Monitoring the Juvenile Pink Salmon Food Supply and Predators in Prince William Sound

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The survival of juvenile pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound (PWS) is a function of the availability of large calanoid copepods (genus *Neocalanus*) and the abundance of predators, especially walleye pollock (*Theragra chalcogramma*) and Pacific herring (*Clupea pallasi*) (Willette et al. 1999a,b). The Prince William Sound Science Center, with support from the Oil Spill Recovery Institute (OSRI), in cooperation with the Alaska Department of Fish and Game and the Ship Escort/Response Vessel System (SERVS), initiated a program in FY00 to begin monitoring spring predator and prey densities along the primary pink salmon out-migration path.

We collected volume backscatter measurements during three cruises in May 2000, using a three-frequency acoustic system (38 kHz, 120 kHz and 420 kHz) along a systematic line-transect survey. The survey design consisted of twelve transects extending along the main basin of PWS from Bligh Island to the Hinchinbrook Entrance and twelve more transects along the primary pink salmon out-migration corridor west and north of Knight Island, extending to Perry Island. This design was based on several criteria: (1) coverage of the historic area of juvenile pink salmon out-migration and hatchery locations, (2) contrast between the western out-migration route and the eastern side or main basin of Prince William Sound, and (3) an area that could be covered within a two-day survey. Transects were designed to be able to contrast near-shore and offshore areas as well as north/south trends. Periodic station data provided zooplankton composition and salinity/temperature profiles. The zooplankton sampling was a 50-m vertical tow using a 0.335-mm 0.5 m-ring net, following procedures of Cooney et al. (1995). Temperature and salinity data were acquired using a SeaBird Electronics Model 19.03 CTD. The three survey dates were May 3–4, May 12–13, and May 22–26.

The acoustic data were analyzed using standard echo integration techniques (Thorne 1983a,b). The plankton samples were analyzed to determine both size and frequency of the major components following procedures outlined in Kirsch et al. (2000). Acoustic backscattering cross-sections for the various zooplankton components were used to estimate abundance. Most values for the acoustic backscattering cross-sections were obtained from previous observations and scattering models (Stanton et al. 1994, 1996; Wiebe et al. 1997; Kirsch et al. 2000; G.B. Steinhart, 1558 Stanford Rd, Columbus, OH 43212, personal communication). Values for the remaining were estimated by forward problem analysis (Holliday and Pieper 1980; Wiebe et al. 1997). Fish densities were estimated from the 120-kHz data. The fish component to the scattering was estimated by thresholding the acoustic returns at –40 dB (G.B. Steinhart, 1558 Stanford Rd, Columbus, OH 43212, personal communication). A generalized acoustic cross-section equivalent to –32 dB/kg was used to estimate fish biomass from the thresholded returns (Thorne 1983b).

The ratios of volume backscatter from the upper 50 m among the three frequencies were sensitive to the relative components observed in the plankton net samples (Tables 1–2). Overall, the large bodied copepods, primarily *Neocalanus*, were the dominant zooplankton by weight, 73% in Knight Island/Perry Passage and 58% in the main basin. These copepods also dominated the 420 kHz backscatter, 80% in Knight Island/Perry Passage and 64% in the main basin (Fig. 1), were a major factor in the scattering at 120 kHz, and were detectable even at 38 kHz. At the beginning of May, the biomass of large copepods was high in the southern portion of Knight Island Passage (between Knight Island and Chenega Island), and was lower in the northern

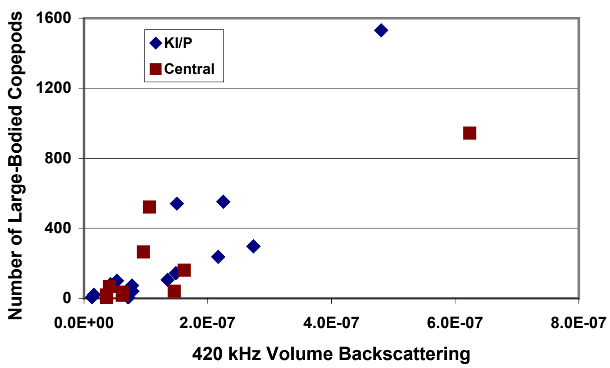
Table 1. Characteristics of plankton net samples in Knight Island (KI)/Perry Passage (P), and the main basin of Prince William Sound (Main).

	% Biomass Composition					Length (mm)		
Location	Small copepods	Large copepods	Oikopleura	Pteropod	Other	Large Copepod	Pteropod	Euphausid
KI/P	19.8	73.2	4.5	0.1	2.5			
Main	35.6	58.4	1.0	0.7	4.2			
Average	27.8	65.8	2.6	0.3	3.5	3.80	1.48	3.26

Table 2. Scattering characteristics of various components in plankton net samples.

	Volume Backscattering		Target Strength (dB)			
Frequency	KI/P	Main	Large Copepods	Small Copepods	Pteropods	Oikopleura
420	1.4E-07	1.4E-07	-97	-113	-95	-107
120	2.5E-07	1.3E-07	-98	-120	-95	-94
38	1.7E-07	6.0E-08	-102	-150	-115	-95

Fig. 1. Relation between 420 kHz volume backscattering and plankton net catches of large copepods in Knight Island Passage and the main (central) basin of Prince William Sound, May 2000.



portion (Perry Passage). As the month progressed, the biomass increased and the distribution shifted north (Fig. 2). During the first half of May, lower abundance was consistently found along the western edge of Knight Island Passage, and was associated with a surface lens of less saline water (Fig. 3). As the peak in abundance moved north, the distribution shifted slightly toward the center of the passage, but still remained low along the western edge. Fish abundance in Knight Island/Perry Passage was much lower than in the central basin at the beginning of May (Fig. 4). The fish abundance in Knight Island/Perry Passage increased at the end of May, while that in the central basin decreased.

The dominance by large copepods simplified the estimation of the various zooplankton components. This result was expected from previous observations (Kirsch et al. 2000), and was one of the reasons for the timing of the study. In addition to the simple composition, backscattering coefficients from the major components are all well documented for 420 kHz (Kirsch et al. 2000), and reasonably well documented for 120 kHz (Steinhart et al. unpublished ms). The differences between the Knight Island/Perry Passage and the main basin provided power to a forward problem analysis to estimate the backscattering cross-section of the other components at 120 and 38 kHz.

Fig. 2. Changes in large copepod abundance and distribution in Knight Island/Perry Passage during May 2000 estimated from 120 kHz.

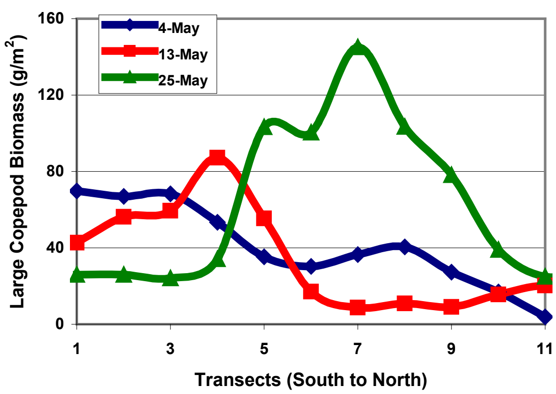
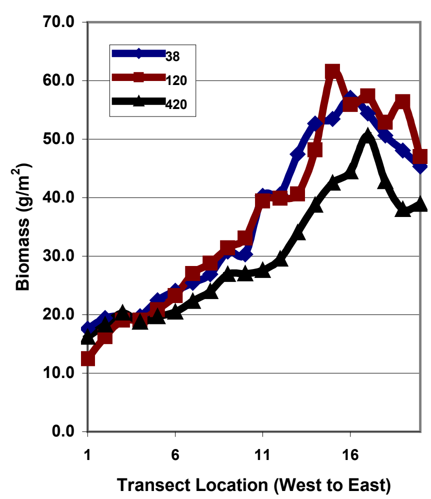
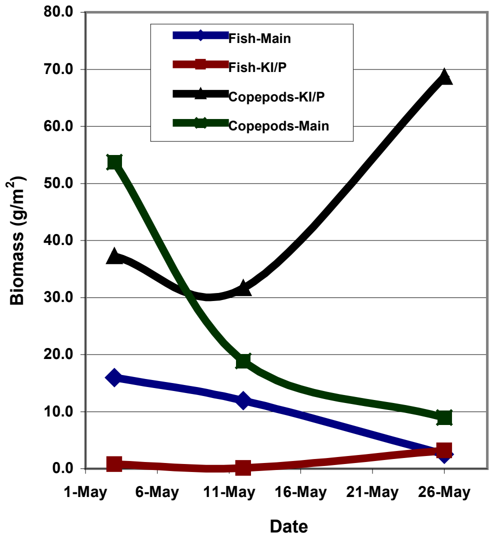


Fig. 3. West to east distribution of large copepod biomass in Knight Island/Perry Passage during the first half of May 2000, estimated from each of three frequencies.



Densities along the west side of the passages were low throughout the month. This observation may have implications for the juvenile salmon, since most hatchery release areas are along the west side. The low abundance of zooplankton along the west side was associated with a lens of less saline water from freshwater run-off. Willette et al. (1999a,b) hypothesized that juvenile salmon survival was improved when multiple storm events occurred in Prince William Sound during spring. The reason for the improved survival was speculated to be the prolonged spring zooplankton bloom that results from storm events. However, our detailed information on the zooplankton distribution suggests an alternative hypothesis, namely,

Fig. 4. Changes in biomass of large copepods and fish in Knight Island/Perry Passage and the main basin of Prince William Sound during May 2000.



that lack of storm events allows a salinity gradient to be established on the west side. The salinity gradient could either directly depress zooplankton abundance or alter the current regime so that zooplankton are advected to the eastern side. May 2000 was characterized by unusually calm conditions.

While the zooplankton distributions appear to be unfavorable for juvenile salmon growth, the lack of predators in Knight Island/Perry Passage would seem to favor juvenile salmon survival. This study is the first detailed monitoring of fish abundance during this time period, but previous studies suggest higher fish densities (Steinhart et al. unpublished ms). One predator, herring, is at historic lows (Thorne 2000), while the pollock remained primarily in the central basin until the end of the month. Future monitoring of this type should allow estimation of the relative importance of food supply and predator abundance on the juvenile salmon survival.

The goal of the OSRI zooplankton-monitoring program is to develop and apply a cost effective approach to estimation of pink salmon food supply and predator abundance. The observations from this study provide a valuable initial data framework to examine juvenile salmon survival. An understanding of the complex environmental conditions that govern juvenile salmon survival will only be obtained by long-term acquisition of this type of information. The results of this study demonstrate that the three-frequency acoustic system, supported by plankton net samples and CTD measurements, can provide a viable methodology, combining high quantification with the extremely high sampling power that is required to obtain sufficient detail in a reasonable time and cost framework.

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