Forecasting Southeast Alaska pink salmon harvest from juvenile salmon data: extension of models

Final Report
September 20, 2012

Pacific Salmon Commission
Northern Fund Project NF-2011-I-3

PERIOD COVERED: May 1, 2011 to February 28, 2013
PERIOD FUNDED: May 1, 2011 to February 28, 2013
TOTAL PSC FUNDS AWARDED: $49,760
PSC FUNDS RECEIVED: $44,784

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The Southeast Coastal Monitoring (SECM) project is operated by the NOAA Auke Bay Laboratories and has sampled juvenile salmon and associated biophysical parameters in the marine waters of the northern region of Southeast Alaska (SEAK) since 1997. This research is accomplished using chartered trawl vessels in years since decommissioning the NOAA Ship *John N. Cobb*. Juvenile salmon are sampled along a seaward migration corridor en route to the Gulf of Alaska after freshwater and early marine periods of high mortality. This SECM annual marine sampling provides information on juvenile year-class strength that can be used with associated biophysical data to develop forecast models that predict adult pink salmon harvest the following year. Since 2004, in seven of eight years, the accuracy of the SECM forecasts has deviated by an average of 7% from the actual harvests (range 0-17% deviation; Wertheimer 2012). However, in 2006, the pink salmon harvest was well below both the SECM forecast based on juvenile salmon abundance and the Alaska Department of Fish and Game (ADF&G) forecast based on a time series of previous pink salmon harvests. Despite this overestimate, the 2006 SECM forecast did accurately identify a downward trend in pink salmon harvest. Moreover, the ADF&G is now incorporating the SECM juvenile data into their annual harvest time series forecast.

The Northern Fund (NF) has provided support to the SECM project to continue biophysical sampling and to improve the forecast modeling. 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, 2011 to February 28, 2013. Specifically, the project addresses the persistent problems of developing reliable forecast methodologies for pink salmon fisheries, and improving knowledge of factors that limit ocean survival. This NF final report includes data summaries from the 2011 sampling season (Orsi et al. 2012) and an evaluation of the 2011 forecast and the model development for the 2012 forecast (Wertheimer et al. 2012).

Sampling in 2011 was successfully completed utilizing the ADF&G research vessel R/V *Medeia* in May and the charter trawl vessel F/V *Northwest Explorer* (*NWE*) in June, July, and August. The *NWE* was assumed to be comparable to the similarly-sized and -powered chartered vessel FV *Chellissa* that was calibrated to the R/V *Medeia*, which was previously calibrated to the NOAA ship *John N. Cobb* (Wertheimer et al. 2010). These paired comparisons permitted the computation of species-specific calibration factors which were applied to the Ln(CPUE+1) for each trawl haul of the *NWE* to convert the data into "Cobb units" directly comparable to the first 14 years of the SECM time series. These calibrated *NWE* catches were therefore reduced proportionally, resulting in large changes in nominal CPUE at high catch levels (Wertheimer et al. 2012).

The SECM project objectives for NF-2011-I-3 were to: (1) Sample juvenile salmon and associated environmental data in the marine waters of the northern region of SEAK in May, June, July, and August of 2011, and (2) Develop a forecast model to predict the SEAK pink salmon harvest in 2012. The work completed to meet these objectives is summarized below; the documents produced from the project to date are cited where appropriate and are attached as part of this final report. The references section of this report also includes professional presentations and publications of SECM research that were partially supported by this project.

Objective 1.

Sample juvenile salmon and associated environmental data in the marine waters of the northern region of Southeast Alaska in May, June, July, and August of 2011

Objective 1 was fully accomplished by sampling inshore, strait, and coastal habitats in the northern region of SEAK in 2011(Table 1). The R/V *Medeia* was used to complete oceanographic sampling in May and the *NWE* was used to complete oceanographic and fish sampling in June through August. A detailed report of sampling methods and the biophysical data collections from 2011 were presented in a North Pacific Anadromous Fish Commission (NPAFC) document (Orsi et al. 2012) attached to this final report. The NPAFC document also includes a synthesis of interannual catch and biophysical trends (1997-2011) with comparison to the current year; these comparisons allow the identification of seasonal and interannual shifts in marine conditions and address the relationship of such climate change to fisheries recruitment.

Objective 2.

Develop a forecast model to predict the Southeast Alaska pink salmon harvest in 2012

Objective 2 was fully accomplished. The 2012 forecast model was developed using the SECM time series of peak June-July catch-per-unit-effort (CPUE) of juvenile pink salmon and associated biophysical data collected from 1997-2011 (Table 2). A two-parameter model using Ln(PeakCPUE) and May20-mTemp was selected (Wertheimer et al. 2012). The forecast of 18.8 M adult pink salmon was within 7% of the actual harvest of 20.2 M (ADF&G preliminary data, September 2012). This forecast was presented at the SEAK Purse Seine Task Force (PSTF) meeting in Sitka on 07 December 2011. The 2011 forecast and the 2012 model development are summarized in a NPAFC document attached to this final report (Wertheimer et al. 2012) and will be presented at the PSTF meeting on December 6, 2012 in Juneau with forecast information for 2013 (funded under project NF-2012-I-3).

Scientific Accomplishments

Maintaining the longterm 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 among ADF&G, other NOAA Fisheries Centers, regional aquaculture associations, commercial fishing constituents, academia, and international salmon fisheries organizations such as NPAFC. 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 2011-12 publications and presentations are included in the references section of this report and can be accessed through http://www.afsc.noaa.gov/ABL/MSI/msi_secm.htm.

Budget Summary

The NF allocated a total of $49,760 for the SECM project. Of this amount, $43,782 has been spent to date; an additional $5,978 has been obligated for spending by February 28, 2013, 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 1).

Budget expenditures for the SECM project NF-2010-I-3 by line item are: amount projected, amount spent (including projected spending through February 28, 2013), amount and percent variance, and a short explanation for variances greater than 10% (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 2).

Web links

NOAA SECM website: http://www.afsc.noaa.gov/ABL/MSI/msi_secm.htm
NOAA pink salmon forecasting: http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm

References

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).

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. 2010. Calibration of juvenile salmon catches using paired comparisons between two research vessels fishing Nordic 264 surface trawls in Southeast Alaska, July 2009. NPAFC Doc. 1277. 20 pp. (Available at http://www.npafc.org).

Wertheimer, A. C., J. A. Orsi, E. A. Fergusson, and M. V. Sturdevant. 2012. Forecasting pink salmon harvest in Southeast Alaska from juvenile salmon abundance and associated biophysical parameters: 2011 returns and 2012 forecast. NPAFC Doc. 1414. 20 pp. (Available at http://www.npafc.org).

Additional SECM publications and reports in 2011 and 2012

Echave, K., M. Eagleton, E. Farley, and J. Orsi. 2012. A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-236, 104 p. (Available at http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-236.pdf).

Nishimura, G., and Sturdevant, M. 2011. Portable Winch Technology: Increased use of small and chartered vessels creates new winch requirements. Sea Technology, July 2011.

Orsi, J.A., E.A. Fergusson, M.V. Sturdevant, W.R. Heard, and E.V. Farley, Jr. 2011. Annual survey of juvenile salmon, ecologically-related species, and environmental factors in the marine waters of Southeastern Alaska, May–August 2010. NPAFC Doc. 1342. 87 pp. (Available at http://www.npafc.org).

Orsi, J., M. Sturdevant, E. Fergusson, and B. Heard. 2011. Southeast Coastal Monitoring pink salmon harvest forecast models: accurate for 2010 and predicting a strong harvest for 2011. AFSC Quarterly Research Reports Oct-Nov-Dec 2010. (Available at http://www.afsc.noaa.gov/Quarterly/ond2010/divrptsABL6.htm and http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm.)

Orsi, J., M. Sturdevant, E. Fergusson, A. Wertheimer. 2011. NOAA's "home run" pink salmon forecast materializes in 2011 and allows Southeast Alaska resource stakeholders to optimize a 58 M fish harvest valued at >$95 M USD. AFSC Quarterly Research Reports Oct-Nov-Dec 2010. (Available at: http://www.afsc.noaa.gov/Quarterly/default.htm.)

Orsi, J.A., E.A. Fergusson, and M. V. Sturdevant. 2011. Recent harvest trends of pink and chum salmon in Southeast Alaska: Can marine ecosystem indicators be used as predictive tools for management? NPAFC International Workshop on Explanations for the High Abundance of Pink and Chum salmon Future Trends. October 30-31, 2011, Nanaimo, B.C. NPAFC Tech. Rep. 8:130-134. (http://www.npafc.org/new/events/workshops/workshop2011/workshop_presentations.html).

Orsi, J., E. Fergusson, M. Sturdevant, and A. Wertheimer. 2011. Forecasting pink salmon harvest in Southeast Alaska. Pages 158-160 in: S. Zador (ed), SAFE Ecosystem Considerations for 2012. North Pacific Fishery Management Council, 255 pp. (Available at: http://access.afsc.noaa.gov/reem/ecoweb/).

Orsi, J. A., M. V. Sturdevant, E. A. Fergusson, W. R. Heard, and E. V. Farley, Jr. 2012. Southeast Alaska Coastal Monitoring (SECM) Survey Plan for 2012. NPAFC Doc. 1367. 15 pp. (Available at http://www.npafc.org).

Orsi, J., E. Fergusson, M. Sturdevant, and A. Wertheimer. 2012. In Press. Using ecosystem indicators from the Southeast Alaska Coastal Monitoring project to forecast pink salmon harvest in Southeast Alaska. S. Zador (ed), SAFE Ecosystems Considerations. North Pacific Fishery Management Council.

Sturdevant, M., E. Fergusson, and J. Orsi. 2011. Longterm zooplankton trends in Icy Strait, Southeast Alaska. Pages 140-142 in: S. Zador (ed), SAFE Ecosystems Considerations for 2012. North Pacific Fisheries Management Council 255 pp. (Available at: http://access.afsc.noaa.gov/reem/ecoweb/index.cfm).

Sturdevant, M., G. Nishimura, and J. Orsi. 2011. Sidewinder: description of a new block winch for deploying instruments at sea. Marine and Coastal Fisheries 3(1):317-323.

Sturdevant, M., J. Orsi, and E. Fergusson. 2012 In Press. Long-term zooplankton and temperature trends in Icy Strait, Southeast Alaska. in: S. Zador, editor. SAFE Ecosystem Considerations. North Pacific Fishery Management Council.

Sturdevant, M., E. Fergusson, N. Hillgruber, C. Reese, J. Orsi , R. Focht, A. Wertheimer, and W. Smoker. 2012. Lack of trophic competition among wild and hatchery juvenile chum salmon during early marine residence in Taku Inlet, Southeast Alaska. Environ. Biol. Fish. 94(1):101-116.

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 4:526-542. (Available at http://www.tandfonline.com/doi/abs/10.1080/19425120.2012.694838).

Weitkamp, L.A., J. A. Orsi, K. W. Myers, and R. C. Francis. 2011. Contrasting early marine ecology of chinook salmon and coho salmon in Southeast Alaska: Insight into factors affecting marine survival. Marine and Coastal Fisheries 3:233-249.

Wertheimer, A. C., J. A. Orsi, E. A. Fergusson, and M. V. Sturdevant. 2011. Forecasting pink salmon harvest in Southeast Alaska from juvenile salmon abundance and associated environmental parameters: 2010 returns and 2011 forecast. NPAFC Doc. 1343, 20 pp. (Available at http://www.npafc.org).

SECM presentations in 2011 and 2012

Beckman, B., J. Orsi, J. Murphy, and J. Moss. 2012. Spatial variation in juvenile chum and pink salmon marine growth: Tales from the Northeast Bering Sea to Southeast Alaska. Oral presentation at Pink and Chum Salmon Workshop, February 13-15, 2012, Juneau, Alaska. (Available at http://pinkandchum.psc.org/Abstracts.html).

Fergusson, E.A., J.A. Orsi, and M.V. Sturdevant. 2011. Southeast Coastal Monitoring (SECM) surveys to sample otolith-marked salmon stocks. Oral team presentation at ADFG Decoding the Otolith Workshop, April 19-20, 2011, Juneau, Alaska.

Fergusson, E.A., M.V. Sturdevant, and J.A. Orsi. 2011. Effects of starvation on energy density of juvenile chum salmon. 2011. Oral presentation at Alaska Marine Science Symposium Workshop: How do Marine Indicators Influence Salmon Population Dynamics? January 17-21, Anchorage, Alaska.

Fergusson, E., J. Orsi, M. Sturdevant, B. Heard, and E. Farley Jr. 2012. Annual trends in biophysical factors associated with juvenile pink and chum salmon. Poster presented at Pink and Chum Salmon Workshop, February 13-15, Juneau, Alaska and Salmon Ocean Ecology Meeting, March 20-22, Newport, Oregon.

Orsi, J.A., M.V. Sturdevant, and E.A. Fergusson. 2011. Applying marine ecosystem indicators to forecast pink salmon harvest in Southeast Alaska: the Southeast Coastal Monitoring (SECM) project 1997-2010. Oral presentation at Alaska Marine Science Symposium Workshop: How do Marine Indicators Influence Salmon Population Dynamics? January 17-21, Anchorage, Alaska.

Orsi, J., E. Fergusson, M. Sturdevant, and A. Wertheimer. 2011. NOAA's forecast for the 2012 Southeast Alaska pink salmon harvest and ecosystem monitoring trends. Oral presentation at Southeast Alaska Purse Seine Task Force Meeting, December 7, 2011, Sitka, Alaska. (Available at http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm).

Orsi, J., M. Sturdevant, E. Fergusson, and A. Wertheimer. 2011. Applying marine ecosystem indicators to forecast pink salmon harvest in Southeast Alaska: the Southeast Coastal Monitoring (SECM) project 1997-2010. Oral presentation at Salmon Ocean Ecology Meeting, March 23-24, 2011, Seattle, WA.

Orsi, J.A., M.V. Sturdevant, and E.A. Fergusson. 2011. Recent harvest trends of pink and chum salmon in Southeast Alaska: Can marine ecosystem indicators be used as predictive tools for management? NPAFC International Workshop: "Explanations on high abundance of pink and chum salmon and future trends." October 31, Nanaimo B.C. Canada.

Orsi, J., E. Fergusson, M. Sturdevant, and A. Wertheimer. 2012. Pink salmon forecasting with ecosystem metrics from the Southeast Alaska Coastal Monitoring project and implications of climate trends on regional pink productivity. (Available at http://pinkandchum.psc.org/Abstracts.html). Oral presentation at Pink and Chum Salmon Workshop, February 13-15, , Juneau, Alaska, and Salmon Ocean Ecology Meeting, March 20-22, Newport, Oregon.

Orsi, J. 2012. Southeast Alaska Chinook salmon research. Southeast Alaska Coastal Monitoring research pertinent to Chinook salmon informally presented to the ADFG as a special Chinook Salmon Task Force meeting held in Juneau during August.

Orsi, J. M. Sturdevant, E. Fergusson, A. Wertheimer, B. Heard, and E. Farley Jr. 2012. The Southeast Coastal Monitoring (SECM) project: Milestones from research at sea over the past 15 years. Poster presented Pink and Chum Salmon Workshop, February 13-15, Juneau, Alaska and Salmon Ocean Ecology Meeting, March 20-22, Newport, Oregon.

Sturdevant, M., E. Fergusson, J. Orsi, R. Brenner, and B. Heard. 2011. Salmon as predators and prey in marine waters of Alaska. Oral presentation at Alaska Marine Science Symposium Workshop, How do Marine Indicators Influence Salmon Population Dynamics? January 17-21, Anchorage, Alaska.

Sturdevant, M., E. Fergusson, J. Orsi, R. Brenner, and B. Heard. 2011. Salmon as predators and prey in marine waters of Alaska. Oral presentation at Salmon Ocean Ecology Meeting, March 23-24, Seattle, WA.

Sturdevant, M., E. Fergusson, J. Orsi, R. Brenner, and B. Heard. 2012. Salmon as predators and prey in marine waters of Alaska. Poster presented at Pink and Chum Salmon Workshop, February 13-15, Juneau, Alaska and Salmon Ocean Ecology Meeting, March 20-22, Newport, Oregon.

List of Attachments

1. Annotated Pacific Salmon Commission NF-2011-I-3 Budget Spreadsheet

2. Management Analyst and Reporting System (MARS) Summary

3. Orsi et al. 2012 - SECM 2011 sampling year summary - NPAFC Doc. 1428

4. Wertheimer et al. 2012 – SECM forecasts for 2011 & 2012 - NPAFC Doc. 1414

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 2011.

			Data collection type[1]				
Dates (days)	Vessel	Habitat	Rope trawl	CTD cast	Oblique bongo	20-m Norpac	Chlorophyll & nutrients
20-22 May (3 days)	R/V *Medeia*	Inshore	0	1	1	1	1
		Strait	0	8	4	8	8
		Coastal	0	4	4	4	4
24-29 June (6 days)	F/V *Northwest Explorer*	Inshore	0	1	1	1	1
		Strait	28	28	4	26	8
		Coastal	4	4	4	4	4
25-30 July (6 days)	F/V *Northwest Explorer*	Inshore	0	1	1	1	1
		Strait	28	25	4	25	8
		Coastal	4	4	4	4	4
28 August-2 September (6 days)	F/V *Northwest Explorer*	Inshore	0	1	1	1	1
		Strait	28	26	4	26	8
		Coastal	4	4	4	4	4
Total			**96**	**107**	**36**	**105**	**52**

[1]Rope trawl = 20-min hauls with Nordic 264 surface trawl 18 m wide by 24 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 catch per unit effort (CPUE) of pink salmon in year *y* to adult harvest in Southeast Alaska (SEAK) in year *y* +1, for *y* = 1997-2011. R^2 = coefficient of determination for model; AIC_c = Akaike Information Criterion (corrected); *P* = statistical significance of regression equation. Adult harvest is the total for SEAK harvest (except Yakutat).

Model	Harvest area	Adjusted R^2	AIC_C	Regression *P* - value	2012 Prediction (M)
Ln(PeakCPUE)	SEAK	83%	99.3	<0.001	17.7
Ln(PeakCPUE) + May20-mTemp	SEAK	89%	95.9	<0.001	18.8

Table 3.—Project NF-2011-I-3 budget expenditures by line item, including amount projected, amount spent (including projected spending through February 28, 2013), 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	$10,941	($441)	(4%)	
Technician support, vessel	$5,760	$5,760	$0	0%	
Biometric support	$9,200	$9,200	$0	0%	
Otolith/water sample processing	$10,000	$10,115	($115)	(1%)	
Total subcontractor & consultants	**$35,460**	**$36,016**	**($556)**	**(2%)**	
			Site/project costs		
Travel	$6,000	$4,863	$1,137	19%	Travel (airfare) not as expensive as originally budgeted; positive variance was applied to other line items.
Site supplies & materials	$7,000	$6,912	$88	1%	
Work & safety gear	$500	$200	$300	60%	We were able to use work and safety gear from previous year; positive variance was applied to other line items.
Repairs & maintenance	$800	$1,769	($969)	(121%)	Maintenance/shipping was included in this line item. Transferred from line item above.
Total site/project costs	**$14,300**	**$13,744**	**$556**	**4%**	
Total project costs	**$49,760**	**$49,760**	**$0**	**0%**	