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
Nov. 11, 2017

Pacific Salmon Commission
Northern Fund Project NF-2016-I-1

PERIOD COVERED: May 1, 2016 to March 30, 2018
PERIOD FUNDED: May 1, 2016 to March 30, 2018
TOTAL PSC FUNDS AWARDED: $69,262
PSC FUNDS RECEIVED: $62,335

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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 type identified was: "Improved information for resource management, including stock assessment; data acquisition & scientific understanding of limiting factors," and covered the period from May 1, 2016 to March 30, 2018. 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 7 documents that cover 2016:

List of Attachments

2016

1. Orsi, J.A., A.K. Gray, W.W. Strasburger, and E.A. Fergusson. 2016. Southeast Alaska Coastal Monitoring (SCEM) survey plan for 2016. NPAFC Doc. 1641. 17 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

2. Memorandum of Understanding between NOAA & the Pacific Salmon Commission. NF-OI-1. AKC-192.

3. Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, E.V. Farley, Jr., and P.R. Mundy. 2016. Forecasting pink salmon production in Southeast Alaska using ecosystem

indicators in times of climate change. N. Pac. Anadr. Fish Comm. Bull. 6: 483–499. doi:10.23849/npafcb6/483.499.

4. Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, and E.V. Farley, Jr. 2016. Chinook salmon first-year production indicators from ocean monitoring in Southeast Alaska. N. Pac. Anadr. Fish Comm. Bull. 6: 169–179. doi:10.23849/npafcb6/169.179.

5. Fergusson E. A., J. Watson, A. Gray, and J Murphy 2017. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2016. (Draft) NPAFC Doc. xxxx. 71 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org)

6. Wertheimer, A.C., J.A. Orsi, and E.A. Fergusson. 2017. Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2016 returns and 2017 forecast. Draft NPAFC Doc. xxxx. 25 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

7. Management Analyst and Reporting System (MARS) Summary

Objectives

The SECM project objectives for NF-2016-I-1 were to: 1) conduct monthly ocean surveys in the marine waters of the northern region of SEAK; 2) provide regional stock assessment metrics for pink and Chinook salmon; and 3) contribute ecosystem monitoring reports to better understand mechanisms related to salmon production. 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 6-7 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 2016);
b. Sample epipelagic fish associated with salmon (June-August 2016);

Objective 1 was fully accomplished by sampling inshore, strait, and coastal habitats in the northern region of SEAK in 2016 (Table 1). Survey plans for the SECM sampling were developed for 2016 SECM surveys and reported in North Pacific Anadromous Fish Commission (NPAFC) documents that are attached to this final report (Orsi et al. 2016a). In 2016, 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. A draft NPAFC document of the biophysical data collections from 2016 (Fergusson et al. 2017) is attached to this final report. A total of 271 biophysical sample collections were made in 2016 (Table 1, Fergusson et al. 2017). Previous documents include syntheses of interannual catch and biophysical trends that allows the 2016 sampling year to be compared to baseline patterns of marine conditions in the time series (i.e., Orsi et al. 2012, 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 2017;
b. Provide data for statewide status of Chinook salmon stock concerns;

Objective 2 was fully accomplished for both pink salmon and Chinook salmon assessments. The pre-season harvest forecast model for pink salmon was evaluated for the actual 2016 SEAK harvest, and the preseason forecast model for pink salmon was developed for 2017 using the SECM time series of peak June-July catch-per-unit-effort (CPUE) of juvenile pink salmon and associated biophysical data collected from 1997-2016 (Table 2). The pre-season pink salmon forecast model has been prepared in a draft NPAFC Document (Wertheimer et al. 2017) 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, 2016). An oral presentation of the 2017 pre-season pink salmon harvest forecast was delivered at the Southeast Alaska Purse Seine Task Force Meeting in Sitka, Alaska in December of 2016. 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. 2016b). Data from this project are also shared with the Alaska Department of Fish and Game (ADFG) for their salmon forecasts.

Chinook salmon stock assessment information was available from the SECM trawl catches 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. 2016c). In 2016 we observed 0 CWT tagged Chinook. Caudal fin clips from all Chinook salmon were also preserved in Alcohol and provided to the ADFG 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 the annual NOAA Ecosystem Considerations Report with contributions;
b. Produce North Pacific Anadromous Fish Commission Documents;

NOAA Ecosystem Considerations Reports were completed for: 1) long-term trends in zooplankton (Fergusson and Orsi 2016); 2) pre-season pink salmon harvest forecasts (Orsi et al. 2016b), 3) Chinook salmon abundance indexes (Orsi et al. 2016c). Several

NPAFC documents were also completed to support and complement these reports such as SECM survey plan (Orsi et al. 2016a), pink salmon forecasts (Orsi et al. 2016d,Wertheimer et. al. 2016 and 2017), Chinook salmon abundance indexes (Orsi et al. 2016e), SECM annual survey reports (Fergusson et al. 2017).

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. Some of the 2016 research products are attached to this report (list of attachments on pgs. 2-3) and text references are in the references section of this report (pgs. 6-7). 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" below).

Budget Summary

The budget summary is provided by Table 3 budget sheet and attached MARS report.

Web links

NOAA 2017 SEAK pre-season pink salmon forecast presentation, Sitka, AK
https://www.afsc.noaa.gov/ABL/EMA/pdf/ORSI-2016-PSTF-Juneau-01Dec2016-FINAL.pdf

NOAA SECM project: http://www.afsc.noaa.gov/ABL/EMA/EMA_SECM.htm
(Updated Jan 2016)

NOAA pink salmon forecasting: http://www.afsc.noaa.gov/ABL/EMA/EMA_PSF.htm
(Updated 15 December 2016)

NOAA Salmon Ocean Ecology Meeting abstracts/presentations:
http://www.afsc.noaa.gov/ABL/EMA/EMA_SOEM-2016.php (Posted April 2016)

References

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., and J. Orsi 2016 – Long-term Zooplankton and Temperature Trends in Icy Strait, Southeast Alaska. In Zador, S., and Yasumiishi, E., 2016. Ecosystem Considerations 2016: Status of the Gulf of Alaska Marine Ecosystem, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501

Fergusson E. A., J. Watson, A. Gray, and J Murphy 2017. Annual survey of juvenile salmon, ecologically-related species, and biophysical factors in the marine waters of southeastern Alaska, May–August 2016. (Draft) NPAFC Doc. xxxx. 71 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org)

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. 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., A.K. Gray, W.W. Strasburger, and E.A. Fergusson. 2016a. Southeast Alaska Coastal Monitoring (SCEM) survey plan for 2016. NPAFC Doc. 1641. 17 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

Orsi, J. A., E. A. Fergusson, A. C. Wertheimer, and A. K. Gray. 2016b. Forecasting pink salmon harvest in Southeast Alaska using ecosystem indicators from the Southeast Alaska Coastal Monitoring (SECM) Project. In Zador, S., and Yasumiishi, E., 2016. Ecosystem Considerations 2016: Status of the Gulf of Alaska Marine Ecosystem, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 995011

Orsi, J. A., E. A. Fergusson, and A. C. Wertheimer, and A. K. Gray. 2016c. Chinook salmon first year production indicators from ocean monitoring in Southeast Alaska. In Zador, S., and Yasumiishi, E., 2016. Ecosystem Considerations 2016: Status of the Gulf of Alaska Marine Ecosystem, Stock Assessment and Fishery Evaluation

Report, North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, AK 99501

Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, E.V. Farley, Jr., and P.R. Mundy. 2016d. Forecasting pink salmon production in Southeast Alaska using ecosystem indicators in times of climate change. N. Pac. Anadr. Fish Comm. Bull. 6: 483–499. doi:10.23849/npafcb6/483.499.

Orsi, J.A., E.A. Fergusson, A.C. Wertheimer, and E.V. Farley, Jr. 2016e. Chinook salmon first-year production indicators from ocean monitoring in Southeast Alaska. N. Pac. Anadr. Fish Comm. Bull. 6: 169–179. doi:10.23849/ npafcb6/169.179.

Orsi, J., E. Fergusson, A. Wertheimer, E. Yasumiishi, J. Murphy, K. Cieciel, W. Strasburger, J. Moss, E. Farley, and A. Gray 2016f. The Southeast Alaska Coastal Monitoring (SECM) Project: Research milestones from nearly 20 years of ocean monitoring. Poster presentation given at the 17th annual Salmon Ocean Ecology Meeting, Juneau, Alaska. p. 52 and link: http://www.afsc.noaa.gov/ABL/EMA/pdf/0-1-SOEMPosterBinder.pdf

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. 1555. 24 pp. Auke Bay Lab., Alaska Fisheries Science Center, NOAA, NMFS. (Available at http://www.npafc.org)

Wertheimer, A. C., J. A. Orsi, and E. A. Fergusson. 2016. Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2014 returns and 2015 forecast. NPAFC Doc. 1618. 26 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

Wertheimer, A. C., J. A. Orsi, E. A. Fergusson, and A. K. Gray. 2017 (Draft). Forecasting pink salmon harvest in southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2015 returns and 2016 forecast. NPAFC Doc. xxxx. 25 pp. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center, Auke Bay Laboratories, Ted Stevens Marine Research Institute (Available at http://www.npafc.org).

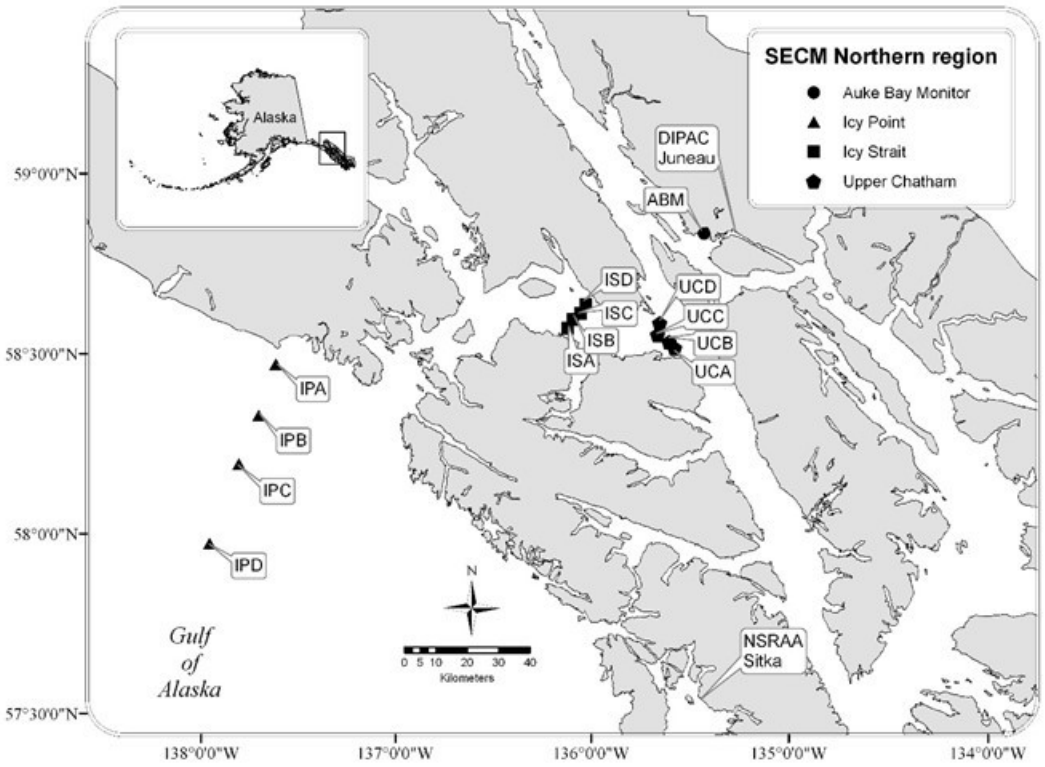

Figure 1.— Stations sampled at inshore, strait, and coastal habitats in the marine waters of the northern region of southeastern Alaska, May–August 2016 by the Southeast Coastal Monitoring project. Transect and station coordinates and station code acronyms are shown in Table 1, Oceanography was conducted in all months and surface trawling for juvenile salmon occurred from June to August.

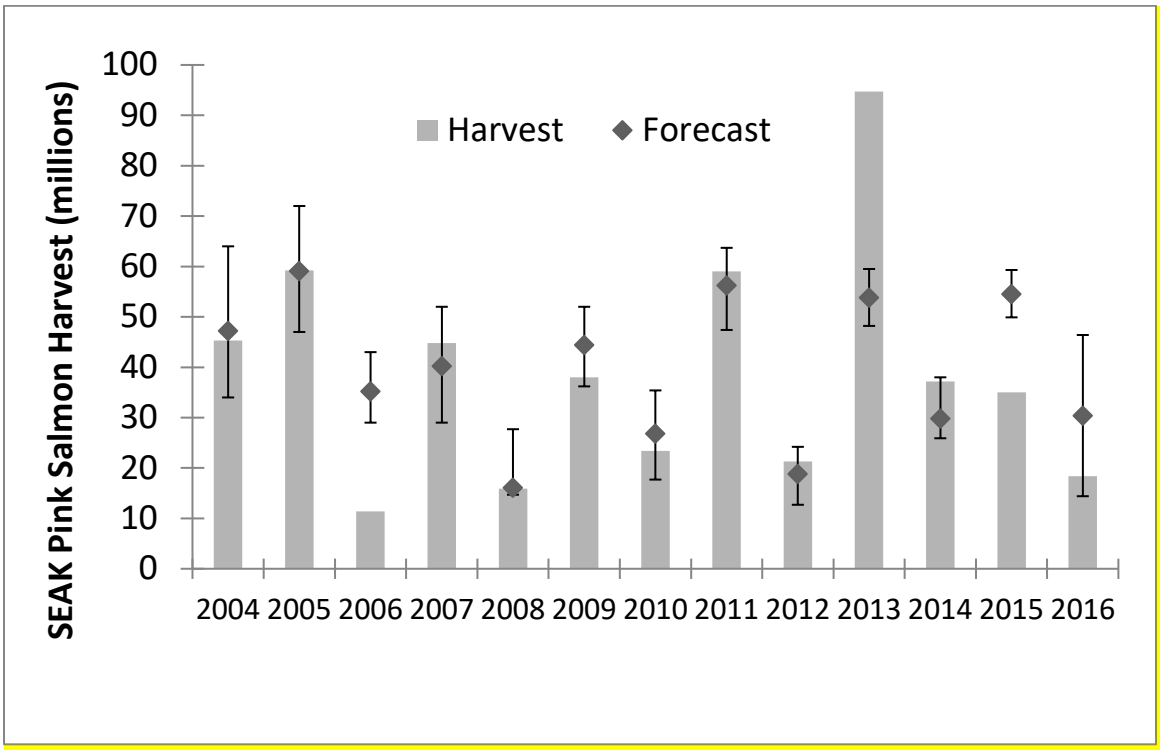

Figure 2.—Previous SECM pink salmon pre-season forecast model predictions (with 80% confidence intervals) and actual SEAK harvests over the past 12 years. Harvest data from the SEAK pink salmon fishery still incomplete for 2017, with harvest currently in the lower confidence level of the forecast estimate (ADFG 2017).

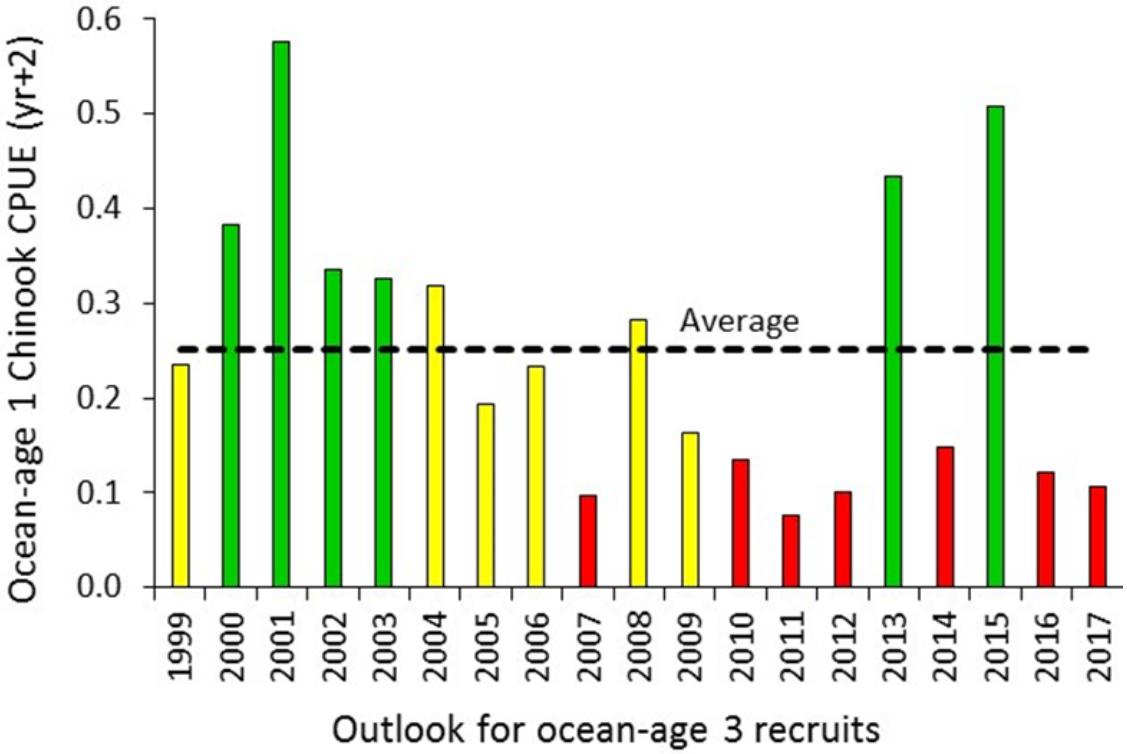

Figure 3.—Outlook for ocean-age 3 recruit Chinook salmon from the Southeast Alaska Coastal Monitoring project. Recruit index estimate based on average LN(CPUE + 1) of ocean-age 1 fish sampled in Icy Strait in June, July, and August lagged two years later to project ocean-age 3 fish, 1999-2017. No trawling was conducted in June of 2009, so the index for 2011 was only based on the July-August average.

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 2016.

			Data collection type[1]			
Dates (days)	Vessel	Habitat	Rope trawl	CTD cast	Oblique bongo	Chlorophyll & nutrients
24-25 May	R/V *Sashin*	Inshore	0	1	1	1
(2 days)		Strait	0	8	4	0
		Coastal	0	0	0	0
25 June - 01 July	F/V *Northwest*	Inshore	0	1	1	1
(7 days)	*Explorer*	Strait	21	21	4	8
		Coastal	4	4	4	4
27 July – 02 August	F/V *Northwest*	Inshore	0	1	1	1
(7 days)	*Explorer*	Strait	28	28	4	8
		Coastal	4	4	4	2
23-29 August	F/V *Northwest*	Inshore	0	1	1	1
	Explorer	Strait	28	29	4	8
(7 days)		Coastal	4	4	4	4
Total			**89**	**102**	**32**	**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 $CPUE_{cal}$) and the Ecosystem Ranks Index in year *y* to adult harvest in Southeast Alaska (SEAK) in year *y* +1, for *y* = 1997-2015. R^2 = coefficient of determination for model; AIC_c = Akiake Information Criterion (corrected); *P* = statistical significance of regression equation. Adult harvest is the total for SEAK harvest (except Yakutat).

Model	Adjusted R^2	AIC_C	Regression *P* -value	2017 Prediction (M)
Ln($CPUE_{cal}$)	59%	161.5	<0.001	61.4
Ln($CPUE_{cal}$) + ISTI	71%	156.0	<0.001	46.2
Ln($CPUE_{ttd}$)	55%	163.2	<0.001	46.6
Ln($CPUE_{ttd}$) + May20Temp	69%	158.0	<0.001	28.2
Ln($CPUE_{ttd}$) + May20Temp +Acoho	82%	149.7	<0.001	29.0
Ecosystem Ranks	66%	157.6	<0.001	68.9
Ecosystem Ranks+May20Temp	78%	150.0	<0.001	55.9

Table 3. Project NF-2016-I-1 budget expenditures by line item, including amount projected, amount spent (including projected spending through March 31, 2018), 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	$20,670	$20,670	$0	0%	
Technician support, vessel	$0	$0	$0	0%	Per accepted variance request, $ in this line item were redirected to equipment purchase (trawl gear) see below
Biometric support	$6,000	$2,500	$0	0%	
Otolith/water sample processing	$9,000	$9,000	$0	0%	
Total subcontractor & consultants	**$35,670**	**$35,670**	**$0**	**0%**	
Site/project costs					
Travel	$7,000	$7000	$0	0%	
Cruise and laboratory supplies	$4000	$4000	$0	0%	
Equipment (Trawl gear)	$19,292	$19,292	$0	0%	In the MARS report, the trawl gear purchased was mistakenly entered in with a supply and materials code and not with an equipment code as it should have been.
Work & safety gear	$500	$500	$0	0%	
CTD calibration, trawl repairs and	$2800	$2800	$0	0%	
Total site/project costs	**$33,592**	**$33,593**	**$0**	**0%**	
Total project costs	**$69,262**	**$69,262**	**$0**	**0%**	