1. Project Number:

20120114-D

2. Project Title:

Continuous Plankton Recorder monitoring of plankton populations on the Alaskan Shelf

3. Principal Investigator(s) Names:

Clare Ostle, Marine Biological Association, UK

Sonia Batten, North Pacific Marine Science Organization

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:

Fortunately, the 2020 continuous plankton recorder (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. Analysts hope to catch up and have data for 2020 completed by summer 2021 as planned, but it is impossible to confirm this with the unpredictable nature of the pandemic. We hope to pick up the rate of analysis of the samples as soon as restrictions ease.

The CPR was deployed on seven transects in 2020, monthly from April to October. Six transects were successful (May to October). In April there was a mechanical issue with the CPR and in June and July the instrument was recovered early, on the outer shelf due to engine problems with the container ship (Fig. 1). Location of the ship's transect continues to be consistent from month to month. At the time of writing, provisional plankton data for May to October are available and the

remaining samples are undergoing analysis and QC. Annual sea surface temperature (SST) in 2020 was warmer than average (over the period 2004 2020) in the Alaskan shelf region (Fig. 2).

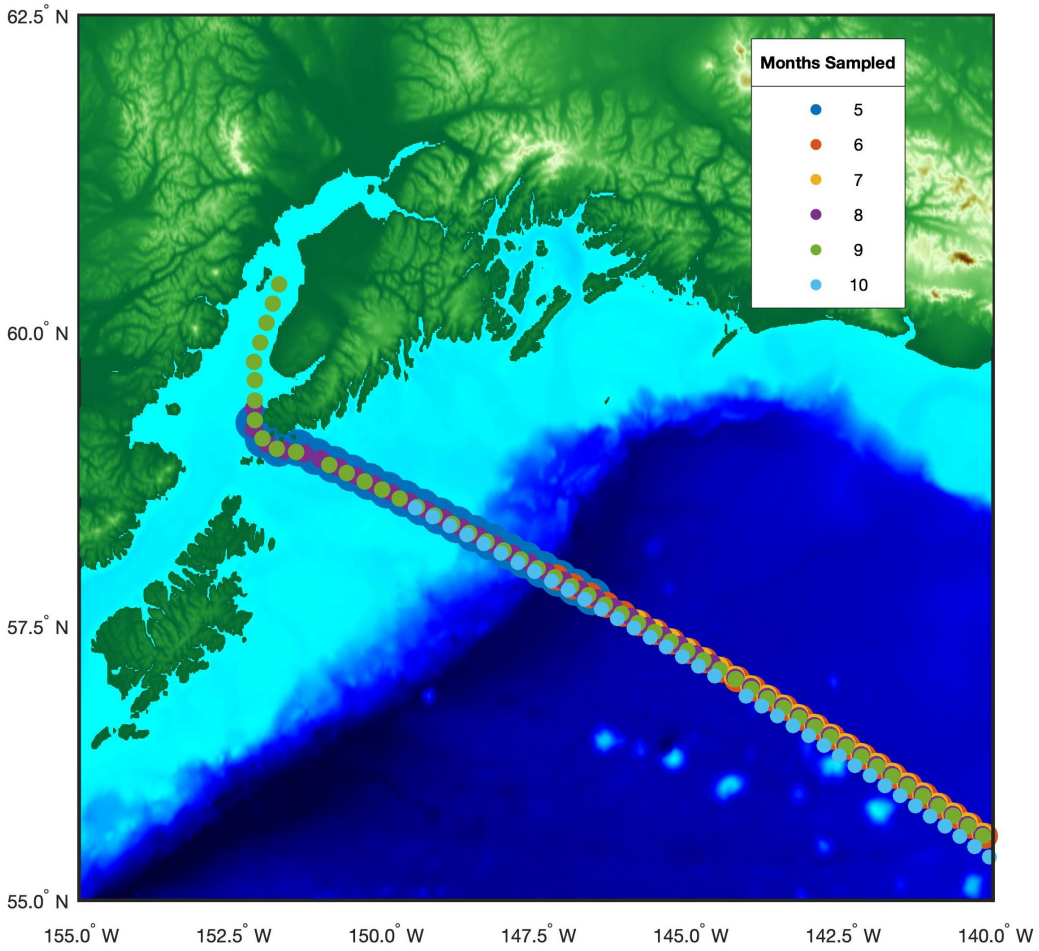

Figure 1. Location of monthly continuous plankton recorder (CPR) transects in 2020.

Figure 2. Monthly mean, annual mean and annual standardised z-score Sea Surface Temperature (SST) within the Alaskan Shelf region (Fig. 1) from 2004 to 2020. Where positive z-score values signify values above the mean (red) and negative values are below the mean (blue). Obtained from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS).

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. As Fig. 3 shows, the provisional results for 2020 suggest similar plankton dynamics to that of 2012.

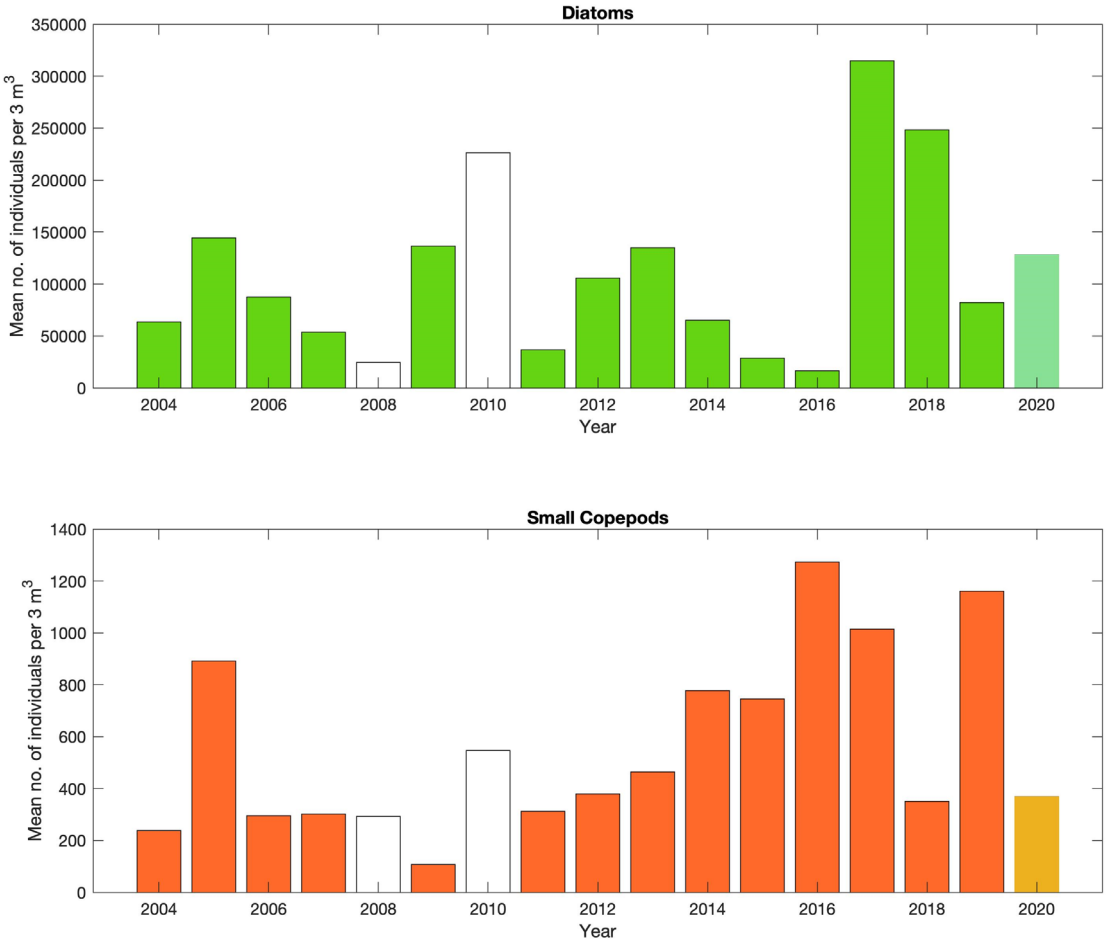

Figure 3. Mean annual diatom (top) and zooplankton (lower) abundance, unfilled years are when sampling was sub-optimal. 2020 data are preliminary and will include more samples when analysis is completed (light green and orange bars).

Other evidence supports the suggestion that plankton are demonstrating a return to cooler conditions than previous years (e.g., 2019) (Fig. 4). Firstly, the mean size of copepods was not significantly different to average (warm years typically see a shift to smaller mean size) and secondly, the abundance of a particular copepod species indicative of warmer conditions (*Calanus pacificus*) looks to be low in 2020 (Fig. 4).

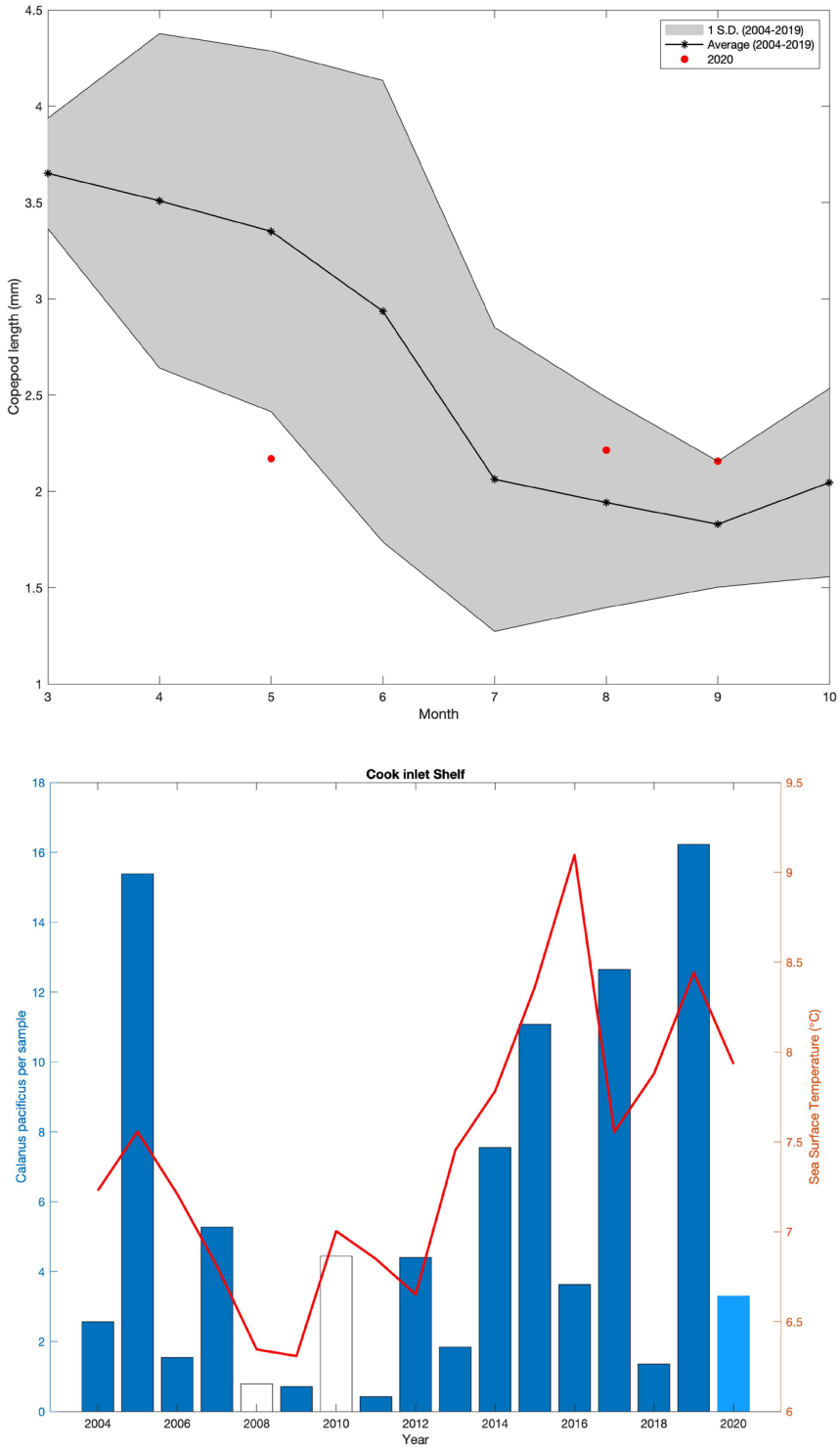

Figure 4. Top panel shows the mean monthly copepod length through 2020 (smaller than average in the spring, and slightly larger in the summer, however not significantly) and bottom panel shows the mean annual abundance of the warm water indicator, Calanus pacificus, (blue bars) together with annual sea surface temperature (SST) (red line). 2020 data are preliminary (light blue bar).

In summary, these results suggest that the marine heatwave impacts appear to be reducing. This is likely to have positive effects on ecosystem functioning.

8. Coordination/Collaboration:

A. Long-term Monitoring and Research Program Projects

1. Within the Program

This project contributed data to two chapters (Chapter 3 Synchronous collapse of forage species disrupts trophic transfer during a prolonged heatwave and Chapter 4 Ecosystem response to a prolonged marine heatwave in the Gulf of Alaska) of the program synthesis report (The Pacific marine heatwave: Monitoring during a major perturbation in the Gulf of Alaska). Both chapters are in the process of publication in peer-reviewed journals (please see Section 9 below).

2. Across Programs

a. Herring Research and Monitoring

We continue to provide 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.

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

Collaboration continues with groups associated with the other members of the North Pacific CPR Consortium, such as Fisheries and Oceans Canada and the North Pacific Research Board (NPRB).

C. With Trustee or Management Agencies

The project continues to contribute indicators to National Oceanic and Atmospheric Administration's Gulf of Alaska Ecosystem Status Report to the North Pacific Fisheries Management Council for 2020 and the Socioeconomic Profile (ESP) for 2020. https://access.afsc.noaa.gov/REFM/REEM/ecoweb/index.php

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

1. Peer-reviewed Publications

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 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

Batten, S., P. Helaouet, C. Ostle, and A. Walne. in prep. Responses of Gulf of Alaska plankton communities during and after a marine heatwave.

Litzow, M., M.E. Hunsicker, E.J. Ward, S.C. Anderson, J. Gao, S.G. Zador, S. Batten, S.C. Dressel, J. Duffy-Anderson, E. Fergusson, R. Hopcroft, B.J. Laurel, R. O'Malley. 2020. Evaluating ecosystem change as Gulf of Alaska temperature exceeds the limits of preindustrial variability. Progress in Oceanography 186 https://doi.org/10.1016/j.pocean.2020.102393.

Hoover, B.A., M. García-Reyes, S.D. Batten, C. Gentemann, and W. Sydeman. in press. Spatio-temporal persistence of zooplankton communities in the Gulf of Alaska. PLOS ONE.

Pinchuk, A.I., S.D. Batten, and W.W. Strasburger. 2021. Doliolid (Tunicata, Thaliacea) blooms in the southeastern Gulf of Alaska as a result of the recent heat wave of 2014-2016. Frontiers in Marine Science – Marine Ecosystem Ecology.

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

Arimitsu, M., J. Piatt, R.M. Suryan, S. Batten, M.A. Bishop, R.W. Campbell, H. Coletti, D. Cushing, K. Gorman, S. Hatch, S. Haught, R.R. Hopcroft, K.J. Kuletz, C. Marsteller, C. McKinstry, D. McGowan, J. Moran, R.S. Pegau, A. Schaefer, S. Schoen, J. Straley, and V.R. von Biela. 2020. Chapter 3 Synchronous collapse of forage species disrupts trophic transfer during a prolonged marine heatwave. In M.R. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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.

Ostle, C., and S. Batten. 2020. Continuous Plankton Recorder data from the Northeast Pacific, 2000-2019. In Ferriss, B., and S. Zador, editors. Ecosystem Status Report 2020 Gulf of Alaska. North Pacific Fishery Management Council, Anchorage, AK.

Suryan, R.M., M. Arimitsu, H. Coletti, R.R. Hopcroft, M.R. Lindeberg, S. Batten, M.A. Bishop, R. Brenner, R. Campbell, D. Cushing, S. Danielson, D. Esler, T. Gelatt, S. Hatch, S. Haught, K. Holderied, K. Iken, D. Irons, D. Kimmel, B. Konar, K. Kuletz, B. Laurel, J.M. Maniscalco, C. Matkin, C. McKinstry, D. Monson, J. Moran, D. Olsen, S. Pegau, J. Piatt, L. Rogers, A. Schaefer, J. Straley, K. Sweeney, M. Szymkowiak, B. Weitzman, J. Bodkin, and S. Zador. 2020. Chapter 4 Ecosystem response to a prolonged marine

heatwave in the Gulf of Alaska. In M.R. Suryan, M.R. Lindeberg, and D.R. Aderhold, eds. The Pacific Marine Heatwave: Monitoring During a Major Perturbation in the Gulf of Alaska. Gulf Watch Alaska Long-Term Monitoring Program Draft Synthesis Report (*Exxon Valdez* Oil Spill Trustee Council Program 19120114). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

3. Popular articles

Batten, S., S. Chiba, and W. Sydeman. 2020. Two decades of the North Pacific CPR program. PICES Press 18:18-21.

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.

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 or Workshop Presentations where EVOSTC-funded Work was Presented

1. Conferences and Workshops

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 pole-ward through the Bering Sea into the Arctic and potential future investigations. Poster presentation, Alaska Marine Science Symposium, Anchorage, AK, January.

2. Public presentations

No new contributions for this reporting period.

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 Data and metadata from 2019 surveys (plankton counts and physical data) have been uploaded to the Research Workspace and made available on the Gulf of Alaska data portal.

10. Response to EVOSTC Review, Recommendations and Comments:

Science Panel Comment (FY21): The Science Panel thanks Sonia for her leadership on this project and is pleased that she will remain as a co-PI. This project continues to generate meaningful information that is used by other researchers.

GWA PI Response (FY21): Thank you for this comment, I am happy to pass the torch on to Clare Ostle but to also stay involved in a supportive role.

Science Panel Comment (FY21): The SP was intrigued by the record in Figure 3 but had some questions and requests for additional clarification about the interpretation of these patterns. For example, the SP did not follow the arguments about the 2017 data point supporting the idea that productivity was reduced during the heatwave. The SP was also interested in how the pre-heat wave record (prior to 2014) generally showed a positive correlation between diatom abundance and small copepod abundance, whereas the heat wave data showed a negative correlation between the two, with just one year (2017) looking more like the pre-2014 years. This led us to wonder about correlations between temperature and top down vs bottom up control as in the work of Ken Frank and colleagues. We understand the limitations of any purely correlational dataset, but nonetheless look forward to seeing additional interpretation of this excellent data set in future updates and in publications, which the PI continues to turn out.

GWA PI Response (FY21): Thank you for this comment. We are exploring the implications of our results on understanding the balance of top down versus bottom up processes that may be operating during and after the heatwave and a manuscript is in preparation. To clarify our comment about productivity in the heatwave and the data from 2017 to now, prior to the heatwave we had noted a positive relationship between large diatoms and small copepods, which would be consistent with a bottom-up forced system. In the heatwave years diatoms were very low but small copepods were high. It could be an effect of grazing pressure by the copepods on the diatoms (i.e., primary productivity may still have been good, but standing stock was kept low by the grazing pressure) and it could have been triggered by an absence of predation on the small copepods allowing them to develop high densities and to graze down the diatoms (so top down effects being evident). However, in 2017 we still had high abundances of copepods AND high diatoms, so this similar density of copepods was not able to deplete the diatoms in 2017 making it more likely that primary productivity was better in 2017 than in the earlier heatwave years, perhaps because of nutrient availability. It does look like predation on the small copepods was reduced during and after the heatwave, but we also need to allow for faster growth and shorter generation times in the warmer conditions enhancing small copepod numbers.

Science Panel Comment (FY20): This project continues to do very good work. We appreciate the leveraged funding and continued collaboration with other EVOSTC projects and continues to produce important scientific publications. We again note the comparison of physical processes with herring in the GOA (2016 paper) which provides a good example of what analyses and synthesis can be achieved with these types of higher trophic data.

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

11. Budget:

Please see provided program workbook. There are no deviations from anticipated cumulative spending.

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
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	$35.82	$36.89	$38.00	$39.1	$40.3	$190.2	$149.8
Travel	$1.11	$1.15	$1.18	$1.22	$1.25	$5.9	$4.7
Contractual	$9.97	$10.26	$10.57	$10.89	$11.22	$52.9	$41.7
Commodities	$3.24	$3.34	$3.44	$3.5	$3.65	$17.2	$13.6
Equipment	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Indirect Costs (*40%*)	$20.1	$20.7	$21.3	$21.9	$22.6	$106.5	$83.9
SUBTOTAL	$70.2	$72.3	$74.5	$76.7	$79.0	$372.7	$293.7
General Administration (9% of subtotal)	$6.3	$6.5	$6.7	$6.9	$7.1	$33.5	N/A
PROJECT TOTAL	$76.5	$78.8	$81.2	$83.6	$86.1	$406.2	
Other Resources (Cost Share Funds)	$183.7	$183.9	$186.3	$188.3	$190.3	$932.5	