Southeast Alaska Coastal Monitoring of Epipelagic Fish and Marine Ecosystem Conditions Associated with Salmon: Continuation of a Long-term Data Series in a Changing Climate

Final Report
September 30, 2015

Pacific Salmon Commission
Northern Fund Project NF-2014-I-1

PERIOD COVERED: May 1, 2014 to March 30, 2016
PERIOD FUNDED: May 1, 2014 to March 30, 2016
TOTAL PSC FUNDS AWARDED: $49,760
PSC FUNDS RECEIVED: $44,784

Co-investigators:

Joseph A. Orsi and Emily A. Fergusson
Research Fish Biologists

NOAA Fisheries,
Alaska Fisheries Science Center,
Auke Bay Laboratories
17109 Pt. Lena Loop Road
Juneau, AK 99801
joe.orsi@noaa.gov
emily.fergusson@noaa.gov

Background

Since 1997, researchers from the NOAA, Alaska Fisheries Science Center, Auke Bay Laboratories' Southeast Coastal Monitoring (SECM) project have sampled juvenile salmon and associated biophysical parameters in the marine waters of the northern region of Southeast Alaska (SEAK) (Figure 1). Because juvenile salmon experience highly variable marine mortality during their early spring residence, fish are sampled later in the season along SECM stations strategically positioned across a primary seaward migration corridor leading into the Gulf of Alaska. This research was originally supported by the NOAA Ship *John N. Cobb*, which was decommissioned in 2008, consequently, subsequent research years has been supported by chartered commercial trawl vessels. The SECM time series provides information on salmon pre-recruit year-class strength and associated biophysical data and is used to develop forecast models of adult pink salmon harvest and an index of Chinook salmon abundance. In addition, the continuous SECM time series has provided a baseline window of biophysical metrics to view the potential impact of climate change on salmon production in marine ecosystems.

The Northern Fund (NF) has provided support to the SECM project to continue biophysical sampling in order to improve salmon forecast modeling and better understand factors in marine ecosystems that influence year class strength. The project was identified under the type, "Development of improved information for resource management, including stock assessment; data acquisition & scientific understanding of limiting factors," and covered the period from May 1, 2014 to March 31, 2016. Specifically, the project addresses the persistent problems of developing reliable forecast methodologies for pink salmon or Chinook salmon fisheries, and improving knowledge of factors that limit ocean survival.

Supplemental information to this NF Project Final Report are in the following 17 attachments that cover the years 2014 (7) and 2015 (10):

List of Attachments

2014

1. Orsi, J. A., E. A. Fergusson, E. V. Farley, Jr., and R. A. Heintz. 2014. Southeast Alaska Coastal Monitoring (SECM) Survey Plan for 2014. NPAFC Doc. 1508. 17 pp. (Available at http://www.npafc.org).

2. Memorandum Of Understanding between NOAA & the Pacific Salmon Commission. March 2014

3. Fergusson, E., J. Orsi, and M. Sturdevant. 2014. Long-term Zooplankton and Temperature Trends in Icy Strait, Southeast Alaska. p. 125-131 In Zador et al. Ecosystem Considerations 2014. National Marine Fisheries Service, NOAA. 263 p. http://www.afsc.noaa.gov/REFM/Docs/2014/ecosystem.pdf

4. Orsi, J, E. Fergusson, and A. Wertheimer. 2014. Forecasting Pink Salmon Harvest in Southeast Alaska. p. 148-152, In Zador et al. Ecosystem Considerations 2014. National Marine Fisheries Service, NOAA. 263 p. http://www.afsc.noaa.gov/REFM/Docs/2014/ecosystem.pdf

5. Orsi, J, E. Fergusson, and A. Wertheimer. 2014. Using Ecosystem Indicators to develop a Chinook Salmon Abundance Index for Southeast Alaska. p. 153-156, In Zador et al. Ecosystem Considerations 2014. National Marine Fisheries Service, NOAA. 263 p. http://www.afsc.noaa.gov/REFM/Docs/2014/ecosystem.pdf

6. Wertheimer, A. C., J. A. Orsi, E. A. Fergusson, and M. V. Sturdevant. 2014. Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2013 returns and 2014 forecast. NPAFC Doc. 1555. 24 pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS. (Available at http://www.npafc.org)

7. Orsi, J., A. Piston, E. Fergusson, and J. Joyce. 2014. Biological monitoring of key salmon populations: Southeast Alaska pink salmon. North Pacific Anadromous Fish Commission Newsletter (36):13-19. http://www.npafc.org/new/publications/Newsletter/NL36/Newsletter36%20%2813-19%29.pdf

2015

1. Orsi, J. A., E. A. Fergusson, E. M. Yasumiishi, E. V. Farley, and R. A. Heintz. 2015. Southeast Alaska Coastal Monitoring (SCEM) survey plan for 2015. NPAFC Doc. 1556. 17 pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS. (Available at http://www.npafc.org).

2. Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, E.V. Farley, and P.R. Mundy. 2015. Forecasting pink salmon production in Southeast Alaska using ecosystem indicators in times of climate change N. Pac. Anadr. Fish Comm. Bull. 6: xx-xx. Submitted to the NPAFC Symposium May 2015.

3. Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, and E.V. Farley. 2015. Chinook salmon first year production indicators from ocean monitoring in Southeast Alaska. N. Pac. Anadr. Fish Comm. Bull. 6: xx-xx. Submitted to the NPAFC Symposium May 2015.

4. Fergusson, E., and J. Orsi 2015 – Long-term Zooplankton and Temperature Trends in Icy Strait, Southeast Alaska –Ecosystems Considerations Report, Submitted August 2015.

5. Orsi, J. A., E. A. Fergusson, and A. C. Wertheimer. 2015. Forecasting pink salmon harvest in Southeast Alaska using ecosystem indicators from the

Southeast Alaska Coastal Monitoring (SECM) Project – Ecosystems Considerations Report, Submitted August 2015.

6. Orsi, J. A., E. A. Fergusson, and A. C. Wertheimer. 2015. Chinook salmon first year production indicators from ocean monitoring in Southeast Alaska – Ecosystems Considerations Report, Submitted August 2015.

7. Orsi and Fergusson 2015 – Annual Survey of Juvenile Salmon, Ecologically-Related Species, and Biophysical Factors in the Marine Waters of Southeastern Alaska, May–August 2014 – Draft NPAFC Doc. to be submitted in 2015.

8. Wertheimer, A. C., J. A. Orsi, and E. A. Fergusson. 2015. Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2014 returns and 2015 forecast. NPAFC Doc. xxxx. xx pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS. (Available at http://www.npafc.org).– Draft NPAFC Doc. to be submitted in 2015.

9. Annotated Pacific Salmon Commission NF-2014-I-1 Budget Spreadsheet

10. Management Analyst and Reporting System (MARS) Summary

Objectives

The SECM project objectives for NF-2014-I-1 were to: (1) Conduct monthly ocean surveys in the marine waters of the northern regions of SEAK; (2) Provide regional stock assessment metrics for pink and Chinook salmon; and (3) Contribute ecosystem monitoring reports to better understand salmon production mechanisms. The work completed to meet these objectives is summarized below; documents produced from the project to date are also cited where appropriate and listed in the references section on page 7 and some are attached as part of this final report.

<u>Objective 1.</u> Monthly ocean surveys in the northern region of SEAK:
a. Sample biophysical environmental metrics (May-August 2014)
b. Sample epipelagic fish associated with salmon (June-August 2014)

Objective 1 was fully accomplished by sampling inshore, strait, and coastal habitats in the northern region of SEAK in 2014 (Table 1). Survey plans for the SECM sampling were developed for both 2014 and 2015 SECM surveys and reported in North Pacific Anadromous Fish Commission (NPAFC) documents that are attached to this final report (Orsi et al. 2014a, 2015a). In 2014, the R/V *Sashin* was used to complete oceanographic sampling in May and the chartered vessel *Northwest Explorer* (*NWE*) was used to complete oceanographic and fish sampling in June, July, and August. The biophysical data collections from 2014 were reported in a NPAFC document (Orsi and Fergusson 2015) and attached to this final report. A total of 277 biophysical sample collections were made in 2014 (Table 2). Previous documents include syntheses of interannual catch and

biophysical trends that allows the 2014 sampling year to be compared to baseline patterns of marine conditions in the time series (i.e., Orsi et al. 2012a, Sturdevant et al. 2012, Fergusson et al. 2013, Orsi and Fergusson 2014).

Objective 2. Regional salmon stock assessments:
a. Develop a forecast model for SEAK pink salmon harvest in 2015
b. Provide data for statewide status of Chinook stock concerns

Objective 2 was fully accomplished for both pink salmon and Chinook salmon assessments.
The preseason harvest forecast model for pink salmon was evaluated in 2014, and the preseason forecast model for pink salmon was developed for 2015 using the SECM time series of peak June-July catch-per-unit-effort (CPUE) of juvenile pink salmon and associated biophysical data collected from 1997-2014 (Table 2). The pre-season pink salmon forecast model has been prepared in a draft NPAFC Document (Wertheimer et al. 2015) and attached to this final report. Accuracy of the pink salmon forecast model has been generally high over the past decade (Figure 2, Wertheimer et al. 2014). An oral presentation of the 2015 pre-season pink salmon harvest forecast was delivered at the Southeast Alaska Purse Seine Task Force Meeting in Petersburg Alaska in December of 2014. This presentation was posted to an online website that can be viewed by the public (http://www.afsc.noaa.gov/ABL/EMA/EMA_PSF.htm) The pink salmon forecast was also submitted to the NOAA Ecosystem Considerations Report (Orsi et al. 2015b). Data from this project are also shared with the Alaska Department of Fish and Game (ADFG) for their salmon forecasts.

Information Chinook salmon stock status was available from the trawl samples and reported. A Chinook salmon abundance index of ocean-age 3 fish was developed using pre-recruit abundances of ocean-age 1 Chinook salmon lagged two years later (Figure 3). The Chinook salmon abundance index was also submitted to the NOAA Ecosystem Considerations Report (Orsi et al. 2015c). Origin information from all coded-wired tagged (CWT) Chinook salmon (n = 5) and numbers of adipose clipped Chinook were reported to the Regional Mark Processing Center (http://www.rmpc.org). Caudal fin clips from all Chinook salmon were also preserved in Alcohol and provided to the Alaska Department of Fish and Game for future genetic work and to better describe the origin of pre-recruit fish in adjacent commercial troll fisheries.

Objective 3. Ecosystem monitoring reports:
a. Update annual NOAA Ecosystem Considerations Report contributions

NOAA Ecosystem Considerations Reports were completed for long-term trends in zooplankton (Fergusson and Orsi 2015), the pre-season pink salmon harvest forecast (Orsi et al. 2015b), the Chinook salmon abundance index (Orsi et al. 2015c), and a sablefish recruitment index (Yasumiishi et al. 2015). Several NPAFC documents were also completed to support and complement these reports such as, SECM survey plans, pink salmon forecast, Chinook salmon abundance index, and the 2014 SECM annual survey report; all documents are attached to this final report.

Scientific Accomplishments

Maintaining the long-term SECM project on juvenile salmon metrics and associated marine biophysical conditions in SEAK has contributed substantially to our understanding of processes affecting salmon production. The SECM forecast has been cited as a pragmatic example of ocean research applied to fisheries management (Turner and Haidvogel 2009). The consistency of the research has fostered communications and cooperation with regional ADF&G offices, other NOAA Fisheries Centers, regional aquaculture associations, commercial fishing constituents, academia, and international salmon fisheries organizations such as NPAFC, Yeongdong Inland Fisheries Research Institute (S. Korea), National Salmon Resources Center (Hokkaido), Canada Department of Fisheries and Oceans, and Skeena Fisheries Commission (British Columbia). The SECM staff have presented numerous oral and poster reports at scientific meetings and to stakeholder groups and have published numerous scientific publications and reports. The 2014-2015 research products are attached to this report (list of attachments on pgs. 2-4) and text references are in the references section of this report (pgs. 7-8). As practicable, data collected is reported in a timely manner and posted online to websites that can be viewed by the public and resource stakeholders (See "web links" p. 6).

Budget Summary

The NF allocated a total of $49,760 for the SECM project. Of this amount, $44,378 has been spent/obligated to date; an additional $5,382 has been obligated for spending by March 31, 2016, contingent upon receipt of the 10% NF hold-back (Table 3). Detailed budget accounting is provided by line item on the attached Pacific Salmon Commission budget form (Attachment 2015-9).

Budget expenditures for the SECM project NF-2014-I-1 by line item are: amount projected, amount spent (including projected spending through March 31, 2016), and amount and percent variance (Table 3). The spending for the project was tracked by the NOAA National Marine Fisheries Service Management Analyst and Reporting System (MARS). A MARS object class summary report is included (Attachment 2015-10).

Web links

NOAA SECM website: http://www.afsc.noaa.gov/ABL/EMA/EMA_SECM.htm
(Updated Jan 2014)

NOAA pink salmon forecasting: http://www.afsc.noaa.gov/ABL/EMA/EMA_PSF.htm
(Updated Jan 2014)

References

Alaska Department of Fish and Game preliminary data. (Accessed September 2015) http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisherysalmon.bluesheet

Fergusson, E. A., M. V. Sturdevant, and J. A. Orsi. 2013. Trophic relationships among juvenile salmon during a 16-year time series of climate variability in Southeast Alaska. N. Pac. Anadr. Fish Comm. Tech. Rep. 9.

Fergusson, E. A. and J. A. Orsi. 2015. Long-term zooplankton trends in Icy Strait, Southeast Alaska. Submitted Aug 2015 to S. Zador, editor. Ecosystem Considerations 2014, Stock Assessment and Fishery Evaluation (SAFE) Report. North Pacific Fishery Management Council, 605 W. 4th Ave. Suite 306, Anchorage, AK 99501.

Orsi, J. A., E. A. Fergusson, M. V. Sturdevant, W. R. Heard, and E. Farley, Jr. 2012. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2011. NPAFC Doc. 1428. 102 pp. (Available at http://www.npafc.org).

Orsi, J. A., E. A. Fergusson, E. V. Farley, Jr., and R. A. Heintz. 2014. Southeast Alaska Coastal Monitoring (SECM) Survey Plan for 2014. NPAFC Doc. 1508. 17 pp. (Available at http://www.npafc.org).

Orsi, J. A. and E. A. Fergusson. 2014. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2013. (NPAFC Doc.). Auke Bay Lab., Alaska Fish. Sci. Cent., Natl. Mar. Fish., NOAA, NMFS, 17109 Point Lena Loop Road, Juneau, 99801, USA. 85 pp. (Available at http://www.npafc.org).

Orsi, J. A. and E. A. Fergusson. 2015 (draft). Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2014. NPAFC Doc. XXX. XX pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS

Orsi, J. A., E. A. Fergusson, E. M. Yasumiishi, E. V. Farley, and R. A. Heintz. 2015a. Southeast Alaska Coastal Monitoring (SCEM) survey plan for 2015. NPAFC Doc. 1556. 17 pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS. (Available at http://www.npafc.org).

Orsi, J. A., E. A. Fergusson, and A. C. Wertheimer. 2015b Forecasting Pink Salmon Harvest in Southeast Alaska Using Ecosystem Indicators from the Southeast Alaska Coastal Monitoring (SECM) Project – Ecosystems Considerations Report, submitted Aug 2015

Orsi, J. A., E. A. Fergusson, and A. C. Wertheimer. 2015c. Chinook Salmon First Year Production Indicators from Ocean Monitoring in Southeast Alaska – Ecosystems Considerations Report, submitted Aug 2015

Sturdevant, M. V., J. A. Orsi, and E. A. Fergusson. 2012. Diets and Trophic Linkages of Epipelagic Fish Predators in Coastal Southeast Alaska during a Period of Warm and Cold Climate Years, 1997–2011, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 4:1, 526-545

Turner, E. and D. B. Haidvogel. 2009. Taking ocean research results to applications: examples and lessons from US GLOBEC. Oceanography 22(4): 233-241.

Wertheimer, A. C., J. A. Orsi, E. A. Fergusson, and M. V. Sturdevant. 2014. Forecasting pink salmon harvest in Southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2013 returns and 2014 forecast. NPAFC Doc. (Available at http://www.npafc.org).

Wertheimer, A. C., J. A. Orsi, and E. A. Fergusson. 2015. Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2014 returns and 2015 forecast. NPAFC Doc. xxxx. xx pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS.

Yasumiishi, E. M., K. Shotwell, D. Hanselman, J. Orsi, and E. Fergusson. 2015. Southeast Coastal Monitoring Survey Indices and the Recruitment of Gulf of Alaska Sablefish– Ecosystems Considerations Report, submitted Aug 2015.

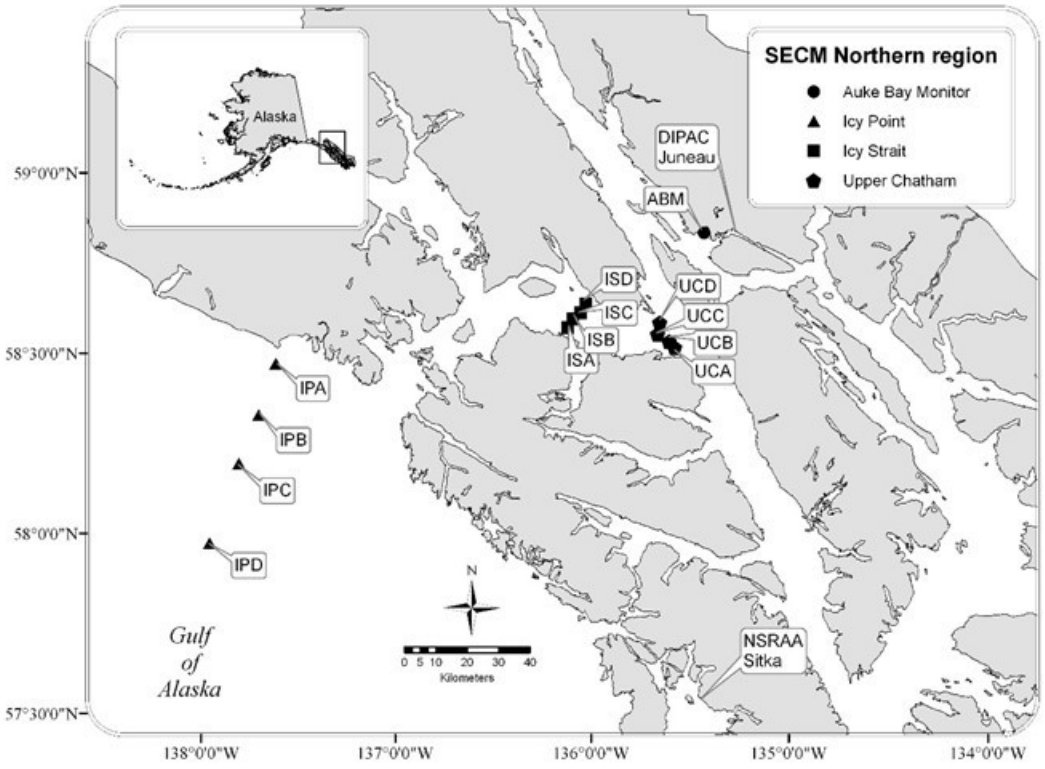

Figure 1.—Stations sampled for juvenile pink salmon and associated biophysical parameters along the Icy Strait transects in the northern region of Southeast Alaska for the development of pink salmon harvest forecast models. Stations were sampled monthly from May to August, 1997–2014. Oceanography was conducted in all months and surface trawling for juvenile salmon occurred from June to August.

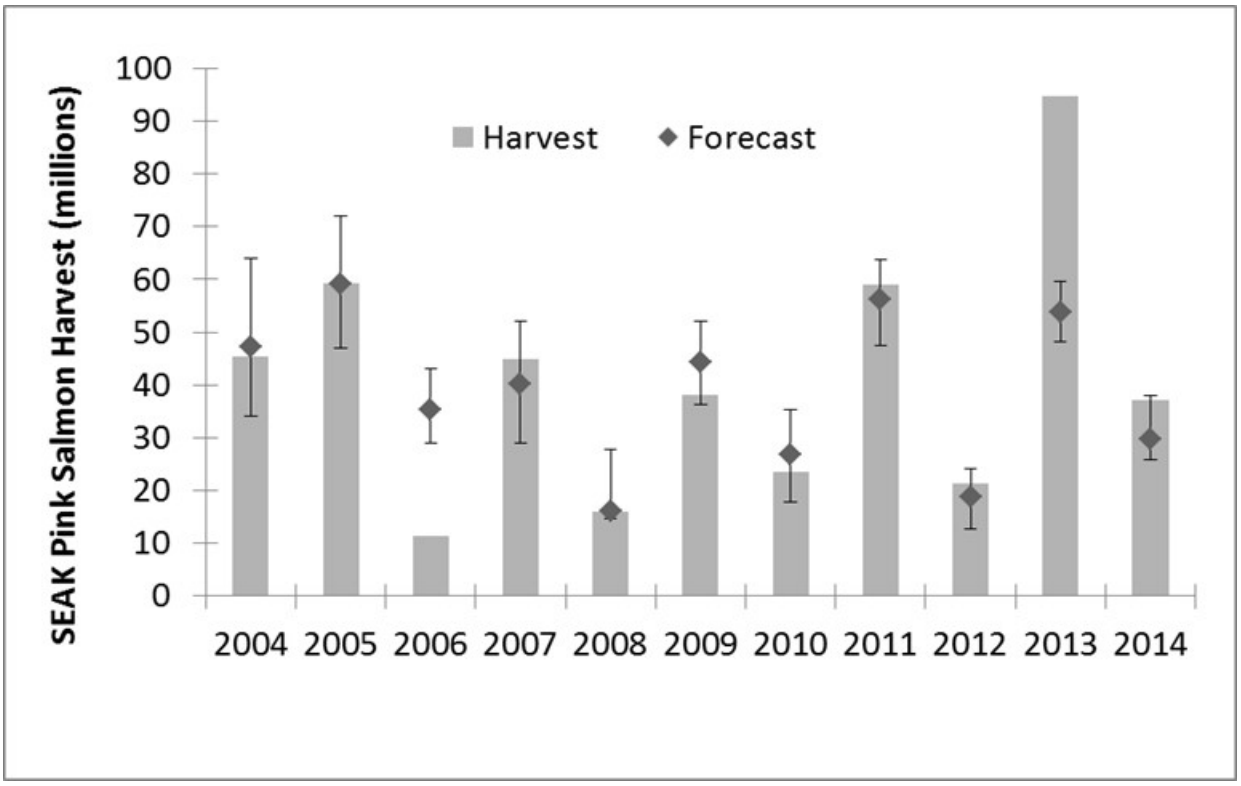

Figure 2.—Southeast Coastal Monitoring (SECM) project pink salmon harvest forecasts for Southeast Alaska (SEAK; symbols), associated 80% confidence intervals (lines), and actual SEAK pink salmon harvests (grey bars), 2004-2014.

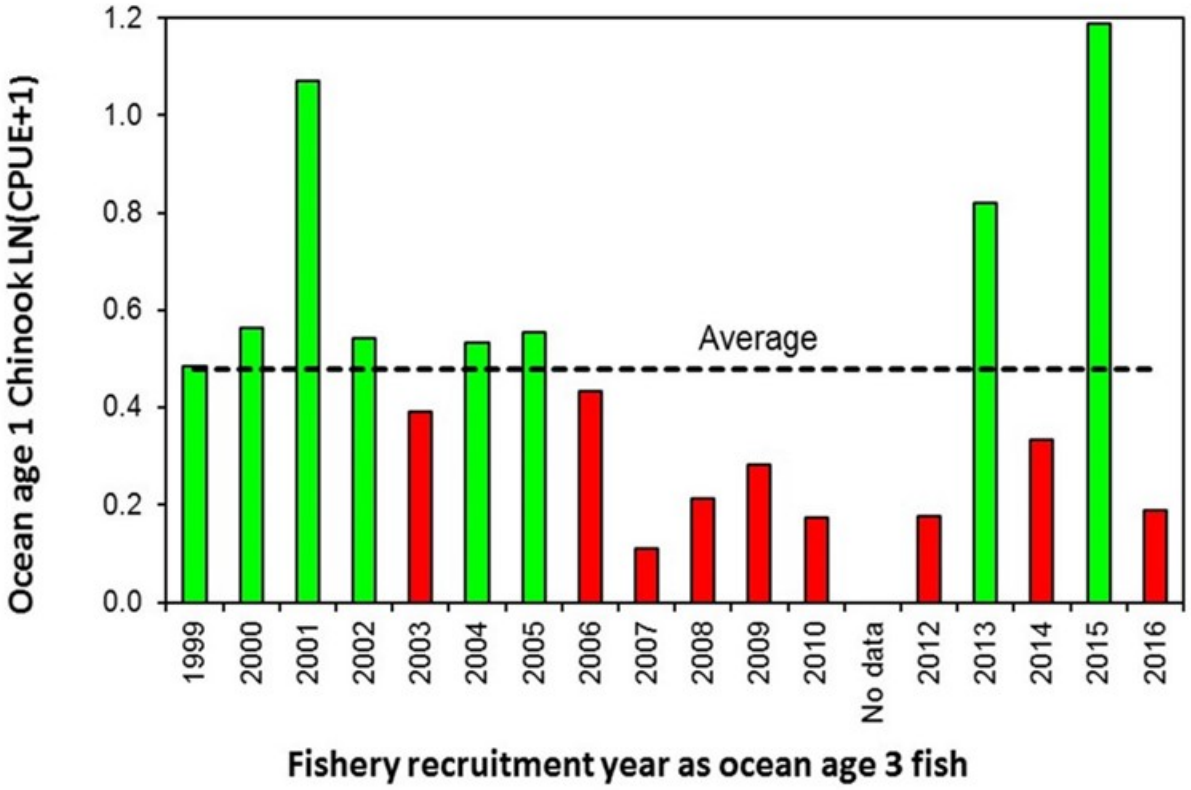

Figure 3.— The Southeast Alaska Coastal Monitoring project Chinook salmon index estimate of ocean age 1 fish sampled in Icy Strait in June, lagged two years later to potential recruitment of ocean age 3 fish, 1999-2016. No trawling was conducted in June of 2009, so the index was unavailable for 2011.

Table 1.—Numbers and types of samples collected in inshore, strait, and coastal habitats by month in the marine waters of the northern region of southeastern Alaska, May–August 2014.

			Data collection type[1]				
Dates (days)	Vessel	Habitat	Rope trawl	CTD cast	Oblique bongo	20-m Norpac	Chlorophyll & nutrients
23-24 May (2 days)	R/V *Sashin*	Inshore	0	1	1	1	1
		Strait	0	8	4	8	8
		Coastal	0	0	0	0	0
27 June - 03 July (7 days)	F/V *Northwest Explorer*	Inshore	0	1	1	0	1
		Strait	29	18	4	0	8
		Coastal	4	4	4	0	4
27 July – 02 August (7 days)	F/V *Northwest Explorer*	Inshore	0	1	1	0	1
		Strait	28	21	4	0	8
		Coastal	4	4	4	0	4
29 August-4 September (7 days)	F/V *Northwest Explorer*	Inshore	0	1	1	0	1
		Strait	28	28	4	0	8
		Coastal	4	4	4	0	4
Total			**97**	**91**	**32**	**9**	**48**

[1]Rope trawl = 20-min hauls with Nordic 264 surface trawl 18 m wide by 21 m deep; CTD casts = to 200 m or within 10 m of the bottom; oblique bongo = 60-cm diameter frame, 505- and 333-µm meshes, towed double obliquely down to and up from a depth of 200 m or within 20 m of the bottom; 20-m Norpac = 50-cm diameter frame, 243-µm conical net towed vertically from 20 m; chlorophyll and nutrients are from surface seawater samples.

Table 2.— Regression models relating juvenile pink salmon catch-per-unit-effort ($CPUE_{cal}$ and $CPUE_{ttd}$) and biophysical parameters in year *y* to adult harvest in Southeast Alaska (SEAK) in year *y* +1, for *y* = 1997-2013. R^2 = coefficient of determination for model; AIC_c = Akiake Information Criterion (corrected); *P* = statistical significance of regression equation. Adult harvest is the total SEAK harvest except Yakutat.

Model	Adjusted R^2	AIC_C	Regression *P* -value	2015 Prediction (M)
Ln($CPUE_{cal}$)	63%	143.0	<0.001	55.5
Ln($CPUE_{cal}$) + ISTI	74%	137.8	<0.001	54.5
Ln($CPUE_{ttd}$)	69%	141.1	<0.001	74.0
Ln($CPUE_{ttd}$) + May20Temp	81%	134.4	<0.001	71.5
Ecosystem Ranks	74%	137.5	<0.001	57.9

Table 3.—Project NF-2014-I-1 budget expenditures by line item, including amount projected, amount spent (including projected spending through March 31, 2016), the amount and percent variance (negative values are shown in parentheses), and a short explanation for variances greater than 10% of the projected spending.

Line item	Projected	Spent	Variance	% Variance	Comments
		Subcontractors & consultants			
Technician support, laboratory	$10,500	$11,500	$1,000	9.5%	The water sample processing was done in house by our technicians
Technician support, vessel	9,960	$9960	$0	0%	
Biometric support	$5,000	$5,000	$0	0%	
Otolith/water sample processing	$10,000	$9,000	($1,000)	10%	See note above
Total subcontractor & consultants	**$35,460**	**$35,460**	**$0**	**0%**	
		Site/project costs			
Travel	$6,000	$5,593	($407)	(7%)	
Site supplies & materials	$7,000	$7,407	$407	6%	
Work & safety gear	$500	$500	$0	0%	
Repairs & maintenance	$800	$800	$0	0%	
Total site/project costs	**$14,300**	**$14,300**	**$0**	**0%**	
Total project costs	**$49,760**	**$49,760**	**$0**	**0%**	