ATTACHMENT B. Annual Project Report Form (Revised 11.21.19)

1. Project Number:

20120114-N

2. Project Title:

Long-term Killer Whale Monitoring in Prince William Sound/Kenai Fjords

3. Principal Investigator(s) Names:

Craig O. Matkin and Dan Olsen, North Gulf Oceanic Society

4. Time Period Covered by the Report:

February 1, 2020-January 31, 2021

5. Date of Report:

March 2021

6. Project Website (if applicable):

www.gulfwatchalaska.org

7. Summary of Work Performed:

We completed 62 survey days in 2020 with timing and geographic components of effort similar to all other years of the Gulf Watch Alaska program (Fig. 1). The total nautical miles surveyed was 3008.8 with 755.7 spent in company of killer whales (Fig. 2). We had 43 total encounters, 40 with resident ecotype killer whales. There were no AT1 (Chugach transient) encounters on survey but four from contributors, and two with Gulf of Alaska transients on survey and with an additional seven contributed. There was one encounter with more than 80 offshore ecotype killer whales in Resurrection Bay.

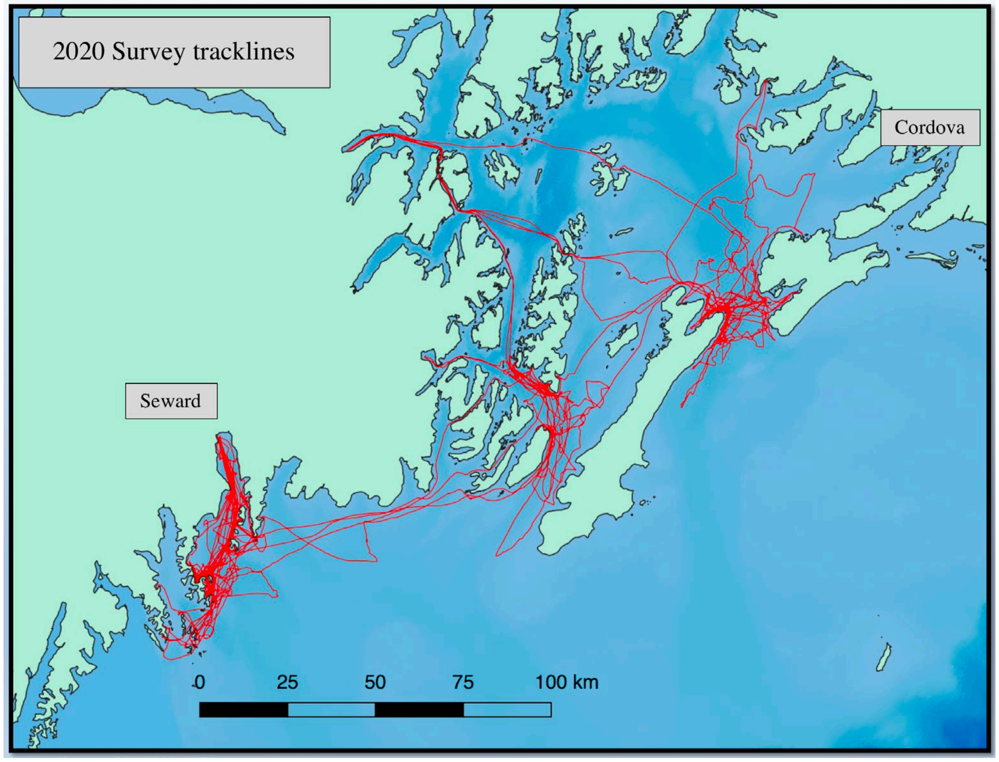

Figure 1. Killer whale effort tracks in Prince William Sound and Kenai Fjords, 2020.

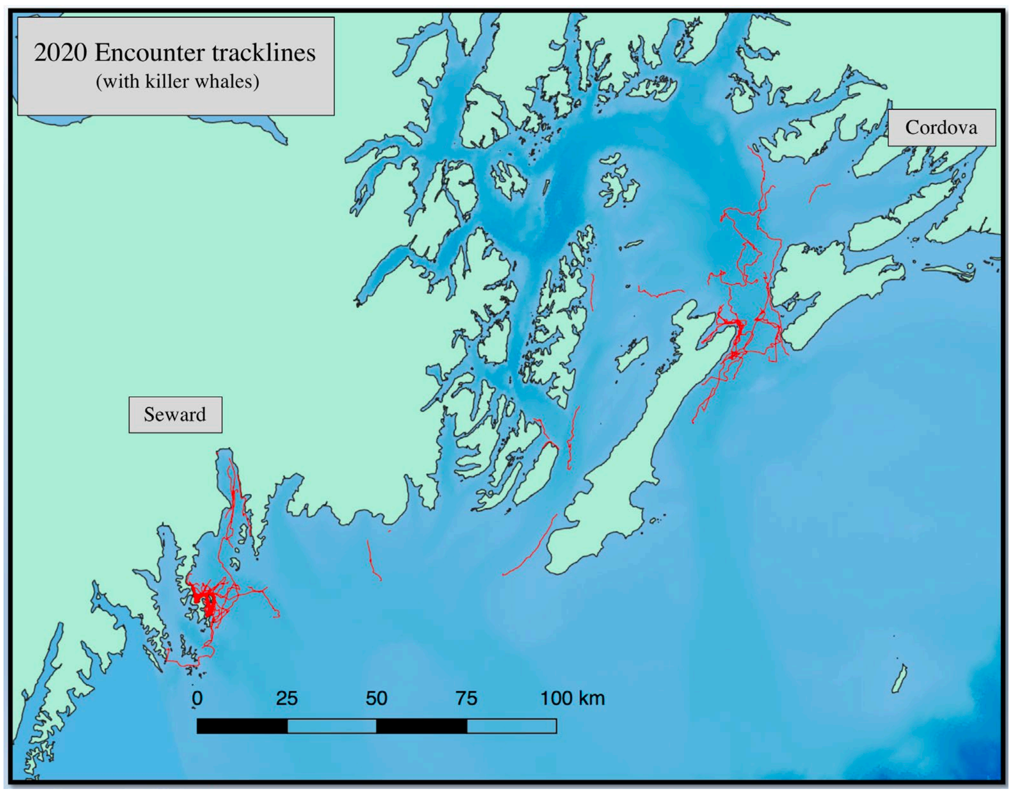

Figure 2. Killer whale encounter tracks in Prince William Sound and Kenai Fjords, 2020.

In 2020, all seven of the AT1 (Chugach) transients were identified (Fig. 3). 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. At least 18 different Gulf of Alaska transient killer whales were documented, however, analysis of contributed photos is not yet complete. For the third year running we expect to have reasonable coverage of the Gulf of Alaska transients in the study region, primarily due to the effort to obtain photographs from contributors.

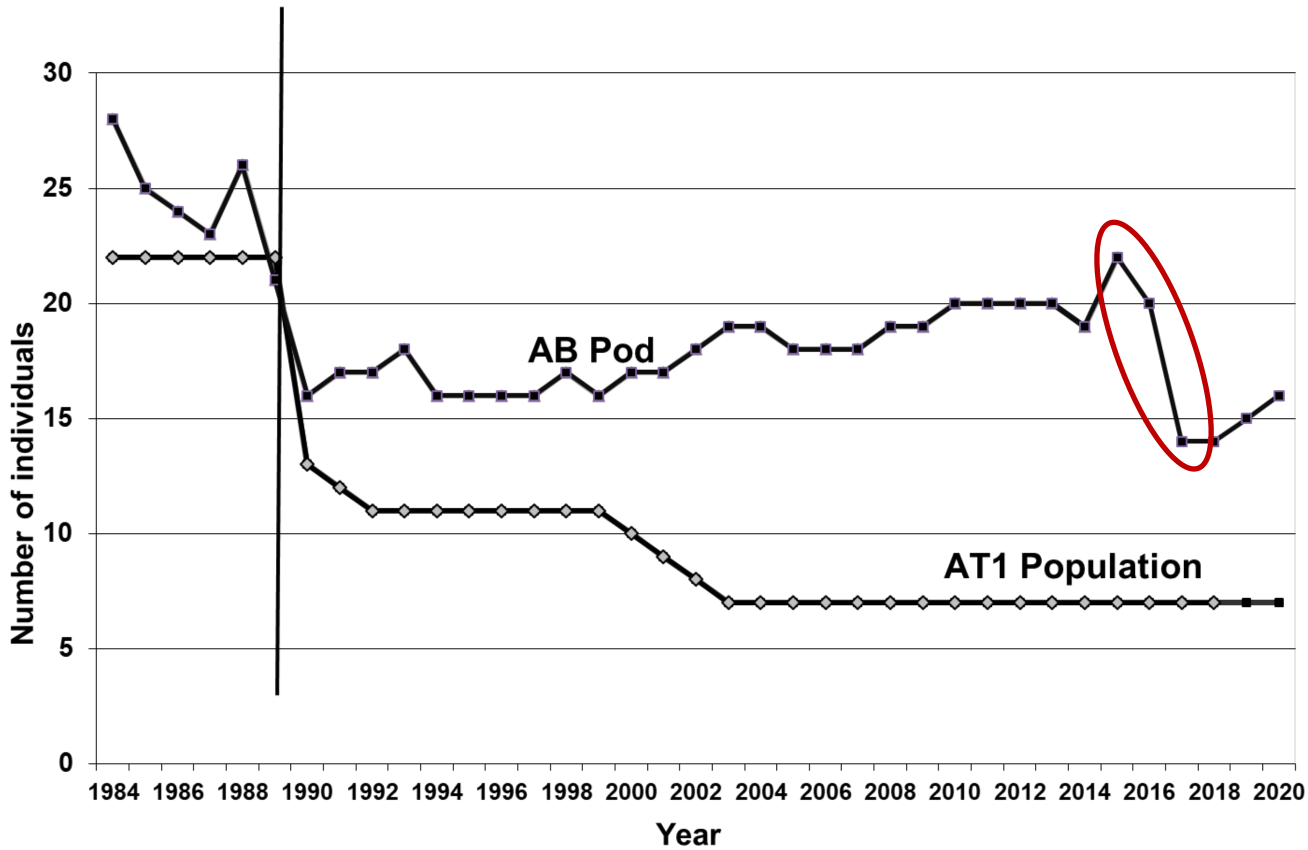

Figure 3. Number of whales in AB pod and AT1 population by year.

We had complete encounters with most of the major resident pods that are monitored for our population dynamics work including the following northern resident haplotype pods AB25 (27 whales, 1 death, 1 birth), AI (8 whales, 0 births, 0 deaths), AJ and AJ8 (66 whales, 1 birth, 1 death), AD8 (10 whales, 0 births, 0 deaths), and AD11 (6 whales, 0 births, 1 death). We also had complete coverage of most southern resident haplotype pods we use in our analysis (except for one matriline in AE pod), including AD8, AD11, and AD16 (27 whales, 1 birth, 1 death); AE (15 whales, 1 birth, 0 deaths, 1 missing matriline); and AK2 and AK6 (26 whales 3 births, 1 death). The instantaneous rate of growth for the northern resident haplotypes is zero in 2020. AJ8 and AJ pods, for many years the fastest growing pods in the study, have had a slightly negative growth rate since 2016 (8 births, 9 deaths). The southern resident haplotype pods, which are more nearshore in range and may have more varied feeding habits, had a positive instantaneous growth rate in 2020 (5 births, 1 death). However, these pods have had a net gain of only 3 whales since 2016 which is less than a third of the rate for the entire population determined by Matkin et al (2014). There is no question that there has been a slowing of growth in the southern Alaska resident population in the past five years, but it seems somewhat uneven across the pods/matrilines. This will require more in-depth quantitative examination at the end of this 5-year contract period.

For the first time in several years, we had repeated encounters with the oil-impacted AB pod (Fig. 3). These encounters confirmed the death of juvenile AB81 who had been missing since 2017. The disappearance of AB17 and her two male offspring (AB 35 and AB43) in 2016, as well as the disappearance of AB14 and her two male offspring (AB24 and AB40) and AB22 and her single male offspring (AB49) in 2017, 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. Our population dynamics analysis (Matkin et al. 2014) found a significant increase in mortality for males in the 30−41 year range and for females in the 50−54 year range. Male offspring also tend to have a lower chance of survival after their mother's die. Another compounding factor may have been the marine heatwave that began in the winter of 2013-14 and persisted for two years, if the marine heatwave had an effect on availability of salmon (Suryan et al. in press).

The trend toward splitting of pods on either a temporary or permanent basis has continued along the same maternal lines as in recent years. This coupled with the changes in overall growth of most pods may reflect a more challenging feeding environment (e.g., fewer numbers of fish or smaller school size) that favors hunting in smaller groups. It is occurring concurrently with a slowing of population growth. In recent decades, the southern Alaska resident killer whale population (except for AB pod) had been growing steadily. As indicated earlier this appears to be changing. In recent years, a similar population trend has accompanied the splitting of pods in the British Columbia northern resident population (Stredulinsky et al. in press). Declines in North Pacific Chinook salmon size (Ohlberger et al. 2018) and abundance coupled with a previously increasing resident killer whale population may have brought these fish-eating whales to a level at or above carrying capacity. This possibility will be more closely examined in the project final report.

Previous research using vessel surveys and satellite transmitters, which has been completed primarily in the summer months, has shown that resident killer whale pods have distinct temporal preferences for certain areas. As a non-invasive and year-round alternative to tagging individuals, we have established acoustic monitoring stations in areas important to southern Alaska resident killer whales during the previous vessel surveys and tagging studies (Fig. 4). The three primary areas monitored are Montague Strait (Little Bay station), Hinchinbrook Entrance (Zaikof Bay station), and outer Resurrection Bay (Pony Cove station).

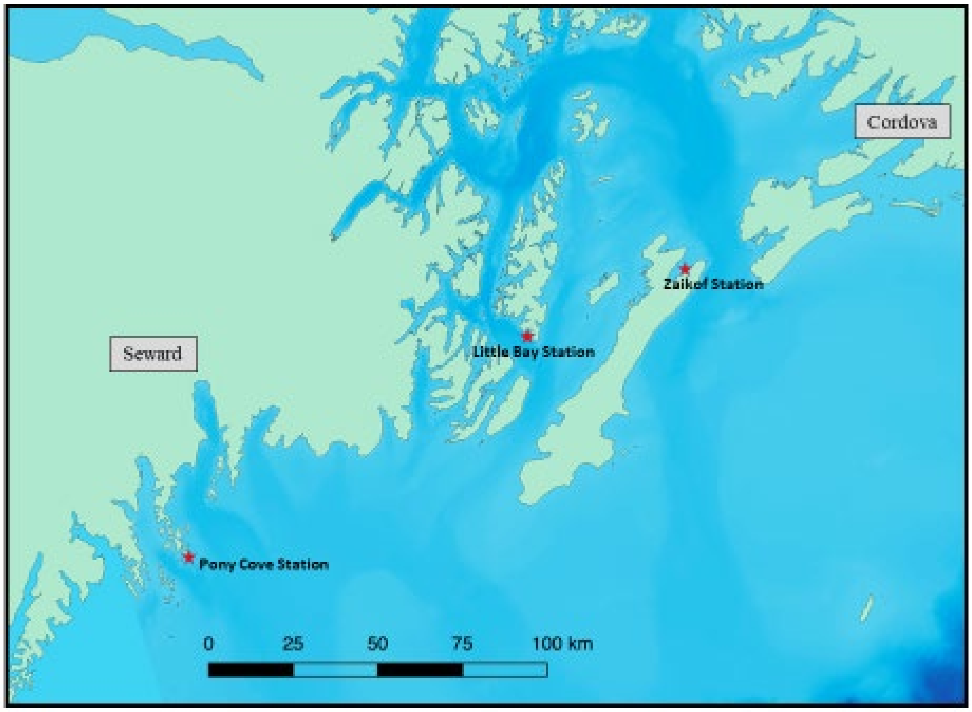

Figure 4. Location of remote hydrophone stations operated by North Gulf Oceanic Society. A mid-Sound station operated by the Prince William Sound Science Center is not shown or reported on here.

The stations monitoring Hinchinbrook Entrance and Montague Strait have operated since 2016 and the outer Resurrection Bay station was first deployed in 2017. In Fig. 5 we summarize the frequency of use (days with killer whale calls) determined since each station was established. The Montague Strait hydrophone was not functional from May to September 2017 and the Pony Cove hydrophone non-operational during November 2017 through April 2018.

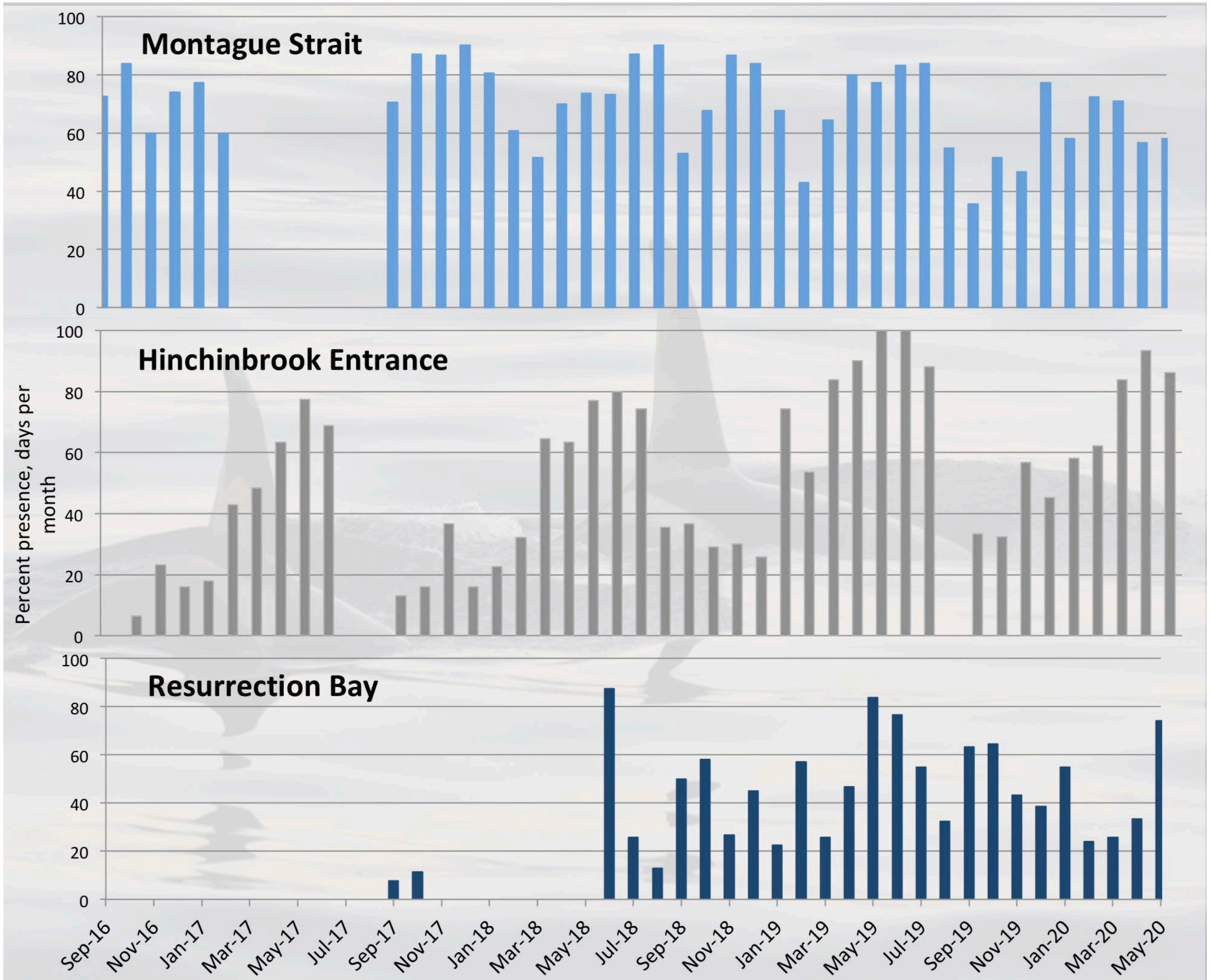

Figure 5. Preliminary results showing percent of days per month that killer whales were recorded across three hydrophone locations. Zeros indicate no recordings were available, killer whales were detected during every month that hydrophones were functional. The Montague Strait hydrophone was not functional from May to September 2017 and the Pony Cove hydrophone non-operational during November 2017 through April 2018.

The passive acoustic monitoring project has provided the first description of year-round killer whale distribution and habit use in Prince William Sound 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 (Fig. 6). 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 (Fig. 6). 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.

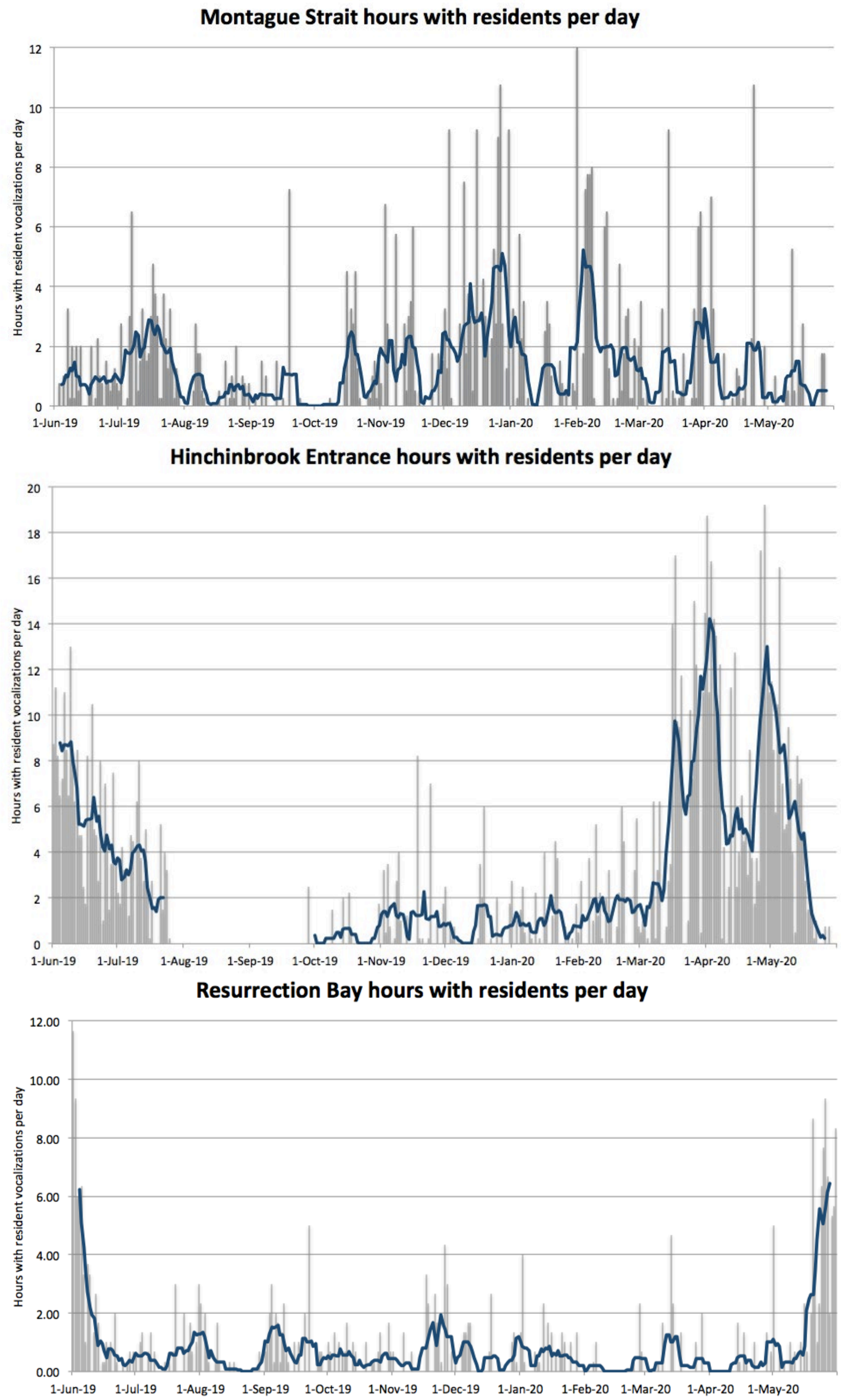

Figure 6. Hours with resident killer whale vocalizations recorded at three hydrophone locations. Gray bars indicate number of hours with vocalizations per day, blue line is a seven-day rolling average. Note that y-axis is up to 20 hours at Hinchinbrook Entrance and up to 12 hours at Montague Strait and Resurrection Bay. No data was available at Hinchinbrook Entrance from July 25th to September 27th, 2019.

One year of recordings (June 2019 to May 2020) was further inspected to separate killer whale ecotypes—resident (fish-eating), transient (mammal-eating), and offshore (largely shark-eating)—and describe the number of hours per day that killer whales were identified at each location (Fig. 7). This analysis further underscored distribution patterns across the three locations. However, the number of hours that killer whales were recorded each day was substantially higher in Hinchinbrook Entrance in the spring than in any other location. This high use (up to 19.25 hours per day) of Hinchinbrook Entrance begins in mid-March. Although this timing is earlier than the arrival of salmon spawners to local streams, it is conceivable that feeding Chinook and chum are present at this time. Genetic assignment of salmon taken by killer whales in spring have indicated fish of non-local origin. The outmigration of tagged herring tracked by transponders in Hinchinbrook Entrance has peaked in May. These fish would be an attractive prey item for feeding salmonids. The large multi-pod aggregations of killer whales recorded in Hinchinbrook in spring may include a number of infrequently sighted pods. Presence of these whales may be driven by both food availability and social factors.

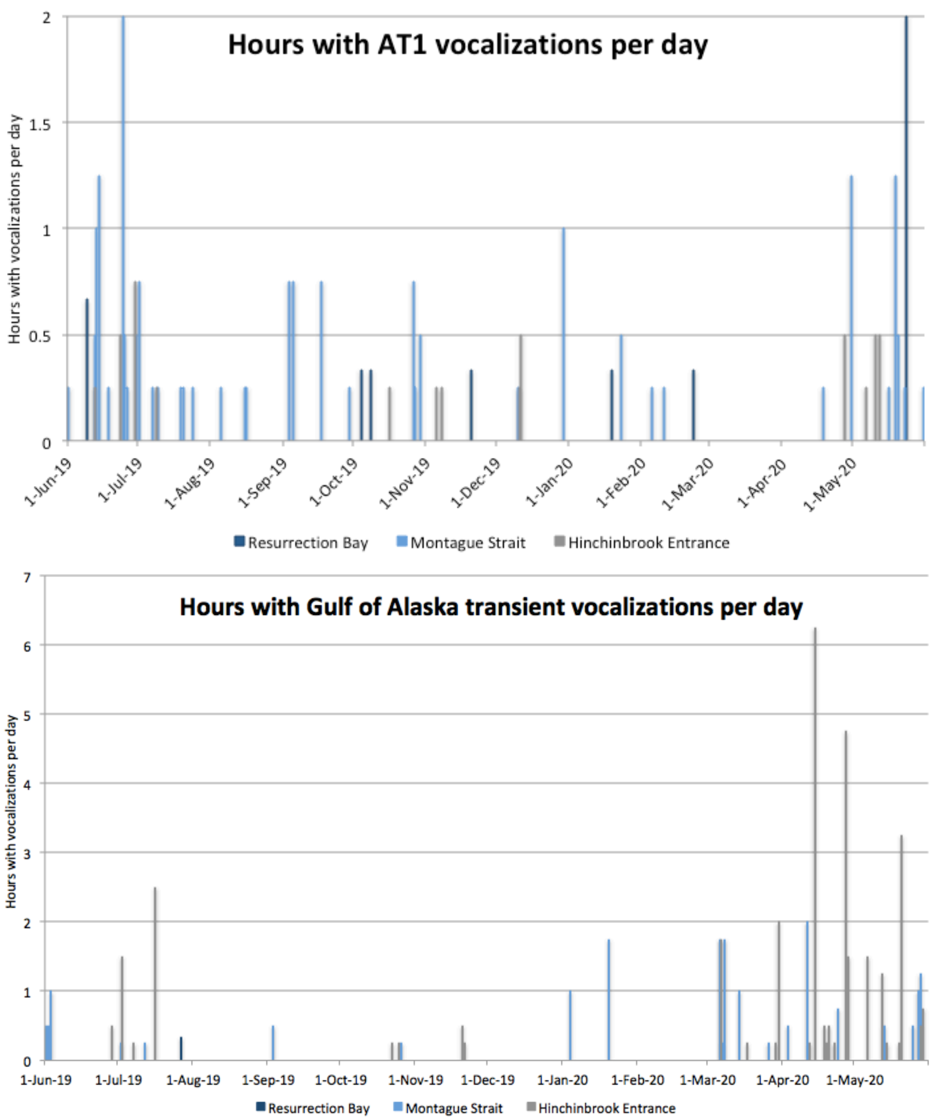

Figure 7. Hours per day that AT1 and Gulf of Alaska transient killer whale vocalizations were recorded across three hydrophone locations.

The AT1 (Chugach) transient killer whale population, identified using the call catalogue developed by Saulitis et al. (2005), was recorded consistently throughout the year at all hydrophone locations (Fig. 7). Another set of stereotyped calls was identified in passive acoustic recordings and subsequently matched with an opportunistic field recording made of a group of rarely sighted Gulf of Alaska transient killer whales in Kachemak Bay in August 2020. This set of calls has now been established as part of the dialect for this group, though it is not yet known how many animals use this set of calls. These Gulf of Alaska transient killer whale calls were recorded throughout the year in Montague Strait and Hinchinbrook Entrance, with a peak in recordings in Hinchinbrook Entrance in April and May (Fig. 7). They were recorded on one day (July 27th, 2019) in Resurrection Bay.

Offshore killer whales were recorded on one day (April 17th, 2020) on the Resurrection Bay hydrophone.

Moving forward, we will update the Yurk et al. (2002) call catalogue of known resident killer whale dialects and use this call catalogue to describe intra-pod interactions and dynamics in habitat use across locations. Next, we plan to develop a model to estimate the number of resident killer whales present in passive acoustic recordings using measures of calling rates and call diversity. NGOS also deployed a fourth hydrophone in Kachemak Bay in August 2020, an area where opportunistic killer whale sightings have recently increased. The passive acoustic monitoring project also contributes a long-term dataset that can be used to identify potential inter-annual patterns or changes in killer whale presence over time.

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 combination of these two sampling techniques will better inform the diet of resident killer whales. Currently, we have analysis performed for only 30 fecal samples, but 70 additional samples await laboratory analysis when COVID-19 restrictions are lifted. 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 (Fig. 8). The DNA composition of fecal samples confirms Chum and Chinook, but we have not yet had the opportunity to collect fecal samples from the Coho season. Additional fecal sampling through the season will be very informative in the coming years, as will the samples currently awaiting analysis. 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 (Fig. 9). Every pod that was sampled had one of these flatfish in the overall diet. 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.

In May and June in Kenai Fjords, both Chum and Chinook salmon appear to dominate the diet, while Chum appears to dominate the diet in Prince William Sound during these months. In July and August, the database of prey remains demonstrates that Coho is very dominant in the diet in Prince William Sound, and Chum in Kenai Fjords. In September, the database of prey remains implies that Coho and Chinook dominate the diet, but the recent fecal sampling indicates that there may be a more balanced diet. Continued sampling will aid in the assessment of resident killer whale diet in Alaska, and its role in the ecosystem.

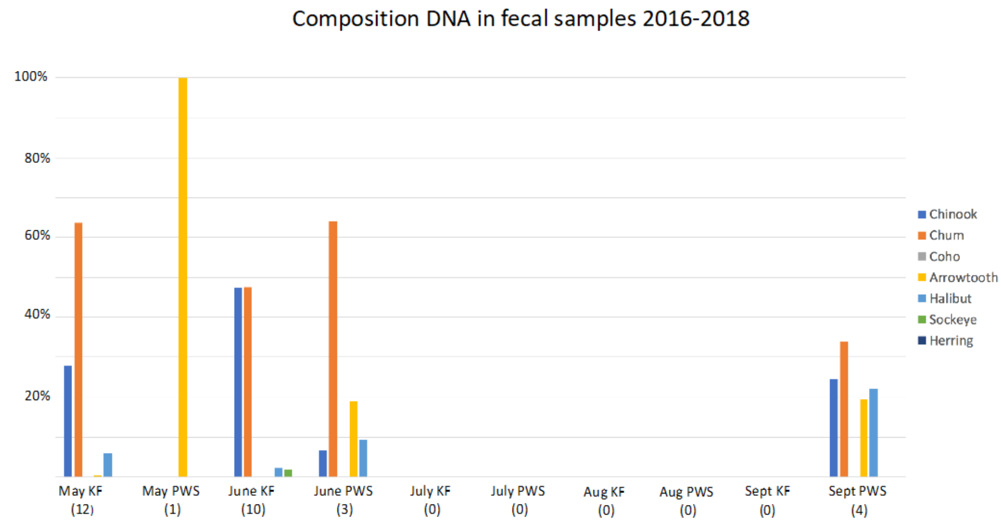

Figure 8. Percentage of prey remains collected in Kenai Fjords (KF) and Prince William Sound (PWS) during May to September, 1991-2018. Numbers of samples in parentheses (##).

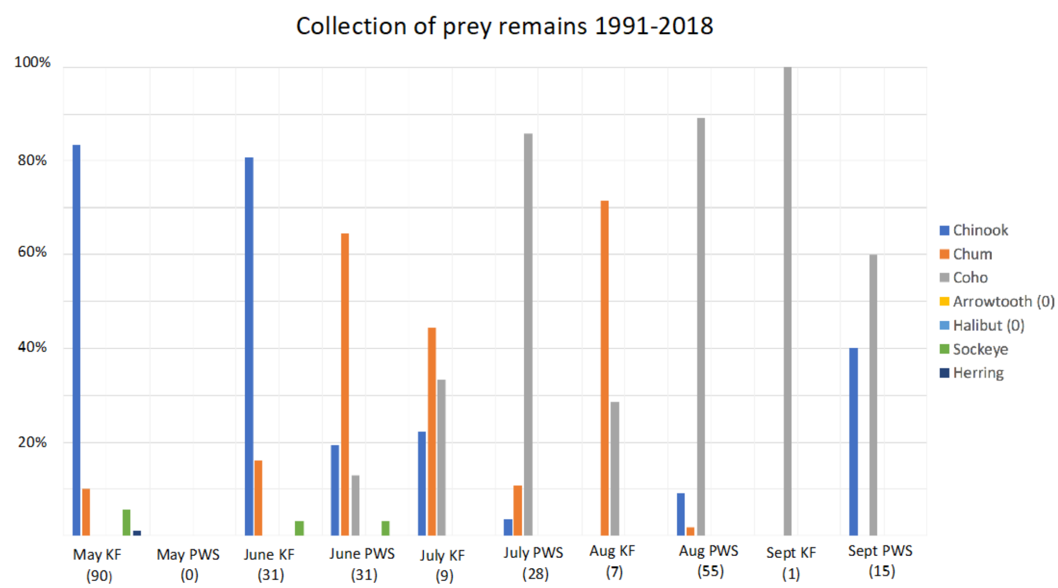

Figure 9. Percentage of prey DNA present in fecal samples collected in Kenai Fjords (KF) and Prince William Sound (PWS) during May, June, September, 2016-2018. Numbers of samples in parentheses (##).

Because of our use of a small vessel with a crew of three individuals, and the ability of the crew to effectively quarantine prior to each field effort, the COVID-19 pandemic did not significantly interfere with field operations or our population analysis in 2020. However, the pandemic has severely hampered our collaboration with National Oceanic and Atmospheric Administration (NOAA), Northwest Fisheries Science Center (NWFSC) and the Pacific Biological Station (PBS) in so far as all laboratory-based analysis of our samples has essentially come to a halt since last March. Our 2019 and 2020 prey and scale samples have been delivered to PBS and our 2019 and 2020 fecal samples have been delivered to NWFSC where they await the for analytical activities to resume. This has effectively halted the addition of new data to our feeding ecology work; however, we are reorganizing and putting old data in a form to permit easier analysis. Initial work on at least two resident killer whale feeding ecology papers has continued and a third, examining changes in stable isotopes and contaminants with a comparison to Southern residents, is in the final stages prior to submission. The target journal for that paper is the second Deep Sea Research special issue spotlighting the Gulf Watch Alaska projects.

Additionally, COVID-19 considerations eliminated our first field season that would include pilot work in the use of drones to take aerial photographs of whales and analyze body measurements to determine condition and pregnancy status of individually identifiable whales. The group supporting our drone crew, Southall Environmental Associates, Seattle, would not permit or fund their travel to Alaska.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

Within the Pelagic Component of Gulf Watch Alaska, we collect humpback whale identification photos and provide data on distribution and abundance of humpback whales (encounter data) as possible during our surveys. The raw data are provided to the humpback whale project (PIs Moran and Straley, project 20120114-O) and to the Happywhale project (https://happywhale.com/home) examining population and distribution of humpback whales in the North Pacific.

We work cooperatively with PI Rob Campbell (Prince William Sound Science Center, project 201204114-G) to deploy a Soundtrap hydrophone on his oceanographic moorings as additional data for our killer whale acoustic monitoring efforts.

We contributed data to Chapter 4 (Suryan et al. 2019) of the GWA science synthesis report assessing the Gulf of Alaska ecosystem response to the Pacific marine heatwave.

2. Across Programs

a. Herring Research and Monitoring

No coordination/collaborations for this reporting period.

b. Data Management

This project coordinates with the data management program by submitting data and preparing metadata for publication on the Gulf of Alaska Data Portal and DataONE within the timeframes required.

B. Individual Projects

No coordination/collaborations for this reporting period.

C. With Trustee or Management Agencies

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.

All population data are supplied to the National Marine Fisheries Service Alaska Fisheries Science Center Marine Mammal Laboratory, Seattle, WA for incorporation into Alaska marine mammal stock assessment reports and use in management applications.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

Olsen, D.W., C.O. Matkin, F.J. Mueter, and S. Atkinson. 2020. Social behavior increases in multipod aggregations of southern Alaska resident killer whales (*Orcinus orca*). Marine Mammal Science 36:1150-1159.

Suryan, R.M., M.L. Arimitsu, H.A. Coletti, R.R. Hopcroft, M.R. Lindeberg, S.J. Barbeaux, S.D. Batten, W.J. Burt, M.A. Bishop, J.L. Bodkin, R.E. Brenner, R.W. Campbell, D.A. Cushing, S.L. Danielson, M.W. Dorn, B. Drummond, D. Esler, T. Gelatt, D.H. Hanselman, S.A. Hatch, S. Haught, K. Holderied, K. Iken, D.B. Iron, A.B. Kettle, D.G. Kimmel, B. Konar, K.J. Kuletz, B.J. Laurel, J.M. Maniscalco, C. Matkin, C.A.E. McKinstry, D.H. Monson, J.R. Moran, D. Olsen, W.A. Palsson, W.S. Pegau, J.F. Piatt, L.A. Rogers, N.A. Rojek, A. Schaefer, I.B. Spies, J.M. Straley, S.L. Strom, K.L. Sweeney, M. Szymkowiak, B.P. Weitzman, E.M. Yasumiishi, and S.G. Zador. In press. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports.

2. Reports

Matkin, C.O., and D.W. Olsen. 2020. Long-term killer whale monitoring in Prince William Sound/ Kenai Fjords. *Exxon Valdez* Oil Spill Restoration Project Annual Report

(Restoration Project 19120114-N), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Seeeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2020. Chapter 4 Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska. In R.M. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

3. Popular articles

Olsen, D. 2021. The seasonal harvest for Alaska's killer whales. Delta Sound Connections, Prince William Sound Science Center.

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

1. Conferences and Workshops

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.

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.

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.

2. Public presentations

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 Penninsula College, September 2020.

Other outreach 2020

12 Kenai Fjords Naturalist Group emails

35 Facebook posts

20 Instagram posts

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

No new contributions for this reporting period.

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

All required datasets have been updated on the Gulf of Alaska Data Portal (https://portal.aoos.org/gulf-of-alaska#metadata/2f42dd1c-d67a-4c49-8c2e-1d63387e0ad0/project/files). The photographic and Soundtrap acoustic files are very large and cannot be uploaded and accessed with a browser easily, and we supplied the data to Axiom via a hard drive. Data through August 2020 will be supplied by May 2021. Currently, data from 2012-2019 (Gulf Watch Alaska time period) have been published by Axiom, which include the following:

- Shipboard acoustic recordings, 2012-2019 (https://portal.aoos.org/gulf-of-alaska#metadata/2f42dd1c-d67a-4c49-8c2e-1d63387e0ad0/project/folder_metadata/2689596)
- Biopsy data, 1994-2019, including results of chemical tracer analysis (https://portal.aoos.org/gulf-of-alaska#metadata/2f42dd1c-d67a-4c49-8c2e-1d63387e0ad0/project/folder_metadata/24158)
- Database of surveys and encounters, 2001-2019 (includes Access database: https://workspace.aoos.org/project/4682/folder/2824129/database-of-surveys-and-encounters-2017-2021)
- Prey sampling, 1991-2018 (https://workspace.aoos.org/project/4682/folder/2529812/prey-genetics)
- Soundtrap (remote hydrophone) data through 2019 have been delivered to Axiom for publication (https://portal.aoos.org/gulf-of-alaska#metadata/2f42dd1c-d67a-4c49-8c2e-1d63387e0ad0/project/folder_metadata/2689596)
- Field identification photos through 2019 were posted by Axiom to a separate site on the Research Workspace because of their large size (https://portal.aoos.org/gulf-of-alaska#metadata/2f42dd1c-d67a-4c49-8c2e-1d63387e0ad0/project/folder_metadata/2689692)

Discussions are underway within Axiom to determine how to deal with datasets with the number of files or sheer volume make it impractical to access through a browser.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY21): *The minor requested budget reallocations seem to be well justified. The Science Panel is pleased to see the involvement of a UAF PhD student in the acoustic analysis portion of this project.*

PI Response (FY20): Thank you for reviewing our budget allocation. We are thrilled to have a PhD student included in our project.

Because of use of our own vessel and quarantining before cruises we were able to complete a full field season. We expect to complete a full field season in FY21. Due to COVID-19 there is hold up in the analysis of feeding and scat samples since federal labs have been closed. This is primarily funded by in-kind donation of services and data sharing arrangements; however, there may be a small amount of analytical funds that may need to be rolled over to FY22. This will become clearer before the end of the program fiscal year in February 2021.

Science Panel Comment (FY20): *The Science Panel appreciates the work that comes out of this project and is pleased to see the involvement of a graduate student in this project. The Panel has no specific comments or questions.*

PI Response (FY20): Thank you for your comments. We appreciate the positive feedback.

11. Budget:

Please see provided program workbook. Below is a summary of the cumulative spending for the project at the close of FY20. We will have some money in contractual commodities left in FY21 that will be applied to the COVID-19 delayed drone/photogrammetry work in 2020.

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
PROGRAM PROJECT BUDGET PROPOSAL AND REPORTING FORM

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$41.0	$41.0	$42.2	$42.2	$42.2	$208.6	$166.5
Travel	$3.2	$3.2	$3.5	$0.0	$0.0	$9.8	$5.5
Contractual	$49.5	$50.5	$52.3	$59.7	$60.5	$272.5	$205.2
Commodities	$33.8	$31.6	$20.6	$15.1	$13.7	$114.7	$94.1
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Indirect Costs (*10%*)	$12.7	$12.6	$11.9	$11.7	$11.6	$60.6	$45.9
SUBTOTAL	$140.2	$138.8	$130.4	$128.7	$128.0	$666.1	$517.2
General Administration (9% of subtotal)	$12.6	$12.5	$11.7	$11.6	$11.5	$59.9	N/A
PROJECT TOTAL	$152.8	$151.3	$142.1	$140.3	$139.6	$726.1	
Other Resources (Cost Share Funds)	$25.0	$25.0	$25.0	$25.0	$25.0	$125.0	

LITERATURE CITED

Matkin, C.O., G.W. Testa, G.M. Ellis, and E.L. Saulitis. 2014. Life history and population dynamics of southern Alaska resident killer whales (*Orcinus orca*). Marine Mammal Science 30(2):460-479

Ohlberger, J., E.J. Ward, D.E. Schindler, and B. Lewis. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries 19:3 https://doi.org/10.1111/faf.12272

Saulitis, E., C.O. Matkin, and F.H. Fay. 2005. Vocal repertoire and acoustic behavior of the isolated AT1 killer whale subpopulation in Southern Alaska. Canadian Journal of Zoology 83:1015-1029.

Stredulinsky, E.H., C.T. Darimont, L. Barrett-Lennard, G.M. Ellis, and J.K.B. Ford. In press. Family feud: permanent group splitting in a highly philopatric mammal, the killer whale (*Orcinus orca*). Behavioral Ecology and Sociobiology.

Suryan, R.M., M.L. Arimitsu, H.A. Coletti, R.R. Hopcroft, M.R. Lindeberg, S.J. Barbeaux, S.D. Batten, W.J. Burt, M.A. Bishop, J.L. Bodkin, R.E. Brenner, R.W. Campbell, D.A. Cushing, S.L. Danielson, M.W. Dorn, B. Drummond, D. Esler, T. Gelatt, D.H. Hanselman, S.A. Hatch, S. Haught, K. Holderied, K. Iken, D.B. Iron, A.B. Kettle, D.G. Kimmel, B. Konar, K.J. Kuletz, B.J. Laurel, J.M. Maniscalco, C. Matkin, C.A.E. McKinstry, D.H. Monson, J.R. Moran, D. Olsen, W.A. Palsson, W.S. Pegau, J.F. Piatt, L.A. Rogers, N.A. Rojek, A. Schaefer, I.B. Spies, J.M. Straley, S.L. Strom, K.L. Sweeney, M. Szymkowiak, B.P. Weitzman, E.M. Yasumiishi, and S.G. Zador. In press. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports.

Yurk, H., O. Filatova, C.O. Matkin, L.G. Barrett-Lennard, and M. Brittain. 2010. Sequential habitat use by two resident killer whale (*Orcinus orca*) clans in Resurrection Bay, Alaska as determined by remote acoustic monitoring. Aquatic Mammals 36: 67-78.