Project NPRB#: B53 – Ichthyoplankton Surveys

Title: Ichthyoplankton: horizontal, vertical, and temporal distribution of larvae and juveniles of walleye pollock, Pacific cod, and arrowtooth flounder, and transport pathways between nursery areas

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Proposed Timeline with Milestones within report period

- Identification of larvae from BEST-led summer cruise
- Collect spring zoo- and ichthyoplankton on February NPCREP cruise
- Use genetic study results to describe distribution of *Atheresthes* spp.
- Consolidate data on distribution and abundance of early life stages (ELS) of target taxa
- Train biological science technician in larval identification

Project Summary

Our project component examines seasonal linkages between spring spawning areas, early summer distribution patterns, and late summer/early fall occurrences for three key fish species in the eastern Bering Sea (EBS): walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (ATF; *Atheresthes stomias*). Studies will be based on a series of cruises conducted from 2008-2010 in spring, summer and fall. We will synthesize biotic and abiotic data from these cruises to

provide a better understanding of the potential effects of hydrographic variations in rearing conditions and on transport, dispersal, and distribution of early life stages of these key marine fish species in the EBS.

We are examining the following hypotheses:

1b. Reduced frequency and intensity of summer storms will reduce surface mixing and increase sea surface temperature, thereby increasing stratification. A substantial decrease in summer winds will result in a mixed layer that is shallower than the euphotic zone, extensive subsurface primary production, and depletion of nutrients in the entire water column. There will be no fall phytoplankton bloom. A moderate decrease or no change in the intensity of summer storms will reduce replenishment of nutrients to the euphotic zone, lowering summer primary and secondary production. Both scenarios will reduce juvenile fish production by reducing their condition (energy density) and over-wintering capability.

1c. An early spring transition will lengthen the period of time of organized onshore flow along the Alaska Peninsula.

2c. Strength of frontal boundaries will weaken due to absence of the summer cold pool, allowing expansion of the inner domain and juvenile and forage fish habitat there. Weaker winds will enhance this effect.

2e. Expected decreases in benthic productivity will negatively affect feeding and survival of small flatfish and crab thereby lowering population levels.

<u>Progress summary:</u>

1. *Identification of larvae from BEST-led summer cruise (UAF):*

   The processing of the collected zooplankton samples is ongoing. As indicated in our work plan, all larval specimens of the three target taxa, walleye pollock, Pacific cod and arrowtooth flounder, will be identified, measured and the data submitted by August of 2009. To date, we have processed 35 of the total number of 43 collected MOCNESS (Multiple Opening Closing Net and Environmental Sensing System) stations on leg 1 of HLY0803. Altogether, a total of 161 samples were collected and of these, 111 samples have been sorted for ichthyoplankton. The remaining samples are currently in the process of being sorted.

2. *Collect spring zoo- and ichthyoplankton on February NPCREP cruise (NOAA)*

   A cruise was conducted aboard the NOAA ship *Oscar Dyson* in February 25 – March 4, 2009. The primary objective of the cruise was to conduct bottom trawl sampling in Bering Canyon to collect ripe adult Greenland halibut (*Reinhardtius hippoglossides*) for an unrelated, NPRB-supported project. However, sampling for the project occurred over Bering Canyon, an area of presumed *Atheresthes* spp. spawning. Accordingly, samples were examined and sorted for any *Atheresthes* spp.

ichthyoplankton for use in this BSIERP project (see *3. Genetics*). Quantitative samples from bongo tows and MOCNESS tows will be sorted in Szczecin, Poland, and abundance and vertical and horizontal distributional data on *Atheresthes* spp. eggs or larvae will be synthesized and provided to the BSIERP program. We deployed the CTD on several occasions for hydrographic sampling. Data from these efforts are part of a previously-funded NPRB project, and will be made available to the BSIERP program as well.

3. *Use genetic study results to describe distribution of Atheresthes spp. (NOAA)*

In January and February, 2009, Dan Cooper and Tracey Smart trained with Ingrid Spies to conduct the at-sea genetics identification of *Atheresthes* spp. larvae. Training and the identification of larvae collected in 2008 were successful. During the February NPCREP cruise, 7 *Atheresthes* spp. larvae were collected from the plankton. D. Cooper was able to identify 6 of these larvae to species while at sea. Five of the six larvae were Kamchatka flounder and one was Arrowtooth flounder.

4. *Consolidate retrospective data on distribution and abundance of ELS of target taxa (NOAA)*

Walleye pollock, *Atheresthes* spp. (ATH), and Pacific cod eggs, larvae, and juveniles were collected in the southeastern Bering Sea from June, 1979, through May, 2008. Cruises generally took place during February, April/May, and September. Depth-discrete sampling for ichthyoplankton occurred either once at multiple stations over a large geographic area, or multiple times at a single station over a diel cycle using a 1-m^2 MOCNESS with either 333 or 505 µm mesh nets. Positive tows with high resolution of the upper water column were used for comparisons of depth-discrete catches. Typical depth intervals used were 0-10 m, 10-20 m, 20-30 m, 30-40 m, 40-50 m, and 50 m and deeper.

To account for differences in swimming abilities, larvae were assigned to three ontogenetic categories based on larval standard lengths:

	Preflexion	**Flexion**	**Postflexion**
Walleye Pollock	4.0-9.9 mm	10.0-16.9 mm	17.0-24.9 mm
Atheresthes spp.	5.0-9.9 mm	10.0-11.9 mm	12.0-25.6 mm
Pacific Cod	4.0-9.9 mm	10.0-16.9 mm	17.0-35 mm

Walleye pollock were the most abundant species examined in this study, occurring in catches during all years of sampling and at a majority of the stations sampled. Eggs were collected as early as February and as late as September. Larvae were collected April through September and juveniles were collected only in September. Most eggs, larvae and juveniles (>24.9 mm) were collected in the upper 30 m of the water column (around the thermocline), but distribution was noted throughout the water column (Fig. 1). Eggs and larvae were collected in each depth interval examined. Juveniles were absent below 50 m.

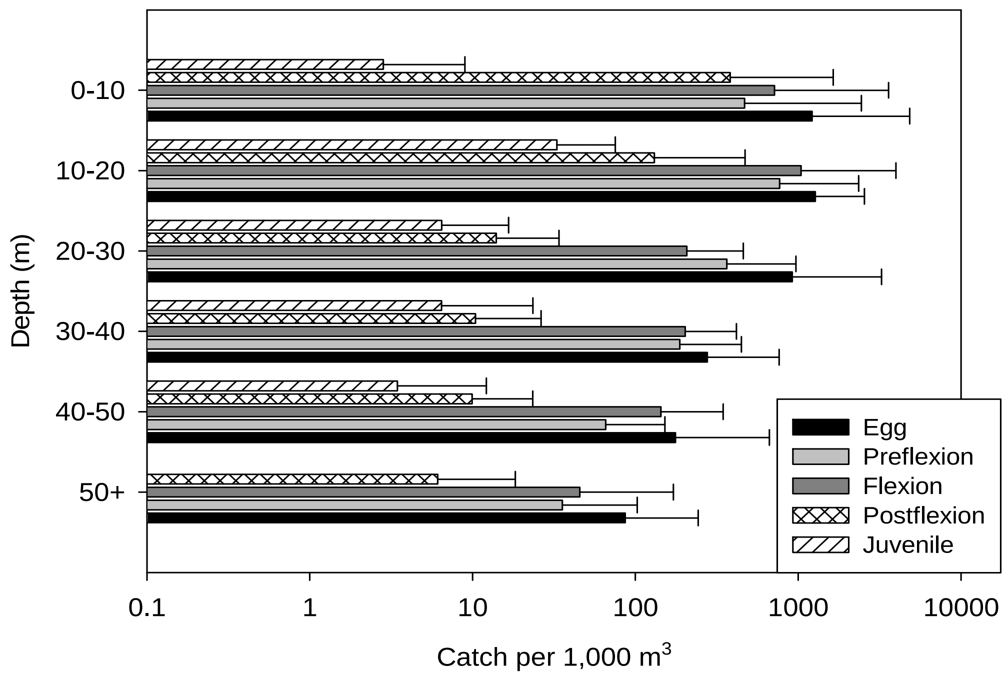
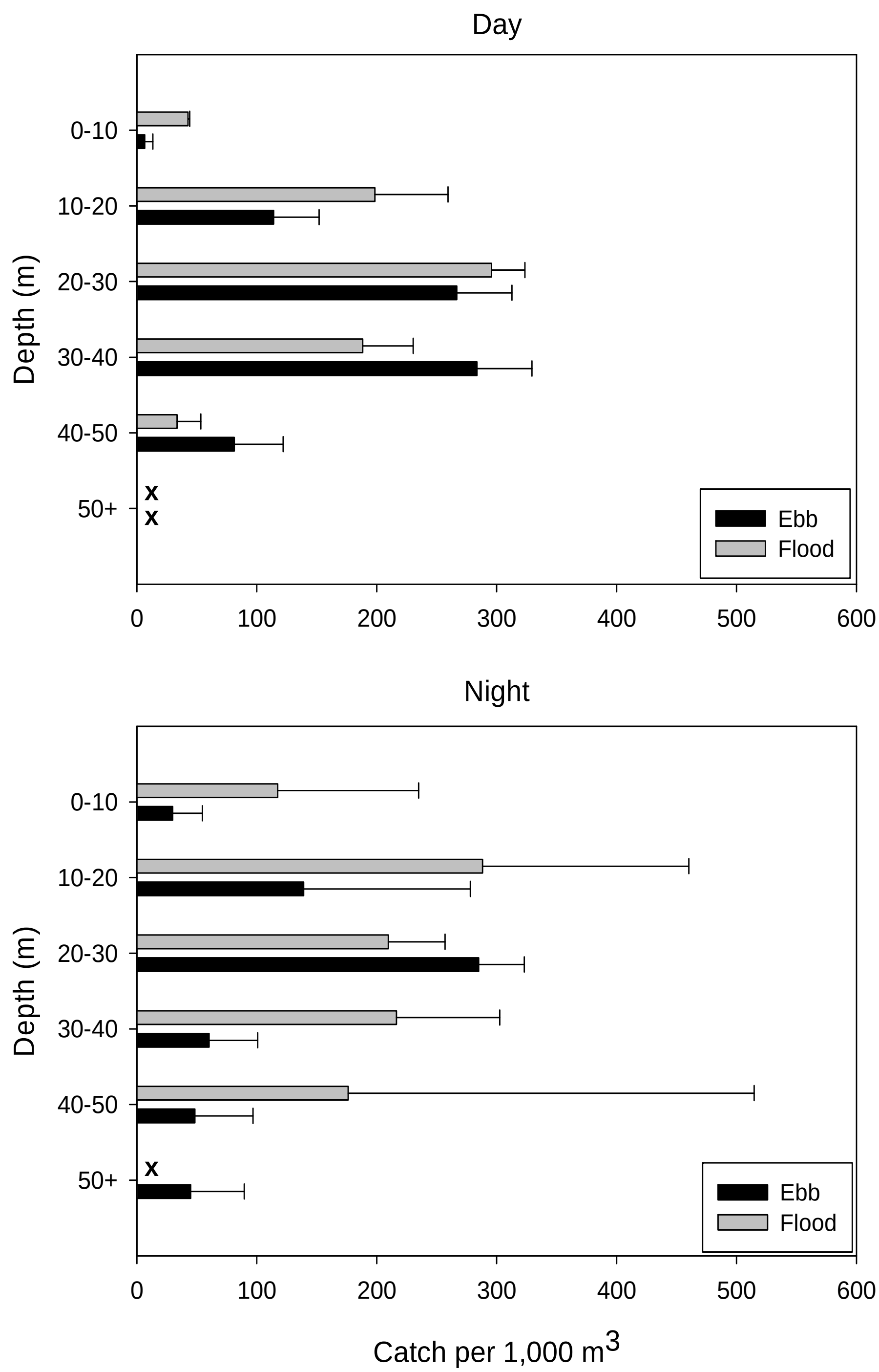


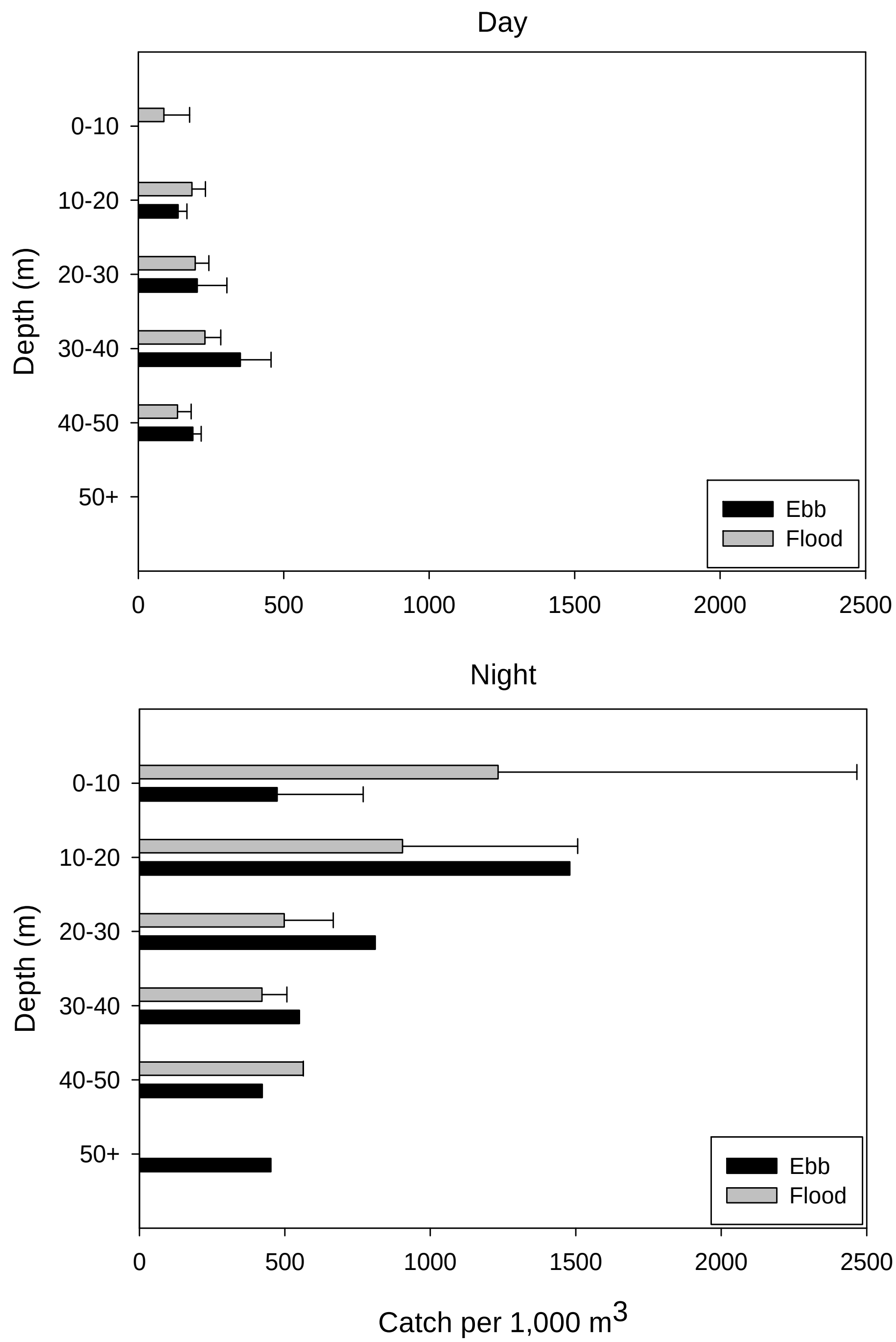
Fig. 1. Vertical distribution of walleye pollock eggs, larvae, and juveniles. Mean +SE.

A series of ANOVA's was used to examine differences in depth-discrete catch of each ontogenetic stage across diel phases, years, and tidal cycles in replicated tows collected at single stations in 2003 and 2008. Flexion and postflexion larvae were only collected during 2003. Preflexion larvae were more abundant in 2008 than 2003. Preflexion walleye pollock occurred deeper in the water column during the day than at night and were deeper during ebb tide than flood tide, but these differences were not significant (Fig. 2). Flexion and postflexion larvae were more abundant in night tows than daytime tows. Both stages appeared to descend into the water column during the day and ascend at night, however, these differences were not significant. Neither flexion nor postflexion larvae responded to tidal cycle. To remove the effect of differences in abundance between years for preflexion larvae and between times-of-day for older larvae, depth-discrete catches were converted to percent of total catch for each tow. A 3-way ANOVA with arcsine-transformed data confirmed differences among depth intervals of preflexion larvae (F=2.973; p=0.026), but not between time-of-day or tidal cycle. Even with catches corrected for differences in abundance, neither flexion nor postflexion larvae significantly responded to diel or tidal cycles. There was no clear pattern for juvenile diel migration possibly because there were few positive tows for juveniles during the diel cycle sampling and all positive tows occurred only during ebb tide.

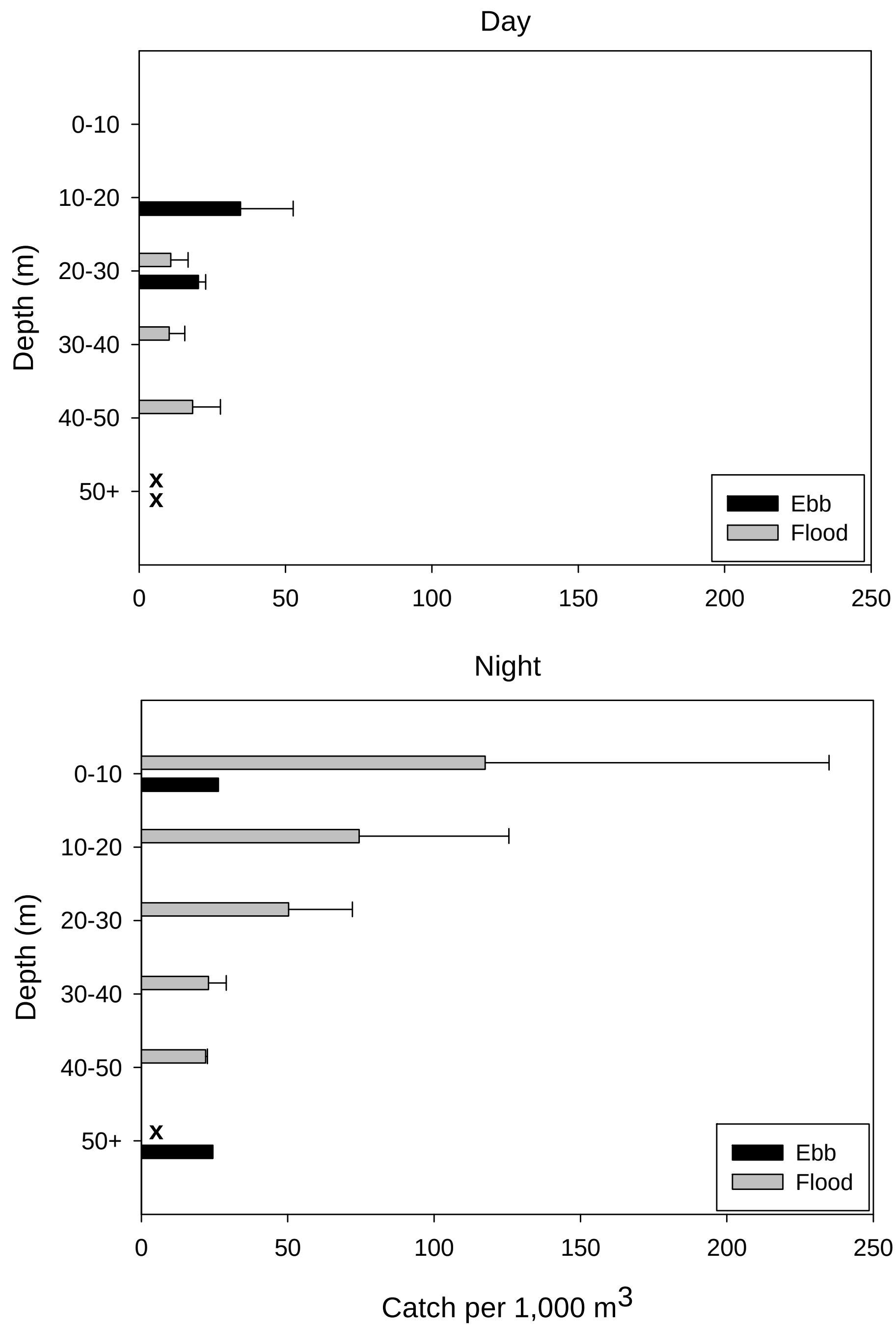
A. Preflexion Larvae



B. Flexion Larvae



C. Postflexion Larvae



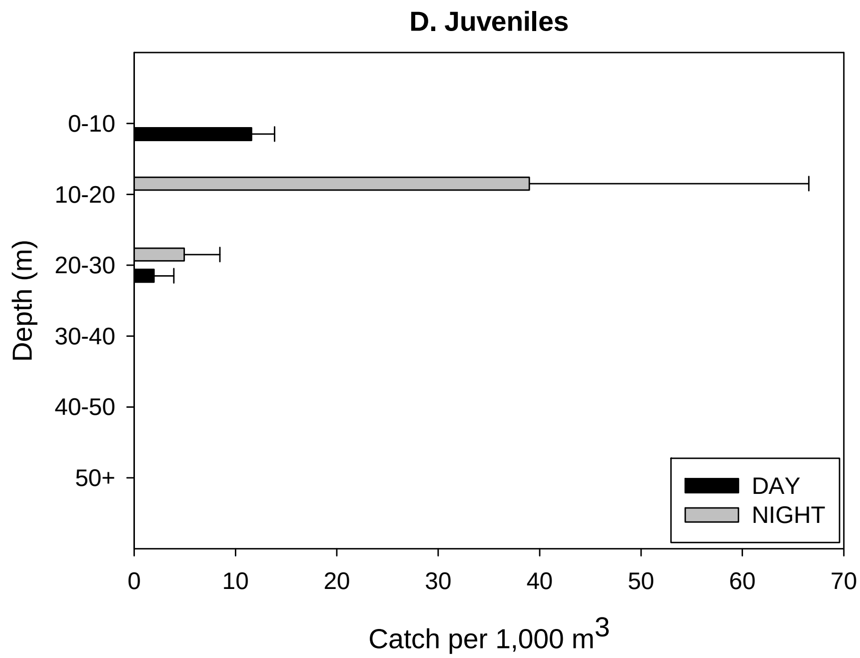


Fig. 2. Diel and tidal vertical distribution of walleye pollock preflexion (A), flexion (B), and postflexion (C) larvae and juveniles (D). X's represent categories in which no data were collected. Mean + SE.

Differences in depth-discrete abundance of walleye pollock between the two temperature regimes (warm and cold) were examined by ANOVA (Fig. 3). Years were assigned to regime based on the depth-averaged temperature from the M2 mooring in the eastern Bering Sea. Peak temperatures during warm years were above 5ºC and below 5ºC during cold years. Years were used as replicates because some years did not contain multiple positive tows. Eggs were significantly more abundant during cold regime years than warm (fourth root transformed: $F=4.648$, $p=0.039$) and more abundant in the upper 30 m of the water column than below during both regimes, though not significantly. The distribution and depth of preflexion larvae were similar between regimes, although in some cases there were more larvae during cold years than warm. Differences, however, were not significant. Differences for flexion larvae across temperature regimes were not analyzed because this stage was collected in only three years and postflexion larvae and juveniles were collected in only 2 years. These patterns will be monitored during field years 2009 and 2010, and data will be added to the analyses as they become available.

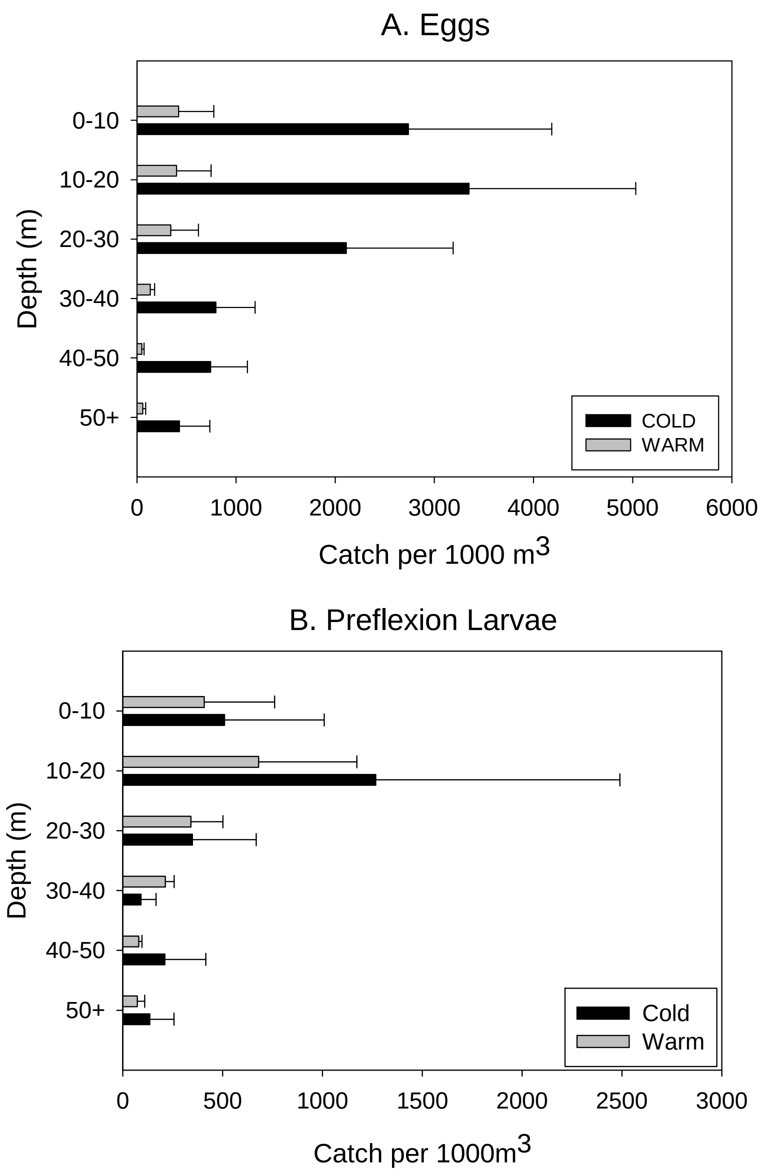


Fig. 3. Vertical distribution of walleye pollock eggs (A) and preflexion larvae (B) during cold and warm regime years. Mean + SE.

Atheresthes spp. larvae were caught in April or May of five of the years in which sampling took place (1992, 1993, 1994, 2006, 2007). No eggs or juveniles were captured in MOCNESS tows. Most ATH captured were preflexion larvae. Most preflexion larvae occurred from 10-20 m, most flexion larvae occurred from 10-30 m, and most postflexion larvae occurred from 10-50 m and were absent below 50 m (Fig. 4).

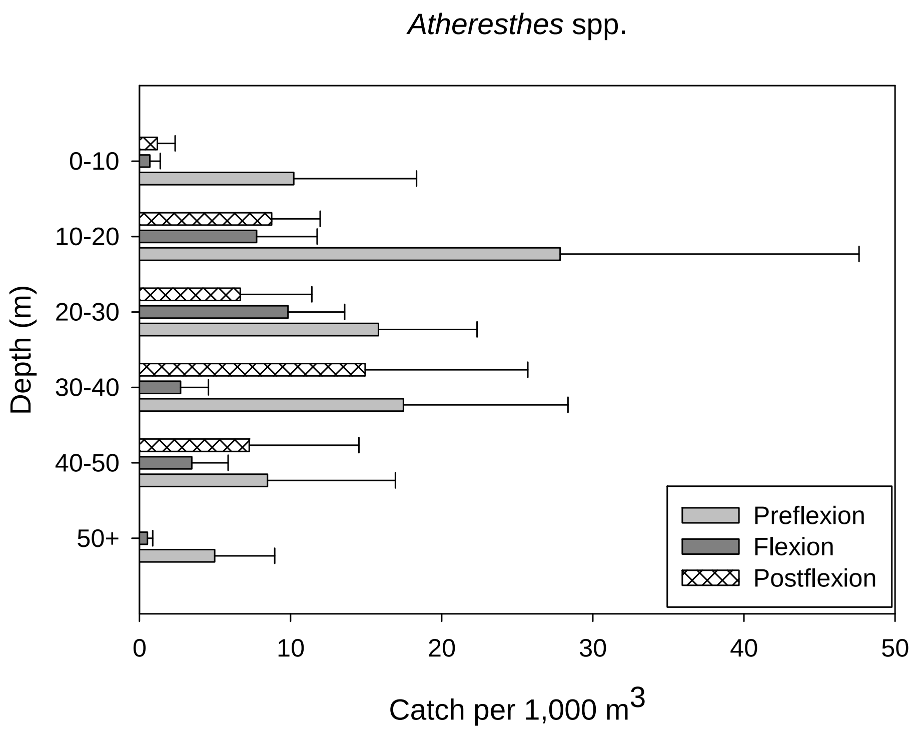


Fig. 4. Vertical distribution of *Atheresthes* spp. larvae. Mean + SE.

Pacific cod eggs and larvae were collected in very few tows, relative to the other two species. Eggs were collected in May of two years (2003 and 2005) and larvae in April through July of six years of sampling. Pacific cod eggs are primarily demersal, so it is uncommon to collect them in plankton tows. Nevertheless, available data were used in the analyses. Pacific cod eggs collected in the plankton were found mainly below 50 m, preflexion larvae were observed from 10-30 m, and flexion larvae from 10-20 m (Fig. 5). No postflexion larvae or juveniles were collected. The distribution and abundance of preflexion larvae were compared across temperature regimes (Fig. 6). Preflexion Pacific cod were typically more abundant in warm years than cold, although depth-discrete abundances were not significantly different across regimes. Preliminary observations of variations in abundance in warm and cold years will be followed up with data from field years 2009 and 2010 as they become available.

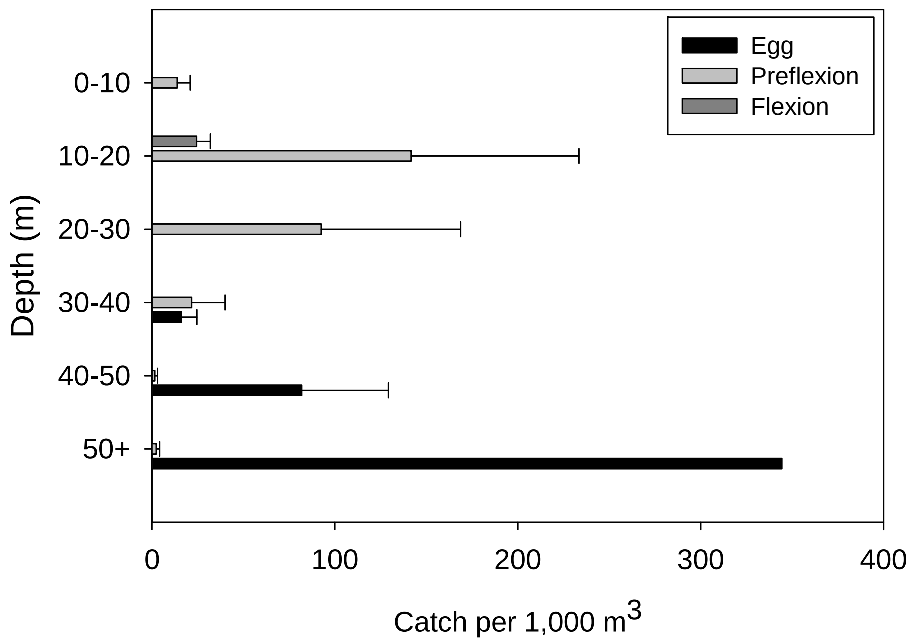


Fig. 5. Vertical distribution of Pacific cod eggs and early larvae. Mean + SE.

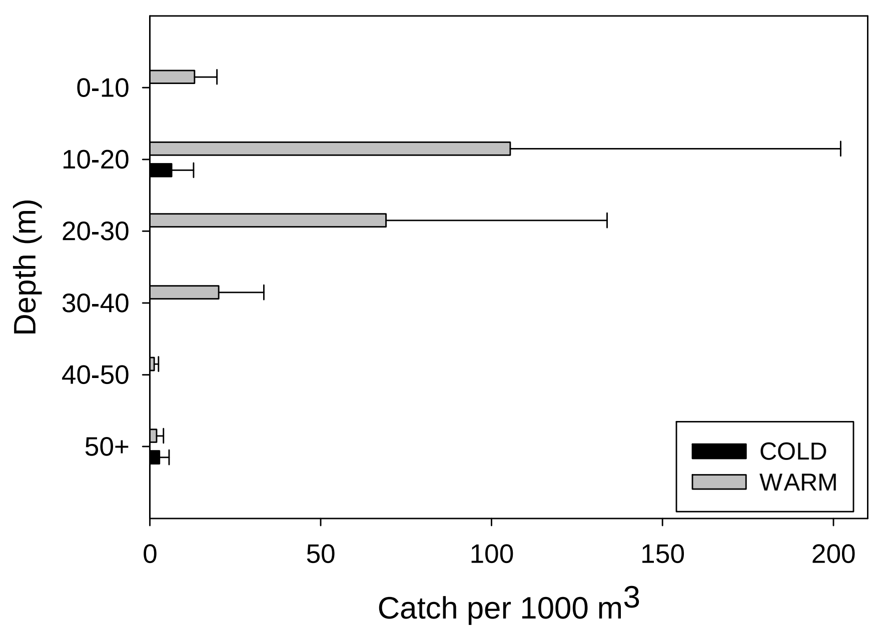


Fig. 6. Vertical distribution of Pacific cod preflexion larvae during cold and warm regime years. Mean + SE.

5. *Train biological science technician in larval identification* (NOAA)

   Lisa DeForest began work in January 2009 as a larval fish taxonomist for the BSIERP project. She has been successfully training in the identification of Bering Sea eggs, larvae, and juveniles. She completed verification of the samples from spring May 2008 so data are now available for analyses. Lisa also participated in the February 2009 cruise.

6. *Acquire supplemental funding to analyze diet of walleye pollock and Pacific cod from the BEST-led summer cruise, HLY0803 (UAF)*

   In December of 2008, a proposal was submitted to the Pollock Conservation Cooperative Research Center (PCCRC) by Dr. Hillgruber and Dr. Pinchuk (BEST) at the University of Alaska Fairbanks (UAF) to obtain funding for a MS student to examine summer feeding patterns of late larval and early juvenile walleye pollock and Pacific cod (Title: Feeding patterns, prey selection, and potential dietary overlap of age-0 pelagic juveniles of walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*) during a cold summer in the eastern Bering Sea). This proposal was subsequently funded and a graduate student (Mr. Wesley Strasburger) has been identified for the study and enrolled in the graduate fisheries program at UAF.

<u>Field Sampling in 2009</u>

Field sampling will continue in 2009 onboard the NOAA Ship *Oscar Dyson* in May and the UNOLS Ship *Knorr* in June/July. The Dyson cruise will collect MOCNESS and bongo net samples in two grids: along the Alaska Peninsula and near the Pribilof Islands. Our goals on this cruise are to collect early stages of the three species of interest and to conduct two diel cycle studies using the MOCNESS, once in each grid. Little data on the vertical distribution of these three species near the Pribilof Islands are available, and this area is likely a separate cohort/ spawning group of walleye pollock from the peninsula. The exact locations of intensive MOCNESS diel sampling will be determined at-sea based on the identification of high abundance patches of larvae using the results of bongo net samples. The R/V *Knorr* cruise will collect MOCNESS and bongo net samples along several east-west transects throughout the eastern Bering Sea. Of particular interest to this project, samples will be collected along the Alaska Peninsula and near the Pribilof Islands. Our goal on this cruise is to increase the information available for the later stages of each species. Stations in both cruises were selected based on their proximity to centers of distribution for the three species of interest and efforts were made in achieving a better match of sampling locations in May and in June/July.

<u>Integration activities</u>

This project was integrated with several other components during the year. Collaborations were made with Heintz (NPRB # B54) to collect and analyze early life stages of walleye pollock, Pacific cod, and *Atheresthes* spp. from all cruises for elucidating seasonal patterns of condition. Collaborations between Pinchuk (BEST) and Hillgruber have been initiated during the summer sampling in 2008 and will continue for the next two years of field work. In addition, Pinchuk and Hillgruber submitted a proposal together to the PCCRC at UAF to obtain funding for a MS student studying feeding patterns of summer collected late larvae and early juveniles of walleye pollock and Pacific cod. Collaborations with Ciannelli and Bailey (NPRB # B60) are ongoing, and discussions and data sharing with the postdoctoral researcher on that project continue. At least one representative of the project was present at all PI meetings. Discussions with P. Stabeno, N. Kachel, N. Hillgruber, and J. Duffy-Anderson have been aimed at improving the station overlap between the upcoming NPCREP spring cruise and the BEST-led summer cruise.

Outreach

Hillgruber, N., Duffy-Anderson, J.T., Eisner, L., Heintz, R., Matarese, A., Napp, J., and Siddon, E. Distribution, transport, and condition of early life stages of walleye pollock, Pacific cod, and arrowtooth flounder in the eastern Bering Sea under the auspice of changing climatic conditions. Contributed poster. Kiel, Germany. August, 2008.

2009 Tasks, Assignments, Timeline

BSIERP B53, Ichthyoplankton: horizontal, vertical, and temporal distribution of larvae and juveniles of walleye pollock, Pacific cod, and arrowtooth flounder, and transport pathways between nursery areas, Nicola Hillgruber et al.

What	*Who*	*Start*	*Other key dates*
Collect spring zoo- and ichthyoplankton on annual NPCREP cruise	**Duffy-Anderson, Smart**	May 2009	Surveys in May of 2008-10
Collect *Atheresthes* spp. for genetic identification of *A. stomias* and *A. evermanni*	**Duffy-Anderson, Smart, Spies**	May 2009	Surveys in May of 2008-10
Collect summer ichthyoplankton and juvenile fish during BEST cruise	**Hillgruber, Siddon, Heintz, Eisner, Smart**	July 2009	Summer BEST surveys in June/July in 2008-10
Collect samples of larval/juvenile fish for energy density	**Heintz**	May 2009	Surveys in spring, summer, fall 2008-10
Coordinate with MACE cruise for sampling of ELS of target taxa	**Hillgruber, Heintz, Wilson,**	Spring 2008	Surveys in July 2008-2010
Coordinate with BASIS cruise for obtaining distributional data and energetic samples of ELS of walleye pollock and Pacific cod	**Farley, Hillgruber, Heintz, Duffy-Anderson**	Spring 2008	Surveys in September 2008-2010
Identification of larvae from BEST-led summer cruises	**PhD, Hillgruber**	2008-2011	Complete ID work: August 2009-2011
Use genetic study results to describe distribution of *Atheresthes* spp.	**Matarese, Duffy-Anderson**	2008-2011	
Consolidate data on distribution and abundance of ELS of target taxa	**Duffy-Anderson, Smart, Hillgruber, Siddon**	2009-2011	
Larval fish distributional data delivery to data managers	**Duffy-Anderson, Smart, Hillgruber, Siddon**	2009	Data will be delivered 1.5 years after each field sampling
Train biological science technician in larval identification	**Matarese**	December 2008	
Identification of larvae from NPCREP-led spring cruises	**Matarese**	2009-2011	