. Records show the vast majority of entanglements occur in trap/pot fishing gear with most reports occurring off California. We used 10 years (2008-2017) of crab pot and whale distribution data collected on the Applied California Current Ecosystem Studies (ACCESS) cruises. We modeled crab pot and whale densities in relation to climate, oceanography, and bathymetry. We estimated co-occurrence by calculating the product of whale and pot densities and used it as a proxy for entanglement risk. Average risk for all years and months showed different patterns for blue and humpback whales. Since whale prey is expected to be compressed close to shore in warm water years, we compared averages of May risk between warm and cold years. Warm years showed higher risk that was more concentrated close to shore. To examine the accuracy of our modeled entanglement risk in predicting entanglements, we compared our predictions to observed entanglements for the study region. We scaled our index so that the maximum predicted risk aligned with the greatest number of entanglements observed in any month of our study period. On an annual basis, our predictions aligned well with observed entanglements. Overall, the predictions captured the significant rise in entanglements in 2016-17, though 2015 was under-predicted. With improved modeling driven by expanded data, our approach can offer important insights into how to mitigate whale entanglement.

Pelagic Data Systems Solar Logger Case Study

Kathi George, Whale Entanglement Response and Prevention Manager, The Marine Mammal Center

In 2019, a pilot project was initiated in California to utilize solar loggers (from Pelagic Data Systems) on commercial Dungeness crab vessels and whale watch vessels to collect and analyze fishing dynamics and whale concentration data. I will highlight the technology used, data analysis conducted, and the challenges and opportunities that solar loggers present. Additionally, I will call attention to proposed regulations for electronic monitoring, and how solar logger technology fits the requirements.