Co-occurrence of Large Whales and Fixed Commercial Fishing Gear: California, Oregon, and Washington

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Abstract

Large whale entanglement in commercial fishing gear off the U.S. west coast has been identified as an issue of concern by the National Marine Fisheries Service (NMFS) because of the potential impacts to both large whales (individually and at a stock/population level) and the commercial fishing industry. Blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), gray (*Eschrichtius robustus*), humpback (*Megaptera novaeangliae*), and sperm *(Physeter macrocephalus)* whales were included in this study based on their endangered status and historic entanglement records. Little information has been confirmed from entanglement reports about the origin of the entangling fishing gear; therefore NMFS has developed analytical tools to assess the potential entanglement risk associated with various fixed gear fisheries relative to their co-occurrence with large whale species. One primary tool was mapping commercial fishing effort, focusing on fisheries with gear that has been confirmed or suspected of entangling whales based upon documented sightings and strandings of entangled animals. Fishing effort represented in this study, both state and federally managed, was derived from landings data obtained through the Pacific Fisheries Information Network (PacFIN). The relative density of fishing effort throughout the calendar year was overlaid with species-specific whale distribution patterns, modeled from systematically-collected marine mammal survey data, to help identify spatial and temporal overlap between whales and fisheries. The co-occurrence model identified potential species-specific "hot spots" of where and when large whales are more likely to encounter fishing gear, thus increasing entanglement risk. Information gained during port visits and interview with fishery representatives and state and federal fishery experts were compiled to improve knowledge of fishing gear off the west coast. The identification of spatial or temporal "hot spots", combined with a better understanding of fishing gear, will improve the ability to minimize or mitigate the risk of large whale entanglement.

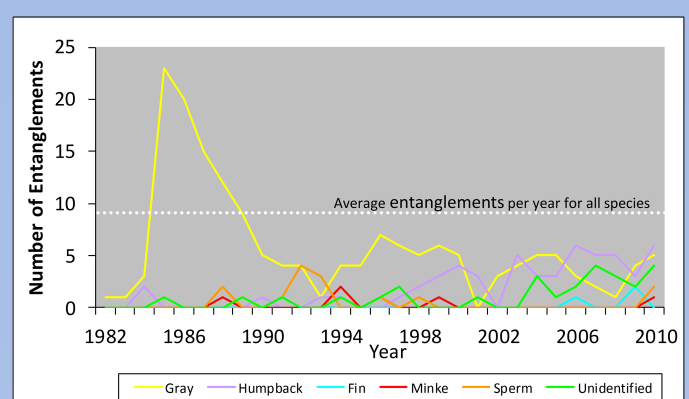


Figure 1. Whale entanglement reports per year per species, 1982 to 2010

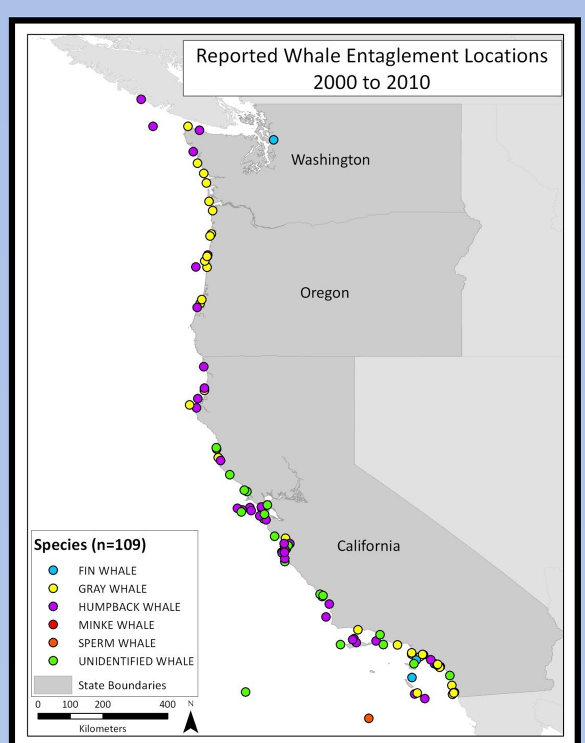


Figure 2. Reported whale entanglement locations from 2000 to 2010*
**may not be where entanglement actually occurred*

I. Whale entanglement history

- Large whales have been documented as entangled along the U.S. west coast since 1982 (Figure 1)
- 272 reported entangled whales from 1982 to 2010 (Table 1)

Table 1. Reported whale entanglements, per region, 1982 to 2010

Whale species	California	Oregon/ Washington	Both Regions
Gray	150	17	167
Humpback	47	7	54
Unidentified	27	0	27
Sperm	14	0	14
Minke	6	0	6
Fin	3	1	4
Total	247	25	272

- Entanglements seen throughout the coast with concentrations near areas where there is higher human population (Figure 2)
- Identified entangling gear types: trap/pot, bottom set longline, and gillnets
- Gillnets were the entangling gear type in the majority of reports pre-2000 (64%) and trap/pot are the majority post-2000 (45%)
- Late 1990's California gillnet regulations change resulted in shift and reduction of gillnet fishing effort

Data source: Reports received by NMFS marine mammal stranding networks and the large whale disentanglement network

II. Fishery mapping

- Need: assess varying spatial and temporal patterns of fisheries for comparison with whale data
- Data source: Fishery landing data is only source of data common to all fisheries considered
  - Pulled data from PacFIN database, a collection of landings reported by each state, in pounds
- Landing data processing:
  - Grouped by port complex; representing landings from fishing ports with common fishing grounds (Figure 3)
  - Averaged over 5-year time frames to capture inter-annual variation of effort
  - Summed over 3 month quarters of the year to capture seasonal variation of effort
- Mapping: Common fishing depths used to define potential fishing areas for each fishery (Figure 4)
  - All fisheries included in this study use fishing gear that contacts the ocean floor
  - Landings linked to map through port complex code from PacFIN (Figure 5)
- Scaled (1 to 7) for comparison with whale data (Table 2)

Fisheries Mapped

Trap/pot: Coonstripe shrimp, California nearshore finfish, Dungeness crab, hagfish, rock crab, sablefish, spiny lobster, and spot prawn; bottom set longline: Pacific halibut and sablefish; Set gillnet: California halibut/white seabass

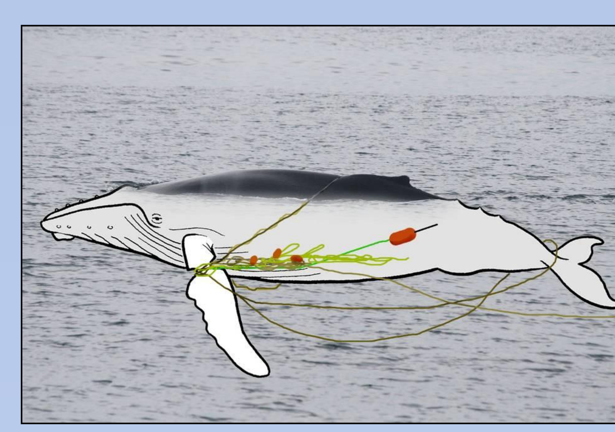


Diagram showing complexity of entanglements with multiple lines, buoys, and attachment points.
Provincetown Center for Coastal Studies. WR-2008-09. Taken under NOAA permit 932-1489

Table 2. Index score with corresponding pounds

Index score	Pounds landed per port complex
1	1 - 1,000
2	1,001 - 10,000
3	10,001 – 100,000
4	100,001 – 500,000
5	500,001 – 1,000,000
6	1,000,001 – 5,000,000
7	5,000,001 – 9,000,000+

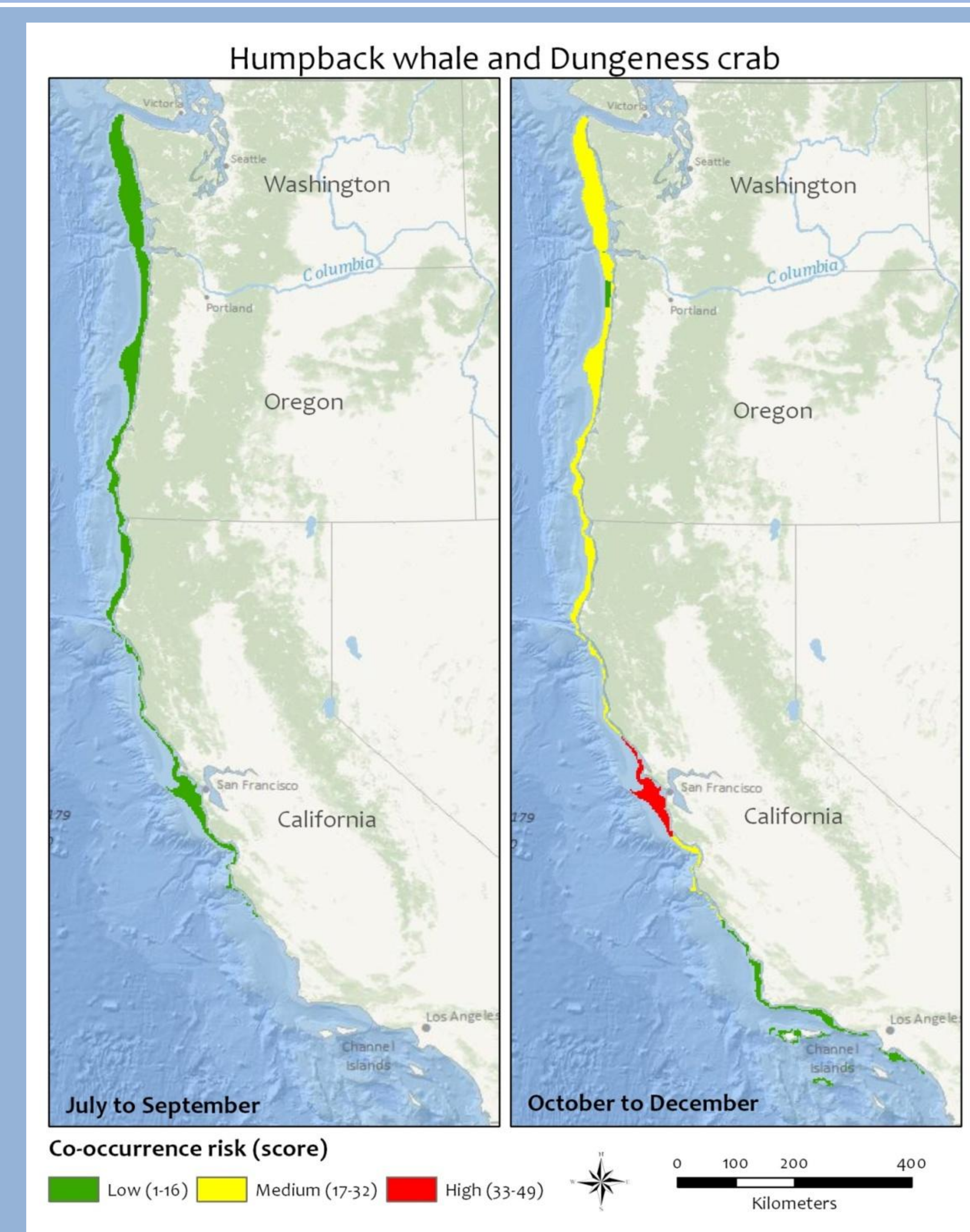


Figure 8. Example output from co-occurrence model: humpback whale and Dungeness crab, July to December
Green= low entanglement risk, Red = high entanglement risk

Conclusion

- Gray and Humpback whales are the most frequently reported entangled large whale species along the U.S. west
- Trap/pot and gillnets are most common entangling gear found on large whales
- Co-occurrence model results:
  - Blue (42), fin (30), humpback (42), and sperm (30) had highest risk in Quarter 4 (October to December)
  - Gray whales had highest risk (28) in Quarter 1 (January to March)
- Highest risk fishery: Dungeness crab trap fishery had highest co-occurrence scores for every whale species
- Potential hot spot: Humpback and blue whales with Dungeness crab off of San Francisco, California (Figure 8)
- Model outcomes align well with historic records where entanglement location was confirmed
- Low risk fixed gear fisheries were identified: California nearshore finfish, coonstripe shrimp, and Pacific halibut
- Limitations: seasonal mismatch of fishing seasons with whale presence & lack of knowledge surrounding the mechanics of whale entanglements and whale behavior

Figure 3. Port complex regions based on PacFIN database

Figure 4. Common fishing depths mapped for example fishery, then cut by port complex region; blue = potential fishing area

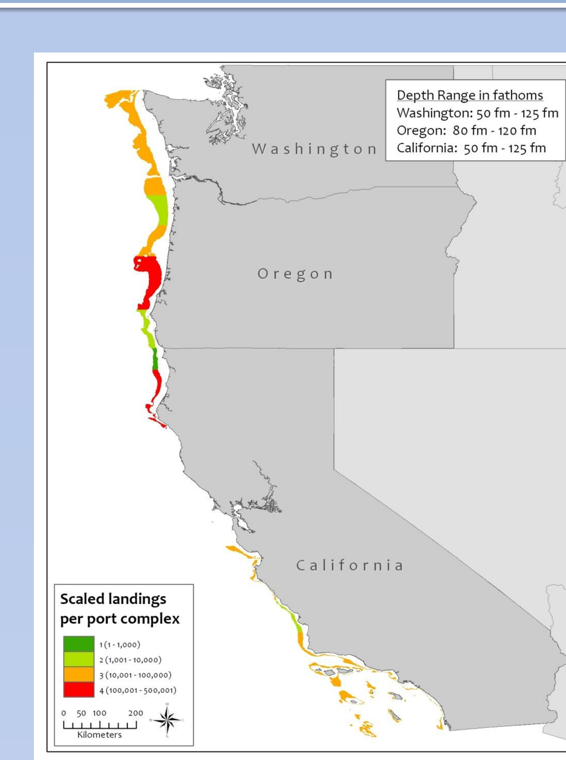


Figure 5. Integration of scaled landing data for example fishery; red = highest scaled landing

III. Whale data

Two data sources were used for whales. Data was scaled (1 to 7) for the co-occurrence model

1. Blue, fin, humpback, and sperm: Becker *et al.* (in prep) species-specific whale density surfaces modeled from systematically-collected data from ship-based survey.
   - Data represents summer/fall distributions; July to November
   - Scaled (1 to 7) per species using ArcGIS natural breaks (Figure 6a - d)
2. Gray: DeAngelis *et al.* (unpublished, poster 10:1) daily density of migrating whales, from shore based surveys
   - Migration corridors spatially bound by distance from shore, per phase
   - Scaled (1 to 7) with peak daily density = 7 (Figure 7)

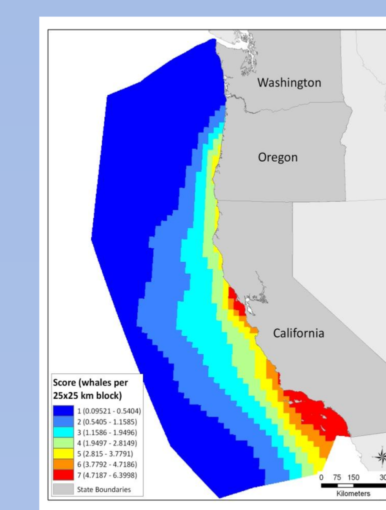
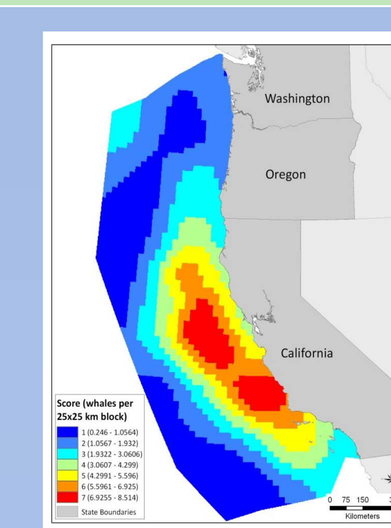
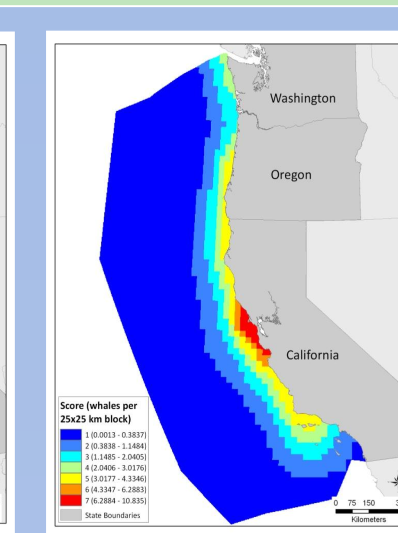


Figure 6a. Blue whale

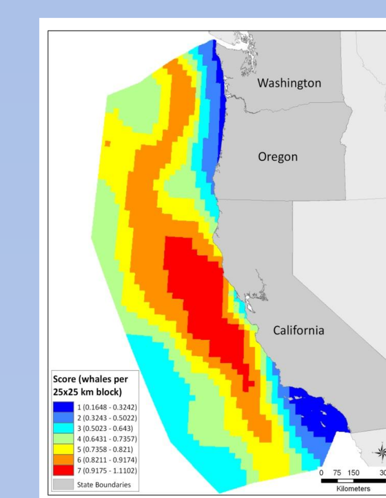


6b. Fin whale



6c. Humpback whale

Blue = low density, red = high density, scale varies by species



6d. Sperm whale

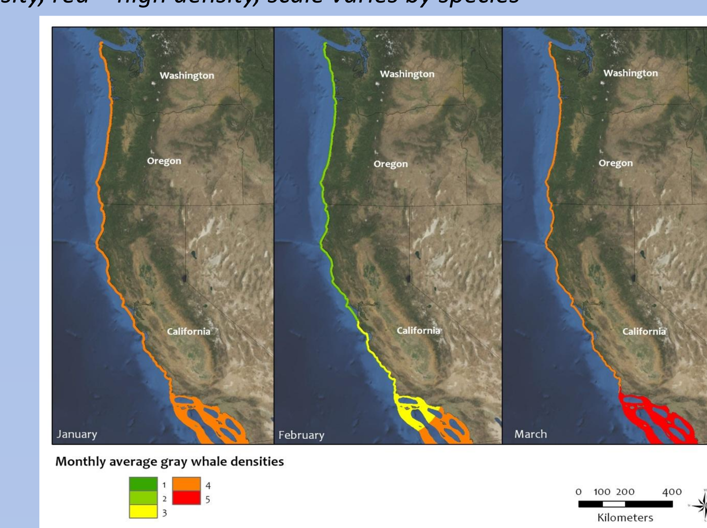


Figure 7. Gray whale monthly densities

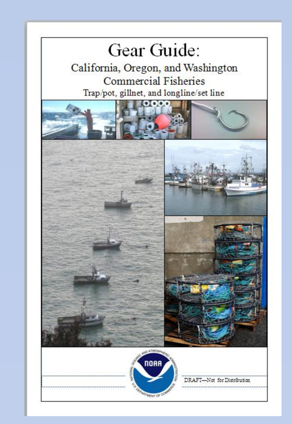
IV. Co-occurrence model

- *Co-occurrence score = scaled landings x scaled whale density*
  - Highest score for blue, fin, humpback, and sperm = 49
  - Highest score for gray = 35 (highest scaled monthly average density value is 5)
  - Co-occurrence model was only performed for time frames where whale densities were applicable (Table 3)
- Model has basic linear assumption: areas where high density of whales occur with high fishing equals high risk of whales likelihood of interaction and subsequent whale entanglement
- Co-occurrence scores were ranked by 33rd percentile and classified as low, medium, and high entanglement risk
  - High: 33 – 49, Medium: 17 – 32, Low 1 - 16

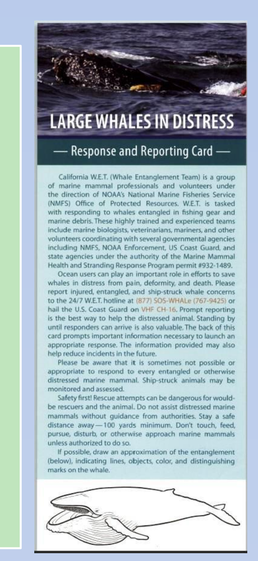
Table 3. Outline of whale species, data type, time frame, and corresponding fishing quarter

Whale species	Whale data type	Whale data timeframe	Corresponding fishing quarters
Blue, fin, humpback, and sperm	Single density surface for each whale species	Summer/Fall (July to November)	Quarter 3 & 4
Gray	Monthly density map	January to June	Quarter 1 & 2

Outreach/Gear Guide



- 24/7 hotline for reporting whales in distress (injured, entangled, stranded or ship-struck)
- Gear Guide was created from the fishery research
  - Combines photos, diagrams, maps, and text to characterize fisheries
  - Expect to improve our ability to identify likely sources of entanglements with a better understanding of the similarities and differences between the gear used by various fisheries off the west coast
  - Soon available on http://swr.nmfs.noaa.gov



Acknowledgments

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