

ATTACHMENT C. Annual Program Status Summary Form (Revised 11.21.19)

1. Program Number:

19120114

2. Program Title:

Gulf Watch Alaska

3. Program Lead Name(s):

Mandy Lindeberg, NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories
(Program Lead)

Katrina Hoffman, Prince William Sound Science Center (Administrative Lead)

4. Time Period Covered by the Summary:

February 1, 2019 to January 31, 2020

5. Date of Summary:

March 2020

6. Program Website (if applicable):

www.gulfwatchalaska.org

7. Overview of Work Performed during the Reporting Period:

Program Introduction

This report summarizes Gulf Watch Alaska (GWA) program progress and achievements for FY19, monitoring year 8. The overarching goal of GWA is to provide sound scientific data and products that inform management agencies and the public of changes in the environment and the impacts of these changes on injured resources. The program has five primary objectives: (1) sustain and build upon existing time series in the *Exxon Valdez* oil spill (EVOS)-affected regions of the Gulf of Alaska (GOA); (2) provide scientific data, data products and outreach to management agencies and a wide variety of users; (3) develop science synthesis products to assist management actions, inform the public, and guide monitoring priorities for 20 years; (4) continue to build on collaborations between the GWA and Herring Research and Monitoring (HRM) programs, as well as other Trustee program focus areas, including Data Management; and 5) leverage partnerships with outside agencies and groups to integrate data and expand capacity through collaborative efforts. Program and project

operations have not changed and continue to add to the legacy of our long-term monitoring datasets and expanding our knowledge of the GOA ecosystem and its changing conditions.

A. Progress toward addressing hypotheses and achieving goals

The GWA program made substantive progress towards our objectives in FY19 (year 8), as noted in the brief summaries presented below.

1. Sustain and build upon existing time series in the EVOS-affected regions of the GOA

- All GWA monitoring projects successfully completed their planned surveys and added another year of data to their time series.
- FY19 was focused on synthesizing GWA time series for the science synthesis report that we submitted in draft form to the Exxon Valdez Oil Spill Trustee Council (EVOSTC) in December. For the report, principal investigators (PIs) contributed four manuscripts that evaluated changes observed throughout the ecosystem in response to the Pacific marine heatwave. In addition to exploring time series data collected as part of GWA, scientists from outside the program contributed data to several of the analyses. More about the science synthesis report is discussed below and under section 7B.

2. Provide scientific data, data products, and outreach to management agencies and a wide variety of users

- GWA program datasets for FY18 (year 7) are available through the Alaska Ocean Observing System (AOOS) Catalog through the Gulf of Alaska Data Portal. GWA project datasets from the first five years of the program are published to DataONE.
- During this reporting period the GWA program produced or participated in 24 peer-reviewed publications, 32 reports, 57 oral and poster presentations at conferences and workshops, 12 popular articles and one podcast, and 31 outreach media/events with the public.
- GWA Program Management Team (PMT) members and PIs participated in scientific conferences during FY19, including the following:
 - Ocean Sciences conference, San Diego, California, February 2019: GWA team members presented oral papers and posters.
 - PICES conference in Victoria, British Columbia, Canada in October 2019: GWA team members presented oral papers and posters.
 - Joint American Fisheries Society and The Wildlife Society Meeting, Reno, Nevada, October 2019: GWA team members presented oral papers.
 - Alaska Marine Science Symposium (AMSS), Anchorage, Alaska, January 2020: GWA team members presented oral papers and posters.
- Several GWA PIs took advantage of weather delays in Chenega to meet with school children and community members and present GWA program activities. Projects and scientists who presented include Forage Fish (19120114-C), Yumi Arimistu, Humpback Whale (19120114-

O), John Moran, and Killer Whales (19120114-N), Dan Olsen (see section 7C for additional information).

- GWA project data collected in FY19 (year 8) are generally on track for submission to the AOOS Gulf of Alaska data portal based on project requirements. In most cases, projects are meeting or exceeding expectations for data sharing and posting to the Research Workspace.
- Each year the GWA program includes two pages of content in PWSSC's annual outreach publication *Delta Sound Connections*. *Delta Sound Connections* is widely distributed throughout the PWS region, Anchorage, and beyond.
- GWA team members from U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and National Park Service (NPS) participated in events around past and current marine bird die-offs that led to statewide, national, and international media attention. See section 7E for more details.
 - GWA PIs led and supported publication of a paper on the common murre die-off during 2014-2016 (Piatt et al. 2020). GWA PI John Piatt (USGS), the lead author, responded to 22 media requests in response to a news release of the publication. The story was reported around the world (see Section 7E for more details). GWA co-authors included scientists from USGS, USFWS, NOAA, and NPS.
 - Multi-species marine bird die-offs occurred around the state, including the GOA, in 2019. Many of these die-offs occurred on NPS lands and NPS maintained a website for updates and issued press releases and articles to inform the public. The GWA Nearshore component provided data to the summaries maintained on the website.
- We continually update GWA's public website which is the primary location for users to find information about the program, recent activities, and access to datasets, reports, publications, news feeds, educational materials, monitoring projects, scientist profiles, and contacts.

3. Develop science synthesis products to assist management actions, inform the public, and guide monitoring priorities for the future

The main focus of science synthesis efforts in FY19 included: 1) completing the four synthesis manuscripts that integrate data across all three GWA components, HRM, and collaborators; 2) coordinating requests for two additional funding requests in FY19 work plans; and 3) providing time series indicators to NOAA's annual Alaska Ecosystem Status report and Ecosystem and Socioeconomic Profiles to support ecosystem-based fisheries management in the GOA (Shotwell et al. 2019, Zador et al. 2019).

- The GWA PMT coordinated efforts to complete the four main synthesis manuscripts that comprised our science synthesis report for the FY17-21 funding cycle. Although this report was a deliverable for the current 5-year funding cycle, we synthesized data and accomplishments from the beginning of GWA (Suryan et al. 2019b). The origin of GWA in 2012 was fortuitous in occurring 2 years prior to the onset of the Pacific marine heatwave in 2014 and, therefore, formed the basis of our synthesis efforts. While the effect of the marine heatwave on the GOA ecosystem was a logical focus of our synthesis efforts, we consider

these four manuscripts the foundation of continued future efforts that address mechanisms and longevity of this major ecosystem perturbation. The four synthesis manuscripts that we produced included varying amounts of cross-component data integration.

- Danielson et al. – “A study of marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells”. This manuscript is a collaborative effort between the Environmental Drivers and Nearshore component teams evaluating ocean temperature, incorporating sea surface and water column data from the open ocean to the intertidal zone of the GOA. Data sources included *in situ* bottom anchored, tide gauge, moored buoy, ship, and satellite observations (Danielson et al. 2019).
- Weitzman et al. – “Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska”. This manuscript compiled multiple data types collected under the Nearshore component across regions from PWS to the Alaska Peninsula to evaluate intertidal species responses to the Pacific marine heatwave (Weitzman et al. 2019).
- Arimitsu et al. – “Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave”. This manuscript incorporated data from GWA’s Environmental Drivers and Pelagic components and HRM to evaluate the role of forage species in the observed response to the marine heatwave by marine birds and mammals (Arimitsu et al. 2019).
- Suryan et al. – “Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska”. We used 113 biological time series in the initial model runs, ranging from intertidal organisms and zooplankton to forage fishes and whales to assess response of the GOA ecosystem to the Pacific marine heatwave (Suryan et al 2019a).
- Planning for longer-term syntheses for years 10-20 includes three additional efforts: i) developing time series indicators for the GOA ecosystem and stakeholder interests, ii) investigating ecosystem modeling efforts, and iii) filling gaps in current efforts that are needed to meet stakeholder interest.
- For the 2019 Ecosystem Status Report (Zador et al. 2019), investigators from all three GWA components (Environmental Drivers, Pelagic Ecosystem, and Nearshore Ecosystem) contributed 19 metrics. Contributors included: Batten (19120114-D, 3 metrics), Danielson (19120114-I, 3 metrics), Hatch/Arimitsu (19120114-C, 4 metrics), Moran/Straley (19120114-O, 1 metric), Hopcroft (19120114-L, 2 metrics), Campbell/McKinstry (19120114-G, 2 metrics), and Coletti et al. (19120114-H, 4 metrics). We also facilitated contributions by HRM (Pegau et al. 19120111, 3 metrics).
- The GWA Program Lead presented an overview of GWA monitoring and time series to the North Pacific Fisheries Management Council in Homer in October 2019.

4. *Enhance connections between GWA and HRM programs as well as other Trustee focus areas*

- GWA PMT and PIs worked collaboratively on monitoring activities including sharing of data, vessel time, and aerial survey time between GWA and HRM projects. For project-specific coordination and collaboration, see section 8A2a.
- GWA and HRM conducted June forage fish surveys in PWS.
- HRM PIs contributed to the GWA science synthesis report.
- The GWA Science Coordinator worked with HRM PIs to include HRM time series into the 2019 NOAA GOA ecosystem status report to the North Pacific Fisheries Management Council (NPFMC).
- The GWA PMT worked closely with the HRM Program Lead to plan and host a joint program annual meeting.
- GWA submitted a proposal to EVOSTC for lingering oil sampling (5-year sampling schedule) in FY20. This project was incorporated into the GWA program as a new component rather than through a separate program focus area.

5. *Leverage partnerships with outside agencies and groups to integrate data from broader efforts*

As the long-term GWA monitoring program has matured over time, opportunities to leverage partnerships and integrate data for broader efforts have expanded. Table 1 lists many of these efforts for each GWA project and their affiliated partners.

A major highlight for the GWA program lies with two GWA PIs who are also lead PIs on the National Science Foundation (NSF) funded northern GOA Long-term Ecological Research (LTER) program. This effort leverages, complements, and enhances overall GWA program activities. Together, GWA and the GOA LTER are the primary annual sampling efforts in the GOA and are major contributors to knowledge of ocean conditions and effects on biological resources.

Table 1. GWA program summary of leveraged partnerships with outside agencies and groups to integrate data from broader efforts.

GWA Project	Affiliated Partner(s)	Description
19120114-A-B	NOAA NMFS AFSC & NPFMC	Coordinate GWA contributions (19) to GOA Ecosystem Status Report for fisheries stock assessments
PWS Forage Fish19120114-C	NPRB/NOAA	Coordinating with GOAIERP PIs on synthesis of capelin in the GOA
PWS Forage Fish19120114-C	NPRB/OSU/ PWSSC/USGS	Providing forage fish and macrozooplankton samples for harmful algal bloom study
PWS Forage Fish19120114-C	USGS/BOEM	Complimentary study of forage fish and seabird trends in areas of oil and gas development in Cook Inlet

GWA Project	Affiliated Partner(s)	Description
CPR 19120114-D	NPRB	NPRB contributes funding at a similar annual level to that requested here, through NPRB's long-term monitoring program
CPR 19120114-D	Canada DFO	The Canadian Department of Fisheries and Oceans (DFO) contributes funding annually to PICES and in-kind support by providing laboratory facilities at the DFO lab in Sidney, BC. Plankton data are contributed to annual State of the Ocean reports
PWS Fall Winter Seabirds 19120114-E	ADF&G	ADF&G provides a vessel for a survey platform annually
PWS Fall Winter Seabirds 19120114-E	USFWS/USGS	Project data are uploaded to the North Pacific Pelagic Seabird Database (NPPSD), maintained by USFWS and USGS and made available to the scientific community for research and analysis
PWS Oceanography 19120114-G	USGS Marrowstone	Plankton samples used to test for fish disease life stages
PWS Oceanography 19120114-G	USGS/UW/ Northeastern	Proposing to add a discrete water sampler to the profiler
PWS Oceanography 19120114-G	USGS/ASC/ Boise State	Proposing to leverage GWA observations in the vicinity of tidewater glaciers
PWS Oceanography 19120114-G	OSU/NOAA Beaufort	Phytoplankton, fish, and shellfish samples being sent to OSU Hatfield Marine Science Center and NOAA Beaufort Laboratory for analysis of the prevalence of paralytic shellfish toxins in the marine foodwebs of PWS and Kachemak Bay
PWS Oceanography 19120114-G	NPRB	NPRB funding is used to evaluate high frequency observations of the secondary production cycle in PWS
PWS Oceanography 19120114-G	ADF&G	The project endeavors to conduct a spring cruise around the time of herring spawning to coordinate oceanographic data with ADF&G spawn survey data
PWS Oceanography 19120114-G	OSRI/UAF	Water samples collected to test the efficacy of additives designed to enhance microbial degradation of oil spills
Nearshore Ecosystems 19120114-H	NPS	Documenting variation in nearshore physical oceanography in relation to tidewater glacial input and quantifying biological responses to that variation across trophic levels in Kenai Fjords NP

GWA Project	Affiliated Partner(s)	Description
Nearshore Ecosystems 19120114-H	NSF/UAA/UAS	Examining how the timing, duration, and character of the freshwater flux from precipitation vs glacial melt influences nearshore biological communities at sites from southeast AK to Kachemak Bay
Nearshore Ecosystems 19120114-H	USGS & USFWS MMM	Katmai National Park and Preserve nearshore data include studies of the status of the southwest Alaska stock of sea otters, which is listed as threatened under MMPA; data are shared with USFWS MMM which has management responsibility for the species
Nearshore Ecosystems 19120114-H	NP Foundation/ USGS WERC/ASLC	The Changing Tides study examines the linkages between terrestrial and marine ecosystems and is based in Katmai National Park and Preserve
Nearshore Ecosystems 19120114-H	BOEM & NPS	Nearshore component PIs are developing recommendations to BOEM for nearshore community assessment and long-term monitoring related to the agency's OCS leasing program in lower Cook Inlet
Nearshore Ecosystems 19120114-H	CMI/BOEM/NPS	Analyzing food web structure in western Cook Inlet and Kachemak Bay
Nearshore Ecosystems 19120114-H	NPS	Collaborating on the Pacific Nearshore Project to assess the overall health of nearshore ecosystems across the north Pacific
GAK1 19120114-I	ADF&G	Data made available to ADF&G for salmon forecasting
GAK1 19120114-I	NPS	Establishing monthly sampling data and processing protocol in Glacier Bay national Park and Preserve
GAK1 19120114-I	AOOS	Data are used for ocean acidification monitoring at a surface buoy near GAK1
GAK1 19120114-I	NSF/IOOS	Project is part of the Northern GOA LTER program
LCI/KBay Oceanography 19120114-J	NOAA Beaufort Lab	Project phytoplankton data used to identify environmental triggers for increases in <i>Alexandrium</i> that causes PSP
LCI/KBay Oceanography 19120114-J	NOAA NMFS	Provide data for the Kachemak Bay Habitat Focus Area
LCI/KBay Oceanography 19120114-J	NOAA NMFS Protected Resources	Provide data for whale and sea lion mortalities in Cook Inlet
LCI/KBay Oceanography 19120114-J	ADF&G/ADEC/ ADHSS	Provide real-time data and historical trends on water temperature to shellfish managers related to harmful algal blooms

GWA Project	Affiliated Partner(s)	Description
LCI/KBay Oceanography 19120114-J	USFWS	Provide vessel platform for opportunistic seabird/marine mammal observers, coordinate on sea otter stranding and sampling, and coordinate with Alaska Maritime NWR on seabird and sea otter mortality events
LCI/KBay Oceanography 19120114-J	NPRB & OSU/ NOAA Beaufort	Phytoplankton, fish, and shellfish samples being sent to OSU Hatfield Marine Science Center and NOAA Beaufort Laboratory for analysis of the prevalence of paralytic shellfish toxins in the marine foodwebs of PWS and Kachemak Bay
LCI/KBay Oceanography 19120114-J	AOOS	The need for routine oceanic observations in Cook Inlet and Kachemak Bay has been identified as a high priority in regional workshops and stakeholder meetings
Seward Line 19120114-L	ADF&G	Data are made available to ADF&G for salmon forecasting
Seward Line 19120114-L	NPRB/AOOS	Multi-disciplinary sampling program that represents the most comprehensive long-term dataset available for the northern GOA
Seward Line 19120114-L	NSF	Project is part of the Northern GOA LTER program
Seward Line 19120114-L	USFWS	Provide vessel platform for seabird/marine mammal observers
Seward Line 19120114-L	NOAA	Provide bongo collections for larval fish assessments
Summer Seabirds 19120114-M	USFS/NPS/ADF&G	Data inform management agencies with lands and waters adjacent to the study area
Summer Seabirds 19120114-M	Alaska Maritime NWR	Data on population trends are provided for inclusion in annual reports on status and trends of seabirds in Alaska
Killer Whales 19120114-N	NOAA NMML	Data are supplied annually to NOAA NMML for application in marine mammal stock assessments
Killer Whales 19120114-N	NOAA Northwest Region	Collaborate on research for the endangered Southern Resident killer whale population
Killer Whales 19120114-N	Canada DFO Pacific Biological Station	Collaborate on research for the endangered Southern Resident killer whale population
Humpback Whales 19120114-O	NOAA PRD	Data from this project will be implemented into the de-listing monitoring plan for humpback whales and builds on data collected on humpback whales in southeast Alaska

GWA Project	Affiliated Partner(s)	Description
Humpback Whales 19120114-O	NOAA NMFS	Draft Biological Report for the Proposed Designation of Critical Habitat for the Central America, Mexico, and Western North Pacific Distinct Population Segments of Humpback Whales
Humpback Whales 19120114-O	NOAA NMML	Collect eDNA from harbor porpoise to identify stock structure
Humpback Whales 19120114-O	ADF&G	Photograph Steller sea lion brands whenever possible, re-sightings used to identify movements and survival rates
Humpback Whales 19120114-O	IWC Comp. Assess. Working Group	Used to inform the population structure model for the IWC's Comprehensive Assessment.
Humpback Whales 19120114-O	Happywhale	Contribute to worldwide humpback whale database
Humpback Whales 19120114-O	Alaska Whale Foundation/UH Manoa	Provide data on humpback whale populations in the GOA

All GWA program-level measurable tasks have been completed for FY19 (year 8; Table 2).

Table 2. Measurable GWA program tasks completed in FY19.

FY19 Measurable Program Tasks	Status
Conduct quarterly program teleconferences	Completed
Submit annual reports for FY18 and semi-annual NOAA report	12 annual project reports and 1 program report submitted March 2019; Program Management I and II annual reports were combined per EVOSTC request
Updates to program website	Ongoing
Submit annual program work plans and semi-annual NOAA report	Completed and submitted August 2019; responded to Science Panel comments September 2019
Participate in EVOSTC annual Public Advisory Committee meeting	Fall meeting postponed by EVOSTC for lack of a quorum
PI data compliance on workspace	Projects are meeting or exceeding expectations for data sharing
Contributions to NOAA Ecosystems Status Report for the GOA	19 GWA metrics used in 2019 report
Present to EVOSTC Trustees	Presentation on October 11, 2019
Annual PI meeting and program review	Completed October 8-9, Homer

FY19 Measurable Program Tasks	Status
Presentation of GWA projects at AMSS; sidebar meeting with PIs	Completed. PIs, team members, and partners presented 4 oral presentations and 16 posters, January 2020; GWA team meeting held on January 29, 2020

B. Noteworthy issues and findings within the GWA program and projects

This section provides brief project-level highlights. Please refer to FY19 project annual reports for more detail. Projects are listed by component (administration, environmental drivers, pelagic, and nearshore).

Integrated Program Management and Administration

Program coordination & science synthesis (19120114-A) (Program Management I; or PMI)

Mandy Lindeberg, Rob Suryan, and Donna Aderhold, NOAA Auke Bay Laboratories

Program administration, logistics, & outreach (19120114-B) (Program Management II; or PMII)

Katrina Hoffman, Prince William Sound Science Center (PWSSC)

- The GWA PMT coordinated efforts to complete the four main synthesis manuscripts that comprised our science synthesis report for the FY17-21 funding cycle (Suryan et al. 2019b) and plan for the February 2020 science synthesis workshop.
- The PMT facilitated quarterly GWA program team meetings during FY19. All meetings were coordinated in communication with the HRM program lead.
- The PMT coordinated submission of 13 FY20 project work plans and a comprehensive program budget workbook. This included an additional work plan for lingering oil sampling. The PMT also submitted a GWA FY20 program work plan.
- The PMT compiled and reviewed all FY18 annual reports. We continue efforts to standardize format and content of reports and work plans to help improve efficiencies in GWA PI reporting efforts and EVOSTC review. We also compiled and edited replies to EVOSTC and science panel review comments on the FY18 annual reports and FY20 work plans.
- The PMT distributed the *Quarterly Currents* newsletter to EVOSTC staff, science panel members, public advisory committee members; GWA outreach steering committee members; and sponsoring agency public relations personnel. We expanded distribution of the newsletter to include interested staff and board members of the PWS and Cook Inlet Regional Citizens' Advisory Councils. All *Quarterly Currents* newsletters are available publicly on the GWA website (<https://gulfwatchalaska.org/resources/quarterly-currents-newsletter/>).
- The PMT continues working with project PIs to identify signature time series that best indicates the state of their part of the GOA ecosystem.

- The PWSSC extended contract amendments to all the non-Trustee Agency sub-awardees for the third year of this grant, FY19 and submitted semi-annual reports to NOAA in both March and August 2019.
- We continue to make updates to the website www.gulfwatchalaska.org. Blog posts regularly updated program announcements such as significant publications, media attention related to the program.
- Each year the GWA program includes two pages of content in PWSSC's annual outreach publication *Delta Sound Connections*. *Delta Sound Connections* is widely distributed throughout the PWS region, Anchorage, and beyond.
- The GWA PMT coordinated regular, frequent communication with the HRM Program Lead to ensure ease of coordination and synthesis between the two programs.

Environmental Drivers Component

GOA mooring (GAK1) (19120114-I)

Seth Danielson and Tom Weingartner, University of Alaska Fairbanks (UAF)

- PI Danielson led a chapter of the GWA synthesis report focused on temperature (Danielson et al. 2019). Significant findings from the chapter include the following:
 - Large-scale modes of climate variability explain only a modest fraction of coastal GOA thermal anomalies.
 - Satellite measures of sea surface temperature (SST) miss 30-40% of the daily anomaly at GAK1.
 - Fidelity of satellite-based measures of SST vary spatially, with better performance offshore and degraded performance nearshore in regions of complex bathymetry (e.g., southeast Alaska archipelago, PWS).
 - Co-variability of SST depends on frequency band of interest and on separation distance between any two stations. Hence, the value of GAK1 as a proxy for other sites depends on time scale of interest and distance.
 - GAK1 is well representative of a dominant portion of the whole northern GOA shelf.
 - SST is not a strong predictor for near-bottom temperatures at four representative long-term monitoring conductivity and temperature at depth (CTD) sites in the coastal GOA (Kachemak Bay KB6, GAK1, PWS KIP2 and Glacier Bay GLBA20).
 - GAK1 SST is inversely correlated with near-bottom temperatures at the shelf break.
 - The Pacific marine heatwave set up with anomalous air-sea heat flux in 2013. Heating continued over the northern shelf through 2014 and 2015.
 - The majority of heat in the 250-m water column at GAK1 is carried by oceanic advection rather than local heating through the surface. Hence, near-bottom warming is delayed relative to heating at the surface.

- During the 2014-2016 Pacific marine heatwave, far offshore waters warmed most rapidly and then cooled beginning in early 2014, while nearshore waters warmed more slowly and with fairly tight synchrony through 2014, cooled in early 2015 and then warmed again through 2016.

Seward line (19120114-L)

Russ Hopcroft, Seth Danielson, and Kenneth Coyle, UAF

- In 2019, the Seward Line program continued its expanded spatial extent, with the additional mid-summer cruise added by the NSF's Northern GOA LTER support.
- During May surface temperatures were roughly between 6.5-7.0°C, with temperatures averaged across the upper 100 m of the Seward Line 0.6°C above the 22-year mean. By July, surface temperatures had warmed to 14-15°C (and even warmer to the east), and the Alaska Coastal Current has begun to intensify by spreading across the shelf to at least the shallow ridge at GAK6. Although cooling has typically begun by September, during 2019 temperatures remained warm (12-13°C).
- Spring 2019 integrated (0-75 m) chlorophyll-a concentrations were generally low except on the inner Seward (GAK) line where large cells dominated, in association with the Alaska Coastal Current.
- Biomass of microzooplankton (cells $\geq 15 \mu\text{m}$ in largest dimension) along the Seward Line was generally higher in May and September than in July. Overall, the 2019 microzooplankton community was quite ciliate-rich, a community structure associated with anomalously warm conditions and phytoplankton communities dominated by small cells.
- Sample analysis for 2019 continues and is suggesting a shift from a dominance by *Neocalanus plumchrus*, to co-dominance with *N. flemingeri* during May, with their combined numbers of this keystone lipid-rich species above normal. There was a return to high numbers southern copepods during 2019, particularly for the September cruise.
- The six 2018-19 Seward Line / LTER cruises allowed us to observe seasonal progression of spatial hot spots of bird abundance over two years. Moderate numbers of birds occurred over the bank in July 2019, and low numbers were seen in April 2018. Birds were also concentrated in Lower Cook Inlet, especially during the fall.

Oceanographic conditions in PWS (19120114-G)

Rob Campbell, PWSSC

- Temperatures in central PWS have been above average since late 2013, as has been observed elsewhere in the GOA.
- Analysis of 2010 to 2018 zooplankton samples suggests that there was a shift in zooplankton taxa in PWS during the marine heatwave years. A shift back towards increased cool water species and decreased warm water species occurred in 2018.

Oceanographic conditions in Lower Cook Inlet/ Kachemak Bay (19120114-J)

Kris Holderied and Steve Baird, NOAA Kasitsna Bay Laboratory and University of Alaska Anchorage (UAA)/Kachemak Bay National Estuarine Research Reserve (KBNERR)

- Since October 2018, Kachemak Bay water temperatures have been warmer than the long-term average, with anomalies of up to 2°C, and averaging near 1°C. These anomalies were very similar to the anomalies during the anomalously warm period from 2014-2016.
- In 2018 the average monthly phytoplankton cell abundance was much lower than previous observations; a pattern that persisted through the usual summer bloom timeframe.
- We did not see high abundances of *Alexandrium* in 2019 and subsequently, toxin levels were also low in our phytoplankton samples and were similar to abundances in PWS. Toxicity levels in forage fish were low, with only a few samples exceeding the Food and Drug Administration limit for safe consumption, and were from Dolly Varden, Pacific sand lance, and Pacific herring.

Continuous plankton recorder (CPR) (19120114-D)

Sonia Batten, Marine Biological Association and Robin Brown, North Pacific Marine Science Organization

- Preliminary analyses of 2019 data suggest that the plankton resemble conditions during the recent marine heatwave.
- Other evidence showing the plankton were experiencing warm conditions in 2019 include a smaller than average mean size of copepods (i.e., smaller species were more abundant) and the high abundance of a particular copepod species indicative of warmer conditions (*Calanus pacificus*).
- These results suggest that the marine heat wave impacts continue to be felt (or are re-occurring) and are influencing the lower trophic levels. This is likely to have impacts on ecosystem functioning.

Pelagic Component

Long-term killer whale surveys (19120114-N)

Craig Matkin and Dan Olsen, North Gulf Oceanic Society

- In 2019, all 7 of the AT1 (Chugach) transients were identified. The youngest female is estimated to be 45 years old and is likely beyond reproductive age.
- We had encounters with most of the major resident pods that are monitored for our population dynamics work, with the notable exception of AB pod. We have no way of knowing if there have been mortalities in the missing AB matriline although some mortalities are likely to have occurred due to the ages of matriarchs as well as the ages of their sons.

- The trend toward splitting of pods on either a temporary or permanent basis has continued along the same maternal lines as in recent years. This may reflect a more challenging feeding environment (e.g., fewer numbers of fish/smaller school size) that favors hunting in smaller groups.
- As a non-invasive and year-round alternative to tagging individuals, we are maintaining acoustic monitoring stations in areas important to southern Alaska resident killer.
- We continue to collect both scales and flesh from sites of predation by resident killer whales in addition to collecting fecal samples when possible for diet studies.
- The initial fecal results, although from a small number of samples, suggest Chinook and chum salmon as important prey during the May, June, and September.

PWS marine bird surveys (19120114-M)

Kathy Kuletz and Robert Kaler, USFWS

- The PWS marine bird survey is conducted in July of even years (2018, 2020), thus no field work was conducted in 2019.
- We completed processing the 2018 marine bird survey data, data were archived and posted to the Research Workspace portal, and metadata were updated.
- Results from summer marine bird status and trends from 1989 to 2018 demonstrated overall downward trends, with the exception of increases in abundance of pelagic species like storm-petrels, jaegers, and murre, whereas nearshore species (e.g., harlequin duck, pigeon guillemot and scoters) declined in 2018.

Forage fish distribution and relative abundance (19120114-C)

Mayumi Arimitsu and John Piatt, USGS Alaska Science Center

- PI Arimitsu led a chapter of the GWA synthesis report focused on the role of forage species during the marine heatwave (Arimitsu et al. 2019). Significant findings from the chapter include the following:
 - Capelin and sand lance occurrence in predator diets declined abruptly.
 - PWS herring spawning biomass declined to historically low levels.
 - Biomass of euphausiids was reduced, in part due to the loss of a cold-water zooplankton species.
 - Changes in age structure, growth, and energy content of capelin, sand lance, and herring were also associated with warming during the heatwave.
 - Spawning capelin grew faster and matured at a younger age but were shorter in length than usual, while sand lance in PWS experienced anomalously low growth rates and lipid storage in 2015-2016.

- Changes in forage fish populations had immediate impacts on predator populations in 2015-2016, when seabirds and marine mammals experienced shifts in distribution, mass mortality, and reproductive failures in the GOA.
- In contrast, some indices of lower trophic level abundance increased during the heatwave.
- The persistent marine heatwave coincided with the collapse of multiple forage fish populations. This reduced the efficiency of energy transfer through the middle trophic level of pelagic food webs, disrupting energy flow to higher vertebrate predators and causing catastrophic reductions in their numbers and productivity.
- In September 2019, we conducted the integrated predator prey (IPP) survey in collaboration with the humpback whale (19120114-O) and fall/winter marine bird surveys (19120114-E). A key finding was that the acoustic macrozooplankton biomass index was greater than any year since 2014.
- The June aerial surveys and boat-based validation for herring and other forage fish occurred in PWS from June 3-28, 2019. The data from 2010-2019 show there were peaks in forage density during June 2013 and 2017, mainly attributed to schools identified as age-1 herring. These peaks correspond with unusually high proportion (>3-4 times the average over the same time period) of age-1+ herring in seabird diets.
- Despite a return of marine heatwave conditions during our 2019 summer acoustic-trawl survey, we encountered adult capelin in trawls for the first time in several years.

Humpback whale predation on herring (19120114-O)

John Moran and Jan Straley, NOAA NMFS Auke Bay Laboratory and University of Alaska Southeast (UAS)

- We did not see a recovery in whale numbers during the spring survey, however, we did see an increase in fall numbers when compared to 2017 and 2018.
- The reduction of humpback whales is related to a decline in the biomass of herring in PWS.
- Humpback whale calf production continues to remain low within PWS, supporting the hypothesis that the reduction in whale numbers is nutritionally based.
- There may have been a shift in the zooplankton species composition during 2019 to *T. spinifera* and *E. pacifica* replacing the typical common species (*T. longipes*, *T. inermis*, and *T. raschii*) seen before the 2105 marine heatwave.
- Young of the year herring continued to be targeted by humpback whales as well as minke whales in 2019. These small schools, usually less than 0.5 m in diameter, are low quality prey that may incur higher foraging cost when compared to large shoals of adult herring.
- We found a strong correlation between the numbers of individual whales identified each year in PWS. In September of 2019, the majority of whales observed appeared to be feeding on euphausiids with a few targeting schools of juvenile rather than adult herring.

Fall and winter habitat use and distribution of seabirds in PWS (19120114-E)

Mary Anne Bishop, PWSSC

- During the November 2019 survey, unusual observations included a large group of shearwaters (~300) in Montague Strait. These shearwaters may be responding to the warming conditions in the Gulf by shifting their distributions nearshore in search of food, similar to how murrelets responded during the heatwave of 2014-2016.
- During the 2019 IPP cruise, we recorded the highest number of forage flocks and the highest number of forage flock-whale interactions so far for IPP surveys.
- We are examining the use of ecosystem indicators to understand the influence of environmental variability on marine bird populations in PWS.

Nearshore Monitoring Component

Nearshore systems in the GOA (19120114-H)

Heather Coletti, Daniel Esler, Kim Kloecker, Dan Monson, Ben Weitzman, Brenda Konar, and Katrin Iken, NPS, USGS Alaska Science Center, and UAF

- PI Weitzman led a chapter of the GWA synthesis report focused on rocky intertidal community structure (Weitzman et al. 2019). Significant findings from the chapter include the following:
 - During the marine heatwave, similarities in community structure increased across regions due to a Gulf-wide decline in macroalgal cover, driven mostly by a decline in the rockweed, *Fucus distichus*, and fleshy red algae.
 - This loss of macroalgae produced an increase in open space in the intertidal, which was followed by a successional sequence of an increase in barnacle cover in 2016, mussel cover in 2017, and a slow return of *Fucus distichus* cover in 2018 and 2019.
 - The marine heatwave had Gulf-wide impacts to the structure of rocky intertidal communities, which continued after the initial marine heatwave had dissipated in 2017.
- Our nearshore temperature data confirm that the physical manifestations of the large-scale heatwave event were expressed in nearshore ecosystems. These data contributed to the Environmental Drivers component synthesis paper evaluating coherence of water temperatures across the central GOA (Danielson et al. 2019).
- Sea star abundance in 2016 began to decline due to the sea star wasting disease epidemic and remained strongly negative across all regions during the marine heatwave, with trends towards potential recovery evident in 2019 (Konar et al. 2019).
- We examined spatial and temporal patterns of variation in the diet of black oystercatcher chicks in the northern GOA. Our findings suggest that while diet has been relatively consistent over time and among regions, local variation at the site level influences patterns of prey composition in black oystercatcher populations.

- In contrast to the black oystercatcher, variation by region is evident in the proportion of prey types in the diet of sea otters.
- In 2018, we collected mussels for analysis of a broad suite of contaminants across all four regions. Preliminary results indicate that there are no contaminants concerns at this time within our study areas.

C. Community involvement/traditional ecological knowledge (TEK), and resource management

The FY17-21 proposal included two information exchanges with communities within the spill-affected region to share scientific observations and local knowledge. One exchange was held in FY18 in the Kachemak Bay village of Port Graham, with additional information sharing as part of a program with Chugachmiut in Homer. Our second information exchange of FY17-21 will occur in FY20 with a community in PWS.

The GWA PMT and project PIs continually seek opportunities for community involvement. During FY19, this included visits by two field crews to Chenega and one to Seldovia.

GWA PIs engage regularly with resource management, and as the program's time series grows longer, data will become more and more relevant to resource management. FY19 resource management engagement included contributions to 16 different efforts of federal and state agencies and universities ranging from ecosystem indicators for fishery stock assessment to harmful algal blooms, salmon forecasting, protected resources, and long-term ecological research sites.

Please see sections 7A and B, 8C, and 9 for further details on the GWA program's involvement with communities and resource management agencies and organizations.

D. Known problems or unusual developments

The GWA program has no known problems or unusual developments to report at this time. We appreciate the EVOSTC's recognition of and response to funding concerns and temporary setbacks due to federal government shutdowns.

E. Other significant information pertinent to the GWA program

GWA program data and PIs were included in significant publications and outreach activities during FY19 that reached broad audiences.

On January 15, 2020 the journal PLoS ONE simultaneously published and issued a press release for the paper "Extreme mortality and reproductive failure of common murrelets resulting from the northeast Pacific marine heatwave of 2014-2016" (Piatt et al. 2020). GWA PI John Piatt was the lead author and several other GWA PIs and team members were co-authors. Piatt responded to 22 media requests in response to the news release and publication. Outlets include Science News, InsideClimate News, Associated Press, New Scientist, Los Angeles Times, Mother Jones, Anchorage Daily News, Alaska Public Media, OPB Oregon Public Broadcasting, The Oregonian (OregonLive), ABC Australia, Austria 1 Radio, Agence France-Presse, KQED San Francisco Public TV and Radio, G1 News Brazil, and more. Ninety other outlets picked up the story via news releases including the New York Times, Washing Post, and BBC News. In addition, PIs John Piatt and

Mayumi Arimitsu provided interviews for a Science Magazine article on the effects of the ‘Blob’ on marine ecosystems. Arimitsu also provided *Last Chance Endeavors, Inc.* with an interview for a podcast about whale prey, forage fish, and seabird die offs.

During 2019, multi-species marine bird die-offs occurred around the state, including the GOA. Many of these die-offs occurred on NPS lands and NPS maintained a website for updates and issued press releases and articles to inform the public. The GWA Nearshore component provided data to the summaries maintained on the website. The seabird die-offs also received coverage on several television and radio networks. The National Park Service also covered GWA nearshore related highlights through their social media outreach. Twenty-six Facebook posts reached thousands of viewers.

2019 was also a big year for the GWA program supporting educational opportunities. GWA PIs mentored 30 students from a variety of universities and programs (Table 3).

Table 3. Summary of GWA PIs that were mentoring students associated with their projects in FY19.

Count	Degree	Affiliation	Topic	Mentor/Advisor
1	Undergrad intern	PEP (UAS/NOAA)	Humpback whales - isotopes	Moran
1	REU	NGA LTER (NSF)	Circulation, FW dist.	Danielson
1	BLAST student	UAF CFOS	Clam populations	Konar/Weitzman
1	Undergrad intern	UAF CFOS	Mussel size frequency	Konar/Iken
1	MS	UAF CFOS	Mussel demographics	Konar/Iken/Weitzman
6	Various	UAF CFOS	Misc. intertidal sampling	Konar/Iken
1	MS	UAF CFOS	Sea star wasting disease	Konar
1	MS	NGOS/UAF	Killer whale acoustics	Matkin/Olsen/Konar
1	Undergrad intern	NGOS	Hydrophone data sorting	Olsen
1	Undergrad intern	NGOS	Programing, data input	Olsen
1	Undergrad intern	NGOS	GIS, archiving data, field	Olsen
1	ANSEP intern	USGS	Lab & fieldwork	Arimitsu
1	Undergrad intern	UAS	GWA-HRM aerial survey	Arimitsu

Count	Degree	Affiliation	Topic	Mentor/Advisor
1	Undergrad intern	NOAA Hollings	Visualizing nearshore data	Holderied
1	Undergrad intern	NOAA Hollings	Nearshore fish	Konar/Holderied
1	Undergrad intern	American Acad. Sci.	Nearshore communities	Konar
1	MS	UAF CFOS	Intertidal communities	Iken/Konar/Lindeberg
1	MS	UAF CFOS	Freshwater pathways	Iken
1	MS	UAF CFOS	Stratification	Iken
1	MS	Simon Fraser Univ.	Black oystercatchers	Esler/Coletti/Robinson
1	MS	Simon Fraser Univ.	Marine birds	Esler
1	Undergrad intern	Alaska Pacific	Mussels	Esler/Coletti/Robinson
1	MS	UAS	Sea otters	Esler
1	Undergrad intern	Alaska Pacific	Sea otters	Kloecker
1	Undergrad intern	Alaska Pacific	Sea otters	Kloecker

8. Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

The GWA program continues to deepen coordination among projects and programs to strengthen collaboration. Summaries are provided here. For additional descriptions of collaborative efforts, please see the individual project reports.

A primary focus of the overall program in FY19 was collaboration among projects and components to prepare the draft science synthesis report that was submitted to EVOSTC in December 2019 and prepare for the science synthesis workshop with EVOSTC staff and science panel members in February 2020 (FY20 activity that required planning during FY19). The synthesis report included an executive summary providing an update on injured species status and recommendations for the next five years of long-term monitoring funding by EVOSTC and four synthesis chapters. The chapters focused on aspects of the Pacific marine heatwave and the implications of ecological perturbation on injured resources: temperature variations in the GOA, changes in rocky intertidal community structure, synchronous collapse of pelagic forage species, and ecosystem response.

EVOSTC funding to the Seward Line project (PI Hopcroft, project 19120114-L) is allowing the collection and processing of discrete nutrient, chlorophyll and zooplankton samples at GAK1 (PI Danielson, project 19120114-I). We provide the GAK1 survey vessel as a platform-of-opportunity to Hopcroft's GAK1 sampling and have now assembled an annual cycle of this multi-disciplinary sampling. When possible, we leverage the occupation of GAK1 by LTER and GWA Seward Line cruises. In the past, this occurred in spring and fall year and now this occurs in summer as well.

The additional monthly Seward Line sampling in Resurrection Bay and at GAK1 provide oceanographic context for the Nearshore activities underway within Kenai Fjords National Park (PI Coletti, project 19120114-H). The new sampling line added through NSF LTER funding now connects seabird work at Middleton Island (PIs Arimitsu and Piatt, project 19120114-C) into the Environmental Drivers sampling domain.

The inclusion of a marine bird and mammal observer aboard the Seward Line and LTER surveys in spring and fall provides direct connections to the Pelagic component projects of GWA (PIs Kuletz and Kaler, project 19120114-M, and PI Bishop, project 19120114-E).

The Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 19120114-J) provides information on seasonal and inter-annual patterns in water temperature, stratification, freshwater content and nutrients to the GWA Nearshore component PIs (PI Coletti, project 19120114-H) to assess drivers of intertidal ecosystem changes at their Kachemak Bay sites. We also collaborated with Seth Danielson and Dan Monson on the science synthesis report chapter on temperature.

Staff for the PWS oceanography project (PI Campbell, project 19120114-G) provide zooplankton identification for the Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 19120114-J) and the two projects collaborate on analyses for a greater ability to compare data across regions.

Beginning in FY19, the PWS oceanographic project (PI Campbell, project 19120114-G) and fall/winter marine birds project (PI Bishop, project 19120114-E) share a vessel for November and March surveys. In addition to sharing a research platform, these surveys will enable us to evaluate patterns in marine bird abundance and distribution in juvenile herring bays relative to *in situ* measurements of sea surface temperature and zooplankton abundance.

The CPR project (PI Batten, project 19120114-D) provides plankton indices as updates to Dr. Pegau (annual anomalies, incremented abundance time series). A current focus is on spring/early summer plankton abundances as a contributing factor to herring recruitment success.

The killer whale project (PI Matkin, project 19120114-N) and humpback whale project (PIs Moran and Straley, project 19120114-O) collect whale identification photos and encounter data and share data between projects as possible during surveys. Both projects share photographs to the Happywhale project (<https://happywhale.com/home>) examining population and distribution of humpback whales in the North Pacific.

The killer whale (PI Matkin, project 19120114-N) and PWS oceanography (PI Campbell, project 19120114-G) projects work cooperatively to deploy a Soundtrap hydrophone on PWS oceanographic moorings as additional data for killer whale acoustic monitoring efforts.

Three pelagic projects, forage fish (PIs Arimitsu and Piatt, project 19120114-C), fall/winter marine birds (PI Bishop, project 19120114-E), and humpback whales (PIs Moran and Straley, project 19120114-O) share a research platform and common goals to conduct the IPP surveys each fall in PWS. In addition, the humpback whale project collects samples for the forage fish project in April.

Summer forage fish surveys (PIs Arimitsu and Piatt, project 19120114-C) and information regarding Middleton Seabird diets and PWS acoustic-trawl surveys also provide a means to understand trends in piscivorous marine birds (PIs Kuletz and Kaler, project 19120114-M).

Collectively, marine bird surveys cross all seasons and survey regions of GWA and allow for regional comparisons of marine bird densities and environmental drivers from PWS (PIs Bishop, 19120114-E, Kuletz and Kaler, project 19120114-M) to Kachemak Bay/Lower Cook Inlet (PIs Holderied and Baird, project 19120114-J), PWS, Kenai Fjords, Kachemak Bay, and Katmai (PI Coletti, project 19120114-H), and Seward Line/Gulf of Alaska (PIs Hopcroft and Kuletz, project 19120114-L).

2. Across Programs

a. Herring Research and Monitoring

GWA considers HRM a sister program with frequent coordination and collaboration. The GWA PMT coordinates regularly with the HRM program. The HRM Program Lead is invited to all GWA meetings and teleconferences. The fall 2019 HRM program PI meeting was held in Homer one day after, and at the same location as, the two-day GWA PI meeting to facilitate cross-program learning and synthesis, as well as economize on data management training opportunities with Axiom staff. The GWA Science Coordinator facilitated coordination and collaboration on the science synthesis report between GWA and HRM. HRM data were used and HRM PIs are included on two of the GWA science synthesis report chapters (see section 9A2). On the administrative side, all non-Trustee Agency administrative functions are combined at PWSSC to serve both the GWA and HRM programs.

The HRM program tagging project (PI Bishop, project 19160111-B) provided a POST array acoustic tag recorder for deployment on the GAK1 mooring (PI Danielson, project 19120114-I). The first recovery of this instrument will take place in March 2020 and a replacement instrument will be deployed at this time.

The Seward Line (PI Hopcroft, project 19160114-L) makes physical and biological data available to the HRM program.

Technicians from HRM project 19160111-B (Annual Herring Migration Cycle) have participated in surveys done by the PWS oceanography project (PI Campbell 19120114-G) to upload data from the tracking arrays in Hinchinbrook Entrance and Montague Strait and to

recover/deploy receivers in other locations in PWS. A receiver was also installed on the profiling mooring in 2019 to further extend the reach of the array. The receiver did detect a herring tagged in 2019 during the deployment and will be re-deployed in 2020. We also provided data to David McGowan for an HRM program science synthesis manuscript on herring spawn timing in PWS.

The PWS marine bird survey project (PIs Kuletz and Kaler, project 19120114-M) intends to use information on abundance and distribution of herring in PWS collected by HRM as a potential explanatory variable in interpreting observed changes in distribution and population trends of marine birds in PWS.

The forage fish project (PIs Arimitsu and Piatt, project 19120114-C) continues collaborative work with Scott Pegau and the HRM program's aerial surveys for juvenile herring and other forage fish (project 19160111-F). In July 2019 we also coordinated closely with Kristin Gorman (PWSSC) to aid in collection of adult herring for a maturation study (project 19170111-D).

The humpback whale project (PIs Moran and Straley, project 19120114-O) is intended to evaluate humpback whale predation on herring in PWS and regularly collaborates with the HRM program in this regard.

The fall/winter marine bird observations (PI Bishop, project 19120114-E) complement the suite of data collected by HRM, including insertion of key predator data into the population modeling of herring.

Discussions between the Nearshore component and the HRM program are in progress with respect to coastal herring spawning habitat.

b. Data Management

GWA coordinates closely with the Data Management program. Data Management staff are invited to all GWA meetings and teleconferences. Data Management one-on-one consultations were incorporated into the fall meeting in Anchorage. A Data Management team member (Buckelew) is active on the Outreach Steering Committee. Data Management is also a part of the NOAA grant through which PWSSC manages all project funds for non-Trustee Agencies. As such, PM II coordinates with the Data Management team on all reporting requirements to NOAA.

GAK1 PI Danielson (19120114-I) is working with Axiom data managers to generate data visualizations and that can be shared via the Alaska Ocean Observing System (AOOS) data portals and other internet web pages. One such example using GAK1 data can be found at: <https://researchworkspace.com/file/2656970/anomaly-plot-gak1-mooring.ipynb>. Another example is the development of a real-time ship tracking interface that could provide up-to-the-hour ship-to-shore data transfers while the Seward Line cruise is in the field on *R/V Sikuliaq*. This functionality would assist adaptive sampling techniques, by forming tighter linkages between the field crew and shoreside support. For example, based on the real-time data feed, onshore analysts could download, compress, and deliver to the field crew remotely sensed data that may be useful in directing the fieldwork. This work is ongoing.

Work is underway to standardize data management of raw marine bird and mammal data collected during nearshore and pelagic surveys. The final product will be programing scripts written in Program R used for data processing (e.g., QA/QC), population trend analyses, and reporting.

B. Individual Projects

GWA summer and winter marine bird surveys in PWS (19120114-H, 19120114-M, and 19120114-E) provide information on population trends of species studied by EVOSTC-funded pigeon guillemot restoration project (19100853). In addition, the GWA Program Coordinator provides support to the pigeon guillemot restoration project as needed. Data from the pigeon guillemot restoration project were used in one chapter of the GWA science synthesis report.

C. With Trustee or Management Agencies

GWA projects are highly collaborative with Trustee and management agencies, as well as other scientist's research and monitoring efforts in the GOA and beyond. Below is a brief sampling of GWA collaboration; detailed information is available in individual project reports.

NOAA

For the 2019 Ecosystem Status Report (Zador et al. 2019), investigators from all three GWA components (Environmental Drivers, Pelagic Ecosystem, and Nearshore Ecosystem) contributed 19 metrics. Among these, the forage fish project (19120114-C) calculates an annual juvenile sablefish growth index that is used in the ecosystem and socioeconomic profile of the sablefish stock assessment for Alaska (Shotwell et al. 2019).

Seward Line/LTER (project 19120114-L) cruises provide bongo collections for larval fish assessment to NOAA Alaska Fisheries Science Center's (AFSC's) EcoFOCI group. LTER and NOAA share data on several projects.

The Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 19120114-J) collaborates with researchers at the National Ocean Service/ National Centers for Coastal Ocean Science Beaufort (NC) and Charleston (SC) Laboratories to use the project oceanography and phytoplankton sampling data to identify environmental triggers for increases in the phytoplankton species (*Alexandrium* spp.) that cause paralytic shellfish poisoning events. This project also collaborates with NOAA National Marine Fisheries Service (NMFS) on the NOAA Kachemak Bay Habitat Focus Area, including clam restoration and paralytic shellfish poisoning risk assessment efforts.

The killer whale project (PI Matkin, project 19120114-M) directly interfaces and collaborates with research conducted on the endangered Southern Resident killer whale population in Washington State waters. Collaborations include sharing costs of genetic fecal analysis directed by Kim Parsons, and a comparison of polychlorinated biphenyl and stable isotope trends with Gina Ylitalo, Brad Hanson, and Candace Emonds, all with the NOAA Northwest Fisheries Science Center, Seattle, WA. All population data are supplied to the NMFS AFSC Marine Mammal Laboratory, Seattle, WA for incorporation into Alaska marine mammal stock assessment reports and use in management applications.

The forage fish project (PIs Arimitsu and Piatt, project 19120114-C) collaborates with Gulf of Alaska Integrated Ecosystem Research Program PIs on a synthesis of capelin in the GOA (Olav Ormseth, David McGowan, NOAA AFSC). This collaboration has led to an increased focus on capelin dynamics in the Kodiak area using NOAA survey data, with the updated time series (2000-2019) reported in the GWA forage fish synthesis chapter.

The forage fish project PIs Arimitsu and Piatt, (project 19120114-C) are currently collaborating with researchers at NOAA Auke Bay Labs to provide time-series data on forage fish diet, isotope, and proximate composition using samples collected by seabirds at Middleton Island since the late 1990s. These data will provide information on trophic changes relevant to marine predators of commercial value and in the northern GOA.

The humpback whale project (Moran and Straley, project 19120114-O) regularly collects data for NOAA: Harbor porpoise eDNA collected for stock structure in collaboration with Kim Parsons (NMFS/Marine Mammal Laboratory) young of the year pollock collected for Louise Copeman (NOAA Cooperative Institute for Marine Resources Studies, OSU), and collected a dead Steller sea lion pup for Kate Savage (NMFS/Alaska Regional Office/Protected Resources Division).

The nearshore project (Coletti et al., project 19120114-H) provides nearshore ecosystem information on essential fish habitat and sensitive early life stages of federally managed fish species to NOAA NMFS.

Department of Interior

The Seward Line (project 19120114-L) provides a platform for visual seabird surveys and marine mammals during three 2018 Northern GOA LTER cruises, in collaboration with USFWS, Kathy Kuletz.

In 2019 the NOAA Kasitsna Bay Laboratory hosted USFWS Marine Mammals Management (MMM) office researchers for a summer-long sea otter tagging and tracking project as part of the Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 19120114-J). Twenty otters were tagged and tracked into the early fall and we are coordinating with USFWS researchers to combine tracking data, our GWA project oceanography data and nearshore prey and habitat information (from GWA Nearshore project and other NOAA, KBNERR, and University of Alaska Fairbanks research projects) to improve understanding of sea otter distributions, habitat associations and foraging. We also coordinate with the USFWS MMM office on sea otter stranding and sampling programs. Project data are provided to USFWS (Alaska Maritime National Wildlife Refuge) and NOAA (NMFS Protected Resources Division) to help investigate potential causes of seabird, sea otter, and whale mortality events.

Working with researchers at the USGS Alaska Science Center, PIs Kuletz and Kaler (project 19120114-M) compared changes in at-sea densities of seabirds in Kachemak Bay from 1996 to 2018. With funding from the NPRB, this project collaborated with USFWS Migratory Bird Management to conduct marine bird and mammal surveys as part of the long-term monitoring program for the northern GOA (Seward Line and additional LTER lines), which is part of the multi-agency (UAF, NPRB, USFWS) program. Also, marine bird data collected at the Naked Island group (Naked, Storey, & Peak islands) from this project will be used to help evaluate the recovery of

pigeon guillemots and other marine bird species (e.g., Arctic tern, parakeet auklet, tufted puffin) that were extirpated by mink introduced to the island group. This collaboration supports the management directives of USFWS to conserve and maintain populations of migratory birds. These survey data provide information important for the continued monitoring of guillemot recovery from the EVOS.

The GWA forage fish (Arimitsu and Piatt, project 19120114-C) work is also complimentary to a related USGS-Outer Continental Shelf and Bureau of Ocean Energy Management (BOEM) study of forage fish and seabird trends in areas of oil and gas development within Cook Inlet. Additionally, our continued coordination and collaboration with GWA PIs (Holderied and Baird, project 19120114-J, and Kuletz and Kaler, project 19120114-N) in Cook Inlet and Kachemak Bay increases the scope of marine ecosystem monitoring in the northern GOA.

Information from GWA projects that collect data on birds (forage fish, 19120114-C, fall/wintering marine birds, 19120114-E, nearshore, 19120114-H, marine bird population trends, 19120114-N) will feed into the NPPSD database maintained by USFWS and USGS.

Nearshore (project 19120114-H) PIs (Ballachey, Bodkin, Coletti, and Esler) are working with NPS on the ‘Changing Tides’ Project and providing needed samples from various marine organisms. This study examines the linkages between terrestrial and marine ecosystems and is funded by the National Park Foundation. National parks in Southwest Alaska face a myriad of management concerns that were previously unknown for these remote coasts, including increasing visitation, expanded commercial and industrial development, and environmental changes due to natural and anthropogenic forces. Building on this work nearshore PIs (Coletti and Ballachey) are collaborating with L. Bowen (USGS) and A. Love (Prince William Sound Regional Citizens Advisory Council) to further develop genetic transcription diagnostics (gene expression) to measure the responses of individuals to stressors in *Mytilus trossulus*. Results suggest gene transcription assays in mussels will be a useful additional tool for monitoring of contaminants. Further collaborations along these lines were with Maya Groner, Maureen Purcell and Paul Hershberger (USGS Western Fisheries Research Center) on their study of the bacterial gill pathogen NIX in razor clams.

Nearshore (project 19120114-H) PIs (Coletti, Iken, Konar, and Lindeberg) have completed recommendations to BOEM for nearshore community assessment and long-term monitoring in western lower Cook Inlet. The BOEM Proposed Final Outer Continental Shelf Oil and Gas Leasing Program included proposed Lease Sale 258 in the Cook Inlet Planning Area in 2021. Until this leasing program, an Outer Continental Shelf Cook Inlet Lease Sale National Environmental Policy Act (NEPA) analysis had not been undertaken since 2003. Updated nearshore information was needed to support the environmental analyses associated with the planned lease sale. The overall objective of this study was to provide data on habitats and sensitive species to support environmental analyses for NEPA documents, potential future Exploration Plans, and Development and Production Plans. Throughout this process, a goal has been to utilize existing nearshore monitoring protocols already developed through GWA when possible to ensure data comparability across all regions. All data are being provided to the AOOS Gulf of Alaska Data Portal.

Funded through the Coastal Marine Institute (CMI), a partnership between BOEM and UAF, nearshore (project 19120114-H) PIs Iken and Konar are working with a student on analyzing food web structure in western Cook Inlet (above-mentioned BOEM project) and at GWA sites in

Kachemak Bay by using carbon and nitrogen stable isotope analysis. This adds valuable information about the energetic links among the species that are analyzed for their abundance and distribution through GWA.

Nearshore (project 19120114-H) PIs (Iken and Konar) tested the use of unmanned aircraft systems (UASs) for various aspects of coastal biological monitoring in Kachemak Bay. With BOEM funding, UASs were compared to traditional methods of rocky intertidal and seagrass sampling with some success and suggestions for future work (Konar and Iken 2018). After this success, UASs were tested to determine their feasibility to complete sea otter foraging observations in Kachemak Bay with USGS funding (Monson and Weitzman).

Nearshore (project 19120114-H) PIs (Esler, Coletti, Weitzman), in collaboration with NPS, have initiated work aimed at documenting variation in nearshore physical oceanography in relation to tidewater glacial input, and quantify biological responses to that variation across trophic levels in Kenai Fjords. This work will allow prediction of changes in nearshore ecosystems in the face of ongoing glacier mass loss and retreat from the marine environment.

Alaska Department of Fish and Game

The PWS oceanography project (19120114-G) generally endeavors to conduct a spring cruise around the time of herring spawning when the ADF&G is doing their surveys (contact: Stormy Haught, ADF&G, Cordova).

Environmental Driver component project (GAK1, 19120114-I, Seward Line, 19120114-L, PWS oceanography, 19120114-G, and Kachemak Bay/lower Cook Inlet oceanography, 19120114-J, and CPR, 19120114-D) data are available to ADF&G biologists for salmon forecasting.

The Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 19120114-J) provides real-time and historical trends for water temperature data to shellfish managers with the ADF&G (Commercial and Sportfish Divisions in Homer) and with ADF&G Aquatic Farming, Alaska Department of Environmental Conservation, and Alaska Department of Health and Social Services through the Alaska harmful algal bloom network. Project data help inform management for shellfish harvest, mariculture operations, harmful algal bloom event response and marine invasive species monitoring.

The humpback whale project photographed Steller sea lion brands for ADF&G (Lauri Jemison).

Other Resource Management and Research Organizations

The Seward Line/LTER (project 19120114-L) is co-funded by EVOSTC, North Pacific Research Board (NPRB), AOOS, and NSF, all sharing common goals of understanding environmental drivers on the GOA shelf and the major passages of PWS. PIs Kuletz and Kaler (project 19120114-M, PWS marine bird surveys) provide a marine bird and mammal observer on this survey. PIs Arimitsu and Piatt (project 19120114-C, forage fish) are leading processing of fish catches (bycatch) from Methot trawls intended to sample jellyfish; this work will facilitate a better understanding of the relationships between seabird diets at Middleton Island and the distribution of forage fish from trawls.

A NPRB project (1801: Prevalence of Paralytic Shellfish Toxins in the Marine Food Webs of PWS and Kachemak Bay, Alaska) began in Sept. 2018. Dr. Xiuning Du (Oregon State University [OSU]) is the lead PI and Campbell (project 19120114-G) and Holderied and Baird (project 19120114-J) are co-investigators. Phytoplankton and toxin samples are being collected for that project at all sites visited by this program. Campbell is also coordinating sampling efforts of larger taxa in PWS (shellfish, forage fish and salmon). Samples are being analyzed for saxitoxin by Dr. Steve Kibler (NOAA, Beaufort Lab).

Our GWA nearshore data (project 19120114-H) from Katmai and western PWS contributed to USGS and NPRB studies of the status of the southwest Alaska stock of sea otters, which is listed as threatened under the Marine Mammal Protection Act. These data are shared with the USFWS, Marine Mammals Management, who is responsible for sea otter management.

9. Information and Data Transfer:

A great deal of information is produced by this program on an annual basis. For convenience, Table 4 summarizes GWA information and data transfer followed by detailed listings in each subsection.

Table 4. FY19 GWA summaries of information and data transfer for Section 9.

Subsection	Information & Data Transfer	Summary
A.1	Peer reviewed publications	21
A.2	Reports	32
A.3	Popular articles	13
B.1	Conferences & workshops	57
B.2	Public presentations	31
C	Developed data & information	Ecosystem indicators (19 time series), quarterly newsletters, and updated website
D	Data & metadata uploaded to Portal	All projects are compliant

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Bowen, L., K. Counihan, B. Ballachey, H. Coletti, T. Hollmen, B. Pister and T. Wilson. *In review*. Monitoring Nearshore Ecosystem Health Using Pacific Razor Clams (*Siliqua patula*) as an Indicator Species. PeerJ.

Campbell, R.W., P.L. Roberts, and J. Jaffe. *In press*. The Prince William Sound Plankton Camera: a profiling *in situ* observatory of plankton and particulates. Accepted, International Council on Exploration of the Sea Journal of Marine Science, 02/2020.

- Counihan, K., L. Bowen, B. Ballachey, H. Coletti, T. Hollmen, and B. Pister. 2019. Physiological and gene transcription assays in combinations: a new paradigm for marine intertidal assessment. *PeerJ* 7:e7800 DOI:10.7717/peerj.7800.
- Coyle, K.O., A.J. Hermann, and R.R. Hopcroft. 2019. Modeled spatial-temporal distribution of productivity, chlorophyll, iron and nitrate on the northern Gulf of Alaska shelf relative to field observations. *Deep-Sea Research II* 165:163-191.
- Davis, R., J. L. Bodkin, H. A. Coletti, D. H. Monson, S. E. Larson, L. P. Carswell, and L. M. Nichol. 2019. Future direction in sea otter research and management. *Frontiers in Marine Science*. 5:510. DOI:10.3389/fmars.2018.00510.
- Doyle, M.J., S.L. Strom, K.O. Coyle, A.J. Hermann, C. Ladd, A.C. Matarese, S.K. Shotwell, and R.R. Hopcroft. 2019. Early life history phenology among Gulf of Alaska fish species: Strategies, synchronies, and sensitivities. *Deep-Sea Research II* 165:41-73.
- Espinasse, B., Hunt, B.P.V., Batten, S.D., and Pakhomov, E. 2019. Defining isoscapes in the Northeast Pacific as an index of ocean productivity. *Global Ecology and Biogeography*. DOI:10.1111/geb.13022.
- Konar, B., T.J. Mitchell, K. Iken, H. Coletti, T. Dean, D. Esler, M. Lindeberg, B. Pister, and B. Weitzman. 2019. Wasting disease and environmental variables drive sea star assemblages in the northern Gulf of Alaska. *Journal of Experimental Marine Biology and Ecology*. DOI:10.1016/j.jembe.2019.151209.
- Lenz, P.H., and V. Roncalli. 2019. Diapause within the context of life-history strategies in calanid copepods (Calanoida: Crustacea). *Biological Bulletin* 237:170-179.
- McGowan, D.W., E.D. Goldstein, M.L. Arimitsu, A.L. Deary, O. Ormseth, A. De Robertis, J.K. Horne, L.A. Rogers, M.T. Wilson, K.O. Coyle, K. Holderied, J.F. Piatt, W.T. Stockhausen, and S.G. Zador. *In Press*. Spatial and temporal dynamics of Pacific capelin (*Mallotus catervarius*) in the Gulf of Alaska: implications for ecosystem-based fishery management. *Marine Ecology Progress Series*.
- Monson D., R. Taylor, G. Hilderbrand, J. Erlenbach, H. Coletti, K.A. Kloecker, G.E. Esslinger, and J.L. Bodkin. *In review*. Brown Bears and sea otters along the Katmai coast: Terrestrial and nearshore communities linked by predation. *Journal of Mammalogy*.
- Olsen, D.W, C.O. Matkin, F.J. Mueter, and S Atkinson. *In press*. Mating Opportunities? Social Behavior Increases in Multi-Pod Aggregations of southern Alaska Resident Killer Whales (*Orcinus orca*). *Marine Mammal Science*.
- Ormseth, O.A., M.M. Baker, R.R. Hopcroft, C. Ladd, C.W. Mordy, J.H. Moss, F.J. Mueter, S.K. Shotwell, and S.L. Strom. 2019. Introduction to understanding ecosystem processes in the Gulf of Alaska, volume 2. *Deep-Sea Research II* 165:1-6.

- Piatt, J.F., J.K. Parrish, H.M. Renner, S.K. Schoen, T.T. Jones, M.L. Arimitsu, K.J. Kuletz, B. Bodenstein, M. García-Reyes, R.S. Duerr, R.M. Corcoran, R.S. A. Kaler, G.J. McChesney, R.T. Golightly, H.A. Coletti, R.M. Suryan, H.K. Burgess, J. Lindsey, K. Lindquist, P.M. Warzybok, J. Jahncke, J. Roletto, and W.J. Sydeman. 2020. Extreme mortality and reproductive failure of common murrelets resulting from the northeast Pacific marine heatwave of 2014-2016. *PLoS ONE* 15:e0226087.
- Robinson, B.H., L. M. Phillips and A.N. Powell. 2019. Energy intake rate influences survival of Black Oystercatcher *Haematopus bachmani* broods. *Marine Ornithology* 47: 277–283.
- Roncalli, V., M.C. Cieslak, M. Germano, R.R. Hopcroft, and P.H. Lenz. 2019. Regional heterogeneity impacts gene expression in the subarctic zooplankton *Neocalanus flemingeri* in the northern Gulf of Alaska. *Communications Biology* 2:1-13.
- Schaefer, A., M.A. Bishop, and R. Thorne. *Accepted pending revisions*. Marine bird response to forage fish during winter in subarctic bays and fjords. *Fisheries Oceanography*. Strom, S.L., K.A. Fredrickson, and K.J. Bright. 2019. Microzooplankton in the coastal Gulf of Alaska: regional, seasonal and interannual variations. *Deep-Sea Research II* 165:192-202.
- Thompson, S.A., M. García-Reyes, W.J. Sydeman, M.L. Arimitsu, S.A. Hatch, and J.F. Piatt. 2019. Effects of ocean climate on the length and condition of forage fish in the Gulf of Alaska. *Fisheries Oceanography* 28:658–671.
- Vandersea, M., P. Tester, K. Holderied, D. Hondolero, S. Kibler, K. Powell, S. Baird, A. Doroff, D. Dugan, A. Meredith, M. Tomlinson and R. Litaker. 2019. An extraordinary *Karenia mikimotoi* "beer tide" in Kachemak Bay Alaska. *Harmful Algae*. DOI:10.1016/j.hal.2019.101706.
- Van Hemert, C., S.K. Schoen, R.W. Litaker, M.M. Smith, M.L. Arimitsu, J.F. Piatt, W.C. Holland, D.R. Hardison, and J.M. Pearce. 2020. Algal toxins in Alaskan seabirds: Evaluating the role of saxitoxin and domoic acid in a large-scale die-off of Common Murrelets. *Harmful Algae* 92:101730.
- von Biela, V.R., M.L. Arimitsu, J.F. Piatt, B.M. Heflin, and S.K. Schoen. 2019. Extreme reduction in nutritional value of a key forage fish during the Pacific marine heatwave of 2014–2016. *Marine Ecology Progress Series* 613:171–182.

2. Reports

- Apeti, D.A., A. Jacobs, and M. Rider. 2019. A Synthesis of Ten Years of Chemical Contaminants Monitoring in National Park Service - Southeast and Southwest Alaska Networks. A collaboration with the NOAA National Mussel Watch Program. NOAA Technical Memorandum NOS NCCOS xxx-xxx. Silver Spring, MD. Xx pp.
- Arimitsu, M.L., J.F. Piatt, and S. Hatch. 2019. LTM Program – Monitoring long-term changes in forage fish distribution, abundance, and body condition in PWS. *Exxon Valdez Oil Spill*

Restoration Project Annual Report (Project 18120114-C), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.

- Arimitsu, M., J. Piatt, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, R.S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V.R. von Biela. 2019. Chapter 3 Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. In R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. *The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska*. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Batten, S. 2019. Continuous Plankton Recorder monitoring of plankton populations on the Alaskan Shelf. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120114-D. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Batten, S. 2019. Continuous Plankton Recorder data from the Northeast Pacific, 2000-2018. In Zador, S., E. Yasumiishi, and G.A. Whitehouse, editors. *Ecosystem Status Report 2019 Gulf of Alaska*. North Pacific Fishery Management Council, Anchorage, AK.
- Bishop, M.A., and A. Schaefer. 2019. Long term monitoring of marine bird abundance and habitat associations during fall and winter in Prince William Sound. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-M.
- Bowen L., A. Love, S. Waters, K. Counihan, B. Ballachey, and H. Coletti. 2019. Report: Port Valdez Mussel Transcriptomics. Prepared for Prince William Sound Regional Citizens' Advisory Council. Contract Number 951.20.06.
- Campbell, R.W. 2019. Monitoring the Oceanographic Conditions of Prince William Sound. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-G.
- Campbell, R.W. and C.A. McKinstry, 2019. Temperature trends in the surface waters of Prince William Sound. pp. 62-63 in Zador, S., Yasumiishi, E. and G.A. Whitehouse (eds) *Ecosystem Status Report 2019: Gulf of Alaska*. North Pacific Fishery Management Council. <https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019GOAecosys.pdf>
- Campbell, R.W. and C.A. McKinstry, 2019. Zooplankton trends in Prince William Sound. pp. 85-87 in Zador, S., Yasumiishi, E. and G.A. Whitehouse (eds) *Ecosystem Status Report 2019: Gulf of Alaska*. North Pacific Fishery Management Council. <https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019GOAecosys.pdf>
- Coletti, H., D. Esler, B. Konar, K. Iken, K. Kloecker, D. Monson, B. Weitzman, B. Ballachey, J. Bodkin, T. Dean, G. Esslinger, B. Robinson, and M. Lindeberg. 2019. *Gulf Watch Alaska: Nearshore Ecosystems in the Gulf of Alaska*. *Exxon Valdez* Oil Spill Restoration Project Annual Report (Restoration Project 18120114-H), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

- Coletti, H., J. Bodkin, T. Dean, D. Esler, K. Iken, B. Ballachey, K. Kloecker, B. Konar, M. Lindeberg, D. Monson, B. Robinson, R. Suryan and B. Weitzman. 2019. Intertidal Ecosystem Indicators in the Northern Gulf of Alaska in Zador, S.G., and E.M. Yasumiishi. 2019. Ecosystem Status Report 2019: Gulf of Alaska. Report to the North Pacific Fishery Management Council, Anchorage, AK.
- Danielson S. 2019. Oceanographic station GAK1 water column properties. *In* Zador, S., E. Yasumiishi, and G.A. Whitehouse, G.A. (editors). 2019, Ecosystem Status Report 2019. North Pacific Fishery Management Council.
<https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019GOAecosys.pdf>
- Danielson, S.L., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. 2019. Chapter 1 A study of marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells. *In* R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Danielson, S.L., and T.J. Weingartner. 2019. Long-term Monitoring of Oceanographic Conditions in the Alaska Coastal Current from Hydrographic Station GAK1. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 17120114-I. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.
- Holderied, K., and S. Baird. 2019. Long-term monitoring of oceanographic conditions in Cook Inlet/Kachemak Bay to understand recovery and restoration of injured near-shore species. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120114-J. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.
- Hopcroft, R.R., S.L. Danielson, and K.O. Coyle. 2019. The Seward Line – Marine ecosystem monitoring in the northern Gulf of Alaska. FY18 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 18120114-L. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Jones, T., S. Saupe, K. Iken, B. Konar, S. Venator, M. Lindeberg, H. Coletti, B. Pister, J. Reynolds, and K. Haven. 2019. Evaluation of nearshore communities and habitats: Lower Cook Inlet nearshore ecosystem. Anchorage (AK): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2019-075. 219 pp.
- Kuletz, K. 2019. II. Migratory Bird Management: Update on seabird mortality events and monitoring. Report B-7: U.S. Fish and Wildlife Service report to the North Pacific Fishery Management Council, October. U.S. Fish and Wildlife Service, Anchorage, Alaska.

- Kuletz, K., and R. Kaler. 2019. Continuing the Legacy: Prince William Sound Marine Bird Population Trends. *Exxon Valdez Oil Spill Restoration Project Annual Report* (Restoration Project 18120114-M), *Exxon Valdez Oil Spill Trustee Council*, Anchorage, Alaska.
- Lindeberg, M., and K. Hoffman. 2019. Gulf Watch Alaska. *Exxon Valdez Oil Spill Long-Term Monitoring Program (Gulf Watch Alaska) Annual Report* (Restoration Program 18120114), *Exxon Valdez Oil Spill Trustee Council*, Anchorage, Alaska.
- Lindeberg, M., and K. Hoffman. 2019. Program Management I – Program coordination and science synthesis and Program Management II – Administration, science review panel, PI meeting logistics, outreach, and community involvement. *Exxon Valdez Oil Spill Long-Term Monitoring Program (Gulf Watch Alaska) Annual Report* (*Exxon Valdez Oil Spill Trustee Council Project: 18120114-A and B*), *Exxon Valdez Oil Spill Trustee Council*, Anchorage, Alaska.
- Matkin, C.O. and D. W. Olsen. 2019. Long-term killer whale monitoring in Prince William Sound/ Kenai Fjords. *Exxon Valdez Oil Spill Restoration Project Annual Report* (Restoration Project 18120114-N), *Exxon Valdez Oil Spill Trustee Council*, Anchorage, Alaska.
- Moran, J., and J. Straley. 2019. Long-term monitoring of humpback whale predation on Pacific herring in Prince William Sound. *Exxon Valdez Oil Spill Restoration Project Annual Report* (Project 18120114-O), *Exxon Valdez Oil Spill Trustee Council*, Anchorage, AK.
- Moran, J., and J. Straley. 2019. Fall Surveys of Humpback Whales in Prince William Sound in Zador, S. G., and E. M. Yasumiishi. 2019. Ecosystem Status Report 2018: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301 Reports.
<https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019GOAecosys.pdf>
- Moran, J., and J. Straley provide data and input for; Draft Biological Report for the Proposed Designation of Critical Habitat for the Central America, Mexico, and Western North Pacific Distinct Population Segments of Humpback Whales (*Megaptera novaeangliae*). Prepared by: National Marine Fisheries Service U.S. Department of Commerce National Oceanic and Atmospheric Administration May, 2019.
<https://www.fisheries.noaa.gov/action/proposed-rule-designate-critical-habitat-central-america-mexico-and-western-north-pacific>
- Moran, J., and J. Straley provide data for: Endangered and Threatened Wildlife and Plants: Proposed Rule to Designate Critical Habitat for the Central America, Mexico, and Western North Pacific Distinct Population Segments of Humpback Whales. 9 October 2019. <https://www.govinfo.gov/content/pkg/FR-2019-10-09/pdf/2019-21186.pdf>

- Robinson, B., D. Esler, H. Coletti. 2019. Long-term monitoring of Black Oystercatchers in the Gulf of Alaska. Annual Summary Compilation: New or ongoing studies of Alaska shorebirds. Alaska Shorebird Group, Anchorage, Alaska.
- Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Seeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2019. Chapter 4 Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. *In* R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Suryan, R.M., M.R. Lindeberg, and D.R. Aderhold, eds. 2019. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Ware, L., D. Green, D. Esler, B. Robinson, H. Coletti. 2019 Field Report: Movement Ecology of the Black Oystercatcher in Alaska. Prepared for the Bird Banding Laboratory, Laurel, MD.
- Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R.M. Suryan, T. Dean, D. Hondolero, and M.R. Lindeberg. Chapter 2 Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. *In* R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

3. Popular articles

Note: several GWA publications and press releases resulted in significant media attention. For a more in-depth description, please see section 7E.

Anonymous. 2019. Our ocean, Great Lakes and coasts—Up close and from a distance (Gulf Watch Alaska Nearshore project photographs). Special photo issue Newsweek News from the U.S. Department of the Interior: Oceans, Great Lakes, and Coasts. Summer Issue.

Backensto, S. and H. Coletti. 2019. Another Year of Seabird Die-Offs. High Latitude Highlights, the NPS Alaska Region Resource Newsletter. Fall Issue: Pp 2-3.

- Batten, S., S. Chiba, and W. Sydeman. 2020. Two decades of the North Pacific CPR program. PICES Press 18:18-21.
- Bernton, H., and L. Mapes. 2019. It's been 30 years since the *Exxon Valdez* oil spill. Here's what we're still learning from that environmental debacle. Seattle Times, March 20 (Section based on killer whale project).
- Campbell, R. W., J. Jaffe, and P. Roberts. 2019. Computers to identify plankton images from Prince William Sound. PWSSC Delta Sound Connections (https://pwssc.org/wp-content/uploads/2019/05/DSC-2019_WEB.pdf).
- Coletti, H., S. Backensto, and N. Chambers. 2019. (Special Feature) Long-term monitoring of nearshore marine ecosystems: Gulf of Alaska 30 years since the *Exxon Valdez* Oil Spill. Newswave News from the Department of the Interior: Ocean, Great Lakes, and Coasts. Spring Issue. Pp 15-17.
- Conservation Connection. 2019. Mayumi Arimitsu: Research ecologist at WhaleFest 2019: Why ... Last Chance Endeavors podcast. <https://www.lastchanceendeavors.com/podcast/episode/2507d869/mayumi-arimitsu-research-ecologist-at-whalefest-2019-or-why-are-the-birds-dead-or-episode-028>.
- Cornwall, W. 2019. Ocean heatwaves like the Pacific's deadly 'Blob' could become the new normal. Science Magazine. DOI:10.1126/science.aaw8401. https://www.sciencemag.org/news/2019/01/ocean-heat-waves-pacific-s-deadly-blob-could-become-new-normal?utm_campaign=NewsfromScience&utm_source=JHubbard&utm_medium=Twitter&fbclid=IwAR3QxH9cP6IWopwQp-HJ3BulkcFEaxvVntNM2zxlJNKRqkLtevn5kRnTjE.
- Danielson, S., R. Hopcroft, K. Holderied, and R. Campbell. 2019. Tracking water layers in the ocean. PWSSC Delta Sound Connections (https://pwssc.org/wp-content/uploads/2019/05/DSC-2019_WEB.pdf).
- Fisher, J., D. Kimmel, T. Ross, S. Batten, E. Bjorkstedt, M. Galbraith, K. Jacobson, J. Keister, A. Sastri, K. Suchy, S. Zeman, and I. Perry. 2020. Copepod responses to, and recovery from, the recent marine heatwave in the Northeast Pacific. PICES Press 18:68-71.
- Lindeberg, M. and R. Heintz. 2019. 30 years since the *Exxon Valdez* Oil Spill: An era of scientific research and monitoring that has changed our understanding of oil spill impacts. Delta Sound Connections 2019-20. 16 pp. http://pwssc.org/wp-content/uploads/2019/05/DSC-2019_WEB.pdf
- Suryan, R., S. Batten, R. Campbell, and S. Danielson. 2019. What does the future hold for the Gulf of Alaska? Delta Sound Connections 2019-20. 16 pp. http://pwssc.org/wp-content/uploads/2019/05/DSC-2019_WEB.pdf

Yelverton, J. 2019. The fragile world of Prince William Sound. Anchorage Press (cover story, Jan 29, 2020). https://www.anchoragepress.com/news/the-fragile-world-of-prince-william-sound/article_67b68770-413f-11ea-97fc-9f581d3d2d77.html

B. Dates and Locations of any Conference, Workshop, or Public Presentations where EVOSTC-funded Work was Presented

1. Conferences and Workshops

Arimitsu, M. 2020. Northern Gulf of Alaska forage fish sampling in 2018, connectivity between LTER and GWA Ecosystem Monitoring Programs. Oral Presentation. NGOA LTER PI meeting. Fairbanks, AK. 21 January.

Arimitsu, M., M.A. Bishop, D. Cushing, S. Hatch, R. Kaler, K. Kuletz, C. Matkin, J. Moran, D. Olsen, J. Piatt, A. Schaefer, and J. Straley. 2020. Changes in marine predator and prey populations in the Northern Gulf of Alaska: Gulf Watch Alaska Pelagic update 2019. Poster Presentation. Alaska Marine Science Symposium. Anchorage, AK. 27-31 January.

Arimitsu, M., J. Piatt, R. Suryan, D. Cushing, S. Hatch, K. Kuletz, C. Marsteller, J. Moran, S. Pegau, M. Rogers, S. Schoen, J. Straley, V. von Biela. 2019. Reduced energy transfer through forage fish disrupted marine food webs during the North Pacific marine heatwave. Oral Presentation. PICES annual meeting. Victoria, BC, Canada. 16-27 October.

Batten, S.D. et al. 2019. Two decades of the North Pacific CPR Survey. Poster presentation, OceanObs19, Honolulu, HI, September.

Batten, S.D. et al. 2019. Two decades of the North Pacific CPR Survey. Poster presentation, PICES Annual meeting, Victoria, BC, October.

Batten, S.D., A.W. Walne, and P. Hélaouët. 2019. Impact of the Marine Heat Wave on Gulf of Alaska plankton communities. Invited speaker, PICES Annual meeting, Victoria, BC, October.

Batten, S.D. et al. 2020. Two decades of the North Pacific CPR Survey. Poster presentation, Alaska Marine Science Symposium, Anchorage, AK, January.

Boswell, K., R. Heintz, J. Vollenweider, J. Moran, and S. LaBua. 2020. The decline of acoustic backscatter associated with overwintering Pacific herring (*Clupea pallasii*) in Lynn Canal, Alaska. Poster Presentation. Alaska Marine Science Symposium, Anchorage, AK. 27-31 January.

Brydie, A., and S. Danielson. 2019. Copper River Plume. LTER REU Mini-Symposium, August.

Campbell, R.W., P.L. Roberts, and J. Jaffe. 2020. The Annual Secondary Productivity Cycle in Prince William Sound Measured with the Prince William Sound Plankton Camera. Alaska Marine Science Symposium, Anchorage, January 2020.

- Coletti, H.A. 2019. Gulf Watch Alaska overview and updates. MARINe and BOEM joint meeting. September.
- Coletti, H.A., R. Suryan, D. Esler, R. Kaler, T. Hollmen, M. Arimitsu, J. Bodkin, T. Dean, K. Kloecker, K. Kuletz, J. Piatt, B. Robinson and B. Weitzman. 2019. Birds of a feather flock together... or do they? Regional and temporal patterns of community composition and abundance in nearshore marine birds across the Gulf of Alaska. Oral Presentation, Alaska Bird Conference. March.
- Coletti, H. A., G. Hilderbrand, D. Monson, J. Erlenbach, B. Ballachey, B. Pister and B. Mangipane. 2019. Where carnivores clash: Evidence of competition - Prey-shifting by brown bears during a period of sea otter recovery. Oral Presentation, Sea Otter Conservation Workshop 2019. March.
- Danielson, S. 2019. Changing stratification over Alaska region continental shelves suggests altered diapycnal mixing and nutrient fluxes, Invited Talk, 3rd International Symposium "Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem", University of Tokyo, May.
- Danielson, S. 2019. 21st Century Oceanography in the Last Frontier, Invited Keynote Presentation, RVTEC, Fairbanks, AK, November.
- Danielson, S. 2019. Presentation to the Alaska Ocean Observing System Board, Anchorage, AK, December.
- Danielson, S. 2020. Presentation to the Northern Gulf of Alaska Long Term Ecological Research Program PI meeting, January.
- Du, X., R. Campbell, S. Kibler, K. Holderied, D. Hondolero, R. Robinson, C. Guo, C. Walker, M. Arimitsu, and J. Piatt. 2020. Prevalence of paralytic shellfish toxins in the marine food web of southcentral and southwest Alaska NPRB #1801: project update. Poster Presentation. Alaska Marine Science Symposium. Anchorage, AK. 27-31 January.
- Fredrickson, K., H. Busse, D. Walker-Phelan, C. Mazur, and S. Strom. 2020. Unexpected importance of the smallest phytoplankton in the northern Gulf of Alaska ecosystem. Poster presentation, Alaska Marine Science Symposium, January.
- Griffin, K., and H. Coletti. 2020. Seabird colonies on the Katmai coast. Poster Presentation, Alaska Marine Science Symposium. January.
- Holderied, K., S. Baird, J. Schloemer and D. Hondolero. 2020. Impact of the warm, dry 2019 summer on nearshore waters in Kachemak Bay, Alaska – rain versus glacial melt? Oral presentation at the Alaska Marine Science Symposium, Anchorage AK, January.
- Holderied, K. 2019. Kachemak Bay Oceanography. Oral presentation for Alaska Department of Fish and Game Alaska/West Coast Razor Clam Summit. Alaska Islands and Ocean Visitor Center. Homer, Alaska, April.

- Hondolero, D., T. Bell, B. Weitzman, and K. Holderied. 2020. Kelp forest mapping in Kachemak Bay, Alaska using a drone. Poster Presentation, Alaska Marine Science Symposium. January.
- Kibler, S., B. Wright, X. Du, R.W. Campbell, K. Holderied, D. Hondolero, R. Masui, C. Guo, and C. Walker. 2020. NPRB 1801 - Prevalence of Paralytic Shellfish Toxins in the Marine Food Web of Southcentral and Southwest Alaska: Year 1 Update. Poster Presentation, Alaska Marine Science Symposium, Anchorage, January 2020.
- Kuletz, K. 2019. Seabird mortality events and distribution of select seabird species in the northern Gulf of Alaska. Oral presentation, Alaska Migratory Bird Co-management Council meeting, September 18-19, Anchorage.
- Kuletz, K., B. Hoover, D. Cushing, J.A. Santora, W.J. Sydeman, R.R. Hopcroft, S.J. Danielson, and E. Labunski. 2019. Seabird distribution relative to biophysical oceanographic properties in North Pacific Ecosystems. Oral presentation, Annual meeting of the Pacific Seabird Group, March 2, Lihue, Kuai, Hawaii.
- Lindeberg, M.R. 2019. Long-term programs of the *Exxon Valdez* Oil Spill Trustee Council. Oral Presentation. 2019 Alaska Forum on the Environment, Feb. 11-15, Anchorage, Alaska.
- Lyman, E., R. Finn, J. Moran, K. Savage, C. Gabriele, J. Straley, N. Davis, F. Sharpe, J. Neilson, A. Jensen, D. Schofield, S. Wright, P. Cottrell, T. Rowles, S. Wilkin, M. Lammers, E. Zang. 2019. Are recent population level changes in the central North Pacific humpback whales, *Megaptera novaeangliae*, affecting entanglement threat and reporting rate? Poster Presentation. World Marine Mammal Conference, Barcelona, Spain. 9-12 December.
- Marsteller, C., M. Arimistu, J. Piatt, K. Kuletz, S. Schoen, B. Heflin, and E. Lubunski. 2019. Where have all the birds gone?: Changes in at-sea densities of seabird in Kachemak Bay, Alaska from 1996 to 2018. Oral Presentation. The 46th Meeting of the Pacific Seabird Group, Kauai, HI. 27 February – 2 March 2019.
- Mendoza-Islas, H., and R.R. Hopcroft. 2019. Abundance and distribution of gelatinous zooplankton in the Gulf of Alaska. Oral presentation, ASLO Aquatic Sciences Meeting, San Juan, Puerto Rico, February.
- Mendoza-Islas, H., and R.R. Hopcroft. 2020. First year pollock and their zooplankton predators in the Gulf of Alaska. Poster presentation, Alaska Marine Science Symposium, January.
- Meyers, H., D. Olsen, C. Matkin, and B. Konar. 2020. Resident killer whale (*Orcinus orca*) spatial use in the Gulf of Alaska. January. Poster presentation at AMSS, Anchorage, Alaska, January.
- Monson, D., R. Taylor, G. Hilderbrand, J. Erlenbach, and H. Coletti. 2019. Top-Level Carnivores Linked Across the Marine / Terrestrial Interface: Sea Otter Haulouts Offer a

- Unique Foraging Opportunity to Brown Bears. Oral Presentation. Sea Otter Conservation Workshop 2019. March.
- Moran, J. 2019. Upper Trophic Conditions: Humpback whales. Oral Presentation. Spring PEEC 2019 [Preview of Ecosystem and Economic Conditions] An Alaska IEA activity AFSC/PMEL, Seattle, WA. 6-7 June.
- Moran, J., and J. Straley. 2020. Humpback whale numbers have not recovered in Prince William Sound following the 2014 – 2016 marine heatwave. Poster Presentation. Alaska Marine Science Symposium, Anchorage, AK. 27-31 January.
- Moran, J., and J. Straley. 2019 Trends in humpback whale (*Megaptera novaenagliae*) abundance, distribution, and health in Hawaii and Alaska Meeting Report. Workshop, oral presentation. NOAA Fisheries Pacific Islands Regional Office, Honolulu, Hawaii. 27-28 November.
- Olsen, D., C. Matkin, and K. Parsons. 2020. Characterization of killer whale (*Orcinus orca*) diet in the Northern Gulf of Alaska through genetic analysis of fecal samples. Poster presentation AMSS, Anchorage, Alaska, January.
- Parrish, J.K., H. Burgess, T. Jones, J. Lindsey, A. Lestenkof, B. Bodenstein, B. Mangipane, E. Labunski, E. Lujan, H. Coletti, H. Renner, J. Christensen, J. Piatt, K. Hilwig, K. Lewandowski, K. Plentnikoff, K. Lefebvre, K. Kuletz, K. Griffin, L. Divine, L. Wilson, M. Romano, M. Cady, M. Good, M. Brubaker, N. Graff, N. Stellrecht, P. Lestenkof, P. Fitzmorris, P. Melovidov, R. Kaler, R. Corcoran, S. Schoen, S. Backensto, S. Knowles, S. Thomas, T. Mullet, C. Wright, A. Will and T. Lewis. 2020. Unabated Mass Mortality of Marine Birds in the Northeast Pacific. Oral Presentation, Alaska Marine Science Symposium. January.
- Piatt, J., M. Arimitsu, S. Schoen, V. von Biela, J. Parrish, H. Renner. 2019. Mass mortality and breeding failure of seabirds during and after the 2014-2016 marine heatwave. Oral Presentation. Joint American Fisheries Society-The Wildlife Society Meeting. Reno, NV. 1-4 October.
- Piatt, J., J.K. Parrish, H.M. Renner, S.K. Schoen, T.T. Jones, M.L. Arimitsu, K.J. Kuletz, B. Bodenstein, M. García-Reyes, R.S. Duerr, R.M. Corcoran, R.S.A. Kaler, G.J. McChesney, R.T. Golightly, H.A. Coletti, R.M. Suryan, H K. Burgess, J. Lindsey, K. Lindquist, P.M. Warzybok, J. Jahncke, J. Roletto, and W.J. Sydeman. 2019. Was an “ectothermic vise” responsible for the mass mortality and breeding failure of seabirds in Alaska following the NE Pacific marine heat wave of 2014-2016? Oral Presentation. PICES annual meeting. Victoria, BC, Canada. 16-27 October.
- Siegert, D., K. Iken, S. Saupe, and M. Lindeberg. 2019. Comparing intertidal food web and community structure across two regions of lower Cook Inlet. Oral Presentation. CMI Annual Review, Anchorage, February.

- Smoot, C.A., and R.R. Hopcroft. 2020. Warm-water zooplankton in the Northern Gulf of Alaska: observations from the Seward Line. Poster presentation, Alaska Marine Science Symposium, January.
- Straley, J., J. Moran, R. Suryan, M. Arimitsu, C. Gabriele, J. Neilson, R. Cartwright. 2019. Understanding population-level changes in response to ecosystem perturbations: Humpback whale monitoring during the North Pacific Marine Heatwave. Oral Presentation. Joint American Fisheries Society-The Wildlife Society Meeting. Reno, NV. 1-4 October.
- Straley, J., J. Moran, B. Witteveen, O. Titova, O. Filatova, C. Gabriele, J. Neilson, C. Matkin, O. von Ziegesar, and T. Cheeseman. 2020. Local collapse of a humpback whale population during the 2014-2016 marine heatwave: Where have all the whales gone? Poster Presentation. Alaska Marine Science Symposium, Anchorage, AK. 27-31 January.
- Suryan, R.M. 2019. Gulf of Alaska ecosystem status for 2018 and early indicators for 2019. Oral Presentation. Alaska Groundfish and Halibut Seabird Working Group, NOAA Alaska regional office, Juneau.
- Suryan, R.M. 2019. Preview of Ecosystem and Economic Conditions, NOAA Integrated Ecosystem Assessment. Oral Presentation. Alaska Fisheries Science Center, Seattle, Washington.
- Suryan, R.M. 2019, Ecosystem and Socioeconomic Profile Data Workshop. Oral Presentation. Alaska Fisheries Science Center, Seattle, Washington.
- Suryan, R.M., M.R. Lindeberg, M. Arimitsu, H. Coletti, R. Hopcroft, D. Aderhold, and K. Hoffman. 2020. Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska: Perspectives from Gulf Watch Alaska. Oral Presentation. Alaska Marine Science Symposium, Anchorage, Alaska, January 27-30.
- Sydeman, W., S.A. Thompson, S. Zador, K. Shotwell, M. Arimitsu, H. Renner, J. Piatt, S. Hatch, and Y. Watanuki. 2019. Oral Presentation. Potential application of seabird data on groundfish stock assessments. PICES annual meeting. Victoria, BC, Canada. 16-27 October.
- Thompson, S.A., M. García-Reyes, W.J. Sydeman, M.L. Arimitsu, S.A. Hatch, and J.F. Piatt. 2019. Effects of ocean climate on the length and condition of forage fish in the Gulf of Alaska. Poster Presentation. PICES annual meeting. Victoria, BC, Canada. 16-27 October.
- Van Hemert, C., M. Smith, R. Dusek, S. Schoen, M. Arimitsu, R. Kaler, J. Piatt, K. Kuletz, J. Pearce, G. Sheffield, G. Baluss, L. Divine, D. Hardison, R.W. Litaker. 2020. Harmful algal blooms and Alaskan seabirds: An emerging issue in northern waters? Harmful algal blooms and Alaskan seabirds: An emerging issue in northern waters? Oral Presentation. Alaska Marine Science Symposium. Anchorage, AK. 27-31 January.

- Van Hemert, C., M. Smith, S. Schoen, R. Dusek, J. Piatt, M. Arimitsu, W. Litaker, J. Pearce. 2019. Harmful algal blooms in northern waters: an emerging issue for Alaskan seabirds? Oral Presentation. International Conference of the Wildlife Disease Association, Tahoe City, CA. 4-9 August.
- von Biela, V., M. Arimitsu, J. Piatt, B. Heflin, S. Schoen, J. Trowbridge, and C. Clawson. 2019. Extreme reduction in nutritional value of a key forage fish during the Pacific Marine Heatwave of 2014-2016. Oral Presentation. Joint American Fisheries Society-The Wildlife Society Meeting. Reno, NV. 1-4 October.
- von Biela, V., J. Piatt, M. Arimitsu, and L. Ball. 2019. Fish and wildlife responses to prolonged heatwaves: A window to the future? Symposium Organizers. Joint American Fisheries Society-The Wildlife Society Meeting. Reno, NV. 1-4 October.
- Weitzman, B. 2019. Can you dig it? Patterns of variability in clam assemblages across the Gulf of Alaska. Oral presentation. UAF College of Fisheries & Ocean Sciences Special Seminar, Fairbanks, AK. February.
- Williamson, E., B. Konar, K. Iken, and M.K. McCabe. 2020. Size frequency distribution of *Mytilus trossulus* in Kachemak Bay. Poster Presentation, Alaska Marine Science Symposium. January.
- Zhang, B., B. Konar, B. Weitzman, H. Coletti, and D. Esler. 2020. Associating clam recruitment with adult standing stock in the Northern Gulf of Alaska. Poster Presentation, Alaska Marine Science Symposium. January.

2. Public presentations

- Arimitsu, M. 2019. Montague Strait trawl catch samples: jelly fish, octopus, capelin, and walleye pollock. Presentation to Chenega school and community. Chenega, AK, September.
- Arimitsu, M. 2019. Forage fish in changing seas. Invited Speaker. Sitka Whalefest, Sitka, AK. 31 October – 2 November.
- Ballachey, B. 2019. The *Exxon Valdez* Oil Spill: Perspectives & Lessons, 30 years later. University of Calgary Continuing Education class; Course BMC153 Environmental Site Assessment. Calgary, CA, March 2019.
- Campbell, R.W., J. Jaffe, and P. Roberts. 2019. The PWS Plankton Cam: an underwater microscope to view the zooplankton ecosystem of Prince William Sound. PWSSC Tuesday Night Talk, Cordova.
- Coletti, H., B. Robinson, et al. 2019. Ocean Alaska Science and Learning Center Teacher Workshop. Kenai Fjords National Park, AK, June.
- Danielson, S. 2019. Assessing recent changes in Alaska region oceanic heat content, Osher Lifelong Learning Institute, Fairbanks, AK, October.

- Grobelny, C. and J. Pfeiffenberger. 2020. Exploring the Fjords: A Hands-On Teacher Workshop. NPS OASLC YouTube video
<https://www.youtube.com/watch?v=N14pFH0oNOU&feature=youtu.be>
- Holderied, K. 2019. Kachemak Bay Research and Monitoring. Oral presentation for Cook Inlet Regional Citizens Advisory Council (CIRCAC) Environmental Monitoring Committee. Homer, Alaska, August.
- Holderied, K., S. Baird, B. Konar and K. Iken. 2019. Kachemak Bay Ecosystem Monitoring. Public evening talk at Kachemak Bay Campus, Kenai Peninsula College, University of Alaska Anchorage. Homer, Alaska, October. (Outreach during annual GWA PI meeting)
- Holderied, K. 2019. Gulf Watch Alaska: Ecosystem Monitoring (and data for you?) in the northern Gulf of Alaska. Public seminar for NOAA National Marine Fisheries Service/Alaska Fisheries Science Center Groundfish Seminar series. Seattle, WA, October.
- Holderied, K. 2019. Harmful Algal Blooms in Alaska. Oral presentation for Alaska Ocean Observing System Board of Directors. Anchorage, Alaska, December.
- Kaler, R. 2020. Sentinels of the Seas: Seabirds as ecosystem indicators, Part I and Part II. Oral presentation. Winter 2020 Opportunities for Lifelong Education, Anchorage, Alaska. 23 & 30 January 2020.
- Lindeberg, M.R. 2019. Gulf Watch Alaska: A long-term monitoring program of the *Exxon Valdez* Oil Spill Trustee Council. North Pacific Fishery Management Council, Homer, Alaska, October 3.
- Lindeberg, M.R. Gulf Watch Alaska: A long-term monitoring program of the *Exxon Valdez* Oil Spill Trustee Council. Evening public lecture series. Kachemak Bay Campus, Kenai Peninsula College, University of Alaska Anchorage. October.
- Olsen, D. 2019. Killer whales of the world. Zegrahm Expeditions, Antarctica. Oral presentation. February 2019.
- Olsen, D. 2019. Killer whales of Southern Alaska. Seward naturalists and boat operators, Seward, Alaska. Oral presentation. May 2019.
- Olsen, D. 2019. Mom knows best: Killer whale culture in Southern Alaska. Kayak Adventures Worldwide guide training, Seward, Alaska. Oral presentation. May 2019.
- Olsen, D. 2019. Killer whales of Kenai Fjords. Kenai Fjords National Park interpretive staff training, Seward, Alaska. Oral presentation. May 2019.
- Olsen, D. 2019. Killer Whale Acoustic Identification. Kenai Fjords National Park staff and general Seward naturalists. Seward, Alaska. Oral presentation. June 2019.

- Olsen, D. 2019. Killer whales of Alaska. Lindblad Expeditions, Southeast Alaska. Oral presentation. July 2019.
- Olsen, D. 2019. Killer whales of Prince William Sound. Chenega School, Chenega, Alaska. Oral presentation. September 2019.
- Olsen, D. 2019. Acoustics of killer whales and other marine mammals. Kenai Peninsula College, Homer, Alaska. Oral presentation. November 2019.
- Matkin, C. 2019, Cetaceans of Southern Alaska. UAA course: Series of Oral Presentations May 20-June 5.
- Matkin, C. 2019. Killer whales in Prince William Sound and continuing effects of the *Exxon Valdez* oil spill. Oral presentation. Kenai Peninsula College, September 2019.
- Matkin, C. 2019. Killer whales and research in Alaska. Film production to be shown on Princess Cruises in Alaska. Mike Valente, Faculty NY, producer. April, Anchorage, Alaska.
- Moran, J. 2019. Humpback whales and entanglement issues. Presentation to Chenega school and community. Chenega, AK, September.
- Robinson, B., H. Coletti, D. Green, L. Ware, D. Esler. 2019. The Black Oystercatcher: Migration, Movement and Monitoring. Oral Presentation. Gulf Watch Alaska Community Outreach Event. Kachemak Bay Campus, Homer, AK. 8 October.
- Suryan, R.M. 2019. Mixed signals of “recovery” from the Gulf of Alaska marine heatwave: Perspectives from Gulf Watch Alaska. University of Alaska Southeast, Juneau, Alaska.
- Suryan, R.M. 2019. Biological response to a marine heatwave in the Gulf of Alaska. Evening public lecture series. Kachemak Bay Campus, Kenai Peninsula College, University of Alaska Anchorage. October.
- Weitzman, B. 2019. Sea otter and clam population dynamics in Kachemak Bay. Kachemak Bay National Estuarine Research Reserve Lunch Lecture Series, Kachemak Bay Campus, Homer, AK. 6 December.
- Weitzman, B. 2019. Monitoring nearshore ecosystems in the Gulf of Alaska through sea otters. Fireweed Academy Community Outreach and Lecture Series, Homer, AK. 13 December.

C. Data and/or Information Products Developed During the Reporting Period, if Applicable

As a program, GWA has developed data and information products for this reporting period ranging from tailored datasets for agencies to newsletters and keeping website information up to date. Table 5 summarizes contributions to the NOAA Fisheries 2019 Ecosystem Status Report (Zador et al. 2019).

Data

Table 5. FY19 ecosystem indicator contributions to the National Oceanic and Atmospheric Administration Fisheries Ecosystem Status Report submitted to the North Pacific Fisheries Management Council, fall 2019.

Project	Ecosystem Indicators
Environmental Drivers Component	(11 time series)
CPR (19120114-D)	Large diatom abundance anomaly Copepod community size anomaly Meso-zooplankton biomass anomaly
GAK1 (19120114-I)	Oceanographic station GAK1 water column conditions
PWS oceanography (19120114-G)	Temperature trends in the surface waters of PWS Zooplankton trends in PWS
Seward Line (19120114-L)	Seward Line May temperatures Spring and fall large copepod and euphausiid biomass along the Seward Line
Pelagic Ecosystem Component	(4 time series)
Forage fish (19120114-C)	Seabird-derived forage fish indicators from Middleton Island juvenile sablefish growth index
Humpback whale (19120114-O)	Fall surveys of humpback whales in PWS
Nearshore Ecosystem Component	(4 time series)
Nearshore Ecosystem in the GOA (19120114-H)	Intertidal ecosystem indicators in the northern GOA

Informational Products

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2019. GWA Quarterly Currents. Newsletter. Volume 3.1-3.2: spring-summer quarters. Link on gulfwatchalaska.org.

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2019. GWA Quarterly Currents. Newsletter. Volume 3.3: fall quarter. Link on gulfwatchalaska.org.

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2019. GWA Quarterly Currents. Newsletter. Volume 3.4: winter quarter. Link on gulfwatchalaska.org.

Online Resources Kept Up To Date

Gulf Watch Alaska – <http://www.gulfwatchalaska.org/>

AOOS Gulf Watch Alaska Data Portal – <http://portal.aos.org/gulf-of-alaska.php>

Additional online data and information are listed in the individual project annual reports.

D. Data Sets and Associated Metadata that have been Uploaded to the Program's Data Portal

All GWA project data and metadata are compliant for FY19. Data have been uploaded to the research workspace and made available to the public through the AOOS data portal as scheduled. Table 6 lists the status of each data set for GWA projects as reported by the Data Management program.

Table 6. January 1, 2020 dataset status report from the Data Management Program, AOOS/Axiom. Key to compliance codes: "2" = obligation to publish data has been met; "1" = obligation to share data to Workspace has been met; "0.5" = obligation to share data has been partially met; "0" = no data from this season was shared for the project; "n/a" = the project was not funded during this season; "P" = process study with data not expected until end of project. Note 2018 data are not required to be published until 31 January 2020 but some datasets are already compliant in 2019.

Project	Dataset	2017	2018	2019	Comments
Environmental Drivers Component					
CPR (19120114-D)	Plankton data	2	2	0	
	Temperature data	2	2	0	
GAK1 (19120114-I)	CTD data	2	1	0	
	Mooring data	2	2	2	
PWS oceanography (19120114-G)	Chlorophyll data	2	2	0	
	CTD data	2	2	2	
	Zooplankton data	2	2	0	
Cook Inlet /Kachemak Bay oceanography (19120114-J)	CTD data	2	2	1	
	KBNERR meteorological data	2	2	0	
	KBNERR nutrient data	2	1	0	PI is waiting for collaborator to submit the last sample
	KBNERR water quality data	2	2	0	
Seward Line (19120114-L)	Zooplankton data	2	2	0	
	Chlorophyll data	2	1	1	
	CTD data	2	1	1	
	Nutrient data	2	1	1	
	Seabird data (Kuletz)	2	1	0	
	Zooplankton data	2	0	0	Longer processing requirements - 2018 currently being processed
Nearshore Ecosystem Component					
Ecological Trends in Kachemak Bay (19120114-H)	Rocky intertidal community data	2	2	2	
	Mussel data	2	2	2	
	Rocky intertidal data	2	2	2	
	Substrate data	2	2	2	
	Seagrass data	2	2	2	

Project	Dataset	2017	2018	2019	Comments
Nearshore Ecosystem in the GOA (19120114-H)	Oystercatcher diet & nest density data	2	1	0	
	Eelgrass data	2	n/a	n/a	
	Invertebrate and algae data	2	2	2	
	Marine bird and mammal data	2	2	1	
	Water quality data	2	2	2	
	Sea otter survey data	2	2	1	
	Sea otter scat data	2	2	1	
Pelagic Ecosystem Component					
Fall and winter marine bird (19120114-E)	Marine bird survey data	2	2	1	
Forage fish (19120114-C)	Forage fish count data	2	2	0	
	Forage fish morph data	2	2	0	
	Seabird diet data	2	2	0	
	Hydroacoustic data	2	2	0	
	Water chemistry (CTD & nutrients) data	2	2	0	
	Zooplankton data	2	2	0	
Humpback whale (19120114-O)	Fluke id catalog	2	2	0	
	Energetic/stable isotope data	2	2	0	
	Whale survey data	2	2	2	
	Porpoise survey data	2	2	2	
Killer whale (19120114-M)	CTD data	2	2	2	
	Acoustic catalog	2	2	1	
	Photo catalog	2	2	0	
	Biopsy data- genetic	n/a	n/a	n/a	A single biopsy was performed in 2017. Biopsy data no longer collected.
	Biopsy data-contaminants	n/a	n/a	n/a	This is based on biopsy data
	Prey genetic sampling	1	1	0	Opportunistic samples. Data in the Workspace but not ready for publication.
Summer marine bird survey (19120114-N)	Summer marine bird survey data	n/a	2	n/a	Even year surveys only

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY19): *Science Panel is pleased to see the continued increase in quality of the program and the program proposals. Science Panel was pleased with the increased emphasis by PIs on dissemination and publication of results from individual projects. The Panel encourages all PIs to bring their data together to tell a story that encompasses a bigger picture, which may be partially accomplished through the proposed synthesis papers.*

PI Response: The GWA PMT and PIs are devoted to the success of the program and maintaining professional quality. Currently, the program and PIs are focused on data syntheses for the 3rd year (monitoring year 8) science synthesis report, which will be a series of peer reviewed papers doing just that, bringing data together to tell bigger picture stories. In the long-term, we are discussing continued cross-component analyses and synthesis projects - including various modeling efforts - that will continue into the next 5-year (FY22-26) funding cycle.

11. Budget:

Please see provided GWA program workbook. Table 7, on the next page, provides a summary of spending to date by project, comparing proposed spending for FY19 (year 8) with actual spending for the year.

Table 7. Spending summary by project, showing proposed FY19 (year 8) and actual cumulative spending for the FY17 (year 6), FY18 (year 7), and FY19 (year 8). All numbers are in thousands and do not include GA.

Project Number	PI	Project Title	FY19 Proposed	Cumulative Total
Environmental Drivers				
19120114-D	Batten	CPR	\$74.5	\$217.0
19120114-G	Campbell	PWS Ocean	\$209.5	\$537.5
19120114-I	Danielson	GAK1	\$121.7	\$295.0
19120114-J	Holderied/Baird	LCI/KBay Ocean	\$168.2	\$372.9
19120114-L	Hopcroft	Seward Line	\$128.0	\$379.5
Pelagic				
19120114-C	Arimitsu/Piatt	Forage Fish	\$268.0	\$681.7
19120114-E	Bishop	Wintering Birds	\$111.8	\$223.3
19120114-M	Kuletz/Kaler	PWS Marine Birds	\$22.9	\$249.6
19120114-N	Matkin	Killer Whales	\$130.4	\$389.1
19120114-O	Moran/Straley	Humpback Whales	\$171.9	\$345.2
Nearshore				
19120114-H	Coletti et al.	Nearshore	\$377.4	\$1,098.2
Integrated Program Management and Administration				
19120114-A	Lindeberg	Synthesis/Coord	\$138.1	\$669.8
19120114-B	Hoffman	Admin/Outreach	\$350.9	\$769.0
19120114-H	Esler	Post-doc	\$57.2	\$45.2
			\$2,330.3	\$6,273.0

Below is a brief explanation for cumulative spending deviations greater than 10% by project for FY19 (year 8).

19120114-I GAK1: In order to take advantage of the M.J. Murdock Charitable Trust matching funds, we postponed spending 2017 equipment funds until 2018. Though not shown in this breakdown, PI Danielson's transition from Research Faculty to Tenure Track Faculty status will allow him to re-allocate some of his salary into student and staff support over FY19-FY21.

19120114-M PWS marine bird population trends, through 19120114-L Seward Line: Dr. Kuletz was allocated of new funds (\$8,000) from the GWA program, via PWSSC, to fund additional offshore surveys in summer 2019, as part of the northern GOA LTER.

19120114-N killer whales: In evaluating the project budget at the close of FY19, we realize the need to shift funds among categories within the project. Additional funds are needed for analysis due to

the amount of data generated by acoustic stations and the complexity of analyses of these data. In contrast, we have found other means to fund much of our travel and lodging and do not need as much for acoustic equipment as initially projected. We anticipate shifting funds from travel and commodities categories to fund additional analytical costs. There will be no change in overall funding request.

19120114-C forage fish: Current expenditures of some line items exceed $\pm 10\%$ deviation from the originally proposed amount in cases where reporting accounts lagged behind actual expenses, inconsistencies between federal and *Exxon Valdez* Oil Spill Trustee Council fiscal year start dates, and because USGS budget system categories differ from those shown on the *Exxon Valdez* Oil Spill Trustee Council proposal. All expenditures are within keeping to our planned budget. These costs will even out over time, and we expect to spend the total proposed budget amount by the end of the project.

19120114-E fall/wintering marine birds: Personnel for this project was underspent in FY19 as the avian research assistant took a 3-month leave of absence and the PI took more leave than expected due to health issues.

19120114-H nearshore: Federal agencies—for FY17, deviation from travel was due to NPS personnel being unable to attend meetings in the winter of 2017/2018 (AMSS and the Ocean Sciences) because of medical issues. Deviation from contracting was due to charter costs being less than anticipated in summer 2017. Those funds are to be put into another contract to assist with stable isotope analyses of past samples from GWA sites, as well as a contract to assist with the ingestion of all Migratory Bird Management survey data into NPPSD. The deviation in spending from commodities and equipment is an artifact of USGS budget categorization. When combined, there is $< 10\%$ deviation. For FY18: There are only minor deviations in actual spending relative to budgeted. These include slightly higher Personnel costs, offset by lower Commodities costs, than expected. Contracts to date have been lower than anticipated, largely due to lower charter vessel costs. However, FY19 charter costs have been higher than expected, which will result in equilibration of Contract expenses.

19120114-H nearshore: UAF—discrepancies in dollars spent to date are due to salaries and services not yet rendered because one PI was unable to participate in field work in 2019 and has not charged salary for that time. An undergraduate student enlisted to help with sampling incurred less cost than the PI would have been. Stable isotope analysis is behind schedule because 2019 samples from all sites have not been sent to UAF yet. We anticipate services and salary to be spent on schedule in subsequent years.

LITERATURE CITED

Arimitsu, M., J. Piatt, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, R.S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V.R. von Biela. 2019. Chapter 3: Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. *In* R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The

Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

- Danielson, S.L., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. 2019. Chapter 1: A study of marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells. In M.R. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. *The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska*. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Konar, B., T.J. Mitchell, K. Iken, H. Coletti, T. Dean, D. Esler, M. Lindeberg, B. Pister, and B. Weitzman. 2019. Wasting disease and environmental variables drive sea star assemblages in the northern Gulf of Alaska. *Journal of Experimental Marine Biology and Ecology*. DOI:10.1016/j.jembe.2019.151209.
- Piatt, J.F., J.K. Parrish, H.M. Renner, S.K. Schoen, T.T. Jones, M.L. Arimitsu, K.J. Kuletz, B. Bodenstern, M. García-Reyes, R.S. Duerr, R.M. Corcoran, R.S. A. Kaler, G.J. McChesney, R.T. Golightly, H.A. Coletti, R.M. Suryan, H.K. Burgess, J. Lindsey, K. Lindquist, P.M. Warzybok, J. Jahneke, J. Roletto, and W.J. Sydeman. 2020. Extreme mortality and reproductive failure of common murrelets resulting from the northeast Pacific marine heatwave of 2014-2016. *PLoS ONE* 15:e0226087.
- Shotwell, S.K., B. Fissel, D.H. Hanselman. 2019. Ecosystem and Socioeconomic Profile of the Sablefish stock in Alaska. Appendix C in Hanselman, D. H., C.J. Rodveller, K.H. Fenske, S.K. Shotwell, K.B. Echave, P.W. Malecha, and C.R. Lunsford. 2019. *Assessment of the Sablefish stock in Alaska*. National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington, USA, NOAA Alaska Fisheries Science Center, Seattle, WA.
- Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Sweeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2019a. Chapter 4: Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. In R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. *The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska*. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, AK.
- Suryan, R. M., M. R. Lindeberg, and D. R. Aderhold. 2019b. *The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska*. Long-Term Monitoring

Program (Gulf Watch Alaska) Synthesis Report, (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R.M. Suryan, T. Dean, D. Hondolero, and M.R. Lindeberg. Chapter 2: Changes in rocky intertidal community structure during a marine heatwave in the northern Gulf of Alaska. *In* R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. *The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska*. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Zador, S., E. Yasumiishi, and G.A. Whitehouse, G.A. (editors). 2019. Ecosystem Status Report 2019. North Pacific Fishery Management Council.

<https://access.afsc.noaa.gov/REFM/REEM/ecoweb/pdf/2019GOAecosys.pdf>