ATTACHMENT C **EVOSTC Annual Project Report Form**

Form Rev. 8.30.18

1. Program Number:

18120114-I

2. Project Title:

Long-term Monitoring of Oceanographic Conditions in the Alaska Coastal Current from Hydrographic Station GAK1

3. Principal Investigator(s) Names:

Seth L. Danielson, Principal Investigator, University of Alaska Fairbanks

Thomas J. Weingartner, Co-Principal Investigator, University of Alaska Fairbanks

4. Time Period Covered by the Report:

February 1, 2018-January 31, 2019

5. Date of Report:

April 1, 2019

6. Project Website (if applicable):

http://www.gulfwatchalaska.org

http://research.cfos.uaf.edu/gak1/

7. Summary of Work Performed:

The project sampling objectives were accomplished with CTDs in most months and a successful annual recovery and re-deployment of the GAK1 mooring in April 2018. Nominally, monthly CTD casts were done from *R/V Sikuliaq*, *M/V Dora*, and *M/V Acorn*; sampling from *Sikuliaq* and *Dora* also included vertical net tows and collection of nutrient and chlorophyll samples.

As noted in the prior FY17 Project Report, we have been working to replace our Seward-based coastal research vessel, the *R/V Little Dipper*, which has serviced the GAK1 CTD monthly profiles since the 1980s but suffered engine failure in summer 2017. We are pleased to report that in 2018 we were able to secure complete funding for a replacement vessel; we put together a bid package and received bids from a number of manufacturers. In the fall, we awarded a construction contract to Armstrong Marine and the construction of this new vessel is now underway, with an on-schedule delivery planned for May 2019. The new vessel is 40' long and 13' wide, a significant upgrade from the 28' x 12' *Little Dipper* (Fig. 1).

Figure 1. Construction of GAK1's new support vessel is underway in Port Angeles, WA.

Data from the 2017-2018 GAK1 mooring is shown in the panels of Fig. 2 and record-length anomaly timeseries for GAK1 are shown in Figs. 3 and 4, along with the best fit linear trend line. Statistics of the trend analysis are provided in Table 1. The data show that the surface waters continue to warm faster than waters near the seafloor. In addition, the surface is freshening and the waters near the seafloor have an opposite trend, but the latter is just barely significantly different than zero at the 95% confidence level. These trends continue to show that the water column is progressively stratifying over time: a result that carries potentially important ramification for the productivity of the Gulf of Alaska ecosystem. Positive temperature anomalies that began during the recent marine heatwave starting winter 2013/2014 in the Gulf of Alaska have persisted throughout the water column at GAK1 through 2018 (Fig. 3)

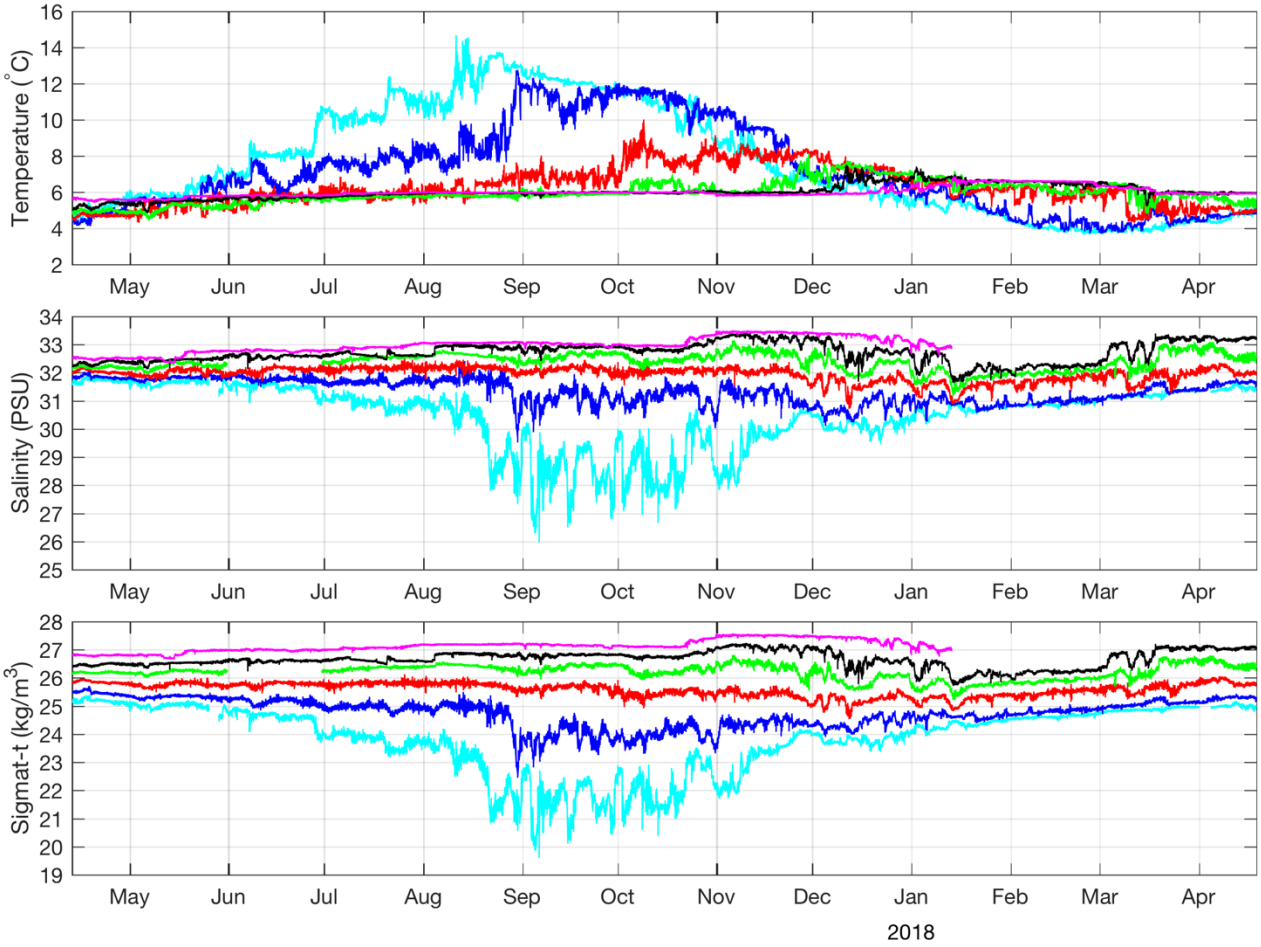

Figure 2. Time series of the 2017-2018 GAK1 mooring records. Colors denote the nominal depth of each instrument from shallow (cyan, 20 m) to deep (magenta, 250 m).

Table 1. Statistics of the temperature and salinity trends observed at GAK1 over 1970-2018. Slope is given as change of parameter per decade. C.I. is the 95% confidence interval on the slope.

Parameter	**Depth Range**	**N**	**Slope (decade^{-1})**	**Slope C.I. (decade^{-1})**	**r^2**	**p**
Temperature	0-50	400	0.24	0.06	0.12	< 0.00
Temperature	200-250	398	0.15	0.04	0.15	< 0.00
Salinity	0-50	400	-0.07	0.03	0.04	< 0.00
Salinity	200-250	395	0.02	0.02	0.01	0.05

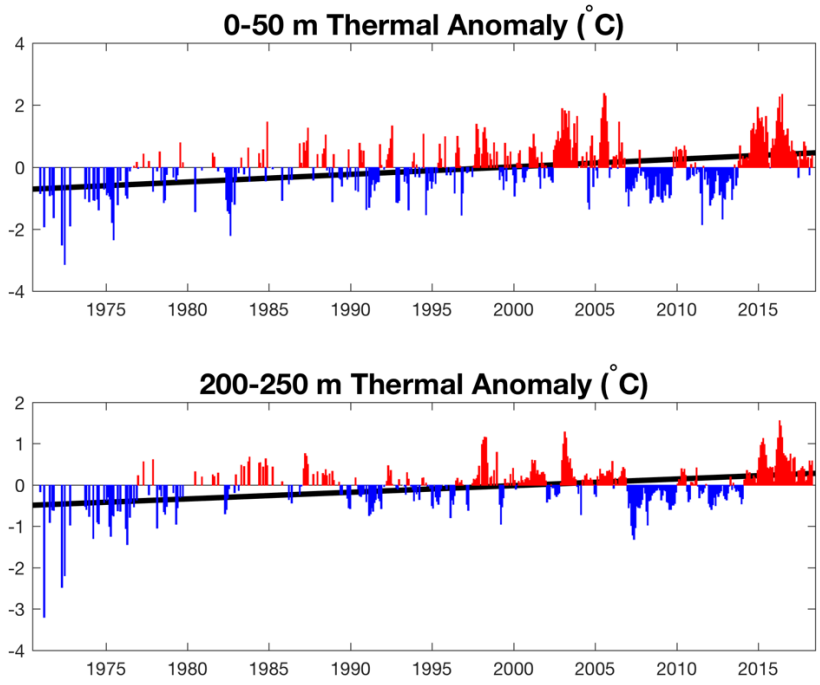

Figure 3. Record-length temperature monthly anomalies for near-surface (0-50m) and near-seafloor (200-250m) depth ranges. Positive anomalies are shown in red, negative anomalies are in blue. The linear trend line is shown in black; statistics of the trends are shown in Table 1.

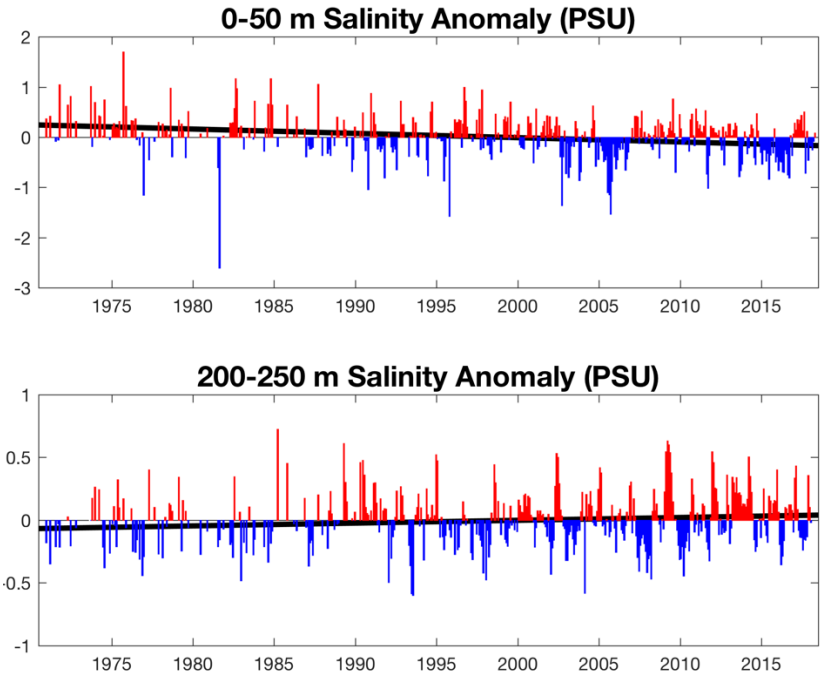

Figure 4. Record-length salinity monthly anomalies for near-surface (0-50m) and near-seafloor (200-250m) depth ranges. Positive anomalies are shown in red, negative anomalies are in blue. The linear trend line is shown in black; statistics of the trends are shown in Table 1.

8. Coordination/Collaboration:

A. Projects Within a Trustee Council-funded program

1. Within the Program

GAK1 provides a coastal long-term context for the Gulf Watch Alaska program as a whole. The Gulf Watch Alaska framework for integration with other principal investigators (PIs) and components of the environmental drivers monitoring, and Herring Research and Monitoring are outlined separately in the project management proposals.

Supplemental *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) funding to the Seward Line project (PI Hopcroft, 18120114-L) is allowing the collection and processing of discrete nutrient, chlorophyll and zooplankton samples at GAK1. We provide the GAK1 survey vessel as a platform-of-opportunity to Hopcroft's GAK1 sampling and have now assembled an annual cycle of this multi-disciplinary sampling.

PI Danielson is contributing to upcoming synthesis manuscripts (led by PI Monson 18120114-H, PI Arimitsu 1820114-C, and PI Suryan 1820114-A). Danielson has also been working on compiling other environmental time series data that may be useful in analysis and interpretation of other Gulf Watch Alaska observations. Such datasets include sea surface height anomalies and geostrophic velocity vectors derived from ocean altimeter satellites. He presented these datasets at the annual Gulf Watch Alaska PI meeting in November 2018 and described their potential utility to the meeting attendees.

2. Across Programs

a. Herring Research and Monitoring

Herring Research and Monitoring project 18160111-B (PI Bishop) recently expressed interest in deploying a Pacific Ocean Shelf Tracking (POST) array acoustic tag recorder on the GAK1 mooring and we are facilitating that new addition to the mooring.

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.

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

c. Lingering Oil

None to report.

B. Projects not Within a Trustee Council-funded program

None to report.

C. With Trustee or Management Agencies

The GAK1 effort has assisted many others with their research over the years. For example, in 2001-02 it provided a test bed for prototype halibut tags (developed by U.S. Geological Survey-Biological Resources Division [USGS-BRD] scientists), which were then used to study halibut migrations in the Gulf of Alaska and the Bering Sea. The data were used by herring biologists to assess energetic costs of overwintering herring (Heintz, pers. comm), and it has been used studies of king crab (Bechtol and Kruse 2009), spiny dogfish Tribuzio et al. (2009), the community structure of rocky coasts (Ingolfsson 2005), rock sole (Fedewa et al. 2015) and salmon (Boldt and Haldorson 2002). We have had requests from Steve Moffitt (Alaska Department of Fish and Game salmon biologist) to use these data as an aid in salmon forecasts (see Eggers et al. 2013, Munro and Tide 2014) and we are aware of several Gulf of Alaska fishermen who routinely access this data set. The GAK1 data are also used by the AOOS-supported ocean acidification (OA) monitoring study on the surface buoy near GAK1, which is known as mooring GAK-OA (Evans et al., 2013). Many other similar examples can be found in the extensive publication list at the GAK1 website (http://www.ims.uaf.edu/gak1/). We continue to offer GAK1 as a platform for others' instruments.

The National Oceanic and Atmospheric Administration (NOAA)-based AOOS (Executive Director M. McCammon) is a regional association within the national Integrated Ocean Observing System (IOOS) network. AOOS and the National Science Foundation-funded Northern Gulf of Alaska (NGA) Long-Term Ecological Research (LTER) program facilitate ocean observations in the Gulf of Alaska in partnership and in conjunction with the EVOSTC-funded GAK1 mooring. For the most recent reporting period, this partnership facilitated the planning, design tasks, and purchase of sensors that will form a new set of outer shelf moorings that will be located near Seward Line station GAK7. The development of the outer shelf mooring expands the network of Gulf of Alaska moorings (the GAK1 mooring, this project; and the Gulf Watch Alaska Prince William Sound Oceanographic mooring, PI Campbell 18120114-G) and helps advance the AOOS vision for multi-disciplinary moored "ecosystem observatories" in each of Alaska's Large Marine Ecosystems. The NGA LTER is providing salary and vessel support for servicing the new outer shelf moorings.

Like other Gulf Watch Alaska Environmental Driver component data, GAK1 data are available to Alaska Department of Fish and Game for salmon forecasting and provided one indicator to NOAA's Gulf of Alaska Ecosystem Status Report to the North Pacific Fisheries Management Council (Zador and Yasumiishi 2018).

We assist the National Park Service (NPS) in a similar quasi-monthly CTD sampling and data processing protocol in Glacier Bay National Park and Preserve through the Inventory and Monitoring program (http://science.nature.nps.gov/im/units/sean/default.aspx; Program Manager M. Bowers), which also serves their data online. The sampling in Glacier Bay provides a complementary data set that is made upstream of GAK1 in terms of the general circulation of the Gulf of Alaska shelf. Collectively, the Glacier Bay, Prince William Sound, Cook Inlet, and GAK1 data sets provide a broad-scale perspective of the Gulf of Alaska shelf environment. We are collaborating at no cost to this proposal with NPS scientists using CTD sampling and analysis protocols identical to those at GAK1. Since southeast Alaska waters contribute to the Alaska Coastal Current, the 27-year Glacier Bay time-series provides the opportunity to assess variability in the northeast and northwest Gulf of Alaska and to understand how these regions co-vary and how the Alaska Coastal Current evolves as if flows westward toward Prince William Sound. University of Alaska Fairbanks and the NPS are actively working toward implementing a GAK1 style mooring for Icy Bay in the Northeast Gulf of Alaska; such a mooring would fill a gap in sampling that exists between the NGA LTER observations and the NPS sampling in Glacier Bay.

9. Information and Data Transfer:

A. Publications Produced During the Reporting Period

Batten, S.D., D.E. Raitsos, S.L. Danielson, R.R. Hopcroft, K.C. Coyle, A. McQuatters-Gollop. 2018. Interannual variability in lower trophic levels on the Alaskan Shelf. Deep Sea Research II. 147, 58-68.

Chenoweth, E.M., K.R. Criddle. 2019. The Economic Impacts of Humpback Whale Depredation on Hatchery-Released Juvenile Pacific Salmon in Southeast Alaska. Marine and Coastal Fisheries, V11, 1, pp. 62-75, https://doi.org/10.1002/mcf2.10061

Chenoweth, E.M. 2018. Bioenergetic and economic impacts of humpback whale depredation at salmon hatchery release sites, Ph.D. Dissertation, University of Alaska Fairbanks, Fairbanks, AK

Danielson, S.L. and R.R. Hopcroft. 2018. Seward line May temperatures *in* Zador, S. G., and E. M. Yasumiishi. 2018. Ecosystem Status Report 2018: Gulf of Alaska. Report to the North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. https://www.fisheries.noaa.gov/resource/data/2018-status-gulf-alaska-ecosystem

Olson, A.P., C.E. Siddon, G.L. Eckert. 2018. Spatial variability in size at maturity of golden king crab (Lithodes aequispinus) and implications for fisheries management. Royal Society Open Science. 5. http://doi.org/10.1098/rsos.171802

Roberts, M.V. 2018. The temporal and spatial distribution of dissolved and particulate iron over the Gulf of Alaska shelf. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, AK

Vandersea, M.W., S.R. Kibler, P.A. Tester, K. Holderied, D. E. Hondolero, K. Powell, S. Baird, A. Doroff, D. Dugan, R.W. Litaker. 2018. Environmental factors influencing the distribution and abundance of Alexandrium catenella in Kachemak bay and lower cook inlet, Alaska, Harmful Algae, V77, pp. 81-92, ISSN 1568-9883, https://doi.org/10.1016/j.hal.2018.06.008.

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

Danielson, S.L. 2018. The short and the long of it: the importance of high-resolution Alaskan marine process studies and monitoring. Oral Presentation. UAF-CFOS FOS Seminar, September. Fairbanks, AK.

Hopcroft, R.R., A. Aguilar-Islas, S.L. Danielson, J. Feichter, S. Strom. 2018. NGA-LTER Overview. LTER PI Meeting, October 2018, Asilomar, CA.

Strom, S., R.R. Hopcroft, A. Aguilar-Islas, S.L. Danielson, J. Feichter. 2019. Resilience Amidst a Sea of Change: The Northern Gulf of Alaska LTER Program, Keynote Presentation, Alaska Marine Science Symposium, January 2019, Anchorage, AK.

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

We are working on Gulf of Alaska region satellite-based estimates of transport and sea level variability. These products may be useful for future analyses.

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

All Data and metadata from 2017 CTD profiles and moored time series 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 (EVOSTC FY18 Work Plan)**:** This is an important long-term data collection project that needs to continue. The Panel supports the research and welcomes the news of the Long-Term Ecological Research (National Science Foundation) funding awarded to the PIs, which will insure the stability of

gathering long-term data while expanding the scope of the project. PIs are using graduate students productively.

PI response: Thank you for the comment.

11. Budget:

Please see attached budget spreadsheet. No significant alterations in funding allocation are anticipated. In order to take advantage of the M.J. Murdock Charitable Trust matching funds, we postponed spending 2017 equipment funds until 2018. Though not shown in this breakdown, PI Danielson's transition from Research Faculty to Tenure Track Faculty status will allow him to re-allocate some of his salary into student and staff support over FY19-FY21.

Budget Category:	Proposed FY 17	Proposed FY 18	Proposed FY 19	Proposed FY 20	Proposed FY 21	TOTAL PROPOSED	ACTUAL CUMULATIVE
Personnel	$47.1	$48.2	$49.3	$50.4	$51.6	$246.6	$73.0
Travel	$4.4	$4.4	$4.4	$4.4	$4.4	$21.9	$5.0
Contractual	$18.7	$18.7	$18.7	$18.7	$18.7	$93.3	$40.0
Commodities	$6.1	$6.1	$6.1	$6.1	$6.1	$30.5	$1.0
Equipment	$39.3	$39.5	$23.7	$15.8	$16.0	$134.3	$73.0
Indirect Costs (*25% of non-equip.*)	$19.1	$19.3	$19.6	$19.9	$20.2	$98.1	$23.0
SUBTOTAL	$134.6	$136.2	$121.7	$115.2	$116.8	$624.6	$215.0
General Administration (9% of	$12.1	$12.3	$11.0	$10.4	$10.5	$56.2	N/A
PROJECT TOTAL	$146.8	$148.4	$132.6	$125.6	$127.4	$680.8	
Other Resources (Cost Share Funds)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	

Literature Cited

Bechtol, W.R. and G.H. Kruse. 2009. Analysis of a Stock Recruit Relationship for Red King Crab off Kodiak Island, Alaska Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 1:29-44. doi: doi:10.1577/C08-052.1 http://afsjournals.org/doi/abs/10.1577/C08-052.1

Boldt, J.L., and L.J. Haldorson. 2002. A bioenergetics approach to estimating consumption of zooplankton by juvenile pink salmon in Prince William Sound, Alaska. Alaska Fisheries Research Bulletin 92, 21 pp.

Eggers, D.M., C. Tide, and A.M. Carroll (eds). 2013. Run forecasts and harvest projections for 2013 Alaska salmon fisheries and review of the 2012 season. Alaska Department of Fish and Game, Special publication 13-03, Anchorage.

Evans, T.G., F. Chan, B.A. Menge, and G.E. Hofmann. 2013. Transcriptomic responses to ocean acidification in larval sea urchins from a naturally variable pH environment. Molecular Ecology 22:1609-1625. https://doi.org/10.1111/mec.12188

Fedewa, E.J., J.A. Miller, and T.P. Hurst. 2016. Pre-settlement processes of northern rock sole (*Lepidopsetta polyxystra*) in relation to interannual variability in the Gulf of Alaska. Journal of Sea Research 111:25-36. https://doi.org/10.1016/j.seares.2015.11.008

Ingolfsson, A. 2005. Community structure and zonation patterns of rocky shores at high latitudes: an interocean comparison. Journal of Biogeography 32:169-182. https://doi.org/10.1111/j.1365-2699.2004.01150.x

Munro, A.R., and C. Tide (eds). 2014. Run forecasts and harvest projections for 2014 Alaska salmon fisheries and review of the 2013 season. Alaska Department of Fish and Game, Special Publication 14-10, Anchorage.

Tribuzio, C.A., C. Rodgveller, J. Heifetz, and K.J. Goldman. 2009. Chapter 18b: Assessment of the shark stocks in the Gulf of Alaska. North Pacific Fishery Management Council Gulf of Alaska Stock Assessment and Fishery Evaluation Report. https://www.afsc.noaa.gov/refm/stocks/2008_assessments.htm

Zador, S. G., and E. M. Yasumiishi. 2018. Ecosystem Status Report 2018: Gulf of Alaska. Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99301. https://www.fisheries.noaa.gov/resource/data/2018-status-gulf-alaska-ecosystem