



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
Fisheries Ecology Division
110 McAllister Way
Santa Cruz, California 95060

Project Report

Date Submitted: October 17, 2022
Platform: NOAA Ship *Reuben Lasker*
Project Number: RL-22-02 (OMAO)
Project Title: Rockfish Recruitment and Ecosystem Assessment
Project Dates: April 28 – June 16, 2022

Prepared by: Keith M. Sakuma _____ Dated: October 13, 2022
Keith Sakuma
Chief Scientist
NOAA NMFS SWFSC FED

Approved by: Steve Lindley _____ Dated: 10/17/2022
Steve Lindley
Laboratory Director
NOAA NMFS SWFSC FED

A. Project period: April 28 – June 16, 2022

Leg 1: April 28 – May 21

Leg 2: May 24– June 16

B. Operating area and days at sea (DAS)

Operating area: San Diego, CA to Columbia River, OR (see Appendix I and II for station sample dates and locations).

DAS: Scheduled for 45 DAS.

DAS lost due to inclement weather=3.

DAS with compromised operations due to inclement weather=1.

DAS lost or compromised due to ship issues=26.

C. Summary of objectives

1. Sample for pelagic young of the year (YOY) rockfish (*Sebastes* spp.) and other epi-pelagic micronekton off California.
2. Characterize prevailing ocean conditions and examine prominent hydrographic features.
3. Map the distribution and abundance of krill (Euphausiacea).
4. Observe seabird and marine mammal distribution and abundance.
5. Collect forage species for stable isotope analysis.
6. Collect forage samples for thiamine deficiency complex (TDC) study.
7. Collect samples for eDNA and MBARI Northern Anchovy Project
8. Adaptive sampling off Piedras Blancas and Trinidad Head trawl lines.

D. Participating organizations

NOAA National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC) Fisheries Ecology Division (FED)

NOAA NMFS SWFSC La Jolla (NOAA NMFS SWFSC LJ)

NOAA Atlantic Oceanographic and Meteorological Laboratory (NOAA AOML)

University of California Santa Cruz (UCSC)

California State Polytechnic University, Humboldt (CSPUH)

Farallon Institute for Advanced Ecosystem Research (FIAER)

Monterey Bay Aquarium Research Institute (MBARI)

Scripps Institution of Oceanography (SIO)

Idaho State University (ISU)

E. Personnel

Leg 1 (Cancelled due to ship's crew shortage)

Transit from San Diego to San Francisco (May 18-21)

Keith Sakuma, Fish Biologist, NMFS SWFSC FED (Chief Scientist)

Tanya Rogers, Fish Biologist, NMFS SWFSC FED

Michael Force, Ornithologist, FIAER

Leg 2-A (May 24 – 30)

Night Shift

Keith Sakuma, Fish Biologist, NMFS SWFSC FED (Chief Scientist)

Tanya Rogers, Fish Biologist, NMFS SWFSC FED

Diana Watters, Fish Biologist, NMFS SWFSC FED

Joe Bizzarro, Asst. Project Scientist, NMFS SWFSC FED

Jessica Choi, Graduate Student, NMFS SWFSC FED

Justin Suca, Postdoc, NMFS SWFSC FED

Lis Henderson, Postdoc, MBARI

Day Shift

Jarrold Santora, Fish Biologist, NMFS SWFSC FED

Michael Force, Ornithologist, FIAER

Leg 2-B (June 3-16)

Night Shift

John Field, Fish Biologist, NMFS SWFSC FED (Principal Investigator) (June 3-8)

Keith Sakuma, Fish Biologist, NMFS SWFSC FED (Chief Scientist) (June 8-16)

Tanya Rogers, Fish Biologist, NMFS SWFSC FED

Ily Iglesias, PhD Student, NMFS SWFSC FED/UCSC

Nastassia Patin, Postdoc, NMFS SWFSC LJ

Rebecca Miller, Asst. Project Scientist, NMFS SWFSC FED/UCSC (June 8-16)

Day Shift

Jarrold Santora, Fish Biologist, NMFS SWFSC FED

Michael Force, Ornithologist, FIAER

Scientist duty hours

Nighttime Shift 1800-0600 (4-7 scientists on duty)

Daytime Shift 0600-1800 (2 scientists on duty)

F. Licenses and permits

This project was conducted under NOAA NMFS scientific research permit SRP-33-2022 as well as NOAA NMFS SWFSC's MMPA LOA for the California Current and ESA section 7 biological opinion and associated incidental take statement WCR ESA consultation 2020-01302. Operations in CA state waters were under California Department of Fish and Wildlife (CDFW) permit S-203450001-21022-003. Operations within the Channel Islands National Marine Sanctuary (CINMS) were under permit CINMS-2021-008 with permitted activities including the use of midwater sampling gear as well as CTDs and all other activities subject to CINMS regulations. Principal Investigator John Field and Chief Scientist Keith Sakuma.

G. Operations and Results

1. Sample for pelagic juvenile YOY rockfish and other epi-pelagic micronekton off California

The start of the survey was delayed due to ship's staffing issues, resulting in the loss of virtually all of Leg 1 sea days. Shortly after getting underway for Leg 2 there was a COVID-19 outbreak on the ship resulting in needing to return to the home port of San Diego due to concerns over maintaining a sufficient number of healthy ship's officers and crew for vessel operation. However, after five days in port the survey was able to resume and with the exception of some impacts due to weather, sampling was maintained until the previously scheduled conclusion of the survey. Due to the loss of sea days, midwater trawls were conducted at only three out of the five regions off California (core, south central, and south with the north central and north regions unsampled) (see Appendix II for regions and trawl station locations). Because of ongoing ship's staffing issues, deck operations were prioritized to ensure sufficient experienced staff to conduct the nighttime midwater trawling operations. With this focused effort, 60 midwater trawls covering the area from San Diego to Point Reyes were successfully completed over 17 nights of sampling with only one night lost to bad weather (see Appendices I and II).

Trawl gear used was a modified-Cobb midwater trawl with a 26 m (86') headrope (effective mouth opening of 8 m x 12 m based on net mensuration data) and a 9.5 mm (3/8") codend liner. Trawls were done at night at a target headrope depth of 30 m unless bottom depths were shallow (e.g. less than 55 m) in which case the target headrope depth was 10 m to avoid contact with the bottom. Tow speed was ~3.7 km/hr (~2 knots) with a trawl duration of 15 minutes at target headrope depth. However, in several cases trawl duration was decreased to 5 minutes due to large abundances of salps (*Salpidae*), pyrosomes (*Pyrosoma atlanticum*), or jellyfish (*Aurelia* spp. and *Chrysaora fuscescens*) which would have damaged the trawl gear. To further prevent damaging the trawl net with overly large gelatinous catches, "test" bongo tows were sometimes implemented prior to trawl deployment. Wire out was determined based on depth recordings collected from the ship's Simrad ITI real-time acoustic net sensing system and also from TDRs post-trawl. Fish and select invertebrates from each trawl were sorted, identified and enumerated. Size information was recorded on select species. All YOY rockfish were frozen for later laboratory analyses. Planned CalCOFI style oblique bongo tows (300 m wire out, wire angle of 45°) to examine gear selectivity with the wide range of life stages (sizes) of pyrosomes was cancelled due to ship's crew logistics to prioritize trawl operations at night.

Time series of the annual means of the log-transformed catches of select species/taxa in the various survey regions off California are shown in Appendix III. 1220 YOY rockfish were caught

north of Point Conception and 722 were caught south. Catches of YOY were rockfish were moderate with a decrease in catches in the south compared to prior years. North of Point Conception widow rockfish (*Sebastes entomelas*), shortbelly rockfish (*S. jordani*), and yellowtail rockfish (*S. flavidus*) were the most abundant species (31%, 25%, and 17% respectively). In contrast, south of Point Conception the most abundant species were the rosy rockfish complex (subgenus *Sebastomus*), blackgill rockfish (*S. melanostomus*), and squarespot rockfish (*S. hopkinsi*) (64%, 17%, and 8% respectively). Other YOY groundfish such as Pacific hake (*Merluccius productus*) and sanddabs (*Citharichthys* spp.) were moderately abundant while very few lingcod (*Ophiodon elongatus*) were caught and only in the core region.

Pacific sardine (*Sardinops sagax*) catches remained very low with only seven adult fish collected north of Point Conception with none in the south and no YOY observed at all. Adult northern anchovy (*Engraulis mordax*) were still quite numerous north of Point Conception with a decreasing trend over the past several years, but catches were greatly reduced in the south. In contrast, YOY northern anchovy were quite abundant in the south with catches were very low north of Point Conception.

Myctophids were relatively abundant north of Point Conception, but catches showed a declining trend in the south. Krill catches showed an increasing trend in all regions. Market squid (*Doryteuthis opalescens*) catches declined north of Point Conception, but remained relatively high in the south. No pelagic red crabs (*Pleuroncodes planipes*) were observed similar to last year.

Thetys salps were relatively abundant in all regions, but other salps showed a southward trend of increasing abundance with the largest catches ever observed in the south region. Pyrosomes were also very abundant with the largest catches ever observed in the core region. Large numbers of *Aurelia* spp. were encountered nearshore off Davenport and the north end of Monterey Bay and *Chrysaora fuscescens* was notably present within the Gulf of the Farallones. Collection of these two species in test bongo tows prior to trawl deployment resulted in the cancellation of four planned trawl stations to avoid damaging the trawl net.

2. Characterize prevailing ocean conditions and examine prominent hydrographic features.

Due to ship's staffing issues daytime CTD stations were not sampled as deck operations were prioritized for the nighttime trawls. CTD casts were done at the first and last trawl stations of the night and if time allowed at one of the middle trawl stations at night. Because of this constraint only 34 CTD casts were done and only at trawl stations. The map in Appendix II shows the lack of daytime CTD stations normally sampled between the trawl station lines. A Seabird Electronics CTD and water sampling system with conductivity, temperature, depth, fluorometer, transmissometer, photosynthetically active radiation (PAR), and dissolved oxygen sensors was used. The CTD was lowered to a maximum depth of 500 m, as bottom depth allowed. Water samples were taken during the upcast for chlorophyll samples and also for eDNA (see objective 7 below). Oceanographic data was also collected while underway by the ship's Turner Designs SCUFA fluorometer and SeaBird thermosalinometer.

3. Map the distribution and abundance of krill

Throughout the project, the EK80 echosounder was operated at 18, 38, 70, 120, 200 and 333 kHz to estimate the biomass of krill between 10 and 700 m depth. Targeted transect lines were run during daylight hours. Seabird and marine mammal observations were recorded concurrently

along the transect lines (see objective 4 below for specifics). Preliminary krill abundances were based on expanding counts from a 10-20 ml subsample from each nighttime midwater trawl. To confirm the at sea krill numbers and to determine species composition a 100 ml subsample from each trawl was preserved in formalin and returned to the laboratory for future work up.

4. Observe seabird and marine mammal distribution and abundance

While Leg 1 of the survey was effectively cancelled, logistics allowed for the observer to transit on the ship from San Diego to San Francisco prior to the scheduled start of Leg 2, providing the opportunity to collect seabird and mammal data during the transit. Seabird and marine mammal observations were maintained throughout the duration of Leg 2. Ornithologists/marine mammal biologists from the FIAER visually surveyed and estimated abundance and distribution of seabirds and marine mammals from the ship's flying bridge during daylight hours while underway. The observer recorded all birds seen within a 300 m strip transect to one side of the vessel while the ship was underway at greater than 5 knots. Marine mammals were surveyed out to the horizon. Each observation included the species, the number of individuals observed, and their behavior (mostly flying or sitting for birds). Observation data were post-processed using standardized species codes, validation of positioning data, and binning of observations into along-track sections 3 km in length. A map of the survey effort is shown in Appendix IV, a summary of survey effort in Appendix V, and the top five most numerous seabirds and marine mammals in Appendix VI. Notable results from the survey include very high densities of two seabird species with cold-water habitat affinity, common murre (*Uria aalge*) and sooty shearwater (*Puffinus griseus*), both of which had the highest density in their time series. Additionally, Brandt's cormorant (*Phalacrocorax penicillatus*), a warmer-water species (but one that is largely endemic to the California Current upwelling domain), showed high densities. Humpback whales (*Megaptera novaeangliae*) were present at very high abundance, the highest in the time series, and this continues an increasing trend in recent years. Blue whales (*Balaenoptera musculus*) were also very abundant (the second highest in their time series) and have also shown a recent increasing trend. Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) were lower than average in abundance but within 1 standard deviation.

5. Collect forage species for stable isotope analysis

Samples of krill and other micronekton were collected to provide baseline samples at multiple trophic levels to explore the potential for developing an "isoscape" analysis of the California Current, as well as to support ongoing investigations related to thiamine studies for central California salmon (objective 6 below). The overall idealized objective was to collect samples from each trawl station with up to five individuals or tissue samples of each species at each station. This included tissue samples from krill, market squid, adult northern anchovy, YOY Pacific hake, and also northern lampfish (*Stenobranchius leucopsarus*), blue lanternfish (*Tarletonbeania crenularis*), and California headlightfish (*Diaphus theta*) (YOY rockfish were also archived for these studies after being processed back at the laboratory).

6. Collect forage samples for thiamine deficiency complex (TDC) study

Tissue samples from a suite of salmon prey items were collected to support ongoing research into the potential drivers of TDC in California Current salmon populations. TDC is a nutritional deficiency of thiamine (vitamin B1) recently linked with high mortalities of early life stage Chinook salmon (*Oncorhynchus tshawytscha*) in several Central Valley (California) salmon populations (for more information, see <https://www.fisheries.noaa.gov/west-coast/science->

[data/monitoring-thiamine-deficiency-california-salmon](#)). Some evidence suggests that TDC may result from a narrowing of diversity in the food habits of Chinook salmon, particularly when the major contributor to that diet is northern anchovy, which are generally higher in thiaminase (an enzyme that destroys or inactivates thiamine) than other forage species. Over 200 samples of northern anchovy, market squid, YOY rockfish, Pacific sardine, krill and other salmon forage species were collected in support of these ongoing studies. Several samples of pyrosomes, which are not typically preyed upon by salmon but which showed surprisingly high levels of Thiaminase during some initial investigations in earlier years, were also collected. The results will support investigations into possible trophic mechanisms driving the increased occurrence of TDC in California salmon populations.

7. Collect samples for eDNA and MBARI Northern Anchovy Project

Samples collected for eDNA spanned 34 stations across 16 transects. In total, 684 L water were filtered for 282 eDNA samples, comprising 94 unique water samples filtered in triplicate. Samples were taken from the surface (0-5 m), deep chlorophyll maximum, and 100 m. Two hundred seventy samples had associated CTD casts, while 12 samples were collected from the surface using a bucket when no CTD was cast. Two hundred fifty-two samples were associated with mid-water trawls. The southernmost transect was San Diego and the northernmost was the Outside Farallones. All filters are currently being processed for metabarcoding (16S, 18S, COI, and 12S marker genes) and shotgun metagenomic sequencing.

Adult northern anchovy (*Engraulis mordax*) were collected from 53 hauls throughout the survey. No more than 10 fish were collected from each haul, bagged, and frozen in a -20°C freezer. These fish were then provided to researchers from MBARI. Fish will be thawed and dissected to collect and preserve stomach contents and muscle tissue for later genomic analyses. The goal of this project is twofold: 1) to describe spatial variability in anchovy diet in the California Current and 2) to define subpopulations using metapopulation genomics. These samples will complement an ongoing study in Monterey Bay which has captured anchovy weekly since August 2021. Samples from the 2022 survey provide a spatial perspective to this otherwise temporally focused project.

8. Adaptive sampling off Piedras Blancas and Trinidad Head trawl lines.

Adaptive sampling off Piedras Blancas and Trinidad Head was cancelled due to the loss of sea days.

H. Disposition of data

Requests and questions regarding the seabird and marine mammal data should be sent to the Farallon Institute for Advanced Ecosystem Research, William Sydeman 707-981-8033 wsydeman@comcast.net.

Requests and questions regarding the stable isotope data should be sent to: MBARI, Steven Litvin 831-775-1939 litvin@mbari.org and SIO, Anela Choy 858-822-3020 anela@ucsd.edu.

Requests and questions regarding the eDNA data should be sent to NMFS SWFSC LJ/NOAA AOML Kelly Goodwin 858-546-7142 kelly.goodwin@noaa.gov.

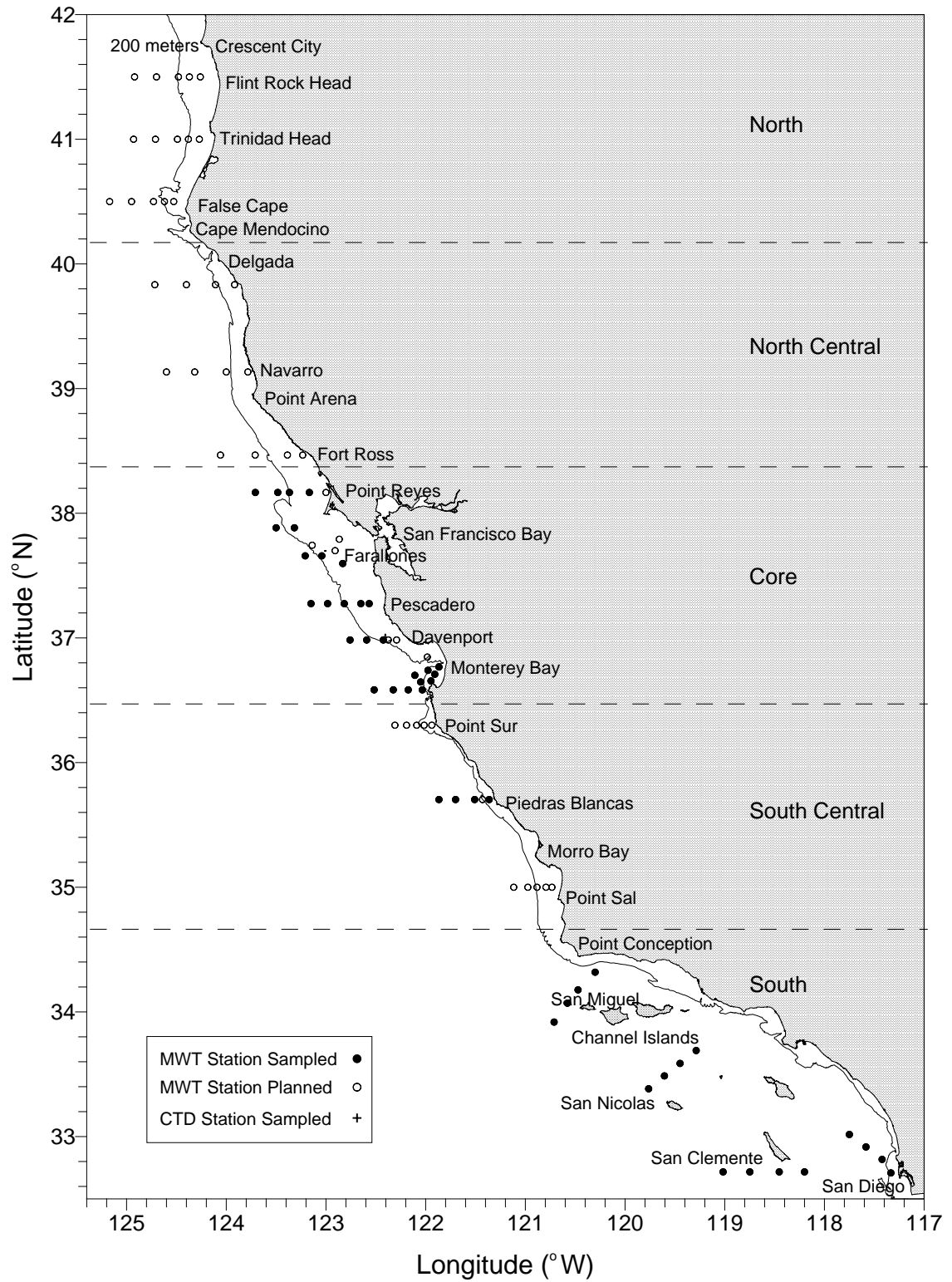
Requests and questions regarding the MBARI Northern anchovy project should be sent to MBARI, Lis Henderson 831-775-2031 henderson@mbari.org

All other data requests should be sent to NOAA NMFS SWFSC FED, Keith Sakuma 831-420-3945 keith.sakuma@noaa.gov.

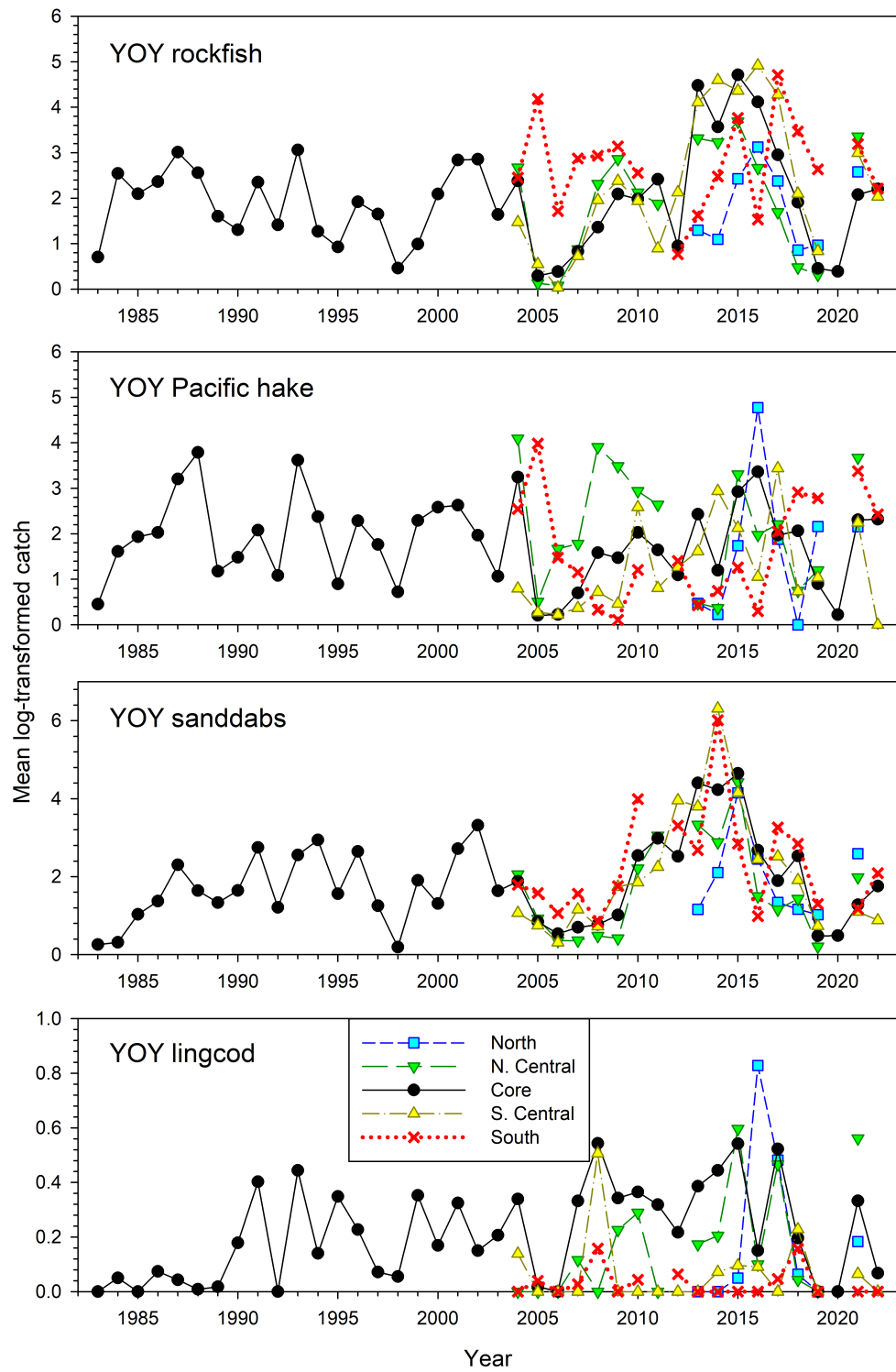
Appendix I: Daily transect schedule

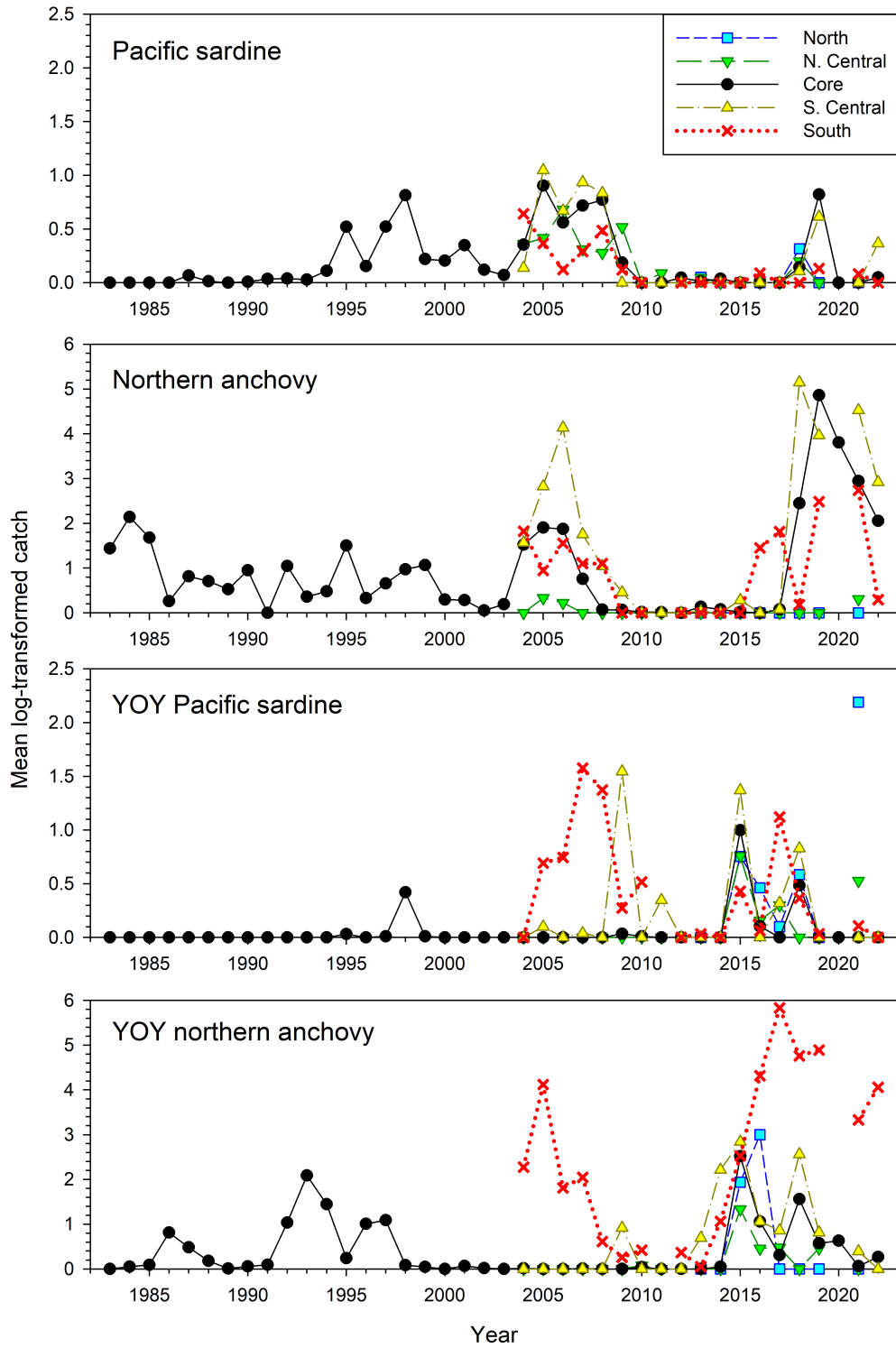
Date	Transect Location	# Sampled	Notes
28-Apr	Delayed		Leg 1 Start Delayed Due to Crew Shortage
16-May	Delayed		Leg 1 Start Delayed Due to Crew Shortage
17-May	In Port		Scientists unpack and setup gear
18-May	Begin Transit		Depart San Diego, CA-Gear Trials
19-May	Transit		Bad Weather
20-May	Transit		Bad Weather
21-May	End Transit		Dock in S.F., CA
22-May	In Port		In Port S.F., CA
23-May	In Port		In Port S.F., CA
24-May	Monterey Inside	0.5	Depart S.F., CA-Begin Leg 2-Bad Weather
25-May	Monterey Outside	1	
26-May	Davenport	0.4	COVID-19 Case
27-May	Outside Farallones	0.8	
28-May	Transit		Saturday-More COVID-19, Transit to San Diego, CA
29-May	Transit		Sunday
30-May	End Transit		Memorial Day Dock in San Diego, CA-Disembark Scientists
31-May	In Port		In Port San Diego, CA
1-Jun	In Port		In Port San Diego, CA
2-Jun	In Port		In Port San Diego, CA
3-Jun	San Diego	0.8	Depart San Diego, CA-Resume Leg 2
4-Jun	San Clemente	1	Saturday
5-Jun	San Miguel	1	Sunday
6-Jun	Piedras Blancas	0.8	
7-Jun	Monterey Outside	1.8	
8-Jun	Davenport	1	Skiff Transfer-Santa Cruz, CA
9-Jun	Pescadero	1	
10-Jun	Gulf of Farallones	0.3	
11-Jun	Point Reyes	0.8	Saturday
12-Jun	Monterey Inside	1.3	Sunday
13-Jun	Bad Weather		Bad Weather
14-Jun	San Nicolas	1	
15-Jun	San Diego	1.8	
16-Jun	Project Ends		Dock In San Diego, CA

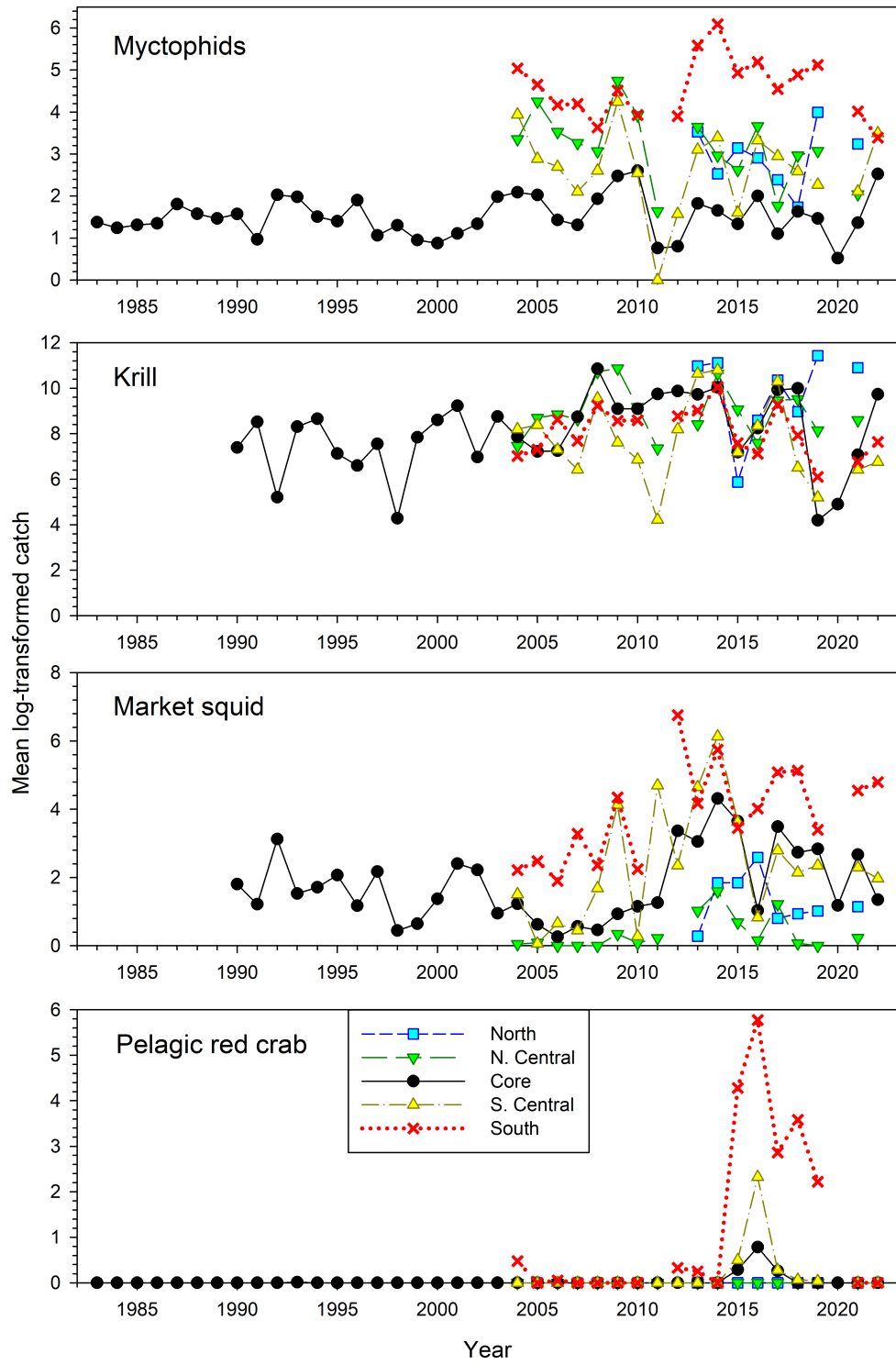
Appendix II: Survey regions and midwater trawl and CTD station locations
SWFSC Stations

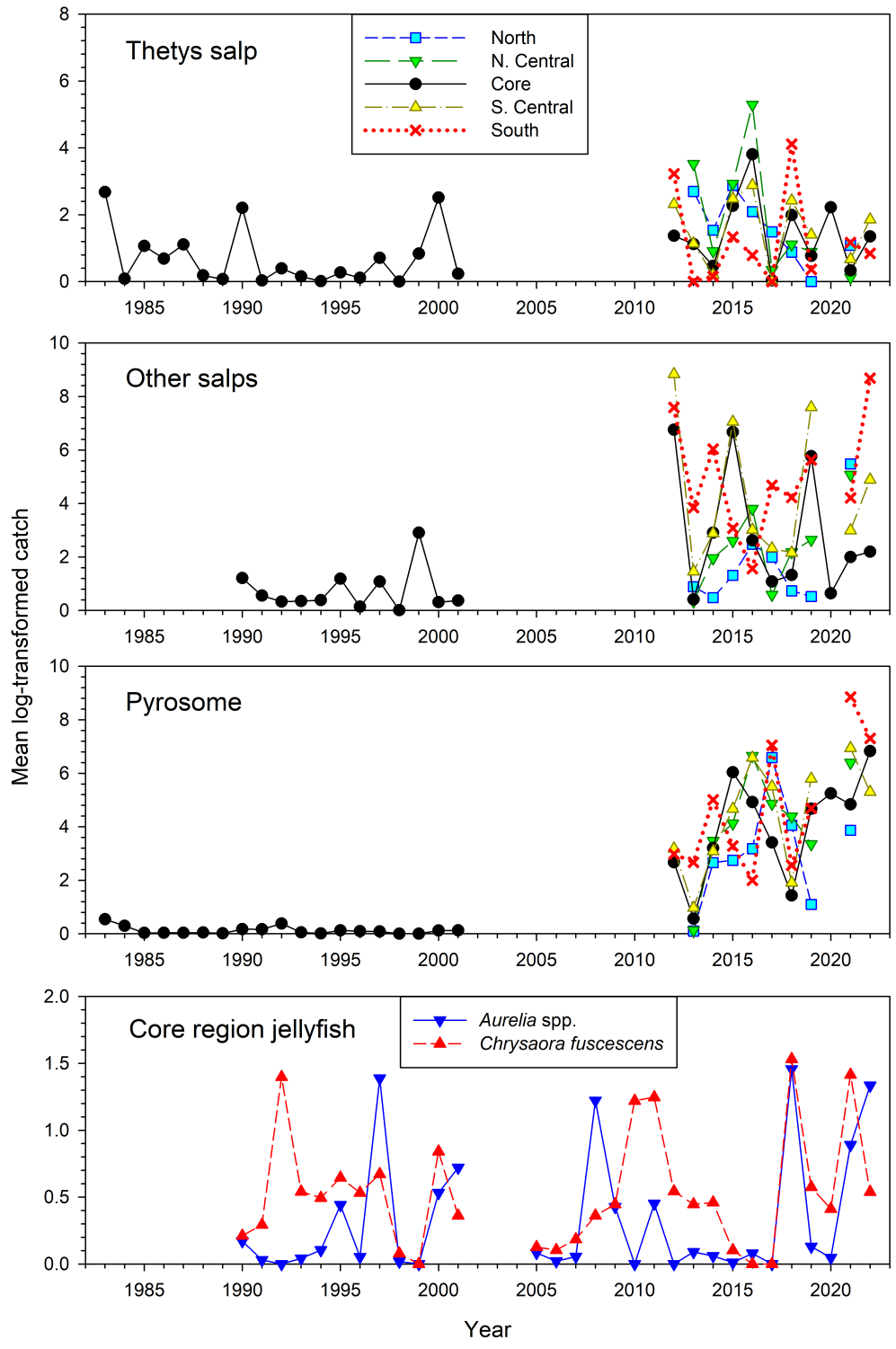


Appendix III: Annual catch summaries for select species/taxa off California

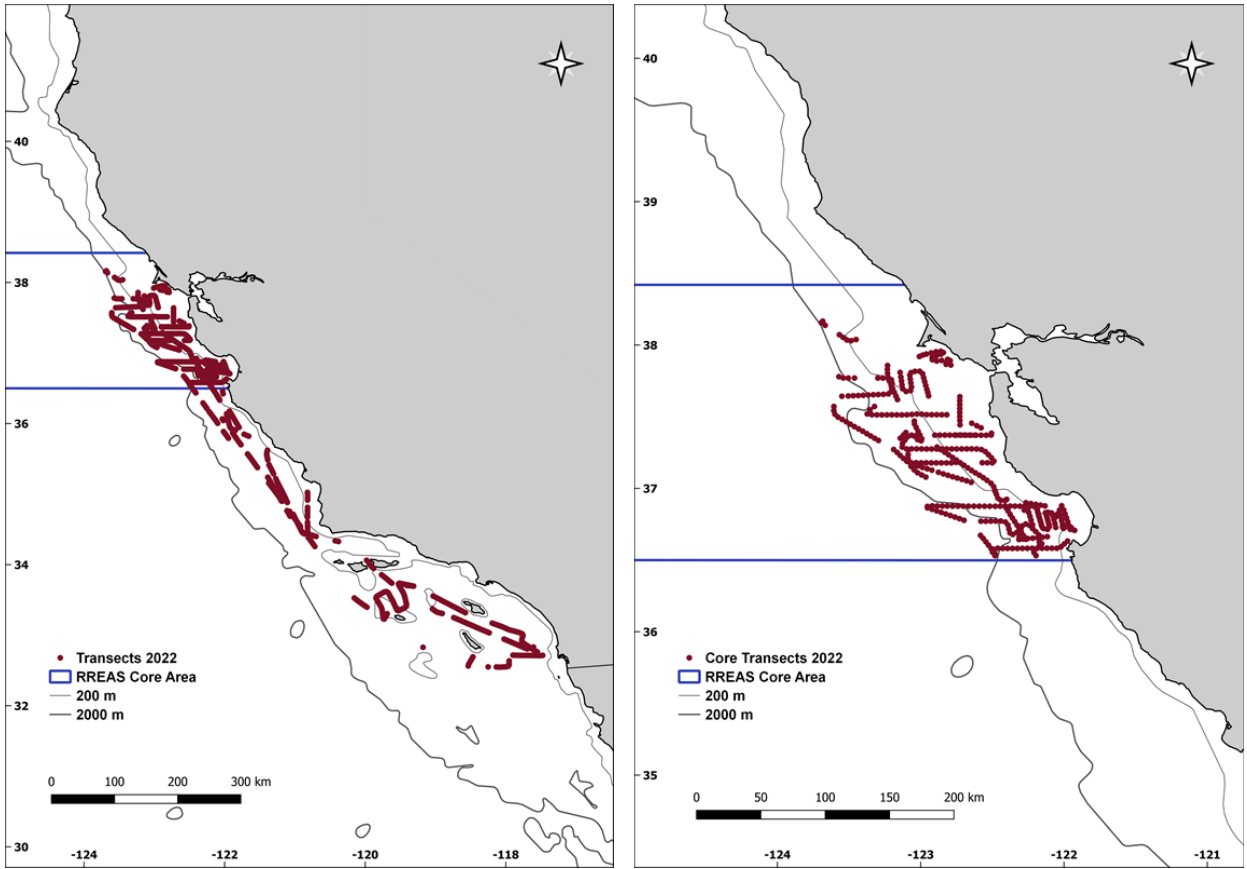








Appendix IV: Seabird and marine mammal transects for the full (left) and core (right) regions. Gaps usually reflect nighttime.



Appendix V: Summary of survey effort and seabird and marine mammal community statistics

2022	Core Area	Full Area
Survey vessel		<i>R/V Reuben Lasker</i>
Start date		5/19/2022
End date		6/15/2022
Number of survey days	12	21
Distance surveyed (km)	1,204	2,357
Area surveyed (km ²)	361	707
Number of bird species	30	45
Overall bird density (per km ²)	118.35	69.53
Total birds observed	42,747	49,155
Number of mammal species	12	18
Overall mammal encounter rate (per 100 km)	152.8	156.3
Total mammals observed	1,840	3,684

Appendix VI: Top five most numerous seabirds and marine mammals observed. For seabirds, cell values = total number of individuals seen / number of species sightings / average density (birds per km²) while for marine mammals cell values = total number of individuals seen / number of species sightings / average density (individuals per 100 km).

Common Name	Scientific Name	Core Region Standardized	Full Region
Sooty Shearwater	<i>Puffinus griseus</i>	28945/1117/80.14	33883/1751/47.93
Common Murre	<i>Uria aalge</i>	10989/1522/30.43	11051/1559/15.63
Pink-Footed Shearwater	<i>Puffinus creatopus</i>	151/106/0.42	755/320/1.07
Western Gull	<i>Larus occidentalis</i>	285/231/0.79	526/38 506 / 113 /
Red Phalarope	<i>Phalaropus fulicaria</i>	428/77/1.19	506/113/0.72

Common Name	Scientific Name	Core Region Standardized	Full Region
Northern Right Whale Dolphin	<i>Lissodelphis borealis</i>	1325/3/110	1346/6/57.1
Common Dolphin	<i>Delphinus delphis</i>		767/9/32.5
Short-Beaked Common Dolphin	<i>Delphinus delphis</i>		370/7/15.7
Humpback Whale	<i>Megaptera novaeangliae</i>	289/127/24	323/144/13.7
Pacific White-Sided Dolphin	<i>Lagenorhynchus obliquidens</i>	110/14/9.1	209/30/8.9