

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

1. Program Number:

20120114

2. Program Title:

Gulf Watch Alaska

3. Program Lead Name(s):

Mandy Lindeberg, NOAA Fisheries, Alaska Fisheries Science Center, Auke Bay Laboratories
Katrina Hoffman, Prince William Sound Science Center

4. Time Period Covered by the Summary:

February 1, 2020 to January 31, 2021

5. Date of Summary:

March 2021

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 FY20, monitoring year 9. 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 FY20 (year 9), as noted in the brief summaries presented below.

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

- The COVID-19 pandemic impacted GWA monitoring projects to varying degrees during 2020. Some projects completed data collection without delays or effects, others able to collect all or a portion of their monitoring work, and several were unable to accomplish data collection while following federal, state, and agency health mandates. Work was only authorized through detailed contingency plans drafted by PIs for conducting field and lab work safely as required by their institutions.
- The challenges of trying to do research and monitoring during a pandemic have been unprecedented. However, there have been some positive realizations for the GWA program. The diverse multi-agency profile of the program and professional relationships developed over the years by the principal investigators (PIs) became an advantage during the pandemic. PIs were able to share resources, conduct sampling for those who could not, and develop creative solutions to maintain their legacy datasets. When it comes to sustaining scientific data, the tenacity and ingenuity of GWA PIs showed they were up for the COVID-19 challenge.

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

- GWA program datasets for FY19 (year 8) are available in 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. Table 6 in Section 9.D provides details for each project data set.
- During this reporting period the GWA program produced or participated in 27 peer-reviewed publications, 26 reports, 66 oral and poster presentations at conferences and workshops, 16 popular articles and one podcast, and 19 outreach media/events with the public.
- GWA Program Management Team (PMT) members and PIs participated in scientific conferences mostly virtually during FY20, including the Alaska Marine Science Symposium, January 2021. GWA team members presented oral papers and posters and participated in keynote and panel presentations.
- 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. During 2020, distribution of *Delta Sound Connections* was focused on the PWSSC's website (<https://pwssc.org/home-2/delta-sound-connections/>) because of travel restrictions during the pandemic.
- The community engagement event planned for PWS communities during FY20 was postponed due to the pandemic. We hope to reschedule the activity for 2021, based on the status of the pandemic and ability to travel to rural communities safely.

- 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.
 - The PMT has continued efforts to develop program graphics for outreach, presentations, publications, and potential interpretive displays. We recently completed graphic illustrations for the Environmental Drivers component to compliment those developed for the pelagic and nearshore components (see project 20120114-A-B annual report).
3. *Develop science synthesis products to assist management actions, inform the public, and guide monitoring priorities for the future*
- The GWA program helped organize and participate in a science synthesis workshop to the EVOS Trustee Council Science Panel and Council staff in Anchorage, February 2020. Presentations were given on the findings presented in the draft science synthesis report.
 - The GWA PMT and lead PIs responded to the EVOS Trustee Council Science Panel reviews of the draft science synthesis report and submitted a final report (Suryan et al. 2020).
 - Authors of the GWA science synthesis report worked on revising and submitting for publication in peer reviewed journals, four manuscripts that were part of the report.
 - Provided GWA time series indicators to the National Oceanic and Atmospheric Administration’s (NOAA’s) annual Alaska Ecosystem Status Report (Ferriss and Zador 2020) and Ecosystem and Socioeconomic Profiles to support ecosystem-based fisheries management in the GOA. GWA components (Environmental Drivers, Pelagic Ecosystem, and Nearshore Ecosystem) contributed 21 metrics. Table 5 in Section 9.C provides information on metrics by component and project.
 - PMT members participated in three workshops for NOAA Fisheries where GWA data contributed to ecosystem-based fisheries management efforts.
 - Continuing leadership toward a Deep-Sea Research Part II special issue titled “Understanding Ecosystem Processes in the Gulf of Alaska: Volume 3”.
 - Planning activities continued in FY20 for longer-term syntheses priorities during monitoring years 10-20 (FY22-31).
 - The GWA Program Lead presented an overview of GWA monitoring at the EVOSTC public meeting, Feb. 28, 2020. The PMT also attended the Trustee’s Oct. 14, 2020 and Jan. 19, 2021 public meetings and the Public Advisory Committee meetings on Feb. 25, 2020, Oct. 13, 2020, and Jan. 8, 2021.
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. This was utilized extensively across programs during the COVID-19 restrictions. For project-specific coordination and collaboration, see section 8.A.2.a.

- HRM PIs contributed to the GWA science synthesis report and subsequent peer reviewed publications.
 - 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 PI meeting.
 - In 2020, GAK-1 PI Danielson upgraded a glider to carry a Vemco RxLive receiver so that they could listen for tagged fish and get detections returned in near real time. This is work done in partnership with PWSSC PIs Mary Anne Bishop (herring migration project 20160111-B) and Rob Campbell (PWS oceanography project 20120114-G).
 - Because the EVOS Trustee Council FY22-31 Invitation incorporates the long-term monitoring and herring programs into one long-term research and monitoring program (LTRM), GWA and HRM began coordinating even more closely during FY20 for planning purposes.
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 (NGA) Long-term Ecological Research (LTER) program. This effort leverages, complements, and enhances overall GWA program activities. Together, GWA and the NGA LTER are the primary annual sampling efforts in the GOA and are major contributors to knowledge of ocean conditions and effects on biological resources.
 - The GWA PMT also made efforts to gain new partnerships and funding that will complement the GWA program. The Program Lead focused on prospects with Bureau of Ocean Energy Management, (BOEM), Alaska Region. BOEM and GWA areas that overlap are in Cook Inlet where oil and gas leases occur in federal waters. The work with BOEM resulted in a GWA priority “profile” included in the Environmental Studies Program - Studies Development Plan for potential funding in FY2022. This later enabled GWA PIs to directly respond to BOEM’s call for input and ideas for new studies.

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
Program Management 20120114-A-B	
NOAA NMFS AFSC & NPFMC	Coordinate GWA contributions (23) to GOA Ecosystem Status Report for fisheries stock assessments

GWA Project / Affiliated Partner(s)	Description
PWS Forage Fish 20120114-C	
NPRB/NOAA	Coordinate with GOA IERP PIs on synthesis of capelin in the GOA
NOAA NMFS AFSC & NPFMC	Contribute forage fish trend data to GOA Ecosystem Status Report for fisheries stock assessments and socioeconomic profiles
USGS/USFWS/NPS/UW	Provide information, data, and samples for documenting a large-scale common murre die-off centered in PWS
NPRB/OSU/ PWSSC/USGS	Provide forage fish and macrozooplankton samples for harmful algal bloom study
USGS/BOEM	Complimentary study of forage fish and seabird trends in areas of oil and gas development in Cook Inlet
Farallon Institute/USGS	Contribute predator diet data for analyses of biogeography and spatio-temporal variation in forage fish from southeast AK to the western Aleutians
BOEM/NOAA/USFWS/UAF	Compile data on forage fish for resource management and planning in areas of oil and gas development
Canada DFO/NPS	Coordinate and advise on forage fish monitoring methods
CPR 20120114-D	
NPRB	NPRB contributes funding at a similar annual level to that requested here, through NPRB's long-term monitoring program
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
NOAA NMFS AFSC & NPFMC	Contribute plankton data to GOA Ecosystem Status Report and Socioeconomic Profiles for stock assessments
PWS Fall/Winter Marine Birds 20120114-E	
ADF&G	ADF&G provides a vessel for a survey platform annually
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
PWSRCAC	Conduct complementary marine bird transects during late winter in and around the oil tanker lane for use by RCAC in oil spill response planning; data also incorporated into the marine bird fall/winter database

GWA Project / Affiliated Partner(s)	Description
PWS Oceanography 20120114-G	
NOAA NMFS AFSC & NPFMC	Contribute 4 oceanographic and plankton indicators to GOA Ecosystem Considerations Report for stock assessments
OSU	Synthesis of physical oceanographic datasets from the inner fjords across the GOA
Georgia Tech/WHOI	Proposing to leverage GWA observations to develop and deploy autonomous drifters near Columbia Glacier
PWSAC	Collaborate with PWSAC staff to use GWA and other observations to better time releases of hatchery fish
APSH	Collect samples for pCO ₂ measurements at Alutiiq Pride Shellfish Hatchery
USGS Marrowstone	Plankton samples used to test for fish disease life stages
USGS/UW/Northeastern	Proposing to add a discrete water sampler to the profiler
USGS/ASC/Boise State	Proposing to leverage GWA observations in the vicinity of tidewater glaciers
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 food webs of PWS and Kachemak Bay
NPRB	NPRB funding is used to evaluate high frequency observations of the secondary production cycle in PWS
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
OSRI/UAF	Water samples collected to test the efficacy of additives designed to enhance microbial degradation of oil spills
Nearshore Ecosystems 20120114-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
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
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

GWA Project / Affiliated Partner(s)	Description
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
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
CMI/BOEM/NPS	Analyzing food web structure in western Cook Inlet and Kachemak Bay
NPS	Collaborating on the Pacific Nearshore Project to assess the overall health of nearshore ecosystems across the north Pacific
Simon Fraser University	Collaboration on studies of black oystercatcher movement ecology and migration strategies
NOAA NMFS AFSC & NPFMC	Contribute 4 nearshore indicators to the GOA Ecosystem Status Report for stock assessments
USGS	Collaborated to ensure marine bird and mammal data collected since 2006 in the GWA nearshore regions were included into the North Pacific Pelagic Seabird Database
GAK-1 20120114-I	
NOAA NMFS AFSC & NPFMC	Contribute oceanographic indicators to GOA Ecosystem Status Report for stock assessments
ADF&G	Data made available to ADF&G for salmon forecasting
NPS	Establishing monthly sampling data and processing protocol in Glacier Bay national Park and Preserve
AOOS	Data are used for ocean acidification monitoring at a surface buoy near GAK-1
NSF/IOOS	Project is part of the NGA LTER program
LCI/KBay Oceanography 20120114-J	
NOAA Beaufort Lab	Project phytoplankton data used to identify environmental triggers for increases in <i>Alexandrium</i> that causes PSP
NOAA NMFS	Provide data for the Kachemak Bay Habitat Focus Area
NOAA NMFS Protected Resources	Provide data for whale and sea lion mortalities in Cook Inlet
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
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
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
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 20120114-L	
NOAA NMFS AFSC & NPFMC	Contribute 2 oceanographic and plankton indicators to GOA Ecosystem Status Report for stock assessments
ADF&G	Data are made available to ADF&G for salmon forecasting
NPRB/AOOS	Multi-disciplinary sampling program that represents the most comprehensive long-term dataset available for the northern GOA
NSF	Project is part of the Northern GOA LTER program
USFWS	Provide vessel platform for seabird/marine mammal observers
NOAA	Provide bongo collections for larval fish assessments
Summer Marine Birds 20120114-M	
USFS/NPS/ADF&G	Data inform management agencies with lands and waters adjacent to the study area
Alaska Maritime NWR	Data on population trends are provided for inclusion in annual reports on status and trends of seabirds in Alaska
Killer Whales 20120114-N	
NOAA NMML	Data are supplied annually to NOAA NMML for application in marine mammal stock assessments
NOAA NMML	Confirm detection of killer whales in Cook Inlet beluga whale monitoring
NOAA Northwest Region	Contribute fecal samples for comparison of microplastics with endangered Southern Resident killer whale
NOAA Northwest Region	Collaborate on publication using fecal samples for comparison of diet with endangered Southern Resident killer whale diet

GWA Project / Affiliated Partner(s)	Description
Canada DFO Pacific Biological Station	Contribute prey remains from killer whale predation events as part of long-term Resident killer whale diet study
Canada DFO Pacific Biological Station	Contribute data and share authorship on publication regarding diet of Offshore killer whales
Orcasound/Google	Contribute autonomous and field recordings to advance coding for active learning automatic detection of killer whale calls
Happywhale	Contribute to worldwide killer whale database
Humpback Whales 20120114-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
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
NOAA NMFS AFSC & NPFMC	Contribute indicators to the GOA Ecosystem Status Report for stock assessments
NOAA NMML	Collect eDNA from harbor porpoise to identify stock structure
ADF&G	Photograph Steller sea lion brands whenever possible, re-sightings used to identify movements and survival rates
IWC Comp. Assess. Working Group	Used to inform the population structure model for the IWC's Comprehensive Assessment.
Happywhale	Contribute to worldwide humpback whale database
Alaska Whale Foundation/UH Manoa	Provide data on humpback whale populations in the GOA

All GWA program-level measurable tasks have been completed for FY20 (year 9; Table 2).

Table 2. Measurable GWA program tasks completed in FY20.

FY20 Measurable Program Tasks	Status
Conduct quarterly program teleconferences	Completed
Submit annual reports for FY19 and semi-annual NOAA report	12 annual project reports and 1 program report submitted March 2020; Program Management I and II annual reports were combined per EVOSTC request

FY20 Measurable Program Tasks	Status
Updates to program website	Ongoing
Submit annual program work plans and semi-annual NOAA report	Completed and submitted August 2020; responded to Science Panel comments September 2020
Participate in EVOSTC annual Public Advisory Committee meeting	Completed
PI data compliance on workspace	Projects are meeting expectations for data sharing while under COVID-19 pandemic restrictions
Contributions to NOAA Ecosystems Status Report for the GOA	21 GWA metrics used in 2020 report
Present to EVOSTC Trustees	Presentation on October 14, 2020
Annual PI meeting and program review	Completed November 17-18, via GoToTraining video platform
Presentation of GWA datasets at AMSS; sidebar meeting with PIs	Completed. PIs, team members, and partners presented 4 oral presentations and 25 posters, January 2021 (AMSS format modified to online platform due to pandemic); joint GWA/HRM team meeting held on January 13, 2021 via GoToMeeting video platform

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

This section provides brief project-level highlights. Please refer to FY20 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 (20120114-A) (Program Management I; or PMI)

Mandy Lindeberg and Rob Suryan, NOAA Auke Bay Laboratories

Program administration, logistics, & outreach (20120114-B) (Program Management II; or PMII)

Katrina Hoffman and Donna Aderhold, Prince William Sound Science Center (PWSSC)

Science Synthesis:

- The Science Coordinator worked with synthesis report chapter authors to publish chapters in peer reviewed journals. Three of the chapters have been published or are in press and the fourth chapter is in review. The chapter led by the Science Coordinator has been accepted for publication in the journal *Scientific Reports* (Suryan et al. in press).
- The PMT continues working with project PIs to identify signature time series that best indicates the state of their part of the GOA ecosystem. Many of these are published annually in the NOAA Ecosystem Status Report (Ferriss and Zador 2020). In 2020, 21 metrics from all three GWA components and 3 metrics from the HRM program were included in the Ecosystem Status Report.

- The GWA team, led by the Program Lead and Science Coordinator, are providing leadership and scientific contributions toward a peer reviewed special issue of Deep-Sea Research Part II in coordination with the North Pacific Research Board GOA Integrated Ecosystem Research Program focused on furthering understanding of the GOA ecosystem.

Administration, logistics, & outreach

- The PWSSC extended contract amendments to all the non-Trustee Agency sub-awardees for the fourth year of this grant, FY20 and submitted semi-annual reports to NOAA in both March and August 2020.
- The PMT successfully facilitated quarterly GWA meetings and coordinated submission of annual work plans, budgets, and reports. The PMT also distributed the *GWA Quarterly Currents* program newsletter.
- We continue to make updates to the website www.gulfwatchalaska.org. During 2020 the outreach team worked with the Nearshore component to update their portions of the webpage to better reflect their work. Blog posts regularly update 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.
- As part of an effort to develop program graphics for outreach, presentations, publications, and potential interpretive displays, the Program Lead worked with PIs from the Environmental Drivers projects to complete graphic illustrations of the oceanographic system and methods of sampling.

Environmental Drivers Component

GOA mooring (GAK-1) (20120114-I)

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

- GAK-1 achieved a major milestone in 2020 by completing its first full half-century of observations, spanning the period December 1970 to December 2020. Immediately following the December 2020 cast, PI Danielson published an Op-Ed piece in the Anchorage Daily News titled “The importance of the University of Alaska-based monitoring of our oceans” using GAK-1 as a focal example of the means in which scientific data are beneficial to the public interest.
- Updated trend analyses were submitted to the NOAA Ecosystem Status Report (Ferriss and Zador 2020) and show that recent water temperatures remain warmer than the 50-year climatology throughout the water column, while near-surface waters have freshened over time and near-bottom waters have salinized.
- In 2020 GAK-1 scientists published a journal article in a special issue (Coastal Hydrology and Oceanography) of the Journal of Geophysical Research. Danielson et al. (2020) describes a 3-d high resolution ice and ocean circulation model of the northwest Gulf of Alaska. It uses a wetting-and-drying algorithm to accurately reproduce the large Cook Inlet tides, and it uses

the high-resolution terrestrial runoff estimates to provide a coastal boundary forcing function of freshwater inputs. GAK-1 data are used to assess model performance.

- The synthesis report chapter led by PI Danielson is currently in review for publication in Deep-Sea Research Part II (Danielson et al. in review).

Seward line (20120114-L)

Russ Hopcroft, Seth Danielson, and Kenneth Coyle, UAF

- As part of the NSF's NGA LTER, the Seward Line completed all three planned cruises from the R/V Sikuliaq despite federal and state COVID-19 health mandates and restrictions. Although all cruises were scaled back in scope, all traditional sampling of the Seward Line and PWS were accomplished.
- During May 2020 surface temperature and salinity were relatively normal in the upper 100m, but salty water was trapped at depth on the inner shelf. Summer conditions were also relatively normal although the thermocline appears to be located somewhat shallower than normal on the outer half of the line.
- During 2020 all three surveys, zooplankton were sampled along the Seward Line, but the Middleton Line was only sampled during summer. After low biomass of large copepods during spring 2019, their biomass during 2020 was relatively typical. Small copepod biomass was somewhat low in spring and summer of 2020, and euphausiid biomass was relatively typical in spring (fall 2020 not yet available).
- We conducted visual surveys for seabirds and marine mammals during two of the three 2020 cruises, COVID-19 restrictions prevented an observer during the spring cruise. During July, we completed 1,370 linear km of surveys and in general, the highest concentrations of birds occurred near the shelf-break and in coastal waters within 15 km of the shore, while the lowest densities occurred over the middle shelf and in the high-nutrient low-chlorophyll offshore waters on the outer Seward Line. During the fall cruise, we conducted 756 km of surveys. Densities of total seabirds were near the long-term average of 5.5 birds km⁻² and the highest abundances were observed near the shelf-break. We observed seven species of marine mammals during the summer cruise and five during fall. The most frequently observed species were killer whales and harbor seals, respectively.

Oceanographic conditions in PWS (20120114-G)

Rob Campbell, PWSSC

- The planned surveys of PWS were conducted during the reporting period, and all 12 standard stations were occupied; the second cruise of the year was delayed briefly by the state health mandates and restrictions due to COVID-19 during March/April and was done at the end of April.
- Temperatures in central PWS have been above average since late 2013, as has been observed elsewhere in the GOA. Following a weak cooling trend into early 2018 and a brief period of negative anomalies, anomalies have again trended warmer than average, which corresponds to basin-wide increases in sea surface temperature observed in late 2018 and 2019.

- Analysis of the 2010 to 2019 samples shows a shift in zooplankton taxa (smaller warm water species) in PWS during the marine heatwave years. A shift back towards increased cool water species occurred in 2018 but may have switched again in late 2019 following the second heatwave.
- The 2020 time series from the profiler shows the annual cycle of surface warming, with the onset of thermal and salinity stratification in spring/early summer and the breakdown of stability in autumn. Temperature anomalies were strongly positive near-surface in spring-summer, and slightly negative at depths below ~15-20m. Deep waters of PWS are warming.
- The images collected by the plankton camera allow examining the depth-time relationship of specific taxa groups very fine scales (at least 5 cm in the vertical). Observations of several large taxa show interannual differences, e.g. the pteropod *Limacina helicina* appears to be common in spring through summer and exhibits short blooms of or two weeks in duration; the tunicate *Oikopleura* sp. appears to have been much more variable from year to year, with both short bloom, and multi-week episodes of higher abundance.

Oceanographic conditions in Lower Cook Inlet/ Kachemak Bay (20120114-J)

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

- Field sampling activities for 2020 were impacted by COVID-19 federal and state health mandates and restrictions beginning in March. We missed the April and May sampling, and only conducted partial sampling in June. We completed the remainder of the sampling in accordance with our proposal.
- Since October 2018, Kachemak Bay water temperatures have been mostly warmer than the long-term average, with anomalies of up to 2°C. These anomalies were very similar to the anomalies during the anomalously warm period from 2014-2016, while 2017 and most of 2018 were closer to the long-term average. Since May 2020 waters have again been slightly warmer than the long-term average. Kachemak Bay waters were also somewhat less saline than the long-term average, although not to the extent seen during 2014-2016.
- In 2020 scientists were able to conduct phytoplankton sampling under stringent COVID-19 protocols. In total the team collected 166 samples for visual counts and qPCR quantitative analysis for *Alexandrium* spp estimates.

Continuous plankton recorder (CPR) (20120114-D)

Clare Ostle and Sonia Batten, Marine Biological Association

- The 2020 CPR sampling has not been impacted by the COVID-19 pandemic; since CPR sampling is semi-autonomous the ships have been comfortable in taking the equipment on board and deploying the unit. All 2020 tows were completed as scheduled; however, there is a delay in the lab-based microscope analysis of the samples due to lab restrictions that have occurred (and are still ongoing) because of the COVID-19 pandemic. We hope to pick up the rate of analysis of the samples as soon as restrictions ease.

- Although only some of the data are available at this time, preliminary analyses suggest that the plankton returned to levels that were more similar to those found during the cooler years. The provisional results for 2020 suggest similar plankton dynamics to that of 2012.

Pelagic Component

Long-term killer whale surveys (20120114-N)

Craig Matkin and Dan Olsen, North Gulf Oceanic Society

- In 2020, all seven of the AT1 (Chugach) transients were identified. Ages within the group are now estimated between 35 and 54 years. The youngest female is estimated to be 46 years old, which is likely beyond reproductive age. No new calves were documented in this population.
- We had complete encounters with most of the major resident pods that are monitored for our population dynamics work. We also had complete coverage of most southern resident haplotype pods we use in our analysis (except for one matriline in AE pod. The instantaneous rate of growth for the northern resident haplotypes is zero in 2020. For the first time in several years, we had repeated encounters with the oil-impacted AB pod. These encounters confirmed the death of juvenile AB81 who had been missing since 2017. The disappearance of AB17 and her two male offspring are now being treated as deaths. Further support for our conclusion comes from the ages of the animals. Two of the females were estimated to be over 63 years of age and one over 47 years.
- The passive acoustic monitoring project has provided the first description of year-round killer whale distribution and habit use in PWS and Kenai Fjords. Overall, year-round presence is highest in Montague Strait, with killer whale vocalizations recorded on 69.8% of days throughout the year. Killer whales showed a strong seasonal pattern of presence in Hinchinbrook Entrance and Resurrection Bay, with high use in March to July (80.6% of days per month) and May to June (82.7% of days per month), respectively. Passive acoustic data also show a decrease in killer whale presence in Montague Strait in September and October since 2018, which is consistent with vessel-based observations.
- Since 2016, the collection of fecal samples has complemented our previous long-standing (1991-present) database of collection of prey remains during feeding events. The database of prey remains contains more than 200 samples, and demonstrates highly seasonal feeding habits, with Coho salmon most dominant, then Chum, then Chinook. Through the fecal samples, we have confirmed Pacific halibut and recently learned that arrowtooth flounder are a small but consistent and likely important contribution to the diet, averaging 7% each. Interestingly, less than one percent of Sockeye salmon, Pink salmon, or herring were detected in either sampling method, these species are likely unimportant in the diet.

PWS marine bird surveys (20120114-M)

Kathy Kuletz and Robert Kaler, USFWS

- The PWS marine bird survey is conducted in July of even years (2018, 2020); however, COVID-19 health mandates and travel restrictions caused the July 2020 survey to be postponed until 2021. Meanwhile, we worked with partner agencies and a contractor to

develop an updated data logging application to streamlining the workflow of data collection, data proofing (QA/QC), and summarizing project results and reporting.

Forage fish distribution and relative abundance (20120114-C)

Mayumi Arimitsu and John Piatt, USGS Alaska Science Center

- Due to the COVID-19 pandemic we were unable to conduct most of our planned sampling in 2020, including USGS-led efforts to validate June HRM program aerial surveys, and the summer and fall acoustic – trawl surveys in PWS. Rob Campbell at PWSSC provided local support for forage fish sample collections, including spawning capelin from Port Etches in July. Those samples are currently being processed in the lab for measures of age-structure and energy content. We believe they will be useful in a planned analysis that compares responses of capelin following the two recent marine heatwaves in the region.
- Middleton Island seabird diet sampling was conducted according to schedule, albeit with a smaller crew than normal due to the COVID-19 pandemic. In 2020, invertebrates (especially squid) and myctophids were important in the kittiwake diet during the pre-laying period (Apr-May), indicating extensive foraging off the continental shelf at that time. Capelin were scarce throughout the season, absent in spring and present in only trace amounts during summer. Sand lance indices were moderate and relatively stable in kittiwake and auklet diets. Cooling conditions in 2020 were associated with greater indices of hexagrammid species, especially age-0 greenlings, as an important part of kittiwake and auklet diets in 2020.
- Herring were sparse in auklet diets in 2020 at Middleton Island. Length frequency data from 2010 to 2020 provide information on herring when auklets forage inshore. For example, 2017 herring were dominated by the 2016 year class. The 2019 herring samples were also dominated by age-0 herring; however, that year class did not show up in seabird diets in 2020.
- Along with small pelagic forage fishes, juvenile stages of commercially important fish such as sablefish and salmon are frequently sampled by seabirds at Middleton Island. Seabirds have proven to be especially reliable samplers of juvenile sablefish over time. In October 2020 we contributed a young of the year sablefish growth index to NOAA for the sablefish ecological and socioeconomic profile in the annual stock assessment (Shotwell et al. 2020).
- The synthesis report chapter led by PI Arimitsu has been accepted for publication in the journal *Global Change Biology*.

Humpback whale predation on herring (20120114-O)

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

- Humpback whale survey work in 2020 was compromised by the COVID-19 pandemic. We were unable to conduct a spring survey. The humpback whale portions of the fall Integrated Marine Predator-Prey (IMPP) was completed without the benefit of the forage fish team and marine bird observer due to COVID-19 restrictions. This limited our ability to identify and capture prey. In addition, pandemic restrictions have caused delays in the chemical analysis of prey samples.

- Humpback whale numbers have failed to rebound in PWS following a decline associated with the 2014-2016 marine heatwave in the GOA. Encounter rates for humpback whales during the 2020 fall survey were lower than the preceding years. The reduction of humpback whales possible related to a decline in the biomass of herring in PWS or lingering population effects from the marine heatwave.
- In the past we found a correlation between the numbers of individual whales identified each year in PWS (this includes data from both standardized surveys and opportunistic efforts) and the mile-days of milt as reported by ADF&G surveys and the HRM program. However, 2020 proved to be an exception. Whale numbers did not increase with the increase with the mile-days of milt.

Fall and winter habitat use and distribution of seabirds in PWS (20120114-E)

Mary Anne Bishop, PWSSC

- Our fall/winter marine bird surveys consist of three cruises conducted during September, November, and March. FY20 was our second winter of fully dedicated marine bird cruises in which we survey consistent, repeated transects that cover open waters, bays, passages, and nearshore transects that coincide with historical USFWS survey transects. These surveys are replicated every November and March and extend our long-term and most consistent (2007-2016) dataset of wintering marine bird abundance and distribution. In FY20 the September 2020 IMPP survey was canceled due to COVID-19 governmental restrictions on fieldwork.
- As of January 2021, we have completed 51 marine bird surveys over 14 fall/winters in PWS. From these surveys, we have documented consistent temporal patterns in density and distribution for the most abundant marine bird species, including common murre, marbled murrelet, black-legged kittiwake, and large gulls. In FY20, March 2020 surveys were below the long-term mean in both nearshore and open water habitats. In November 2020, marine bird densities were above the mean in nearshore habitats, but slightly below the mean in open water habitats.

Nearshore Monitoring Component

Nearshore systems in the GOA (20120114-H)

Heather Coletti, Daniel Esler, Kim Kloecker, Dan Monson, Brenda Ballachey, James Bodkin, George Esslinger, Brian Robinson, Sarah Traiger, Brenda Konar, Katrin Iken, Mandy Lindeberg, Ben Weitzman, and Thomas Dean, NPS, USGS Alaska Science Center, UAF, NOAA, and Coastal Resources Inc.

- In FY20, due to the COVID-19 global pandemic, normal field operations were significantly reduced or cancelled. Minimal sampling was conducted in Kenai Fjords National Park (KEFJ) and western Prince William Sound (WPWS), while none was completed in Katmai National Park and Preserve (KATM). Most intertidal work was completed in Kachemak Bay (KBAY), but upper trophic level surveys were significantly reduced there.
- The nearshore ecosystem component contributes to the annual NOAA Ecosystems Status Report (Ferriss and Zador 2020), reporting a physical indicator (intertidal water temperature) and three biological indicators that represent key nearshore ecosystem components of

primary production (algal cover), prey abundance (mussel density), and predator abundance (sea star density). Intertidal water temperature and mussel density data, while collected at some sites in 2020, are not currently available due to COVID-19 laboratory health restrictions constraining sample analysis. Rockweed percent cover was collected only in KBAY, while sea star densities were documented at all sites in KBAY and WPWS.

- Nearshore water temperature trends in all four intertidal zones from PWS to the Alaska Peninsula show warming beginning in 2014, corresponding to the large marine heatwave phenomenon (“the Blob”) detected by more pelagic sensors.
- We used percent cover of the perennial intertidal, dominant alga *Fucus distichus* as a metric of trends in a primary producer. Despite considerable variability in percent cover among sites and generally positive anomalies through 2014, KATM and KEFJ sites showed consistently negative values during the recent marine heatwave, continuing through 2019. KBAY has continued to have roughly average *Fucus* cover without a noticeable response to the heatwave through 2020. Anomalies in WPWS had become slightly positive in 2019 and may indicate recovery from the heatwave effects after temperatures cooled in 2018. Percent cover in WPWS, KEFJ and KATM was not measured in 2020.
- We have examined trends in abundance of the mussel *Mytilus trossulus*, a ubiquitous invertebrate filter feeder, as a common nearshore prey species that transfers primary production to higher trophic levels, including various sea stars, annually. However, mussel site sampling was greatly reduced in 2020, therefore this metric was not included in the NOAA 2020 Ecosystems Status Report. In summary, densities of large mussels (≥ 20 mm) show a strong trend across all regions consistent with timing of the marine heatwave, but in this case switching from generally negative to positive anomalies – an opposite response compared to *F. distichus* and sea stars. Mussel sites were sampled in KBAY in 2020 but data analysis is pending. Mussel sites in WPWS, KEFJ and KATM were not sampled in 2020.
- A key predator in structuring nearshore communities are sea stars. For sea star abundance, variability in density, diversity, and dominance of individual sea star species varied greatly among regions through 2015. Between 2015 and 2017, abundance declined and remained strongly negative across all regions through 2018, likely due to sea star wasting disease. In 2019, there was some recruitment and recovery in WPWS and to a lesser degree in KATM. However, KBAY continues to show no signs of recovery through 2020. There could be some lag in recovery in KBAY as sea star wasting disease seemed to move across the GOA from east to west, with first records in WPWS, then KEFJ, and then KBAY. In 2020, the sea star species thought to be unaffected by sea star wasting disease in the northern GOA (primarily *Henricia leviuscula* and *Dermasterias imbricata*) continued to be present. The positive anomaly in WPWS during 2020 surveys was driven by high numbers of *D. imbricata* (81%). At the two sites sampled in KEFJ in 2020, 88% of observed sea stars were *D. imbricata*. The once more dominant sea stars (primarily *Pycnopodia helianthoides*, *Evasterias troschellii*, and *Pisaster ochraceus*) continue to be absent (or rare) in many of the GWA sites sampled in 2020, although one site in WPWS showed some recovery potential with many small *P. helianthoides*.

- The synthesis report chapter led by PI Weitzman has been accepted for publication in the journal *Frontiers in Marine Science* (Weitzman et al, 2021).

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 was planned for with a community in PWS. The information exchange planned for PWS communities was postponed to 2021 because the COVID-9 pandemic and associated health mandates precluded any visits to remote villages. Our Outreach team evaluated using a video-based method for information exchange but did not move forward with this option because of internet stability and bandwidth issues in the remote communities.

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. FY20 resource management engagement included contributions to 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 7.A and B, 8.C, 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

Federal, state, and local health mandates in response to the COVID-19 pandemic were implemented in mid-March 2020. The pandemic impacted GWA monitoring projects to varying degrees during 2020. Some projects completed data collection without delays or effects, others found innovative means to collect all or a portion of their monitoring work, and several were unable to accomplish data collection while following federal, state, and agency health mandates. Details on specific project impacts are presented above in item B—Noteworthy issues and findings within the GWA program and projects.

E. Other significant information pertinent to the GWA program

GWA's Environmental Drivers PI Dr. Seth Danielson published an Anchorage Daily News Op-Ed titled "The importance of UA-based scientific monitoring in Alaska's oceans" (Danielson 2020). A few excerpts are worth highlighting here:

"UAF passed a remarkable milestone this month when scientists from the College of Fisheries and Ocean Sciences completed a half-century of regular observations at a Gulf of Alaska oceanographic station. Station GAK-1 is located near Seward at the mouth of Resurrection Bay, and it has the longest set of sustained measurements of surface-to-seafloor temperature and salinity in all of Alaska's coastal and offshore waters."

"The first GAK-1 observation was taken in December 1970 by UAF faculty member Tom Royer, who then began visiting the site every month or two. Royer later used the data to help

accurately predict the time it would take oil from the 1989 *Exxon Valdez* oil spill to reach Kodiak.”

“What does this mean for our state? GAK-1 is providing data to drive good decision-making and help us evaluate risks to Alaska’s marine ecosystem and economy as the ocean becomes warmer and more acidic due to climate change. This monitoring contributes to our understanding of melting glacier runoff in the ocean, variations in Alaska’s commercial fisheries, and the population status of marine mammals.”

“Although monitoring can be expensive, the alternative—not establishing and maintaining key data records—can be even more costly, far beyond dollars and cents, to ecological, cultural, and social impacts that affect the well-being of us all.”

Also worth noting, the GWA program has been supporting educational opportunities throughout the FY17-21 funding cycle. Supporting the next generation of young scientists has been a rewarding highlight for the program. GWA PIs to date have mentored 38 students from a variety of universities and programs using their EVOS Trustee Council funded projects as a platform for learning opportunities in the Gulf of Alaska (Table 3).

Table 3. Summary of Gulf Watch Alaska Principal Investigators mentoring students associated with their monitoring projects funded by the Exxon Valdez Oil Spill Trustee Council.

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

Count	Degree	Affiliation	Topic	Mentor/Advisor
1	Undergrad intern	NGOS	Data QC, error checking field acoustics	Olsen
1	ANSEP intern	USGS	Lab & fieldwork	Arimitsu
1	Undergrad intern	UAS	GWA-HRM aerial survey	Arimitsu
1	Artist intern	USGS	Fall integrated predator-prey survey	Arimitsu
1	Undergrad intern	NOAA Hollings	Visualizing nearshore data	Holderied
1	Undergrad intern	NOAA Hollings	Nearshore fish	Konar/Holderied
1	Undergrad intern	American Acad. Underwater Sci.	Nearshore communities	Konar
1	MS	UAF CFOS	Mussel dynamics in 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 (Barrow's goldeneyes)	Esler
1	Undergrad intern	Alaska Pacific	Mussel core size and counts	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
1	Undergrad intern	Alaska Pacific	Mussels	Kloecker
1	MS	UAF CFOS	Jellyfish	Hopcroft
1	MS	UAF CFOS	Neocalanus copepods	Hopcroft
1	MS	UAF CFOS	Larvaceans & pteropods	Hopcroft
1	MS	UAF CFOS	In situ plankton imaging	Hopcroft

8. Coordination/Collaboration:

We have now completed monitoring year 9 of the GWA program and coordination and collaboration has expanded to an impressive level. Much of this can be attributed to the stable support of the EVOS Trustee Council and the trust developed over time by the PIs, collaborators, and partnerships. The web of scientific information being generated now goes well beyond the original boundaries of the projects and program.

A. Projects Within a Trustee Council-funded program

1. Within the Program

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

The PMT faced new challenges due to the COVID-19 pandemic. A great deal of effort was put into mitigating the impacts of the pandemic to the program's objectives, especially maintaining the long-term monitoring datasets. The PMT worked with all program members to identify scientific priorities and adapt schedules and budgets to the best of their ability. Detailed contingency plans for conducting field and lab work safely were coordinated and shared among the PIs to meet the various requirements of federal and state agencies. The PMT helped PIs prioritize their scientific objectives and advised them on how to proceed with appropriate budgetary adjustments. Some creative solutions for resources and data collection were developed across projects, a clear benefit of a multi-agency program. The PMT also successfully hosted its first virtual annual PI meeting during the pandemic with more than 40 attendees. Highlights included virtual surveys on the fly so all participants could weigh in on topics and the traditional group photo was just a little different – a composite of selfies at their computer.

The synthesis report and subsequent publications were highly collaborative efforts among the GWA projects. All sampling projects contributed to at least one report chapter and publication and several projects contributed to all four of the chapters and publications.

The Seward Line project (20120114-L, PI Hopcroft) links tightly with the GAK-1 mooring (project 20120114-I, PI Danielson), providing a cross shelf context for its observations. It complements the CPR (project 2020114-D, PIs Ostle and Batten) and PWS and Lower Cook Inlet/Kachemak Bay oceanographic long-term monitoring efforts (projects 20120114-G, PI Campbell, and 20120114-J, PIs Holderied and Baird, respectively) by providing more detailed oceanographic evaluation of the GOA shelf and the major passages in PWS than is provided by the other projects. These components overlap relatively little in their sampling locations - enough to ensure comparability between datasets, but not enough to be duplicative and wasteful of resources. The addition of monthly sampling in Resurrection Bay aligns sampling periodicity with the other Environmental Driver components. The additional monthly sampling in Resurrection Bay and at GAK-1 provide oceanographic context for the GWA Nearshore activities underway within KEFJ. The new sampling line added through NGA LTER funding now connects seabird work at Middleton Island (project 20120114-C, PIs Arimitsu and Piatt) 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.

The seabird component (project 20120114-M, PIs Kuletz and Kaler) of the NGA-LTER also collaborates with the Environmental Drivers Component of GWA. The seabird surveys are conducted from the NGA-LTER research vessel and we will be integrating the seabird data with environmental and zooplankton data collected during concurrent cruises (Seward Line project 20120114-L, PI Hopcroft).

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 20120114-G) provide zooplankton identification for the Cook Inlet/Kachemak Bay oceanography project (PIs Holderied and Baird, project 20120114-J) and the two projects collaborate on analyses for a greater ability to compare data across regions.

Because COVID-19 shutdowns of the federal labs led to the cancellation of forage fish collection activities and aerial survey validations by Arimitsu (project 20120114-C), the PWS oceanography project (PI Campbell, project 20120114-G) conducted some survey validations during regular cruises and did some extra sorties to collect forage fish samples.

Beginning in FY19, the PWS oceanographic project (PI Campbell, project 20120114-G) and fall/winter marine birds project (PI Bishop, project 20120114-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 nearshore project (PI Coletti, project 20120114-H) is working with the killer whale project (PI Matkin, project 20120114-N) of the Pelagic component to provide logistical support to deploy a hydrophone in Kachemak Bay and UAF student time to process hydrophone data. In general, the geographic scale of our study (GOA-wide) will continue to provide greater ability to discern both potential linkages across these diverse components, as well as among the study areas within the Nearshore component, allowing evaluation of variability and relations among the nearshore resources.

The killer whale (PI Matkin, project 19120114-N) and humpback whale (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.

The nearshore project (PI Coletti, 20120114-H) collaborates with two Pelagic component projects, including summer (PIs Kuletz and Kaler, 20120114-M) and fall-winter (PI Bishop, 20120114-E) marine bird population trend projects, to conduct comparable surveys throughout the GWA study area. Contrasting the changes occurring in the pelagic and nearshore environments during the recent years when GOA waters have warmed by several degrees may be particularly illuminating.

Collaboration within the GWA Pelagic Component (forage fish [project 20120114-C, PIs Arimitsu and Piatt], summer marine bird [project 2012-004-M], humpback whale [project 2012-114-O, PIs Moran and Straley], killer whale [project 20120114-N, PI Matkin], and fall/winter marine bird [project 20120114-E, PI Bishop]), and between the pelagic and herring programs, will continue to focus on physical and biological features of locations where whales and seabirds have been found to overlap in time and space.

Three pelagic projects, forage fish (PIs Arimitsu and Piatt, project 20120114-C), fall/winter marine birds (PI Bishop, project 2012114-E), and humpback whales (PIs Moran and Straley, project 20120114-O) share a research platform and common goals to conduct the IMPP surveys each fall in PWS. In addition, the humpback whale project collects samples for the forage fish project in April. The IMPP survey was not conducted because of COVID-19 health restrictions.

Summer forage fish surveys (PIs Arimitsu and Piatt, project 20120114-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 20120114-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, 20120114-E, Kuletz and Kaler, project 20120114-M) to Kachemak Bay/Lower Cook Inlet (PIs Holderied and Baird, project 20120114-J), PWS, Kenai Fjords, Kachemak Bay, and Katmai (PI Coletti, project 20120114-H), and Seward Line/Gulf of Alaska (PIs Hopcroft and Kuletz, project 20120114-L).

A cross-component (Nearshore and Pelagic) effort continues (projects 20120114-C, E, H, L, M, and O) with the intent to integrate bird survey data to examine spatial and temporal trends in a variety of species and guilds across the northern GOA. The Pelagic and Nearshore components worked with ABR Inc. to create a survey tool (SeaLog) and a processing tool (QAQSea) for rapid QA/QC as well as automating the processing required to upload survey data into the NPPSD maintained by USGS. Previous efforts compiled Nearshore survey data from all four regions and provided to USGS for the NPPSD v3 release in 2020. Incorporation of all GWA marine bird survey data into NPPSD will allow for larger scale analyses of marine bird trends throughout the GOA over time.

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. HRM team members were invited and encouraged to attend the two-day GWA PI meeting held virtually via GoToTraining and

many attended all or portions of the meeting as their schedules allowed. HRM team members also participated in breakout sessions used to discuss program components. The fall 2020 HRM program PI meeting was held via GoToMeeting one day after the virtual two-day GWA PI and many GWA team members participated. 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 9.A.2) and subsequent publications (see Section 9.A.1). On the administrative side, all non-Trustee Agency administrative functions are combined at PWSSC to serve both the GWA and HRM programs.

The GAK-1 project (20120114-I, PIs Danielson and Weingartner) makes physical and biological data available to the HRM program. For instance, PI Heintz has been using GAK-1 data to assess energetic costs of overwintering herring. In addition, PI Bishop (herring migration project 20160111-B) inquired about the availability of GAK-1 as a platform for mounting an acoustic tag receiver for the purpose of detecting tagged herring. We installed this sensor on the GAK-1 mooring deployed in spring 2019, spring 2020, and will continue to do so for future deployments as needed.

Danielson's oceanography lab (GAK-1 project 20120114-I) operates a fleet of Teledyne Webb autonomous underwater Slocum gliders. In 2020, we upgraded a glider to carry a Vemco RxLive receiver so that we could listen for tagged fish and get detections returned in near real time. This is work done in partnership with PWSSC PIs Mary Anne Bishop (herring migration project 20160111-B) and Rob Campbell (PWS oceanography project 20120114-G), and NOAA AFSC Auke Bay Labs scientist John Eiler. The upgrades were implemented in summer/fall 2020 and the glider was deployed January 20, 2021 and recovered on February 23.

The CPR project (PI Ostle and Batten, project 20120114-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 Seward Line (PI Hopcroft, project 20160114-L) makes physical and biological data available to the HRM program.

Technicians from HRM project 20160111-B (Annual Herring Migration Cycle) have participated in surveys done by the PWS oceanography project (PI Campbell 20120114-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 and 2020 to further extend the reach of the array.

The PWS marine bird survey project (PIs Kuletz and Kaler, project 20120114-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 20120114-C) continues collaborative work with Scott Pegau and the HRM program's aerial surveys for juvenile herring and other forage fish (project 20160111-F).

The humpback whale project (PIs Moran and Straley, project 20120114-O) is intended to evaluate humpback whale predation on herring in PWS and regularly collaborates with the HRM program in this regard. The spring humpback whale survey was cancelled in 2020 due to COVID-19 and the collaboration will return when the survey is safely conducted again.

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. 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.

B. Projects not Within a Trustee Council-funded program

GWA summer and winter marine bird surveys in PWS (20120114-H, 20120114-M, and 20120114-E) provide information on population trends of species studied by EVOSTC-funded pigeon guillemot restoration project (20100853). 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.

In 2020, the PWS oceanography project (PI Campbell 20120114-G) began collecting samples to monitor for ocean acidification for project 20200127 (PI Hetrick). Samples are collected at two sites in PWS during every regular survey, one in central PWS (representative of "open water" conditions) and one in Whale Bay (where acidification is expected to be enhanced by melting ice).

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 2020 Ecosystem Status Report (Ferriss and Zador 2020), investigators from all three GWA components (Environmental Drivers, Pelagic Ecosystem, and Nearshore Ecosystem) contributed 21 metrics. Among these, the forage fish project (20120114-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. 2020). Table 5 in Section 9.C. summarizes each contribution.

Seward Line/LTER (project 20120114-L) cruises provide bongo collections for larval fish assessment to NOAA AFSC's EcoFOCI group. LTER and NOAA share data on several projects.

The *in situ* camera and machine vision system developed for the PWS oceanography (project 20120114-G) profiler is being spun off into novel applications. In 2020 funding was obtained under the NOAA Saltonstall Kennedy program to develop low-cost and low-power camera systems to be deployed in small clear water streams to count salmon passage. The camera systems will include an onboard micro supercomputer that will be trained to identify different species of salmon as they pass and detect if they are moving up- or down-stream. The systems will be designed to transmit their counts of species-specific fish passage in near real-time through a cellular or satellite data connection.

In August 2019, nearshore (project 20120114-H) PIs (Hondolero and Weitzman) with an academic collaborator (Tom Bell – University of California Santa Barbara) used an unmanned aircraft system (UAS) to map canopy kelp and eelgrass habitats in Kachemak Bay with support from NOAA Kasitsna Bay Lab. The pilot effort proved successful, resulting in a poster at the 2020 Alaska Marine Science Symposium. The Kasitsna Bay Laboratory intends to pursue more UAS mapping of kelp and other nearshore habitats in 2021.

The GAK-1 project (20120114-I) collaborates with the Ocean Acidification Research Lab to help facilitate the GAK-OA buoy turnaround and provides the GAK-1 mooring as a platform for OARC sensors. The GAK-OA mooring is located close to GAK-1, in Sunny Cove and is funded by NOAA's Ocean Acidification program.

The Danielson lab's (GAK-1 project 20120114-I) fleet of Teledyne Webb autonomous underwater Slocum gliders are operated in partnership with NOAA AFSC Auke Bay Labs scientist John Eiler. The glider, upgrades, and piloting were supported by via funding from the Integrated Ocean Observing System and its regional partner, AOOS. See the interactive tool online for the glider "Shackleton" at AOOS (<https://portal.aos.org/?ls=vmAmhyRR#platform/07197b36-867c-596b-bfc6-c059eefd3941/v2?c=rainbow&interp=grid&pid=12>). Our plans are to next deploy the glider for a second month-long mission and then attempt to fly the glider from PWS to Seward, pausing at the GAK-1 mooring for some continuous days of late-winter hydrographic sampling. If this proof-of-concept test flight goes well, then we may consider future glider missions to GAK-1.

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.

We directly interface and collaborate 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 (PCB) and stable isotope trends with Gina Ylitalo, Brad Hanson, and Candace Emonds, all with NOAA

NWFSC, Seattle, WA. In 2021 (delayed due to COVID-19 in 2020), we are scheduled to initiate a collaborative effort with John Durban and Holly Fernbach of Southall Environmental Associates, Seattle, WA to compare condition of individual killer whales using body condition indices. Killer whale 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) 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 (20120114-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 (project 20120114-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 20120114-L) provides a platform for visual seabird surveys and marine mammals during three 2018 Northern GOA LTER cruises, in collaboration with USFWS, Kathy Kuletz.

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 marine bird data (project 20120114-M) collected as part of the NGA-LTER has provided the USFWS and NOAA with data on location, habitat use, and abundance of short-tailed albatross and two other albatross species. The short-tailed albatross is listed under the Endangered Species Act and is thus a concern in NOAA's regulation of commercial fishing in the Gulf of Alaska. All three albatross species are subject to incidental take in commercial long-line fisheries, along with other species such as northern fulmar, shearwaters, and gulls. BOEM has also requested the pelagic survey data from the NGA-LTER, to incorporate into their internal database. The Anchorage office of BOEM is responsible for environmental assessment of Cook Inlet oil and gas lease sales;

assessments include adjacent waters and resources that could be impacted by development or accidents associated with these sales.

The GWA forage fish (project 20120114-C) work is also complimentary to a related USGS-Outer Continental Shelf and 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 (projects 20120114-J and 20120114-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, 20120114-C, fall/wintering marine birds, 20120114-E, nearshore, 20120114-H, marine bird population trends, 20120114-N) feed into the NPPSD database maintained by USFWS and USGS.

In kind support from GWA and NPS was provided to the USGS Pacific Nearshore Project (<https://pubs.usgs.gov/fs/2010/3099/>) that investigated methods to assess overall health of nearshore ecosystems across the north Pacific. In particular, samples were collected during nearshore (project 20120114-H) trips to KATM and WPWS to examine the sources of primary productivity to two fish species that differed in their feeding mode (kelp greenling/nearshore benthic vs. black rockfish/pelagic). Sample collection is on-going throughout all four regions of the Nearshore component. This project forms the foundation of the new MS student projects starting in 2021, supported by NPS and carry over dollars not expended due to COVID-19.

Nearshore (project 20120114-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 Herschberger (USGS Western Fisheries Research Center) on their study of the bacterial gill pathogen NIX in razor clams.

Funded through the Coastal Marine Institute (CMI), a partnership between BOEM and UAF, nearshore (project 20120114-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 20120114-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 (20120114-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).

The *in situ* camera and machine vision system developed for the PWS oceanography (project 20120114-G) profiler will be developed for Eshamy Creek, a small sockeye, pink, and coho salmon stream in PWS that has historically been managed in part with a small weir where fish passage was directly counted, but which was cancelled due to budget cuts in 2011. The project will fund ADF&G (lead: Jeremy Botz, Area Management Biologist, Cordova) to redeploy the Eshamy Creek weir to provide training images and ground-truth data for the camera systems, and to provide direct passage counts for use in in-season management of salmon fisheries in western PWS for 2021 and 2022. If successful, the cameras are expected to be an economical method for estimating fish passage that will complement or potentially replace other existing methods. We have also found that the machine vision algorithms developed to identify the plankton images collected by the profiler (Campbell et al. 2020) show promise for aging salmon scales. In preliminary tests with scale images of Copper River sockeye furnished by Rachel Ertz and Stormy Haught at ADF&G in Cordova, the plankton optimized classifier identified year 1-2 freshwater-ocean fish with 100% accuracy and year 1-3 fish with 91% accuracy “out of the box” with no modifications. We are currently adding to the scale images set and refining the algorithms and have begun work on a proposal to be submitted to NPRB to develop the method further.

Environmental Driver component project (GAK-1, 19120114-I, Seward Line, 20120114-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.

Other Resource Management and Research Organizations

The Seward Line/LTER (project 20120114-L) is co-funded by EVOSTC, 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 20120114-M, PWS marine bird surveys) provide a marine bird and mammal observer on this survey. PIs Arimitsu and Piatt (project 20120114-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 20120114-G) and Holderied and Baird (project 20120114-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). Arimitsu and Piatt (project 20120114-C) provide forage fish and microzooplankton samples for this study.

Our GWA nearshore data (project 20120114-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	27
A.2	Reports	26
A.3	Popular articles	16
B.1	Conferences & workshops	66
B.2	Public presentations	19
C	Developed data & information	Ecosystem indicators (21 time series), quarterly newsletters, and updated website
D	Data & metadata uploaded to Portal	Some delays in 2020 data are due to the COVID-19 pandemic

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Arimitsu, M., J. Piatt, S. Hatch, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Haught, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J.R. Moran, S. Pegau, A. Schaefer, S. Schoen, J. Straley, V. von Biela. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. *Global Change Biology*. <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15556>.

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- Bowen, L., K. Counihan, B. Ballachey, H. Coletti, T. Hollmen, B. Pister and T. Wilson. 2020. Monitoring Nearshore Ecosystem Health Using Pacific Razor Clams (*Siliqua patula*) as an Indicator Species. PeerJ 8:e8761 DOI 10.7717/peerj.8761
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- Coletti H., L. Bowen, B. Ballachey, T. Wilson, M. Booz, K. Counihan, T. Hollmen, and B. Pister. In prep. Gene transcription profiles in two razor clam populations: discerning drivers of population status.
- Coletti, H.A. In press. Sea Otter Behavior and Its Influence on Littoral Community Structure. In R.W. Davis and A. Pagano (Eds) The Ethology of Marine Mammals: Polar Bears and Sea otters. Springer.
- Danielson, S.L., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. *in review*. Thermal variability in the Northern Gulf of Alaska across years of marine heatwaves and cold spells. Submitted to Deep-Sea Research II Special Issue.
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- Davis, R.W., and J.L. Bodkin. In Press. Sea otter foraging behavior. In R.W. Davis and A. Pagano (Eds) The Ethology of Marine Mammals: Polar Bears and Sea otters. Springer.
- Hauri, C., C. Schultz, K. Hedstrom, S. Danielson, B. Irving, S.C. Doney, R. Dussin, E.N. Curchitser, D.F. Hill, and C.A. Stock, C.A. in press. A regional hindcast model simulating ecosystem dynamics, inorganic carbon chemistry, and ocean acidification in the Gulf of Alaska. Biogeosciences Discussions <https://doi.org/10.5194/bg-2020-70>
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- Litzow, M.A., M.J. Malick, N.A. Bond, C.J. Cunningham, J.L. Gosselin, and E.J. Ward. 2020. Quantifying a Novel Climate Through Changes in PDO Climate and PDO Salmon Relationships. *Geophysical Research Letters* p.e2020GL087972
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- Kandell, A. 2020. Spatial and temporal variability of dissolved aluminum and manganese in surface waters of the northern Gulf of Alaska. MS. Thesis, University of Alaska Fairbanks.
- Mendoza-Islas, H.M. 2020. Abundance, composition and distribution of predatory gelatinous zooplankton in the Northern Gulf of Alaska. MS Thesis University of Alaska Fairbanks.
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2. Reports

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- Batten, S. 2020. Continuous Plankton Recorder monitoring of plankton populations on the Alaskan Shelf. FY19 annual report to the *Exxon Valdez* Oil Spill Trustee Council, project 19120114-D. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.
- Bishop, M.A., and A. Schaefer. 2020. Long-term monitoring of marine bird abundance and habitat associations during fall and winter in Prince William Sound. FY19 Annual Report to the *Exxon Valdez* Oil Spill Trustee Council, project 19120114-E.
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3. Popular articles

- Aderhold, D. 2020. Scientists integrate studies of predators and prey in Prince William Sound. *Delta Sound Connections*. Prince William Sound Science Center <https://pwssc.org/wp-content/uploads/2020/07/DSC-2020-web.pdf>
- Arimitsu, M., J. Piatt, and S. Hatch. 2020. Forage fish in the Northern Gulf of Alaska: on the road to recovery at last? *Delta Sounds Connections* 2020-2021. <https://pwssc.org/wp-content/uploads/2020/07/DSC-2020-web.pdf>
- Bailey, A. 2020. Sikuliaq to embark on limited research cruise in May. UAF news and information. <https://news.uaf.edu/sikuliaq-to-embark-on-limited-research-cruise-in-may/>

- Batten, S., S. Chiba, and W. Sydeman. 2020. Two decades of the North Pacific CPR program. PICES Press 18:18-21.
- Campbell, R.W., J. Jaffe, and P. Roberts. 2020. Computers identify plankton images from Prince William Sound. PWSSC Delta Sound Connections (<https://pwssc.org/wp-content/uploads/2020/07/DSC-2020-web.pdf>).
- Coletti, H. 2020. Refuge Notebook: What happened when the ocean warmed. Peninsula Clarion. July 30.
- Danielson, S.L. 2020. The importance of University of Alaska-based monitoring of our oceans. Anchorage Daily News Op-Ed, 12 Dec. 2020. (This was also a UAF press release and was re-printed in January 2021 by deltawindonline.com.)
- Duncommbe, J. 2020. What it's like to social distance at sea. Eos Science News by AGU. <https://eos.org/articles/what-its-like-to-social-distance-at-sea>
- 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.
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- Long, K. 2020. At UAF, two major programs highlight the struggle. Fairbanks Daily News-Minor. http://www.newsminer.com/news/local_news/at-uaf-two-major-programs-highlight-the-struggle/article_2434858a-7c66-11ea-83be-2fd578cd2714.html
- Moran, J. 2020. What Happened to the Whales? Delta Sound Connections. Prince William Sound Science Center.
- National Science Foundation. 2020. Ocean research in the time of COVID-19: Expedition to the Gulf of Alaska keeps vital research and data collection on course. NSF. <https://beta.nsf.gov/science-matters/ocean-research-time-covid-19-expedition-gulf-alaska-keeps-vital-research-and-data>
- Pennisi, E. 2020. Pandemic carves gaps in long-term field projects. Science News. <https://science.sciencemag.org/content/368/6488/220>
- Schaefer, A. 2020. Are warmer waters driving shearwaters into PWS? Delta Sound Connections. Prince William Sound Science Center <https://pwssc.org/wp-content/uploads/2020/07/DSC-2020-web.pdf>
- Turns, A. 2020. Tiny plankton tell the ocean's story – this vast marine mission has been listening. Article about the CPR survey in The Guardian: <https://www.theguardian.com/environment/2020/jun/19/tiny-plankton-tell-the-oceans-story-this-vast-marine-mission-has-been-listening>

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

1. Conferences and Workshops

- Aguilar-Islas, A.M. 2020. The Northern Gulf of Alaska Long Term Ecological Research Site: Nutrient dynamics across the shelf from Kayak to Kodiak islands. University of South Florida. Invited talk. Tampa, FL.
- Aguilar-Islas, A.M., M. Kaufman, and S. Strom, S. 2020. Nutrient dynamics and their influence in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.
- Arimitsu, M. 2020. Tools for data collection, processing, and synthesis of at-sea marine bird survey data. Gulf Watch Alaska Marine Bird Working Group meeting. 9 November.
- Arimitsu, M., M.A. Bishop, D. Cushing, S. Hatch, R. Kaler, K. Kuletz, C. Matkin, J. Moran, D. Olsen, J. Piatt, A. Schaeffer, and J. Straley. 2020. Changes in marine predator and prey population 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, S. Hatch, R. Suryan, S. Batten, M.A. Bishop, R. Campbell, H. Coletti, D. Cushing, K. Gorman, R. Hopcroft, K. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, W.S. Pegau, A. Schaeffer, S. Schoen, J. Straley, and V. von Biela. 2021. Heatwave-induced collapse of forage fish species disrupts energy flow to top pelagic predators. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.
- Arimitsu, M., J. Piatt, R. M. Suryan, S. Batten, M. Bishop, R. W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R. Hopcroft, K. J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V. R. von Biela. 2020. Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. Oral presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27, 2020.
- Brydie, A., and S.L. Danielson. 2020. Copper River discharges in the Northern Gulf of Alaska: freshwater distribution and evolution during the July 2019 freshet. Ocean Sciences Meeting. San Diego, CA.
- Burt, W., R.R. Hopcroft, S.L. Strom, and S.L. Danielson. 2020. Quantifying phytoplankton biomass and productivity at unprecedented spatial scales in the Northern Gulf of Alaska LTER Program using ship-board optical measurements. Alaska Marine Science Symposium. Anchorage, AK.
- Burt, W., R.R. Hopcroft, S.L. Strom, and S.L. Danielson. 2020. Use of ship-board optical measurements to quantify plankton biomass and productivity across multiple trophic levels in the Northern Gulf of Alaska LTER program. Ocean Sciences Meeting. San Diego, CA.
- Busse, H., S. Strom, and J. Fiechter. 2020. Grazing by mixotrophic nano- and dinoflagellates in the Northern Gulf of Alaska in response to gradients in light, inorganic nutrients, and prey availability. Ocean Sciences Meeting. San Diego, CA.
- Coleman, D., and R.R. Hopcroft. 2020. Habitat utilization by diapausing copepods in the Northern Gulf of Alaska. Alaska Marine Science Symposium, Anchorage, AK.

- 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. ASLO Ocean Sciences Meeting, San Diego 16-21 February.
- Campbell, R.W. 2021. Impacts of the recent marine heat waves on the oceanography and plankton ecosystem of Prince William Sound. Alaska Marine Science Symposium, online, Jan 26-28.
- Cushing, D. et al. 2021. Summer tourists: The rare, amazing, out-of-their-range visitors observed during seabird surveys in the northern Gulf of Alaska. Poster Presentation. Alaska Marine Science Symposium, 26-28 January.
- Danielson, S.L. 2020. Freshwater in the Gulf of Alaska: New Observations and Model Results. Presentation to NOAA Coastal and Marine Modeling Branch (CMMB) seminar series. Distance video presentation. 15 Dec.
- Danielson, S.L., 2020. Presentation to the Northern Gulf of Alaska Long Term Ecological Research Program: 2020 Field Updates, Nov. 2020
- Danielson, S.L. 2020. Presentation to GWA PI meeting: 2020 Field Updates, Nov.
- Danielson, S.L. 2021. Presentation to the Northern Gulf of Alaska Long Term Ecological Research Program PI meeting, Jan.
- Danielson, S.L. 2020. Freshwater in the Northern Gulf of Alaska: New model results and observations. NOAA Coastal Marine Modeling Branch seminar series, December 16.
- Danielson, S., T.D. Hennon, D.H. Monson, R.M. Suryan, R.W. Campbell, S.J. Baird, K. Holderied, and T.J. Weingartner. 2020. A study of marine temperature variations in the northern Gulf of Alaska across years of marine heatwaves and cold spells. Oral presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27.
- DeCino, K., and K. Holderied. 2021. Highlighting ecosystem status for Alaska coastal communities in Kachemak Bay, Alaska. Poster presentation. Alaska Marine Science Symposium, Anchorage AK, January.
- DeCino, K., K. Holderied, B. Weitzman, and M. Renner. 2021. State of Kachemak Bay: A tool for understanding and reporting change. Poster presentation. Alaska Marine Science Symposium January.
- Dias, B.S., D.W. McGowan, R.W. Campbell, and T.A. Branch. 2021. What affects spawning phenology of herring (*Clupea pallasii*) in Prince William Sound? Alaska Marine Science Symposium, online, Jan 26-28.
- Dowling, A., B. Konar, and K. Iken. 2021. Size distribution variability in Pacific blue mussels (*Mytilus trossulus*) in glacially influenced estuaries. Poster presentation. Alaska Marine Science Symposium, January.
- Dowling, A., B. Konar, and K. Iken. 2020. Size distribution variability in Pacific blue mussels (*Mytilus trossulus*) in glacially influenced estuaries. Poster presentation. World Conference on Marine Biodiversity, December.

- Du., X., R.W. Campbell, S. Kibler, and B. Wright. 2021. Seasonal dynamics of the harmful dinoflagellate *Alexandrium* and associated paralytic shellfish toxin contamination in shellfish: NPRB 1801 project updates for Prince William Sound. Alaska Marine Science Symposium, online, Jan 26-28.
- Hasan, L., B. Konar, T. Jones, and H. Coletti. 2021. Subtidal habitat mapping in Cook Inlet for current and predictive sea otter habitat associations. Poster presentation. Alaska Marine Science Symposium, January.
- Hernandez, A., and R.R. Hopcroft. 2020. The effects of environmental changes in the Northern Gulf of Alaska on the synthesis of lipid in *N.flemingeri* and *N.plumchrus* from 2018 to 2019. Ocean Sciences Meeting. San Diego, CA.
- Holderied, K., M. Renner, A. Jyzk, D. Hondolero, and B. Weitzman. 2021. Speed dating through meroplankton? Linking ocean and nearshore ecosystems in Kachemak Bay, Alaska. Poster. Alaska Marine Science Symposium, January.
- Kaler, R. 2020. Prince William Sound marine bird survey: Loon population trends. Oral presentation. Loons in northern Alaska: Information exchange and coordination meeting, Anchorage, AK. 25 February.
- Kandel, A., and A.M. Aguilar-Islas. 2020. Temporal variability of dissolved aluminum and manganese in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.
- LaBua, S., K. Boswell, J. Vollenweider, and J. Moran. 2021. The decline of acoustic backscatter associated with overwintering herring (*Clupea pallasii*) in Lynn Canal, Alaska. Poster Presentation. Alaska Marine Science Symposium, Anchorage, AK. 26-28 January.
- Lalande, C., S.L. Danielson, A. McDonnell, R.R. Hopcroft, and J. Grebmeier. 2020. Time - series measurements of export fluxes across the Bering Strait. Alaska Marine Science Symposium, Anchorage, AK.
- Lindeberg, M. 2020. Gulf Watch Alaska program: Website overview. Oral Presentation. EVOSTC Public Advisory Committee. EVOSTC Science Synthesis Workshop. Anchorage, Alaska, Feb. 26.
- Lindeberg, M., and J. Bodkin. 2020. Gulf Watch Alaska: Program overview and highlights and monitoring upper trophic consumers in the nearshore. Oral Presentation. Virtual MARINE Annual Workshop, March 13.
- Lindeberg, M., R. Suryan, D. Aderhold, and K. Hoffman. 2020. Gulf Watch Alaska: Program overview and highlights (FY2012-2019). Oral Presentation. EVOSTC Public Advisory Committee. EVOSTC Science Synthesis Workshop. Anchorage, Alaska, Feb. 26.
- Lindeberg, M., R. Suryan, D. Aderhold, K. Hoffman, R. Hopcroft, H. Coletti, M. Arimitsu. 2021. Gulf Watch Alaska: Building partnerships to understand ecosystem change. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.
- Lindeberg, M., and S. Traiger. 2021. Changes in nearshore ecosystems and relevance to coastal communities – Gulf of Alaska. Panelists. Alaska Marine Science Symposium, virtual, January 26-28.

- Lowin, B., S.L. Strom, and W. Burt. 2020. Phytoplankton dynamics across hydrographic fronts and mesoscale features: Preliminary results from the new NGA-LTER Ocean Optics Program. Alaska Marine Science Symposium, Anchorage, AK.
- Mayer, K., C. Clarke-Hopcroft, and R.R. Hopcroft, R.R. 2020. Spatial and temporal patterns of zooplankton species in the Gulf of Alaska as revealed by image analysis. Ocean Sciences Meeting. San Diego, CA.
- Mazur, C., S. Strom, and A. Aguilar-Islas. 2020. Comparing the bioavailability of a natural and synthetic iron source: Do past experiments adequately model diatom growth in response to episodic iron addition. Ocean Sciences Meeting. San Diego, CA.
- Mearns, A., D. Janka, S. Pegau, and B. Robinson. 2021. Inter-Annual and longterm variability of rocky intertidal biota at selected sites in Prince William Sound, 1989 to 2020. Alaska Marine Science Symposium, January 26-28.
- Mendoza-Islas, H.M., and R.R. Hopcroft. 2020. Abundance and distributions of gelatinous zooplankton in the Northern Gulf of Alaska. Ocean Sciences Meeting. San Diego, CA.
- 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.
- Meyers, H., D. Olsen, C. Matkin, and B. Konar. 2020. Passive acoustic monitoring reveals year-round spatiotemporal distribution patterns of southern Alaska resident killer whales. Oral presentation, Western Society of Naturalists Annual Meeting, online, November 5-8, 2020.
- Meyers, H., D. Olsen, C. Matkin, and B. Konar. 2021. Year-round habitat use and distribution patterns of killer whales in the northern Gulf of Alaska, as determined by passive acoustic monitoring Poster presentation, Alaska Marine Science Symposium, online, January 26-28, 2021.
- Monell, K., V. Roncalli, P.H. Lenz, and R.R. Hopcroft. 2020. Characterization of cell division during early oogenesis in copepod females emerging from diapause. Ocean Sciences Meeting. San Diego, CA.
- Moran, J., and J. Straley. 2020. Observations on humpback whales in Prince William Sound and Southeast Alaska following a marine heatwave. SPLASH-2 Virtual Workshop 1-3, December.
- Moran, J., and J. Straley. 2020. Observations on humpback whales in Prince William Sound and Southeast Alaska following a marine heatwave. US Biologically Important Areas II Startup Virtual Workshop 8 & 9, December.
- 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.
- Ostle C., and Batten S. 2020. The Continuous Plankton Recorder report to MONITOR committee 2020. Oral and report. 2020 Annual PICES MONITOR meeting. October.

- Ostle, C., S. Batten, J. Fisher, D. Johns, B. Hunt, H. Melling, D. Moore, R.J. Nelson, and R. Stern. 2021. Extending the North Pacific Continuous Plankton Recorder Survey poleward through the Bering Sea into the Arctic and potential future investigations. Poster presentation, Alaska Marine Science Symposium, Anchorage, AK, January.
- Pearson, H., S. Atkinson, J. Maselko, J. Moran, M. Rogers, and S. Teerlink. 2021. Humpback whales and tourism in Juneau, AK Establishing Baseline Measurements during the Covid 19 Pandemic. Oral presentation. Alaska Marine Science Symposium, Anchorage, AK. 26-28 January.
- Reister, I., and S.L. Danielson. 2020. Freshwater in the Northern Gulf of Alaska marine environment. Alaska Marine Science Symposium, Anchorage, AK.
- Renner, M., K. Holderied, C. McKinstry, D. Hondolero, and R.W. Campbell. 2021. Is it spring yet? Seasonal clusters of phyto- and zooplankton communities in Kachemak Bay and Lower Cook Inlet. Alaska Marine Science Symposium, online, Jan 26-28.
- Roncalli, V., M.C. Cieslak, A. Castelfranco, R.R. Hopcroft, D. Hartline, and P.H. Lenz. 2020. From suspended animation to fully active: Post-diapause transcriptomic restart in a high latitude zooplankter. Alaska Marine Science Symposium, Anchorage, AK.
- Roncalli, V., M.C. Cieslak, P.H. Lenz, and R.R. Hopcroft. 2020. Energy allocation in a diapausing copepod: a transcriptomics analysis. Ocean Sciences Meeting. San Diego, CA.
- Schaefer, A.L, M.A. Bishop, and R. Thorne. 2020. Marine bird response to forage fish during winter in bays of Prince William Sound, AK. Oral presentation. Alaska Marine Science Symposium, January 2021, Anchorage, AK.
- Stidham, E., and R.R. Hopcroft. 2020. Seasonal abundance and biomass of pelagic tunicates and snails in the Gulf of Alaska and Prince William Sound. Alaska Marine Science Symposium, Anchorage, AK.
- Suryan, R., M. Lindeberg, D. Aderhold, and K. Hoffman. 2020. Gulf Watch Alaska Program Science Synthesis - Overview. Oral presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27.
- Suryan, R., M. Lindeberg, D. Aderhold, and K. Hoffman. 2020. GWA 2012-2019 highlights and wrap-up. Oral presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27.
- Suryan, R., M. Arimitsu, H. Coletti, R. Hopcroft, M. Lindeberg, S. Barbeaux, S. Batten, W. Burt, M. Bishop, J. Bodkin, R. Brenner, R. Campbell, D. Cushing, S. Danielson, M. Dorn, B. Drummond, D. Esler, T. Gelatt, D. Hanselman, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, A. Kettle, D. Kimmel, B. Konar, K. J. Kuletz, B. Laurel, J. M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, W. Palsson, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, I. Spies, J. Straley, S. Strom, K. Sweeney, M. Szymkowiak, B. Weitzman, E. Yasumiishi, S. Zador. 2020. Ecosystem Response to a Prolonged Marine Heatwave in the Gulf of Alaska. Oral Presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27, 2020.

- Traiger, S.B., J.L. Bodkin, H.A. Coletti, B. Ballachey, T. Dean, D. Esler, K. Iken, B. Konar, M.R. Lindeberg, B. Robinson, R.M. Suryan, B. Weitzman. 2021. How the mighty have fallen: Indirect effects of sea star wasting syndrome on mussel abundance in the Northern Gulf of Alaska. Alaska Marine Science Symposium, January.
- Traiger, S.B., J.L. Bodkin, H.A. Coletti, B. Ballachey, T. Dean, D. Esler, K. Iken, B. Konar, M.R. Lindeberg, B. Robinson, R.M. Suryan, and B. Weitzman. 2020. How the mighty have fallen: Indirect effects of sea star wasting syndrome on mussel abundance in the Northern Gulf of Alaska. Western Society of Naturalists, November.
- Van Hemert, C., M. Smith, S. Schoen, M. Arimitsu, J. Piatt, D. Gerik, C. Marsteller, J. Pearce. 2021. Harmful algal blooms and Alaska seabirds: a multifaceted approach to a complex issue. Poster presentation. Alaska Marine Science Symposium. Anchorage, AK. 26-28 January.
- Weitzman, B., B. Konar, K. Iken, H. Coletti, D. Monson, R. M. Suryan, T. Dean, D. Hondolero, and M. R. Lindeberg. 2020. Changes in Rocky Intertidal Community Structure During a Marine Heatwave in the Northern Gulf of Alaska. Oral Presentation. EVOSTC Science Review Panel. Science Synthesis Workshop. Anchorage, Alaska, Feb. 27, 2020.

2. Public presentations

- Campbell., R.W. 2020, Effects of the recent marine heat waves on the waters of Prince William Sound. Prince William Sound Natural History Symposium, online, May 18.
- Danielson, S.L. 2020. Presentation and Q&A for Chugach School District classrooms in Chenega Bay, Tatitlik, and Whittier, 10 Nov.
- Danielson, S.L. 2020. Three classroom visits with Chugach School District individual classrooms in Chenega Bay, Tatitlik, and Whittier, 24 Nov.
- Kaler, R. 2020. Prince William Sound marine bird population trends: 1989 – 2018. Oral presentation. Virtual Board of Directors Meeting of the Chugach Regional Resource Commission, 7 December.
- Lindeberg, M.R. 2020. Gulf Watch Alaska: A Long-Term Monitoring Program of the *Exxon Valdez* Oil Spill Trustee Council. Oral Presentation. 2020 EVOSTC Trustee’s Public meeting, October 14, virtual, Anchorage, Alaska.
- Lindeberg, M. and J. Bodkin. 2020. Gulf Watch Alaska: Program Overview and Highlights and Monitoring Upper Trophic Consumers in the Nearshore. Oral Presentation. Virtual MARINE Annual Workshop, March 13, 2020.
- Olsen, D. 2020. Killer whales of the world. Zegrahm Expeditions, Antarctica. Oral presentation. January 2020.
- Olsen, D. 2020. Killer whales of Kenai Fjords. Kayak Adventures Worldwide guide training, Seward (Zoom), Alaska. Oral presentation. May 2020.
- Olsen, D. 2020. Mother knows best: Killer whale culture and generational learning. U.S. Forest Service PWS Natural History Symposium, Whittier (Zoom), Alaska. Oral presentation. May 2020.

- Olsen, D. 2020. Killer whales of Kenai Fjords. Wildlands Studies, Seward (outdoor), Alaska. Oral presentation. August 2020.
- Olsen, D. 2020. Acoustics of killer whales and other marine mammals. Kenai Peninsula College, Homer (Zoom), Alaska. Oral presentation. October 2020.
- Olsen, D. 2020. Mom knows best: Killer whale culture. Sitka Whalefest, Sitka (Zoom), Alaska. Oral presentation. November 2020.
- Matkin, C. 2020. Aspects of Killer Whale biology in Prince William Sound/Keani Fjords and continuing effects of the *Exxon Valdez* oil spill. Oral presentation. Kenai Peninsula College, September 2020.
- Moran, J. 2020. What happens in Alaska doesn't stay in Alaska. Whale Tales, Kapalua, Hawaii. 14-17 February.
- Moran, J. 2020. Large whale entanglements in Alaska and fisheries interactions. University of Alaska College of Fisheries and Ocean Sciences seminar series. Juneau, AK. 6 March.
- Moran, J. 2020. Large whale entanglements in Alaska and fisheries interactions. University of Alaska Southeast marine mammal class. Juneau, AK. 7 April.
- Moran, J. 2020. How are the whales responding to fewer tourists in the waters off Juneau, AKL Summer survey underway to learn more – Post 1. NOAA Fisheries Science Blog. <https://www.fisheries.noaa.gov/science-blog/how-are-whales-responding-fewer-tourists-waters-juneau-ak-summer-survey-underway-learn>.
- Moran, J. 2020. Global check in speaker. Whale Tales. <https://www.whaletales.org/>.
- Nicklin, F. 2020. Humpback chronicles, episode 39 – John Moran. Whale Trust. <https://www.youtube.com/watch?v=FDNZk0Np64k>

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 2020 Ecosystem Status Report (Ferriss and Zador, 2020).

Data

*Table 5. FY20 ecosystem indicator contributions to the National Oceanic and Atmospheric Administration Fisheries Ecosystem Status Report submitted to the North Pacific Fisheries Management Council, fall 2020. * Used in the ecosystem and socioeconomic profile of the sablefish stock assessment for Alaska (Shotwell et al. 2020).*

Project	Ecosystem Indicators
Environmental Drivers Component	(12 time series)
CPR (20120114-D)	1 Large diatom abundance anomaly
	2 Copepod community size anomaly
	3 Meso-zooplankton biomass anomaly

Project	Ecosystem Indicators
GAK-1 (20120114-I)	4 GAK-1 water column temperature
	5 GAK-1 water column salinity
PWS oceanography (20120114-G)	6 PWS surface water temperature trends
	7 PWS zooplankton trends
Seward Line (20120114-L)	8 Seward Line May temperatures
	9 Large copepod biomass
	10 Euphausiid biomass
Lower CI/KB (20120114-J)	11 Saxitoxin in Kachemak Bay shellfish
	12 Kachemak Bay paralytic shellfish toxicity
Pelagic Ecosystem Component	(7 time series)
Forage fish (20120114-C)	13 Middleton Island (MI) black-legged kittiwake diet
	14 MI black-legged kittiwake reproductive success
	15 MI rhinoceros auklet diet
	16 MI rhinoceros auklet reproductive success
	17 MI pelagic cormorant reproductive success
	18 Juvenile sablefish growth index*
Humpback whale (20120114-O)	19 PWS humpback whale encounter rates
Nearshore Ecosystem Component	(2 time series)
Nearshore Ecosystem in the GOA (20120114-H)	20 Northern GOA rockweed percent cover
	21 Northern GOA sea star density

Informational Products

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2020. GWA Quarterly Currents. Newsletter. Volume 4.1: spring quarter. Link on gulfwatchalaska.org.

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2020. GWA Quarterly Currents. Newsletter. Volume 4.2: summer quarter. Link on gulfwatchalaska.org.

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2020. GWA Quarterly Currents. Newsletter. Volume 4.3: fall quarter. Link on gulfwatchalaska.org.

Lindeberg, M., K. Hoffman, R. Suryan, and D. Aderhold. 2021. GWA Quarterly Currents. Newsletter. Volume 4.4: 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

Due to the COVID-19 pandemic, some GWA project data were not collected, some data collection was delayed, and some data that were collected are awaiting processing due to lab closures and staff limitations. Those who were able to, uploaded their metadata and datasets to the research workspace and made them 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 2020 data are not required to be published until 31 January 2021 but some datasets are already compliant in 2020.

Project	Dataset	2017	2018	2019	2020	Comments
Environmental Drivers Component						
CPR (20120114-D)	Plankton data	2	2	2	0	2020 processing delayed
	Temperature data	2	2	2	0	
GAK1 (20120114-I)	CTD data	2	2	2	n/a	No CTD samples for 2020
	Mooring data	2	2	2	0	
PWS oceanography (20120114-G)	Chlorophyll data	2	2	2	0	Project delays due to state mandates
	CTD data	2	2	2	2	
	Zooplankton data	2	2	2	0	
Cook Inlet /Kachemak Bay oceanography (20120114-J)	CTD data	2	2	2	2	
	Meteorological data	2	2	2	0	
	Nutrient data	2	2	2	0	
	Water quality data	2	2	2	0	
Seward Line (20120114-L)	Zooplankton data	2	2	2	n/a	
	Chlorophyll data	2	2	1	0	
	CTD data	2	2	2	1	
	Nutrient data	2	2	1	0.5	
	Seabird data (Kuletz)	2	2	1	1	Data to be archived in April 2021 per LTER requirement
	Zooplankton data	2	2	1	0	
Nearshore Ecosystem Component						
Ecological Trends in Kachemak Bay (20120114-H)	Rocky intertidal community data	2	2	2	0	2020: May cancelled; partial June collection
	Mussel data	2	2	2	0	
	Rocky intertidal data	2	2	2	0	
	Substrate data	2	2	2	0	
Nearshore Ecosystem in the GOA (20120114-H)	Seagrass data	2	2	2	0	
	Oystercatcher diet & nest density data	2	2	2	n/a	
	Eelgrass data	2	n/a	n/a	n/a	
	Invertebrate & algae	2	2	2	n/a	2020 field cancelled
						No data after 2017

Project	Dataset	2017	2018	2019	2020	Comments
	Marine bird and mammal data	2	2	2	n/a	
	Water quality data	2	2	2	n/a	
	Sea otter survey data	2	2	2	n/a	
	Sea otter scat data	2	2	2	n/a	
Pelagic Ecosystem Component						
Fall and winter marine birds (20120114-E)	Marine bird survey data	2	2	2	n/a	2020: fall survey scheduled for Oct 2021
Forage fish (20120114-C)	Forage fish count	2	2	2	n/a	2020: summer field season cancelled
	Forage fish morph	2	2	2	n/a	
	Seabird diet data	2	2	2	n/a	
	Hydroacoustic data	2	2	2	n/a	
	CTD & nutrient data	2	2	2	n/a	
	Zooplankton data	2	2	2	n/a	
Humpback whale (20120114-O)	Fluke id catalog	2	2	2	0	2020: field season delayed
	Energetic/stable isotope data	2	2	2	0	
	Whale survey data	2	2	2	0	
	Porpoise survey data	2	2	2	0	
	CTD data	2	2	2	0	
Killer whale (20120114-M)	Acoustic catalog	2	2	1	n/a	Biopsy data no longer collected
	Photo catalog	2	2	0	n/a	
	Biopsy data - genetic	n/a	n/a	n/a	n/a	
	- contaminants	n/a	n/a	n/a	n/a	
	Prey genetic sampling	1	1	1	n/a	
Summer marine birds (20120114-N)	Summer marine bird survey data	n/a	2	n/a	n/a	2020: surveys postponed to 2021

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY21):

The Science Panel appreciates the creative measures taken to accomplish field work and surveys during the Covid pandemic. We may see more of the same pandemic-related restrictions on field work and access to labs, which will require alternative plans that were not stated in the program and project proposals. Each project should address the following questions. What are the program and project contingency plans for FY21 in regard to accomplishing goals and field activities? The SP understands that it may be challenging to develop extensive and detailed contingency plans for the future, but some planning is required. Will any unused funds for FY21 be repurposed for additional lab and/or data analyses? Or are they requested to rollover to FY22 (pending proposal approval)? Other ways to accomplish field work - i.e., other vessels that could be used or other projects that can be leveraged?

Overall, the PIs did a much better job of interpreting project data and results as requested by the SP in previous reviews. It is also noted that the PIs are making progress to address SP synthesis report comments.

Program Lead Response (FY21):

The GWA program appreciates the Science Panel's comments on program improvements and their understanding during these trying times. The primary goal of the GWA program and projects is to complete all field work, analyses, and deliverables on time including spending out all budgets by the end of FY21.

We realize the COVID-19 pandemic could continue to impact our progress in FY21. If we experience further delays due to the pandemic, our PIs now have a better understanding of how this will impact their projects given their experience in the past six months under various agencies, organizations, and mandates. If the pandemic precludes spending funds as planned, projects will prioritize alternate activities that take FY21 unused funds and repurpose them for creative solutions or other objectives, as the Science Panel suggests (e.g., additional lab and data analyses). If it is clear funds cannot be spent in FY21, we will notify the EVOSTC Executive and Science Directors that we will be requesting they be rolled over (spring 2021) and then submit a detailed FY22 Work Plan for approval as part of the normal EVOSTC funding cycle (August 2021). Please see PI responses to the Science Panel, at the project level, regarding their plans for further COVID-19 delays. They have addressed the Science Panel's concerns to the best of their knowledge at this time.

The program management team has worked with the projects to prioritize interpreting project data and results in our Work Plans. We enjoyed the February workshop with the Science Panel, appreciate the time the Science Panel took to review the synthesis reports and provide detailed comments, and believe our interactions with the Science Panel greatly improved the synthesis report product and future publications.

Science Panel Comment (FY20):

The Science Panel appreciates that the reports and proposals continue to be carefully prepared and well written. We note that there is good leverage and integration within projects and with the Herring Research and Monitoring program, and there is notable progress on synthesis. Projects are also meeting milestones in a timely manner. The Panel is pleased that the two admin projects have been combined as recommended. For future proposals, please separate out peer-reviewed publications from agency and data reports and include subheading of published, in prep, in review if necessary. We would also like to see more interpretation and discussion of data and figures presented in the proposals; this is included in some of the proposals such as in project D. The Panel is not looking for new or additional analyses in the proposals. We are looking for context and some interpretation to allow us to evaluate the proposal.

Program Lead Response (FY20):

The Gulf Watch Alaska program is proud of its achievements and values the science panel's feedback. There is always room for improvement and in future proposals we will focus on providing more interpretation and discussion including the separation of various types of publication products accordingly.

11. Budget:

Please see provided GWA program workbook. Table 7 provides a summary of spending to date by project, comparing proposed total spending and proposed spending for FY21 (year 10).

Table 7. Spending summary by project, showing proposed FY21 (year 10), proposed 5-year total, and actual cumulative spending for the first four years (FY17-FY20, years 6-9). All numbers are in thousands and do not include GA.

Project Number	PI(s)	Project Title	FY21 Proposed	5 Year Proposed Total	Cumulative Total
Environmental Drivers					
20120114-D	Ostle/Batten	CPR	\$79.0	\$372.7	\$293.7
20120114-G	Campbell	PWS Ocean	\$218.8	\$1,048.0	\$762.7
20120114-I	Danielson	GAK1	\$116.8	\$624.6	\$436.0
20120114-J	Holderied/Baird	LCI/KBay Ocean	\$122.2	\$730.6	\$537.3
20120114-L	Hopcroft	Seward Line	\$134.5	\$640.3	\$504.8
Pelagic					
20120114-C	Arimitsu/Piatt	Forage Fish	\$277.8	\$1,210.0	\$930.0
20120114-E	Bishop	Wintering Birds	\$117.3	\$511.3	\$368.3
20120114-M	Kuletz/Kaler	PWS Marine Birds	\$33.2	\$496.9	\$306.6
20120114-N	Matkin	Killer Whales	\$128.0	\$666.1	\$517.2
20120114-O	Moran/Straley	Humpback Whales	\$162.4	\$794.2	\$479.2
Nearshore					
20120114-H	Coletti et al.	Nearshore	\$390.9	\$1,943.3	\$1,311.7
Lingering Oil					
20120114-P	Lindeberg/Heintz	Lingering Oil	\$12.0	\$59.9	\$46.5
Integrated Program Management and Administration					
20120114-A	Lindeberg	Synthesis/Coord	\$146.8	\$842.9	\$700.2
20120114-B	Hoffman	Admin/Outreach	\$369.1	\$1,592.1	\$1,082.3
20120114-H	Esler	Post-doc	\$57.2	\$171.6	\$160.5
			\$2,366.1	\$11,704.4	\$8,437.0

Numerous projects were affected by federal and state COVID-19 health mandates which resulted in travel restrictions, temporary restrictions in access to facilities, and cancelled, postponed, or reduced field programs. Individual projects have developed plans for spending or reallocating funds during FY21. Brief explanations are provided below for those projects whose budgets were most affected in FY20:

20120114-C: PIs Arimitsu and Piatt cancelled field work in 2020 because of COVID-19. They transferred funds to PWSSC to collect some data and redirected funds to maintenance and

upgrade of equipment and support for acoustic data analysis to help accomplish forage fish project goals.

20120114-E: PI Bishop's budget is underspent in personnel because of COVID-19 and the avian research assistant took a leave of absence during the FY20 fiscal year. Personnel spending will increase in FY21.

20120114-H: In FY20 (due to COVID-19 restrictions) we are redirecting funding that was unused for field operations to support a MSc student at UAF to conduct a project evaluating stable isotope variation in nearshore food webs and associated effects on productivity of nearshore flora and fauna.

20120114-J: PI Holderied's budget is underspent because of reduced travel and commodity costs due to COVID-19. Some funds were reallocated to the Kasitsna Bay Lab labor contract to assist with GWA data synthesis efforts and the remaining funds will be spent on commodities.

20120114-M: PIs Kuletz and Kaler cancelled the planned even-year PWS marine bird survey in FY20 because of COVID-19. The survey will be conducted in FY21 instead and the full project funds will be spent.

20120114-O: PIs Moran and Straley were unable to conduct the spring 2020 humpback whale survey in PWS because of COVID-19. They plan to make up the survey during FY21 when conditions allow.

20200114-P: PIs Lindeberg and Heintz cancelled planned 2020 field work because of COVID-19. Field work is planned for 2021.

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