NOAA Species Recovery Grant Semi-Annual Progress Report

Grant number: NA22NMF4720105

Agency agreement: 176-22

Project title: Enhancing Co-occurrence Assessment of Whales and Fishing Gear in Oregon Waters through Incorporation of Prey Data and Residency Analysis

Grantee name: Oregon Department of Fish and Wildlife

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Dates of the award period: 7/1/2022-6/30/2025

Dates covered by the progress report: 7/1/2023-12/31/2023

Description of the tasks scheduled for the reporting period and tasks accomplished during the reporting period:

As described in the project proposal, the Oregon Department of Fish and Wildlife (ODFW) planned for most of the work under this award to be conducted by Oregon State University (OSU) under an Intergovernmental Agreement (IGA) establishing a contractual relationship between the two parties, which was executed on August 5, 2022. This report addresses tasks scheduled during the reporting period as outlined in *Figure 3. Milestone timeline of proposed project* of the project proposal.

Data collection and compilation

Step 1: Vessel-based endangered species survey and prey data collection

One ship-based survey was conducted during this reporting period as part of this award. Ship-based survey methods are described by Derville et al. 2022. One marine mammal observer (Solène Derville) was onboard the R/V *Bell M. Shimada* for the September Northern California Current (NCC) cruise as part of OSU's collaboration with NOAA (chief scientist: Jennifer Fisher) and funded by this award. The cruise totaled five survey days and 36 groups of cetaceans were observed including seven different species of dolphins and whales: one sperm whale, a possible Sei whale, fin whales, blue whales, humpback whales, and pods of Pacific white-sided dolphins, Dall's porpoises and common dolphins. Sightings of baleen whales included (in number of individuals): two fin whales, one whale suspected to be a Sei whale, three blue whales, nine humpback whales, and 16 unidentified baleen whales. One humpback whale was photo-identified.

OSU/MMI also conducted two cruises as part of the MOSAIC project (Marine Offshore Species Assessment to Inform Clean Energy; funded by the US Department of Energy) onboard the R/V *Pacific Storm*. The rorqual whale data collected during these cruises conducted in August 2023 (9 days; 212 rorqual whale validated group sightings) and October 2023 (8 days; 152 rorqual whale validated group sightings) will be compiled with the dataset collected under this award to contribute to Step 13 (Rorqual whale Species Distribution Models, SDMs).

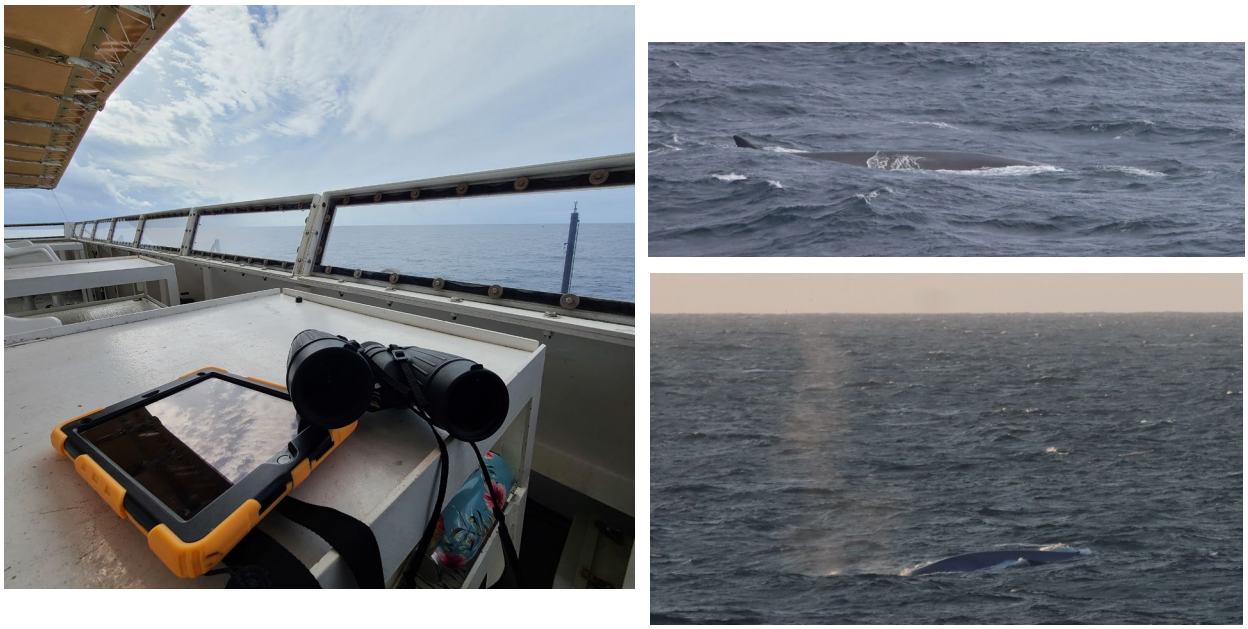


Figure 1: Photos taken during the September 2023 NCC cruise. Left: marine mammal observer equipment. Top: fin whale. Bottom: blue whale. Photo credit: Solène Derville / GEMM Lab.

Step 2: Endangered species helicopter transects

Monthly helicopter surveys of Oregon coastal waters were continued through a partnership with the United States Coast Guards (USCG) during this reporting period. Four 150 nm transects were flown each month out of USCG stations in North Bend (NB), Newport and Astoria/Warrenton, weather permitting. Survey methods are described by Derville et al. 2022.

A total of 20 cetacean surveys have been conducted aboard USCG helicopters since July 1, 2023 (Table 1). As of December 31, 2023, OSU conducted the following number of complete surveys: NB-South = 5; NB-North = 5; Newport = 6; Warrenton = 4. During these surveys, at total of 7 species of cetaceans were recorded: gray whales (4 individual on-effort sightings), humpback whales (35 sightings), fin whales (24 sightings), blue whales (2 sightings), harbor porpoise (3 sightings), Pacific white-sided dolphin (35 sightings) and Risso's dolphin (12 sightings). In addition, there were 29 sightings of unidentified whales.

Table 1. Dates of cetacean surveys conducted aboard USCG helicopters off the Oregon coast, by month, and transect, since July 2023. Grey boxes indicate that the transect was not surveyed during that month, due to weather or helicopter mechanical issues.

		NB, South	NB, North	Newport	Warrenton
2023	Jul		8-Jul	29-Jul	
	Aug			26-Aug	22-Aug
	Sep	3-Sep	2-Sep	9-Sep	17-Sep
	Oct	25-Oct	26-Oct	31-Oct	
	Nov	17-Nov	15-Nov	7-Nov	28-Nov
	Dec	11 + 19-Dec	15-Dec	21-Dec	23-Dec

Step 3: Fishery effort mapping

ODFW continued to collect and enter logbooks from Dungeness crab and other fixed gear fisheries. Data QA/AC for the 2021-2022 season progressed but was not completed. This data should be available to update fishery effort maps in the next reporting period. ODFW began exploration of other fixed gear logbook data, including groundfish longline and pot gear.

Step 4: Small boat surveys

Three small boat surveys funded by this award plus one survey funded by IGA 214-22 were conducted off Newport and Port Orford during this reporting period. One day of

survey effort was completed in the previous reporting period, totaling four surveys days supported by this award in 2023.

During the four survey days in this reporting period, twenty-five groups of humpback whales totaling 36 individuals were observed. Among these, 30 individuals were uniquely identified by photo-identification. Comparison to records from HappyWhale showed that most of these individuals had been sighted over the US West Coast or in breeding grounds in the past (n = 28). Two individuals were new to this collaborative database that includes most of the research (e.g., Cascadia Research Collective, CRC) and citizen science photos collected in this region. Twenty-five tissue biopsy samples were also collected and transferred to the Cetacean Conservation and Genomic Laboratory (CCGL) for analysis.

One recently entangled humpback whale was observed. On August 26 off Cape Blanco, an individual later identified as CRC17743 was observed in a group of three adult humpback whales. The back and the tailstock of this individual were abraded and raw, indicating a very recent entanglement in fishing gear that was somehow recently shed. Data and photos documenting this case were forwarded to Kristin Wilkinson, the NOAA Fisheries Regional Stranding & Entanglement Coordinator.

These surveys were also an opportunity to collect data on other rorqual whale species foraging in Oregon waters (Figure 2). OSU worked on four different groups of fin whales, comprising six individuals over which two biopsy samples and one fecal sample were collected. OSU also encountered a great number of blue whales off Cape Blanco on August 26 and worked on three groups comprising six individuals over which four biopsy samples were collected.

Figure 2: Photos taken during one of the small boat surveys off Cape Blanco (August 26, 2023). Left: humpback whale and seabirds. Right: blue whale. Photo credit: Allison Dawn / GEMM Lab.

Step 5: Compilation of environmental predictor variables

Compilation of environmental variables continued over this reporting period, building off previous work that included environmental conditions up to September 2021 (Derville et

al., 2022). The technical issue affecting the servers of the Regional Ocean Modeling System (ROMS) was partially resolved and a custom Matlab / Rcode was produced to download the ROMS variables up to April 2023. Access to this data allowed the development of krill distribution models (Step 11) to continue during this reporting period.

Outreach and Engagement

Step 6: Promote reporting of whale sightings

The reporting of whale sightings continues to be promoted on OSU's website home page (https://mmi.oregonstate.edu/gemm-lab). Moreover, fishermen engaged in another related research project led by OSU/MMI (SLATE: https://mmi.oregonstate.edu/gemm-lab/slate) are directly reporting whale sightings through custom made data sheets.

Step 7: Develop and manage fleet alert system

OSU continued to provide monthly reports to ODFW on whale aggregations observed during surveys throughout the reporting period. Following the observation of an aggregation of blue and humpback whales within 40 fathoms off the southern Oregon coast by OSU/MMI and Cascadia Research Collective, a fleet advisory was announced on August 17 (https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/whale_entanglement/ODFW_Fleet_Advisory_081723_FINAL.pdf) The alert was distributed via ODFW's commercial Dungeness crab and commercial nearshore fishery listservs (15,141 and 14,536 subscribers respectively), direct email to other fixed gear fishery participants, ODFW's recreation report, and email to the Oregon Dungeness Crab Advisory Committee and the Oregon Entanglement Advisory Committee. Finally, 13 derelict crab gear sets detected by OSU/MMI during helicopter and boat-based surveys in August and September were reported to ODFW and locations were posted on the ODFW website to inform vessels interested in recovering derelict gear.

Step 8: Develop R shiny app to predict whale distribution on a weekly scale

This task was not prioritized during this reporting period and OSU has no progress to report. OSU anticipates this work to primarily occur toward the end of the project, once whale predictive models are being finalized.

Step 9: Raise awareness of issue and project

A presentation entitled "Modelling whale distribution and co-occurrence with Dungeness crab fishing effort in Oregon waters to reduce the risk of entanglement" was given by Dr. Torres at the Pacific States Management Council annual meeting in Salishan, Oregon in October 2023.

A presentation entitled "Going in for the Krill: How our Favorite Zooplankton Can Help Lower Entanglement Risk for Whales in Oregon." was given by Rachel Kaplan at Palmer Station in August 2023.Two blog posts shared about the research conducted under this award:

https://blogs.oregonstate.edu/gemmlab/2023/12/11/el-nino-de-navidad-what-is-atmospheric-santa-claus-bringing-to-oregon-krill-and-whales/

https://blogs.oregonstate.edu/gemmlab/2023/10/16/cruising-through-space-and-time-a-gemm-labs-journey-in-the-northern-california-current/

Spatial and ecological analysis of prey and whales

Step 11: Analysis of krill data

Krill biomass and length distribution - Using data from nighttime bongo net tows collected on NCC cruises between 2018 and 2022, OSU quantified the length frequency distributions of Euphausia pacifica and Thysanoessa spinifera krill (n = 2,915 and n = 647, respectively). These data are used to derive species-specific krill biomass estimates from acoustic NASC data.

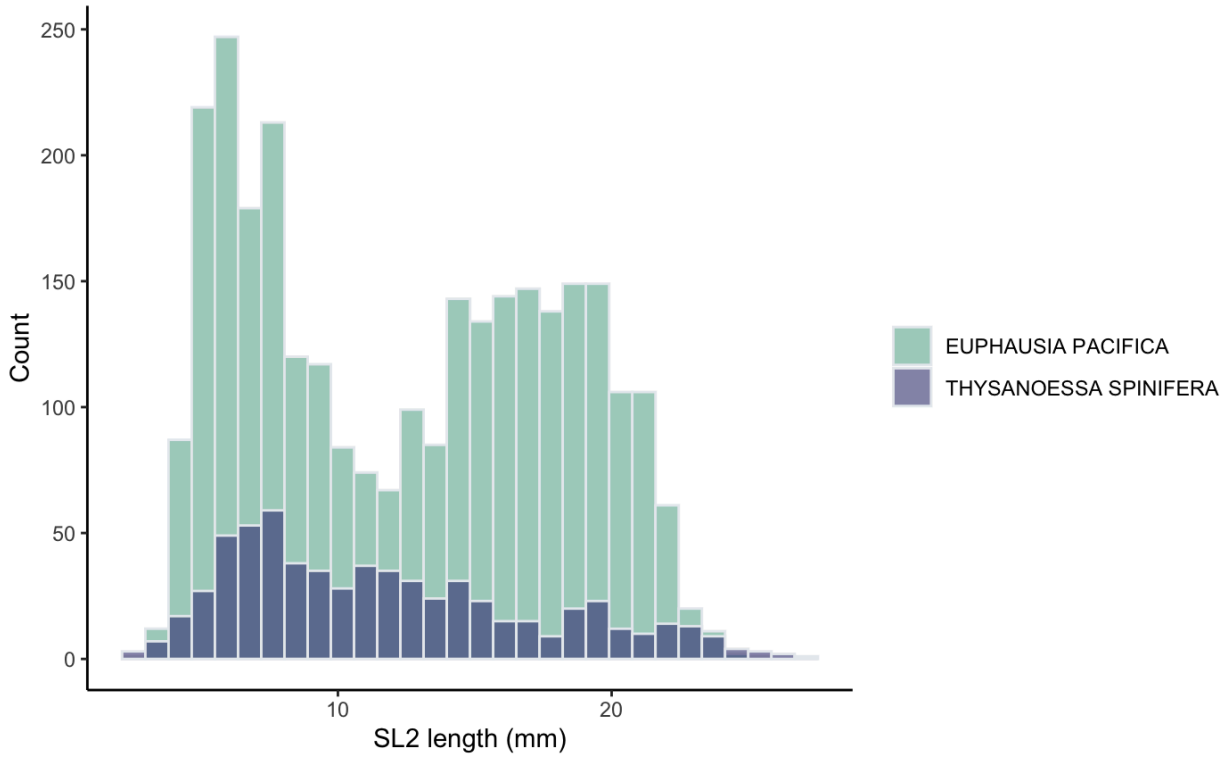


Figure 3. Species-specific length frequency distributions for Euphausia pacifica and Thysanoessa spinifera krill collected between 2018 and 2022.

Krill swarm classification - Krill acoustic data from 2018-2022 were processed to detect discrete swarm structures (n = 3,982) and quantify their characteristics. Using Hierarchical Cluster Analysis, three distinct swarm types were identified, distinguished by their depth in the water column, swarm height, backscatter intensity, and other descriptors. These data help describe the preyscape encountered by foraging whales in the NCC region, and elucidate important prey quality characteristics.

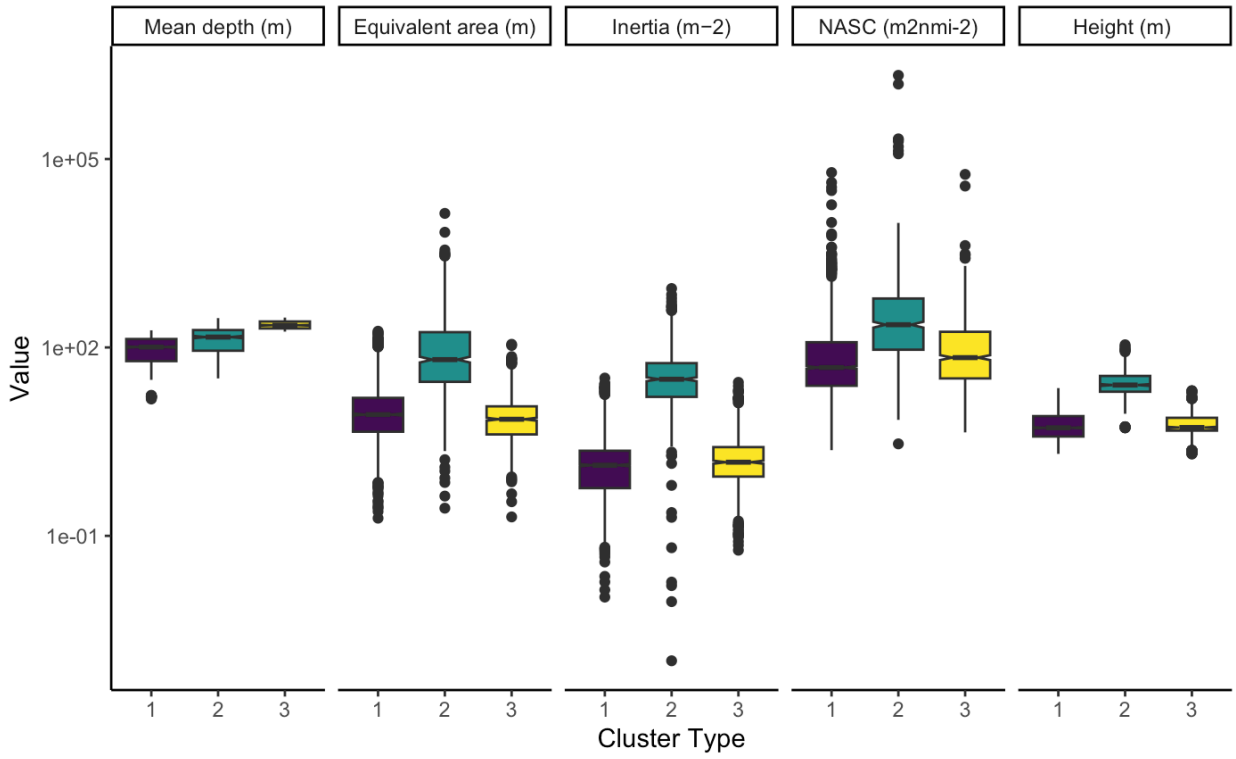


Figure 4. Krill swarm metrics used to identify three distinctly different types of krill swarms (Cluster Type). Variable descriptions are as follows: Aggregation Index (m-1) is a measure of the distribution density. Mean depth (m) is a measure of the mean swarm depth. Height (m) is a measure of the swarm height. Equivalent Area (m) is a measure of the distributed evenness within a krill swarm. Inertia (m−2) is a measure of a swarm's dispersion or spread. NASC (Nautical Area Scattering Coefficient, m2nmi-2) is a measure of the acoustic backscattering area per swarm and is used as a proxy for scatterer density. These data were obtained via NCC cruise acoustic data.

Krill distribution model – Using an acoustic proxy of krill abundance (Nautical Area Scattering Coefficient, NASC, $m^2.nmi^{-2}$) derived from echosounder data, as well as krill carbon biomass estimated from bongo net tows ($mg.m^{-3}$) collected across NCC cruises 2018-2022, OSU generated models of *Thysanoessa spinifera* (TSPIN) and *Euphausia pacifica* (EPAC) krill distribution. Two different approaches were implemented to derive monthly predictions of EPAC and TSPIN relative abundance from a combination of NASC and net tow biomass data (Figure 5). Generalized Additive Models (GAM) and Boosted Regression Trees (BRT) were used to hierarchically model krill NASC along transects and krill biomass at tow stations with a two-step approach: 1) model the probability of presence of krill following a binomial distribution (values equal to 0 or 1), and 2) model

the abundance or biomass of krill conditional on presence following a Gamma or a log-normal distribution (values > 0). Cross-validation was used to evaluate the descriptive and predictive performance of models, as well as their stability. Cross-validation folds were blocked on cruises, so that at every run of the model, one cruise would be withheld from the training dataset and used for external evaluation.

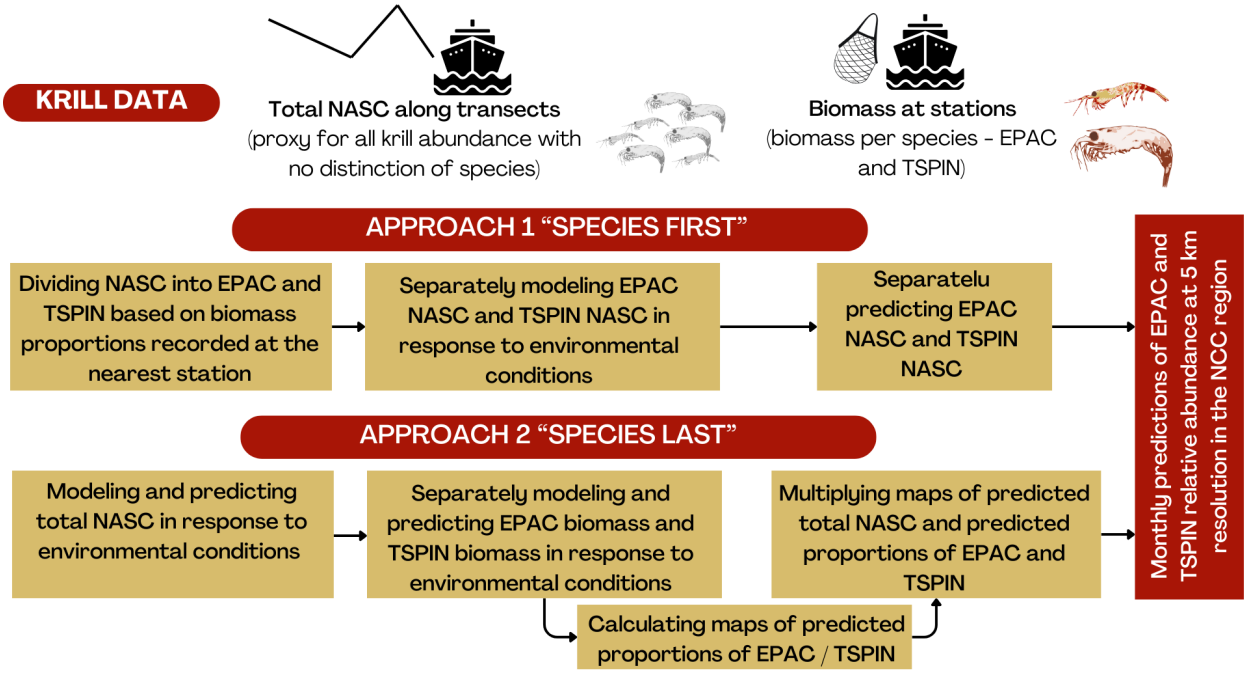
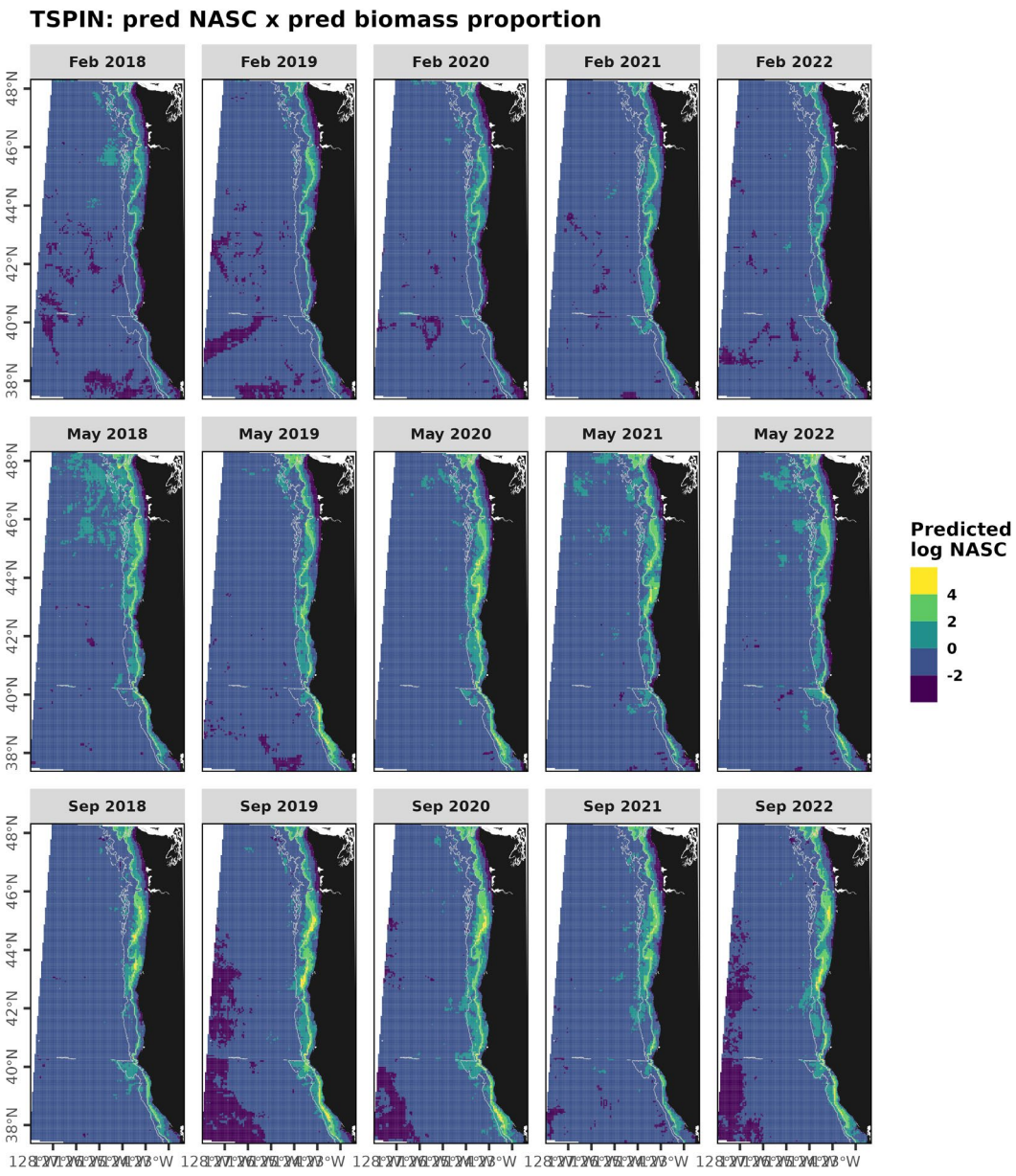


Figure 5: Schematic workflow to derive predictions of krill abundance based on NASC derived from echosounder data long the ship tracks and biomass calculated from bongo net tows. Two different approaches are currently being tested.

Overall, 800 different models were generated and outputs were averaged across folds, per approach, species, and predictor set. Descriptive and predictive performance of models were evaluated with percent deviance explained, AUC, and Pearson correlation coefficients of observed vs predicted abundance. Model outputs such as partial dependence plots, predictor influence plots, predicted maps of relative abundance (Figure 6) and predicted seasonal trends were derived from the top performing models. Outputs were assessed by a group of experts that met in November 2023 and deemed ecological sound in terms of temporal and spatial distribution predicted for the two krill species of interest. A manuscript is in preparation to present the results of this krill distribution modeling effort in the NCC.


TSPIN: pred NASC x pred biomass proportion
Feb 2018
Feb 2019
Feb 2020
Feb 2021
Feb 2022
May 2018
May 2019
May 2020
May 2021
May 2022
Sep 2018
Sep 2019
Sep 2020
Sep 2021
Sep 2022
48°N
46°N
44°N
42°N
40°N
38°N
128°W
Predicted log NASC
4
2
0
-2

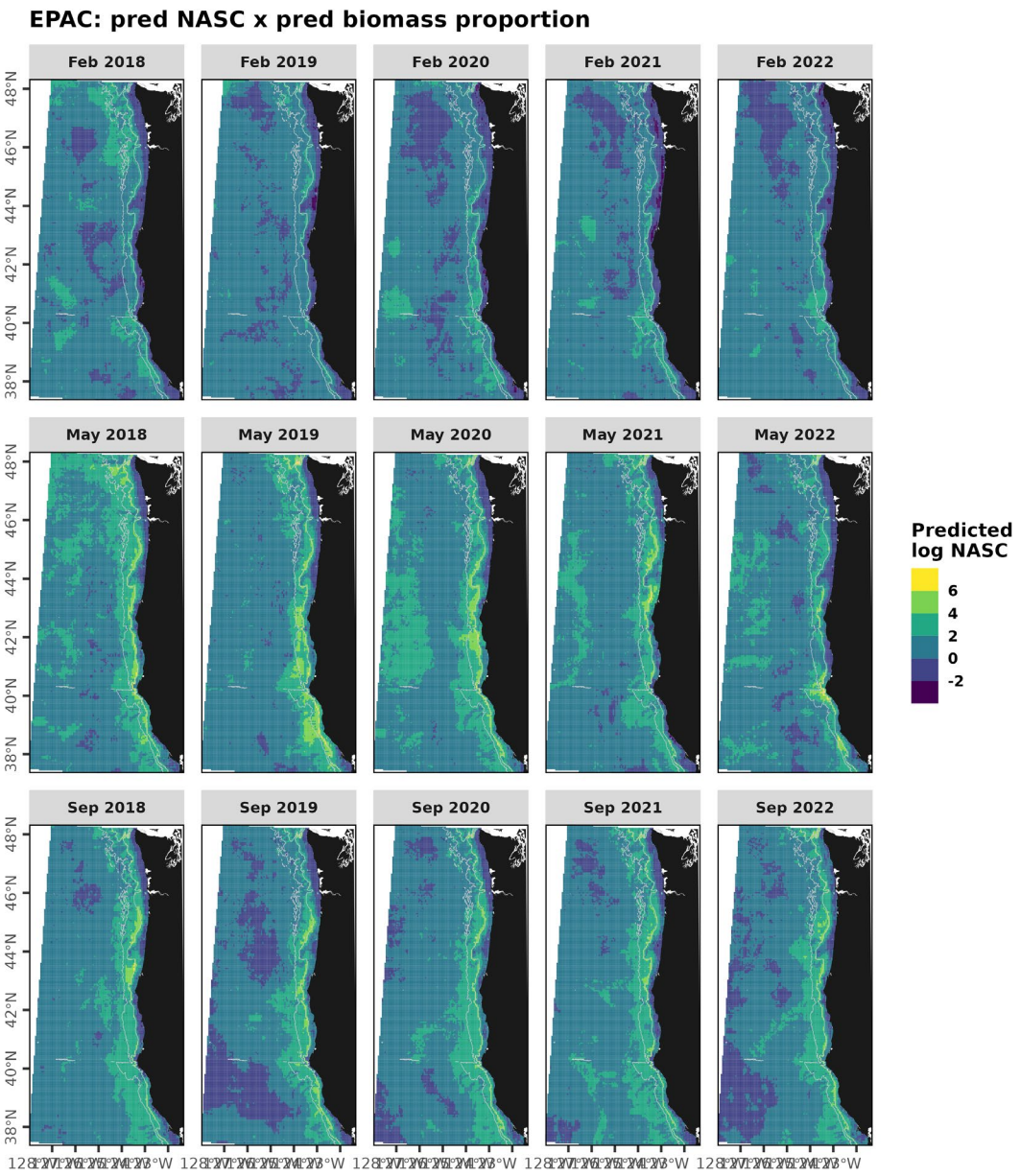


Figure 6. Preliminary outputs from approach 2 “species last” deriving monthly predictions of EPAC and TSPIN. The maps show the EPAC (bottom) and TSPIN (top) relative abundance on a log-transformed colored scale, with yellow indicating higher abundance and purple indicating lower abundance. The abundance proxy presented here is a predicted NASC value scaled to predicted biomass proportion of the species of interest.

Step 13: Generate rorqual whale SDMs

Relationships between krill and whales – The study led by PhD student Rachel Kaplan investigating spatially-explicit relationships between humpback whales and krill was submitted to the journal *Marine Ecology Progress Series* during the previous reporting period and was accepted for publication (Kaplan et al. In press).

Rorqual whale SDMs – The development of rorqual whale SDMs awaits completion of the boat-based and helicopter-based surveys that will continue until June 2024. The krill SDMs, which will provide predicted layers of monthly krill abundance over the study region and period are anticipated to be finalized during the next reporting period. Hence, all components necessary to the rorqual whale SDMs (whale data, krill data, fish data, and ROMS data) will be ready to complete Step 13 during the summer 2024.

Humpback whale genetic and photo-ID analysis

Step 17-18: genetic DPS assignment and site fidelity analysis by individual and DPS

Thirty-two biopsy samples were collected from humpback whales during the 2023 field season and total genomic DNA has been extracted from all samples. A full DNA profile, consisting of mtDNA haplotype, sex and 15 microsatellite loci, has been generated for the first 16 samples. DNA profile matching of these 16 samples to a database of humpback whale individuals sampled across the North Pacific identified three recaptures of previously sampled individuals. One was a recapture of a female sampled in Oregon in 2020, one was a recapture of a male sampled in California in 2004 and the final one was a recapture of a male previously sampled in Baja, Mexico in 2004. DNA profiling is now underway for the remaining samples. A postdoc has been hired (under supervision of Dr. Scott Baker) to undertake the DPS assignment analysis and they are expected to begin on the 1st of April.

Table 2: Date, sex and mtDNA haplotype of humpback whale biopsy samples collected off the Oregon Coast during 2023. 'Genetic ID' is the individual ID as determined by DNA profiling and matching to a database of humpback whale individuals sampled across the North Pacific. 'TBD' indicates information still to be determined via DNA profiling.

Sample ID	Field ID	Date	Genetic ID	A recpSex	mtDNA
Mno23OR01	GEMM-Mn1-2023	2 Jun 23	gMno23OR01	F	A+
Mno23OR02	GEMM-Mn2-2023	2 Jun 23	gMno23OR02	M	A-
Mno23OR03	GEMM-Mn3-2023	2 Jun 23	gMno23OR03	M	A+
Mno23OR04	GEMM-Mn4-2023	2 Jun 23	gMno23OR04	F	E7
Mno23OR05	GEMM-Mn5-2023	2 Jun 23	gMno20OR22	F	E10
Mno23OR06	GEMM-Mn6-2023	2 Jun 23	gMno23OR06	F	E1
Mno23OR07	GEMM-Mn7-2023	2 Jun 23	gMno23OR07	F	F1

Mno23OR08	20230707GEMM_Mn1	7 July 23	gMno23OR08	M	E7
Mno23OR09	20230826GEMM_Mn1	26 Aug 23	gMno23OR09	F	A+
Mno23OR10	20230826GEMM_Mn2	26 Aug 23	gMno23OR10	M	E5
Mno23OR11	20230826GEMM_Mn3	26 Aug 23	gMno23OR11	F	E1
Mno23OR12	20230826GEMM_Mn4	26 Aug 23	gCA04-45398	M	E3
Mno23OR13	20230826GEMM_Mn5	26 Aug 23	gMno23OR13	F	F2
Mno23OR14	20230826GEMM_Mn6	26 Aug 23	gMnoBC04-59	M	E1
Mno23OR15	20230826GEMM_Mn7	26 Aug 23	gMno23OR15	F	E1
Mno23OR16	20230826GEMM_Mn8	26 Aug 23	gMno23OR16	M	F2
Mno23OR17	20230826GEMM_Mn9	26 Aug 23	TBD	F	A+
Mno23OR18	20230826GEMM_Mn10	26 Aug 23	TBD	F	A+
Mno23OR19	20230826GEMM_Mn11	26 Aug 23	TBD	F	TBD
Mno23OR20	20230830GEMM_Mn1	30 Aug 23	TBD	F	TBD
Mno23OR21	20230830GEMM_Mn2	30 Aug 23	TBD	F	TBD
Mno23OR22	20230830GEMM_Mn3	30 Aug 23	TBD	M	TBD
Mno23OR23	20230830GEMM_Mn4	30 Aug 23	TBD	M	TBD
Mno23OR24	20230830GEMM_Mn5	30 Aug 23	TBD	M	TBD
Mno23OR25	20230830GEMM_Mn6	30 Aug 23	TBD	M	TBD
Mno23OR26	20230830GEMM_Mn7	30 Aug 23	TBD	F	TBD
Mno23OR27	20230830GEMM_Mn8	30 Aug 23	TBD	F	TBD
Mno23OR28	20230906GEMM_Mn1	6 Sept 23	TBD	M	TBD
Mno23OR29	20230906GEMM_Mn2	6 Sept 23	TBD	M	TBD
Mno23OR30	20230906GEMM_Mn3	6 Sept 23	TBD	M	TBD
Mno23OR31	20230906GEMM_Mn4	6 Sept 23	TBD	M	TBD
Mno23OR32	20230906GEMM_Mn5	6 Sept 23	TBD	F	TBD

Explanation of any problems or delays in accomplishing planned activities:

Five planned helicopter transects were not completed during the reporting period. Helicopter surveys may be missed for a combination of reasons that are out of OSU's control and are often unpredictable. Scheduling opportunities with USCG for flights are limited and do not always align with good weather for survey effort. Search and rescue operation (SAR) may also cancel a flight unexpectedly. Helicopter maintenance and availability of trained personnel may also limit survey schedules.

References

Derville, S., Barlow, D. R., Hayslip, C. E., & Torres, L. G. (2022). Seasonal, Annual, and Decadal Distribution of Three Rorqual Whale Species Relative to Dynamic Ocean Conditions Off Oregon, USA. *Frontiers in Marine Science*, *9*, 868566. https://doi.org/10.3389/fmars.2022.868566

Kaplan, R. L., Derville, S., Bernard, K. S., Phillips, E. M., & Torres, L. G. (In press). Humpback-Krill Relationships are Strongest at Fine Spatial Scales in the Northern California Current Region. *Marine Ecology Progress Series*.