

**Comparisons of the Size of Juvenile Pink and Chum Salmon
Caught during Surface Rope and Pair Trawling
in the Marine Waters of Southeastern Alaska, June 2004**

by

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Abstract

The standard sampling gear used in the Southeast Alaska Coastal Monitoring Project (SECM) for juvenile salmon (*Oncorhynchus* spp.) is a 264 Nordic rope trawl (24 m wide × 20 m deep) fished with the headrope at the surface of the water column. To determine if this gear selectively catches larger juvenile salmon in early summer, a comparison of the average sizes and size frequency distributions of juvenile pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*) caught with the rope trawl were made to those of fish caught with a Kodiak pair trawl (6 m wide × 3 m deep). The Nordic rope trawl has larger cod-end mesh and is fished faster, deeper, and for a longer duration than the pair trawl; the Kodiak pair trawl is often fished in nearshore waters and catches juvenile salmon as small as 31 mm fork length (FL). Both trawl types were fished in Icy Strait, Alaska from 25 to 28 June of 2004, at neritic stations routinely sampled in the SECM project. Average sizes of both pink and chum salmon juveniles were smaller from the rope trawl (101.0 mm FL and 107.0 mm FL) than those from the pair trawl (105.6 mm FL and 112.4 mm FL), indicating that the rope trawl catch was not biased towards larger fish. Frequency distributions of the catch also indicated that the rope trawl was not missing smaller juvenile salmon in the habitat sampled. These results support the assumption that juvenile salmon caught by rope trawl in neritic habitats are representative of the actual size distribution present.

Introduction

Studies on the early ocean ecology of Pacific salmon (*Oncorhynchus* spp.) require suitable capture methodology to adequately assess size, abundance, and growth of these species. To sample offshore epipelagic habitat off southeastern Alaska, researchers have recently added trawling as a sampling tool to collect juvenile salmon once they leave estuarine habitat and disperse into the marine environment (Orsi et al. 1997; Murphy et al. 1999). The sizes of fish captured in research projects such as the Southeast Alaska Coastal Monitoring project (SECM) are generally assumed to be representative of the juvenile salmon utilizing the habitat sampled, and are used to make inferences about growth in these habitats (Orsi et al. 2000). Size selectivity of targeted species by sampling gear may result from the inability of the gear to capture either smaller or larger individuals from the population, and thus result in biased estimates of average size and apparent growth rates. It is therefore prudent to evaluate the size range and length frequency of target species, particularly in open water sampling where both horizontal and vertical avoidance of sampling gear by epipelagic fish, such as salmon, is possible. To examine the possibility that the standard SECM rope trawl (Nordic¹ 264) was size-selective and under-

¹ Reference to trade names does not imply endorsement by the Auke Bay Laboratory, National Marine Fisheries Service, NOAA Fisheries.

sampled small juvenile salmon, we sampled juvenile pink and chum salmon using both the rope trawl and another surface trawl, a Kodiak pair trawl, at approximately the same time and same sampling area. The Kodiak pair trawl is smaller and has smaller mesh in the cod-end, and is effective at capturing small salmon early in their marine life-history (Gosho 1977; Mortensen and Wertheimer 1988). This study compares the size of juvenile pink (*O. gorbuscha*) and chum salmon (*O. keta*) caught by the Nordic 264 rope trawl to the size of these species caught by the Kodiak pair trawl during synoptic sampling in the marine waters of southeastern Alaska in June of 2004.

Methods

Trawl specifications

The two surface trawl types used in this comparison, the Nordic 264 rope trawl and the Kodiak pair trawl, have been fished extensively in the marine waters of Alaska (Gosho 1977; Mortensen and Wertheimer 1988; Orsi et al. 1997; Murphy et al. 1999; Mortensen et al. 2000). In this comparison, both trawls were fished from the NOAA ship *John N. Cobb*, a 29-m long research vessel, with a main engine of 325 hp and a cruising speed of 10 knots. The Nordic rope trawl has larger cod-end mesh and is fished faster, deeper, and for a longer duration than the pair trawl (Table 1). Both trawls are fished with the headrope on the surface and floats on the wingtips. The Nordic rope trawl was fished directly astern the research vessel and was spread open with trawl doors, whereas the Kodiak pair trawl was fished between two vessels and was spread open horizontally by the vessels and held open vertically by rigid pipes. The Nordic rope trawl can be fished in seas to about 3 m while the Kodiak pair trawl can only be fished in seas to about 1 m. The Nordic rope trawl can be safely fished over bottom depths greater than 50 m, while the Kodiak pair trawl can be fished over depths as shallow as 10 m. Routine sampling periods typically differ by each trawl type. The Nordic rope trawl is usually fished during daylight hours to minimize undesired bycatch of vertically migrating planktivores fishes that are highly abundant at night. Conversely, the Kodiak pair trawl typically is fished during night, when net avoidance of this gear by juvenile salmon is less (Gosho 1977). Fishing speed and trawl duration also differed by trawl type, with the Nordic rope trawl fished at 1.5 m/sec for 20 min and the Kodiak pair trawl fished at 1.0 m/sec for 10 min. These differing speeds and duration of trawl times by gear type are tailored to clogging of gelatinous material, the horsepower of the vessel(s), and the perceived amount of time needed for fish to filter down into the cod end of the net.

The Nordic rope trawl was 184 m long and had a mouth opening (depth by width) of 24 m by 30 m (Table 1). A pair of 3-m foam-filled Lite trawl doors, each weighing 544 kg (91 kg submerged), was used to spread the trawl open. Earlier gear trials with this vessel and trawl indicated the actual fishing dimensions of the trawl are 18 m vertical (head rope to foot rope) and 24 m horizontal (wingtip to wingtip), with a spread between the trawl doors ranging from 52 m to 60 m (Orsi et al., unpubl. cruise report 1996). Trawl mesh sizes from the jib lines aft to the cod end were 162.6 cm, 81.3 cm, 40.6 cm, 20.3 cm, 12.7 cm, and 10.1 cm over the 129.6-m meshed length of the rope trawl. A 6.1-m long, 0.8-cm knotless liner was sewn into the cod end. The trawl also contained a small mesh panel of 10.2-cm mesh sewn along the jib lines on the top panel of the trawl between the head rope and the 162.6-cm mesh to reduce loss of small fish. To keep the trawl headrope at the surface, a cluster of three A-4 Polyform buoys, each encased in a

knotted mesh bag, was tethered to each wingtip of the headrope, and one A-3 Polyform float was inserted into a mesh pocket on a kite at the center of the headrope. The trawl was fished with 137 m of 1.6-cm wire main warp attached to each door, and two 55-m (one 1.0-cm and one 1.3-cm) wire bridles from each door to the wings of the net. Each trawl haul was fished across a station, and current, swell, and wind conditions dictated the direction in which the trawl was set. Deployment, fishing, and retrieval time for each 20-min haul was about 45 min.

The Kodiak pair trawl was 15 m long and had a mouth opening (depth by width) of 6 m by 3 m (Table 1). The trawl was spread open by the use of an additional 7.3 m towing vessel, the RV *QUEST*, powered with twin 115-hp outboards. The towing vessel was equipped with a stanchion post positioned just forward of the transom. Aft of the stanchion, a quick-release device (“Canadian release”) was suspended with an attached ring and connected to a tow line. Each tow line was a 73.2-m in length of 2.5-cm dia polypropylene. Each tow line was also attached to a bridle connecting the top and bottom rings of one of the two 3-m rigid steel spreader pipes. The spreader pipes had three large stainless steel rings welded to them, two on the top and one on the bottom. The first top ring served as a bridle and A-2 Polyform float attachment point. The second top ring served as an attachment point or a pass-through eye for a purse line. The purse line was an 82.3-m length of 1.6-cm dia braid-on-braid nylon and was pursed with a hydraulic winch from the *John N. Cobb*. The sole bottom ring served as an attachment point for one end of a bridle and a 10-kg lead cannonball. The four corners of the net were attached to the top and bottom rings on the two spreader pipes. Trawl mesh sizes from the head and foot ropes aft to the cod end were 7.6 cm, 3.8 cm, 1.9 cm, and 0.6 cm over the 14.9 meshed length of the pair trawl. Deployment and retrieval of the pair trawl was done from the larger support vessel, *John N. Cobb*. The 3-m spreader bars were hung from a triangular aluminum plate, and the first one released as the *QUEST* pulled away and came to the end of the outboard tow line, then the second one was released as the first spreader bar had pulled away, thereby opening and clearing the net opening. Each trawl haul was fished across a station, and current, swell, and wind conditions dictated the direction in which the trawl was set. Deployment, fishing, and retrieval time for each 10-min haul was about 30 min.

Sampling area and times

Juvenile salmon were captured by trawling in the marine waters of Icy Strait from 25 to 28 June 2004 (Table 2). At this time of year, juvenile salmon begin to appear in more offshore neritic waters in southeastern Alaska and small salmon are likely to be encountered (Orsi et al. NPAFC bulletin). The marine offshore distance of all the sampling ranged from 3.2 to 6.4 km offshore. Each trawl fished in similar areas, but on separate days. All sampling was done at standard sampling stations within the Icy Strait area identified by previous research (Orsi et al. 2001; 2002). The Nordic rope trawl was fished at Icy Strait stations ISA, ISB, ISC, and ISD, whereas the Kodiak pair trawl was fished at Icy Strait Stations ISC and ISD in order to maximize the fishing effort by minimizing the running time between stations for this gear type. For the Nordic rope trawl, all four stations were fished once during the day (800-1600) on 25 June and station ISC was fished once at night (0100) on 28 June. For the pair trawl, all fishing at the two stations was done on the nights (2130-0115) of 26-27 and 27-28 June.

Sample Processing and Statistical Analyses

All juvenile salmon captured in the trawls were identified to species, enumerated, and measured from snout to fork of tail (fork length, FL) immediately following retrieval of the trawl. The fish were measured to the nearest mm FL with a Limnoterra FMB IV electronic measuring board (Chaput et al. 1992). Average sizes for pink and chum salmon were compared using two-sample *t*-tests. These two species were selected for comparison because they are the most abundant and smallest species of juvenile salmon in Icy Strait.

Results and Discussion

A total of 18 trawl hauls were made during the comparison fishing period: 5 with the Nordic rope trawl and 13 with the Kodiak pair trawl (Table 2). Totals of 654 juvenile pink salmon and 777 juvenile chum salmon were sampled with the rope trawl. Totals of 131 juvenile pink salmon and 427 juvenile chum salmon were sampled with the pair trawl.

For both pink and chum salmon, average sizes were larger for fish captured by the pair trawl (Table 3). The average size for pink salmon was 105.6 mm FL from the pair trawl, significantly ($P < 0.001$) larger than the 101.0 mm FL average size from the rope trawl. The average size for chum salmon was 112.4 mm FL from the pair trawl, significantly ($P < 0.001$) larger than the 107.0 mm FL average size from the rope trawl. Most of the juvenile salmon sampled by the rope trawl were captured on June 25, one to two days earlier than the pair trawl. Juvenile pink and chum salmon can grow at 1.0-1.5 mm per day (Orsi et al. 2000), so the differential capture time could cause a low bias in the size of the salmon in the rope trawl catches. However, the differences observed between the two trawl types are 2-3 times larger than possible bias due to growth over the sampling period. Thus, there was no indication based on average sizes that the rope trawl was selecting for larger fish.

Frequency distributions of the catches also did not indicate that the rope trawl selected for larger fish. For both pink and chum salmon, the modes of the distributions were smaller for the fish caught by the rope trawl than for the fish caught by the pair trawl (Figures 1 and 2). The general distributions of rope trawl samples were shifted to the left (smaller) more than those of pair trawl samples. For pink salmon, 44% of fish in the rope trawl sample were <100 mm FL, versus 31% of the pair trawl sample. For chum salmon, 18% of fish in the rope trawl sample were <100 mm FL, versus 9% for the pair trawl sample.

Minimum size of the juvenile salmon captured by the rope trawl was 77 mm FL for both pink and chum salmon (Table 2). The minimum size of chum salmon captured by the pair trawl was 78 mm FL, similar to the rope trawl. The minimum size of pink salmon captured by the pair trawl was 72 mm FL, which could indicate the rope trawl was missing fish of this size. However, fewer than 1% of fish in the pair trawl catch were less than 77 mm FL. Also, during rope trawl hauls from 21 to 24 June, prior to the gear comparison trials, the rope trawl captured chum salmon juveniles as small as 71 mm FL, and pink salmon juveniles as small as 69 mm FL (Orsi et al. 2004). These results indicate little or no size-selectivity of the rope trawl relative to the pair trawl for fish as small as ~70 mm FL.

We did not expect to observe significantly larger average sizes of pink and chum salmon from the pair trawl. The pair trawl has been shown to be size-selective against juvenile pink salmon at sizes over 180 mm FL (Gosho 1977). Because the rope trawl is larger and fished faster

than the pair trawl, and routinely catches immature chinook and adult salmon (Orsi et al. 1997, 2000, 2002), we have assumed that it is not size-selective against larger juveniles over the size range of juvenile salmon in their first summer at sea. The catches of juvenile coho (*O. kisutch*) and sockeye (*O. nerka*) during the trawl comparisons support this assumption relative to pair trawl catches. Coho salmon captured by the pair trawl averaged 138.5 mm FL, with a range of 109-197 mm FL; coho salmon caught by the rope trawl averaged 183.4 mm FL, with a range of 140-237 mm FL (Table 3). Sockeye salmon caught by the pair trawl averaged 110.2 mm FL, with a range of 91-136 mm FL; sockeye salmon caught by the rope trawl averaged 111.2 mm FL, with a range of 78-172 mm FL. The rope trawl thus caught much larger individuals of these larger, older species, relative both to the pair trawl and to the size range of pink and chum salmon juveniles from either gear type.

The Kodiak pair trawl is used to sample in nearshore as well as neritic habitats, and has been shown to effectively sample juvenile salmon as small as 31 mm FL (Gosho 1977; Mortensen and Wertheimer 1988). In the neritic habitat of Icy Strait, we found little evidence that the pair trawl sampled smaller juvenile salmon than the Nordic rope trawl used as the standard sampling gear for SECM. These results support our assumption that juvenile salmon sampled by the rope trawl are representative of those present in these neritic habitats. Several different trawls are currently being used for the ocean sampling of salmon (Makas et al. 1997). Further investigation is needed to evaluate the effectiveness and catchability coefficients of the trawls, because there is evidence to suggest that different trawl types can be both species- and size-selective (Parkinson et al. 1994; Fabrizio et al. 1997).

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Table 1.—Characteristics, dimensions, and fishing effort of the Nordic 264 rope trawl and the Kodiak pair trawl used to sample juvenile salmon in the marine waters of Icy Strait, Alaska, 25-28 June 2004.

Feature	Trawl type	
	Nordic 264 rope trawl	Kodiak pair trawl
Trawl characteristics		
Typical fishing period	Day	Night
Number of vessels used to trawl	One: 29 m/ 350 hp	Two: 29 m/350 hp; 8 m/230 hp
Fishing position of trawl to vessel(s)	Astern	Amidships
Number of operational people needed	Four	Four
Trawl deployment and retrieval time	40 min	30 min
Vertical spreading mechanism	3 m Lite NETS Doors	3 m rigid vertical pipes
Maximum fishable sea state	3 m	1 m
Minimum fishable bottom depth	50 m	10 m
Trawl fishing dimensions		
Net length	129.6 m	14.9 m
Mesh size within net opening	162.6 cm square	7.6 cm square
Cod-end knotless mesh size	0.8 cm square	0.6 cm square
Net spread (horizontal × vertical)	(24 m × 20 m)	(6 m × 3 m)
Fishing speed	1.5 m/sec	1.0 m/sec
Fishing duration	20 min	10 min
Surface area swept	43,200 m ²	3,600 m ²
Trawling effort		
Number of hauls	5	13
Dates fished	25 and 28 June	26-27 and 27-28 June
Fishing time	0800-1600 & 0100	2130-0115
Stations sampled	ISA, ISB, ISC, and ISD	ISC and ISD

Table 2.—Numbers and sizes (mm) of juvenile salmon captured during Nordic 264 rope trawl and the Kodiak pair trawl comparison trials in the marine waters of Icy Strait, Alaska, 25-28 June 2004.

Salmon species	Trawl type	Number captured	Minimum size	Maximum size	Average size	SD
Pink	Rope	654	77	131	101.0	8.5
	Pair	131	72	136	105.6	13.2
Chum	Rope	777	77	131	107.0	8.2
	Pair	427	78	135	112.4	9.7
Sockeye	Rope	117	91	172	111.2	15.3
	Pair	20	78	136	110.2	12.9
Coho	Rope	17	140	237	183.4	25.1
	Pair	4	109	136	138.5	40.3

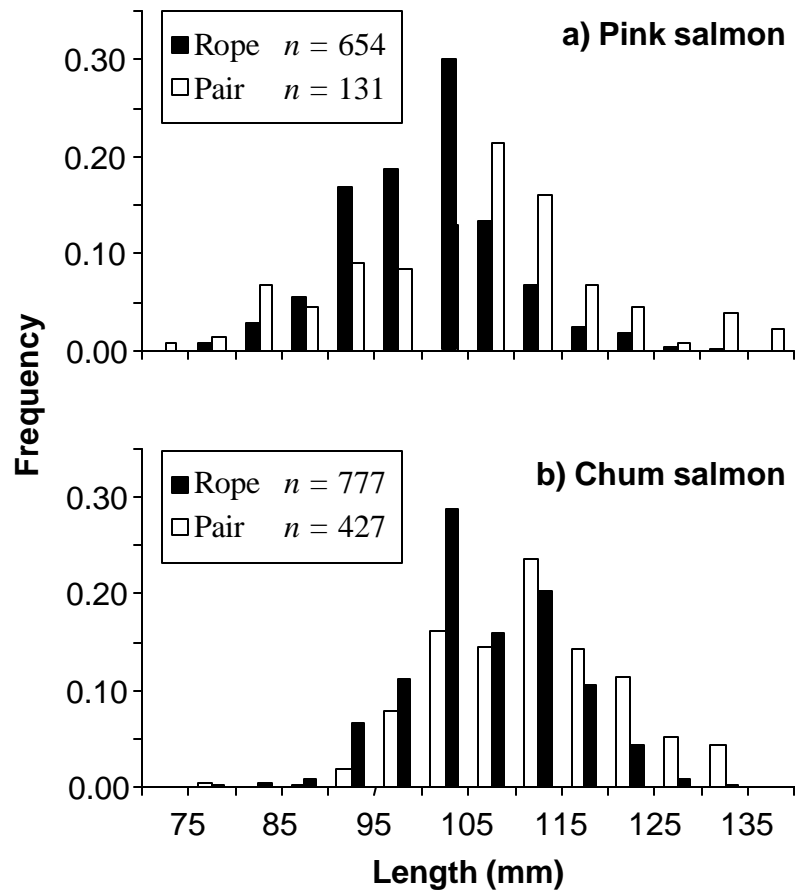


Figure 1.—Frequency distributions of snout-fork lengths of juvenile a) pink salmon, and b) chum salmon caught with the Nordic 264 rope trawl and the Kodiak pair trawl in the marine waters of Icy Strait, Alaska, 25-28 June 2004.