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Paired Comparisons of Juvenile Salmon Catches Between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeastern Alaska, July 2007

by

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Paired Comparisons of Juvenile Salmon Catches Between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeastern Alaska, July 2007

Abstract

Juvenile salmon (*Oncorhynchus* spp.) catches were compared from 28 surface trawl hauls conducted by two research vessels in marine waters of the northern region of southeastern Alaska, July 2007. This calibration study was initiated because the National Oceanic and Atmospheric Administration (NOAA) ship *John N. Cobb* was scheduled to be decommissioned in 2008. The Alaska Department of Fish and Game vessel *Medeia* was fished concurrently with the *John N. Cobb* in Icy and Chatham Straits. The vessels fished Nordic 264 rope trawls for 20 minutes synoptically at the surface along adjacent, staggered trawl paths. Trawl speed, distance trawled, and catch rates, species compositions, and size of juvenile salmon were compared between vessels. In paired-difference tests, trawl paths were significantly longer (11%, $P < 0.001$) for the *Medeia* compared to the *John N. Cobb*. The total number of juvenile salmon caught was also significantly greater ($P < 0.05$) for the *Medeia* than the *John N. Cobb* (1,064 vs. 639). However, no significant differences ($P > 0.1$) in catch between vessels were detected at the individual species level for pink (*O. gorbuscha)*, chum (*O. keta)*, sockeye (*O. nerka*), or coho (*O. kisutch*) salmon. Numbers of Chinook salmon (*O. tshawytscha*) caught were too low for statistical comparisons to be made. Overall species composition was not significantly different (Chi-square, $P = 0.31$) between the two vessels. Average size of all juvenile salmon was not different (analysis of variance, $P = 0.54$) between the two vessels, but significant species differences were noted ($P < 0.001$). This study will permit future catch-per-unit-efforts to be compared with the existing 11-year time series of data previously collected by the *John N. Cobb* in Southeast Alaska.

Introduction

The Southeast Coastal Monitoring Project (SECM) is a coastal monitoring study of the National Oceanic and Atmospheric Administration (NOAA) Auke Bay Laboratories (ABL) in the northern region of southeastern Alaska. The SECM was initiated to annually study the early marine ecology of Pacific salmon (*Oncorhynchus* spp.) and associated epipelagic ichthyofauna and to better understand effects of environmental change on salmon production. From 1997 to 2007, SECM has used the NOAA ship *John N. Cobb* to accrue an 11-yr time series of catches using a Nordic 264 rope trawl fished at the surface in marine waters of the northern region of southeastern Alaska (Orsi et al. 2001, 2006, 2007). Juvenile pink salmon (*O. gorbuscha*) catches from this time series are a key parameter in forecast models for pink salmon harvests in Southeast Alaska (Orsi et al. 2006; ADF&G 2007; Wertheimer et al. 2008). The Alaska Department of Fish and Game (ADF&G) research vessel *Medeia* has also deployed the surface trawl gear for specific projects for ABL. Surface rope trawls have also been used to estimate abundance of juvenile coho salmon (*O. kisutch*) in the Strait of Georgia (Beamish et al. 2000) and to compare regional abundances of juvenile salmon and co-occurring epipelagic fish species in the Alaska and California Currents (Orsi et al. 2007). The *John N. Cobb* was scheduled to be decommissioned in 2008, with eventual replacement in 2010. This project compared species composition, catch rates, and sizes of juvenile salmon caught by the two vessels in 2007 in order to: (1) determine if there are significant differences in these indices between the vessels; and (2) develop appropriate calibration factors if these indices differ. This study compared trawl catches between vessels for maintaining the integrity of the long-term SECM data set, and established a standard for future calibration of a *John N. Cobb* replacement vessel.

Methods

The *Medeia* and the *John N. Cobb* are research vessels rigged for stern trawling. The *Medeia* is 33 m in length and has two main engines producing 1250 hp. The *John N. Cobb* is 29 m in length and has a single main engine producing 325 hp. Each vessel fished a Nordic 264 rope trawl, modified to fish the surface water directly astern The trawl was 184 m long and had a mouth opening of 24 m by 30 m (depth by width). 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 to be 18 m deep (head rope to foot rope) by 24 m wide (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 mesh 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 between the head rope and the 162.6-cm mesh to reduce loss of small fish. To keep the trawl headrope at the surface, two clusters of three A-4 Polyform buoys (each inflated to 0.75 m diameter and encased in a knotted mesh bag), were clipped to opposing corner wingtips of the headrope, and one A-3 Polyform float (inflated 0.5 m diameter), was clipped into a mesh kite pocket in the center of the headrope. The trawl was fished with a 9.1 m length of 1.6-cm wire trailing off the top and bottom of each trawl door (back strap), and each back strap connected with a “G” hook and flat link to a 70.1-m wire swiveled bridle. The head rope bridles were 1.0-cm wire and the footrope bridles were 1.3-cm wire. The *Medeia* deployed

the trawl with 75 m of 1.6-cm wire main warp attached to each door, and typically averaged 3.0 kt while fishing. The *John N. Cobb* deployed the trawl with 150 m of 1.6-cm wire main warp attached to each door, and typically averaged 2.4 kt while fishing. Start and stop trawling times were recorded as the time in which the doors were set in full fishing position and the time the door haul back was initiated.

Sampling was conducted along two SECM transect lines (encompassing four stations each) located in upper Chatham and Icy Straits in the northern region of southeastern Alaska (Table 1, Figure 1). For each pair of trawls, the *John N. Cobb* initiated the trawling and the *Medeia* fished a parallel track in the same direction, starting about 10 min later. The *Medeia* trawl track was off-set from the *John N. Cobb* trawl track for each haul by 200-250 m, alternating between port and starboard. Trawl duration after the trawl doors were deployed was 20 min.

After each trawl haul, the fish were anesthetized with tricaine methanesulfonate (MS-222), identified, enumerated, measured, labeled, bagged, and frozen. After the catch was sorted, juvenile salmon were measured to the nearest mm fork length (FL) with a Limnoterra FMB IV electronic measuring board (Chaput et al. 1992). In general, up to 50 of each species of juvenile salmon per haul were individually bagged and frozen, up to 100 were measured, and any in excess of 100 were counted only.

The distance traveled per trawl haul and the number and size of juvenile salmon caught were evaluated for statistical differences between the two vessels. Distance traveled was computed from GPS coordinates as the straight-line distance between the starting point and ending point of the 20-min fishing period. Paired-difference t-tests were used to compare distance traveled, the total number of juvenile salmon caught, and the number of juvenile pink, chum (*O. keta*), sockeye (*O. nerka*), and coho salmon caught. Chinook salmon (*O. tshawytscha*) catches were not analyzed statistically because of the small number captured. Prior to testing, numbers caught per trawl haul were transformed by Ln(catch+1) to normalize the variance of the catches and to be consistent with data used in pink salmon forecasting models (Heinl 2008; Wertheimer et al. 2008). The species composition in the catches was compared in two ways: (1) Chi-square test of the 2 x 5 contingency table with 2 rows (vessels) and 5 columns (number of juveniles caught per species); and (2) paired-difference t-test of the proportion of coho salmon (the largest species of juvenile salmon on average) in each haul. The proportion data were transformed by the arcsine of the square root of the proportion prior to testing. Mean lengths of each species of juvenile salmon were compared using a two-way analysis of variance (ANOVA), with vessel and species as fixed factors; two-sample t-tests were performed if significant differences were indicated.

Results

A total of 28 matched pairs of trawl hauls were completed (Table 2). The *Medeia* trawl track averaged a distance of 1.73 km during the 20-min fishing period, 11% further than the *John N. Cobb,* which averaged 1.56 km. The paired-difference test indicated that the distance traveled while fishing was significantly ($P < 0.001$) greater for the *Medeia*.

The total number of juvenile salmon caught during the paired sampling was greater for the *Medeia* (n = 1,064) than for the *John N. Cobb* (n = 639) (Tables 3 and 4). Species-specific catches were also greater for the *Medeia* than the *John N.* Cob for pink salmon (273 versus 173), chum salmon (452 versus 252), sockeye salmon (138 versus 99), and coho salmon (197 versus

108). However, the *Medeia* caught fewer Chinook salmon, the least abundant species (< 1%), than the *John N. Cobb* (4 versus 7). The paired-difference analysis of the catches indicated that the total number of juvenile salmon caught was significantly ($P < 0.05$) greater for the *Medeia* than for the *John N. Cobb* (Table 5). However, no species-specific significant ($P > 0.1$) difference was observed between the vessel catches.

Relative catch efficiency of the *Medeia* to the *John N. Cobb* was calculated by dividing the average catch of the *Medeia* by the average catch of the *John N. Cobb* for total juvenile salmon and for juvenile pink, chum, sockeye, and coho salmon (Table 6). The ratios of the averages between the two vessels for all juvenile salmon were 1.67 for the untransformed catch, and 1.19 for the Ln-transformed catch. For the individual species, the ratios ranged between 1.39 and 1.82 for the average catch-per-haul and between 1.13 and 1.26 for the average Ln-transformed catch (Table 6).

Catch patterns for each species were similar for the two vessels, with juvenile chum salmon the most abundant, followed by juvenile pink, coho, sockeye, and Chinook salmon (Tables 3 and 4). No significant difference was indicated for overall species composition between the two vessels (Chi-square, $P = 0.31$). Similarly, no significant difference was indicated for the proportion of juvenile coho salmon in each haul between the two vessels (paired difference test, $P = 0.89$) (Table 5).

Of the juvenile salmon species captured, coho salmon were the largest and pink and chum salmon were the smallest (Figure 2). Average size of juvenile salmon caught by the two vessels did not differ (ANOVA, $P = 0.54$), but significant differences ($P < 0.001$) were found among species. However, the interaction term between vessels and species was also significant ($P = 0.02$), indicating that species-specific size differences were not consistent between vessels: two species (chum and sockeye salmon) averaged larger for the *Medeia*, and two species (pink and coho salmon) averaged larger for the *John N. Cobb* (Figure 2). Nonetheless, these differences in average size were significant only for one species: chum salmon sampled on the *Medeia* were larger (2-sample t-test, $P = 0.014$), while pink, sockeye, and coho salmon size did not differ ($P > 0.1$) between vessels.

Discussion

The *Medeia* was more effective than the *John N. Cobb* at catching total numbers of juvenile salmon with the surface trawl. We assumed that the fishing dimensionality of the trawls was similar. However, the *Medeia* fished faster than the *John N. Cobb*, and thus covered 11% more fishing distance during a standard trawl haul. However, the *Medeia* catches of total juvenile salmon and species (except juvenile Chinook salmon) increased by more than 11%, indicating that the higher catches were due not only to increased area fished but also to increased net efficiency (less net avoidance). We therefore hypothesize that because the trawling speed of the *John N. Cobb* was slower than the *Medeia*'s, the spread of the net was narrower and deeper. Shallower fishing depths by the *Medeia* could also explain the lower catch frequency for juvenile Chinook salmon (14% versus 25% of the hauls), because this species has a deep vertical distribution (Orsi and Wertheimer 1995).

We found little evidence that the species composition or the size of juvenile salmon captured varied between the two vessels. The frequency of the species in the catch was similar, including the proportion of juvenile coho salmon, which are the largest species and thus presumably would be most affected by differences in trawl speed.

Overall, the catch of juvenile salmon was very low in July 2007 (Orsi et al. 2008). Low catches were driven largely by juvenile pink salmon, which are commonly the most abundant species in this time period. In 2007, the catch per trawl of juvenile pink salmon was the third lowest on record in the 11-yr time series of SECM sampling (Orsi et al. 2008; Wertheimer et al. 2008). The low average catches, high variability, and high frequency of zero catches for some species may have contributed to the lack of significant differences detected at the species level. In 2008, we planned to do additional paired comparisons between the *Medeia* and the *John N. Cobb* to increase sample size for better resolution of relative fishing power of the two vessels. However, the *John N. Cobb* suffered a fatal mechanical failure in June of 2008, which precluded any additional calibration with the *Medeia*. Thus, the ratios of fishing efficiency observed between the two vessels in 2007 will be the only standard available for calibrating and comparing other sampling vessels, either NOAA ships or contracted research vessels, to extend the SECM juvenile salmon catch time series.

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Literature Cited

Beamish, R., D. McCaughran, J. R. King, R. M. Sweeting, and G. A. McFarlane. 2000. Estimating the abundance of juvenile coho salmon in the Strait of Georgia by means of surface trawls. North Am. J. Fish. Mgmt. 20:369-375.

Chaput, G. J., C. H. LeBlanc, and C. Bourque. 1992. Evaluation of an electronic fish measuring board. ICES J. Mar. Sci. 49:335-339.

Heinl, S. 2008. Forecast area Southeast Alaska, species pink salmon. Pp. 41-44 *in* P. Nelson, M. D. Plotnick, and A. M. Carroll (eds.), Run forecasts and harvests projections for 2008 Alaska salmon fisheries and a review of the 2007 season. Alaska Department Fish and Game Special Publication 08-09. <www.sf.adfg.state.ak.us/FedAidPDFs/sp08-09.pdf>

Orsi, J. A. and A. C. Wertheimer. 1995. Marine vertical distribution of juvenile Chinook and coho salmon in southeastern Alaska. Trans. Am. Fish. Soc. 124:159-169.

Orsi, J. A., M. V. Sturdevant, J. M. Murphy, D. G. Mortensen, and B. L. Wing. 2000. Seasonal habitat use and early marine ecology of juvenile Pacific salmon in southeastern Alaska. NPAFC Bull. 2:111-122.

Orsi, J. A., E. A. Fergusson, M. V. Sturdevant, B. L. Wing, A. C. Wertheimer, and W. R. Heard. 2006. Survey of juvenile salmon and ecologically-related species in the marine waters of southeastern Alaska, May–August 2005. (NPAFC Doc. 955) Auke Bay Lab., Alaska Fish. Sci. Cen., Nat. Mar. Fish. Serv., NOAA, 11305 Glacier Highway, Juneau, AK 99801-8626, USA, 108 p.

Orsi, J. A., E. A. Fergusson, M. V. Sturdevant, B. L. Wing, A. C. Wertheimer, and W. R. Heard. 2007. Annual survey of juvenile salmon and ecologically related species and environmental factors in the marine waters of southeastern Alaska, May–August 2006. NPAFC Doc. 1057. 72 p.

Orsi, J. A., J. A. Harding, S. S. Pool, R. D. Brodeur, L. J. Haldorson, J. M. Murphy, J. H. Moss, E. V. Farley, Jr., R. M. Sweeting, J. F. T. Morris, M. Trudel, R. J. Beamish, R. L. Emmett, And E. A. Fergusson. 2007. Epipelagic fish assemblages associated with juvenile pacific salmon in neritic waters of the California Current and the Alaska Current. American Fisheries Society Symposium 57:105–155.

Orsi, J. A., E. A. Fergusson, M. V. Sturdevant, B. L. Wing, A. C. Wertheimer, and W. R. Heard. 2008. Annual survey of juvenile salmon and ecologically related species and environmental factors in the marine waters of southeastern Alaska, May–August 2007. NPAFC Doc. 1xxx. 82 p.

Wertheimer, A. C., J. A. Orsi, M. V. Sturdevant, and E. A. Fergusson. 2008. Forecasting pink salmon abundance in Southeast Alaska from juvenile salmon abundance and associated environmental parameters. Final Report, Pacific Salmon Commission Northern Fund. 41 pp.

Table 1.—Stations sampled during trawl calibrations between the ADF&G research vessel *Medeia* and the NOAA ship *John N. Cobb,* with location coordinates, distances offshore (km), and bottom depths (m), in marine waters of the northern region of southeastern Alaska, July 2007.

Station	Latitude	Longitude	Offshore distance (km)	Bottom depth (m)
		Upper Chatham Strait		
UCA	58°04.57’N	135°00.08’W	3.2	400
UCB	58°06.22’N	135°00.91’W	6.4	100
UCC	58°07.95’N	135°04.00’W	6.4	100
UCD	58°09.64’N	135°02.52’W	3.2	200
		Icy Strait		
ISA	58°13.25’N	135°31.76’W	3.2	128
ISB	58°14.22’N	135°29.26’W	6.4	200
ISC	58°15.28’N	135°26.65’W	6.4	200
ISD	58°16.38’N	135°23.98’W	3.2	234

Table 2.—Number of trawl hauls, average distance traveled (km), and difference between average distance traveled for paired 20-min trawl hauls conducted by the ADF&G vessel *Medeia* and the NOAA ship *John N. Cobb* in marine waters of the northern region of southeastern Alaska, July 2007. Distances traveled by the *Medeia* were significantly greater than those for the *John N. Cobb* (paired t-test, $P < 0.001$).

Vessel	Number of trawls	Distance traveled per trawl (km)	
		Average	SE
Medeia	28	1.73	0.04
John N. Cobb	28	1.56	0.04
Paired differences (*Medeia – Cobb*)	28	0.17	0.03

Table 3.—Juvenile salmon catches, transformed catches (Ln[catch+1], in parentheses), and proportion of juvenile coho salmon in total catch, in trawl samples from the ADF&G vessel *Medeia* during paired comparisons with the NOAA ship *John N. Cobb*, in marine waters of the northern region of southeastern Alaska, July 2007.

		Number caught and (Ln[catch+1])						Proportion
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**	**Coho**
26 July	UCD	2 (1.10)	1 (0.69)	7 (2.08)	21 (3.09)	1 (0.69)	32 (3.50)	0.66
26 July	UCC	1 (0.69)	2 (1.10)	14 (2.71)	13 (2.64)	0 (0.00)	30 (3.43)	0.43
27 July	UCA	0 (0.00)	0 (0.00)	3 (1.39)	11 (2.48)	0 (0.00)	14 (2.71)	0.79
27 July	UCB	5 (1.79)	7 (2.08)	5 (1.79)	20 (3.04)	1 (0.69)	38 (3.66)	0.53
27 July	UCC	0 (0.00)	3 (1.39)	4 (1.61)	19 (3.00)	0 (0.00)	26 (3.30)	0.73
27 July	UCD	0 (0.00)	1 (0.69)	2 (1.10)	11 (2.48)	0 (0.00)	14 (2.71)	0.79
27 July	UCB	0 (0.00)	0 (0.00)	0 (0.00)	12 (2.56)	1 (0.69)	13 (2.64)	0.92
27 July	UCA	0 (0.00)	0 (0.00)	1 (0.69)	21 (3.09)	0 (0.00)	22 (3.14)	0.95
28 July	ISA	0 (0.00)	2 (1.10)	0 (0.00)	6 (1.95)	0 (0.00)	8 (2.20)	0.75
28 July	ISB	0 (0.00)	1 (0.69)	1 (0.69)	7 (2.08)	0 (0.00)	9 (2.30)	0.78
28 July	ISC	1 (0.69)	5 (1.79)	3 (1.39)	3 (1.39)	0 (0.00)	12 (2.56)	0.25
28 July	ISD	9 (2.30)	20 (3.04)	6 (1.95)	1 (0.69)	0 (0.00)	36 (3.61)	0.03
28 July	ISD	19 (3.00)	37 (3.64)	4 (1.61)	5 (1.79)	0 (0.00)	65 (4.19)	0.08
29 July	ISD	2 (1.10)	15 (2.77)	4 (1.61)	1 (0.69)	0 (0.00)	22 (3.14)	0.05
29 July	ISC	1 (0.69)	5 (1.79)	0 (0.00)	4 (1.61)	0 (0.00)	10 (2.40)	0.40
29 July	ISB	38 (3.66)	51 (3.95)	12 (2.56)	1 (0.69)	0 (0.00)	102 (4.63)	0.01
29 July	ISB	48 (3.89)	125 (4.84)	29 (3.40)	0 (0.00)	0 (0.00)	202 (5.31)	0.00
29 July	ISA	19 (3.00)	23 (3.18)	8 (2.20)	3 (1.39)	0 (0.00)	53 (3.99)	0.06
29 July	ISA	3 (1.39)	9 (2.30)	2 (1.10)	0 (0.00)	0 (0.00)	14 (2.71)	0.00
30 July	ISA	76 (4.34)	92 (4.53)	8 (2.20)	0 (0.00)	0 (0.00)	176 (5.18)	0.00
30 July	ISB	5 (1.79)	3 (1.39)	2 (1.10)	4 (1.61)	0 (0.00)	14 (2.71)	0.29
30 July	ISC	0 (0.00)	7 (2.08)	4 (1.61)	3 (1.39)	0 (0.00)	14 (2.71)	0.21
30 July	ISC	1 (0.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.69)	0.00
30 July	ISD	13 (2.64)	8 (2.20)	1 (0.69)	2 (1.10)	0 (0.00)	24 (3.22)	0.08
30 July	UCA	29 (3.40)	14 (2.71)	14 (2.71)	18 (2.94)	1 (0.69)	76 (4.34)	0.24
31 July	UCB	0 (0.00)	2 (1.10)	0 (0.00)	4 (1.61)	0 (0.00)	6 (1.95)	0.67

Date	Station	Number caught and (Ln[catch+1])						Proportion Coho
		Pink	Chum	Sockeye	Coho	Chinook	Total	
31 July	UCC	0 (0.00)	13 (2.64)	4 (1.61)	0 (0.00)	0 (0.00)	17 (2.89)	0.00
31 July	UCD	1 (0.69)	6 (1.95)	0 (0.00)	7 (2.08)	0 (0.00)	14 (2.71)	0.50
TOTAL		273	452	138	197	4	1064	
AVG		9.8 (1.32)	16.1 (1.92)	4.9 (1.35)	7.0 (1.62)	0.1 (0.10)	38.0 (3.16)	0.36

Table 4.—Juvenile salmon catches, transformed catches (Ln[catch+1], in parentheses), and proportion of juvenile coho salmon in total catch, in trawl samples from the NOAA ship *John N. Cobb* during paired comparisons with the ADF&G vessel *Medeia*, in marine waters of the northern region of southeastern Alaska, July 2007..

		Number caught and (Ln[catch+1])						Proportion
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**	**Coho**
26 July	UCD	1 (0.69)	0 (0.00)	0 (0.00)	1 (0.69)	0 (0.00)	2 (1.10)	0.50
26 July	UCC	1 (0.69)	3 (1.39)	6 (1.95)	15 (2.77)	0 (0.00)	25 (3.26)	0.60
27 July	UCA	0 (0.00)	2 (1.10)	3 (1.39)	8 (2.20)	1 (0.69)	14 (2.71)	0.57
27 July	UCB	1 (0.69)	1 (0.69)	1 (0.69)	1 (0.69)	1 (0.69)	5 (1.79)	0.20
27 July	UCC	0 (0.00)	0 (0.00)	0 (0.00)	6 (1.95)	1 (0.69)	7 (2.08)	0.86
27 July	UCD	1 (0.69)	1 (0.69)	4 (1.61)	4 (1.61)	1 (0.69)	11 (2.48)	0.36
27 July	UCB	0 (0.00)	2 (1.10)	1 (0.69)	5 (1.79)	0 (0.00)	8 (2.20)	0.63
27 July	UCA	0 (0.00)	0 (0.00)	0 (0.00)	14 (2.71)	0 (0.00)	14 (2.71)	1.00
28 July	ISA	0 (0.00)	0 (0.00)	0 (0.00)	5 (1.79)	0 (0.00)	5 (1.79)	1.00
28 July	ISB	1 (0.69)	0 (0.00)	1 (0.69)	1 (0.69)	0 (0.00)	3 (1.39)	0.33
28 July	ISC	0 (0.00)	1 (0.69)	0 (0.00)	1 (0.69)	0 (0.00)	2 (1.10)	0.50
28 July	ISD	46 (3.85)	47 (3.87)	9 (2.30)	2 (1.10)	0 (0.00)	104 (4.65)	0.02
28 July	ISD	12 (2.56)	21 (3.09)	7 (2.08)	3 (1.39)	0 (0.00)	43 (3.78)	0.07
29 July	ISD	2 (1.10)	8 (2.20)	3 (1.39)	2 (1.10)	0 (0.00)	15 (2.77)	0.13
29 July	ISC	1 (0.69)	6 (1.95)	3 (1.39)	0 (0.00)	1 (0.69)	11 (2.48)	0.00
29 July	ISB	4 (1.61)	7 (2.08)	1 (0.69)	6 (1.95)	0 (0.00)	18 (2.94)	0.33
29 July	ISB	1 (0.69)	18 (2.94)	9 (2.30)	1 (0.69)	0 (0.00)	29 (3.40)	0.03
29 July	ISA	1 (0.69)	9 (2.30)	2 (1.10)	4 (1.61)	0 (0.00)	16 (2.83)	0.25
29 July	ISA	8 (2.20)	17 (2.89)	6 (1.95)	4 (1.61)	0 (0.00)	35 (3.58)	0.11
30 July	ISA	27 (2.20)	50 (3.93)	6 (1.95)	2 (1.10)	0 (0.00)	85 (4.45)	0.02
30 July	ISB	0 (0.00)	6 (1.95)	1 (0.69)	1 (0.69)	0 (0.00)	8 (2.20)	0.13
30 July	ISC	8 (2.20)	23 (3.18)	19 (3.00)	5 (1.79)	1 (0.69)	56 (4.04)	0.09
30 July	ISC	5 (1.79)	2 (1.10)	1 (0.69)	0 (0.00)	0 (0.00)	8 (2.20)	0.00
30 July	ISD	8 (2.20)	2 (1.10)	2 (1.10)	0 (0.00)	0 (0.00)	12 (2.56)	0.00
30 July	UCA	21 (3.09)	7 (2.08)	6 (1.95)	8 (2.20)	0 (0.00)	42 (3.76)	0.19
31 July	UCB	24 (3.22)	17 (2.89)	8 (2.20)	6 (1.95)	1 (0.69)	56 (4.04)	0.11

Date	Station	Number caught and (Ln[catch+1])						Proportion Coho
		Pink	Chum	Sockeye	Coho	Chinook	Total	
31 July	UCC	0 (0.00)	2 (1.10)	0 (0.00)	3 (1.39)	0 (0.00)	5 (1.79)	0.60
31 July	UCD	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	--
TOTAL		173	252	99	108	7	639	
AVG		6.2 (1.17)	9 (1.58)	3.5 (1.14)	3.9 (1.29)	0.3 (0.17)	22.8 (2.65)	0.32

Table 5.—Paired-difference t-tests of juvenile salmon catches in paired trawl hauls by the ADF&G vessel *Medeia* and the NOAA ship *John N. Cobb* in marine waters of the northern region of southeastern Alaska, July 2007. Prior to testing, the numbers of fish caught in each haul were transformed by Ln (catch+1) and the proportion of coho salmon caught in each haul was transformed by the square root arcsine. The averages shown are the *Medeia* values minus the *John N. Cobb* values (see Tables 3 and 4); t-statistic and *P*-values are for the test of the average not equal to zero. Only 27 paired comparisons were possible for the proportion of coho salmon because both vessels had zero catches of this species in the last haul made at ISC on July 30.

Comparison	**n**	**average**	**SE**	**t-statistic**	***P*-value**
Total juvenile salmon	28	0.51	0.22	2.37	0.025
Juvenile pink salmon	28	0.15	0.24	0.60	0.554
Juvenile chum salmon	28	0.33	0.20	1.67	0.107
Juvenile sockeye salmon	28	0.21	0.20	1.07	0.295
Juvenile coho salmon	28	0.33	0.20	1.62	0.117
Proportion of coho salmon	27	0.01	0.07	0.13	0.899

Table 6.—Between-vessel ratios of average catch-per-haul and average Ln (catch+1) per haul for juvenile salmon species captured in 28 paired trawl hauls by the ADF&G vessel *Medeia* and the NOAA ship *John N. Cobb* in marine waters of the northern region of southeastern Alaska, July 2007.

Species	Ratio of average catch-per-haul	Ratio of average Ln (catch+1) per haul
Pink salmon	1.58	1.13
Chum salmon	1.79	1.21
Sockeye salmon	1.39	1.19
Coho salmon	1.82	1.26
Total juvenile salmon	1.67	1.19

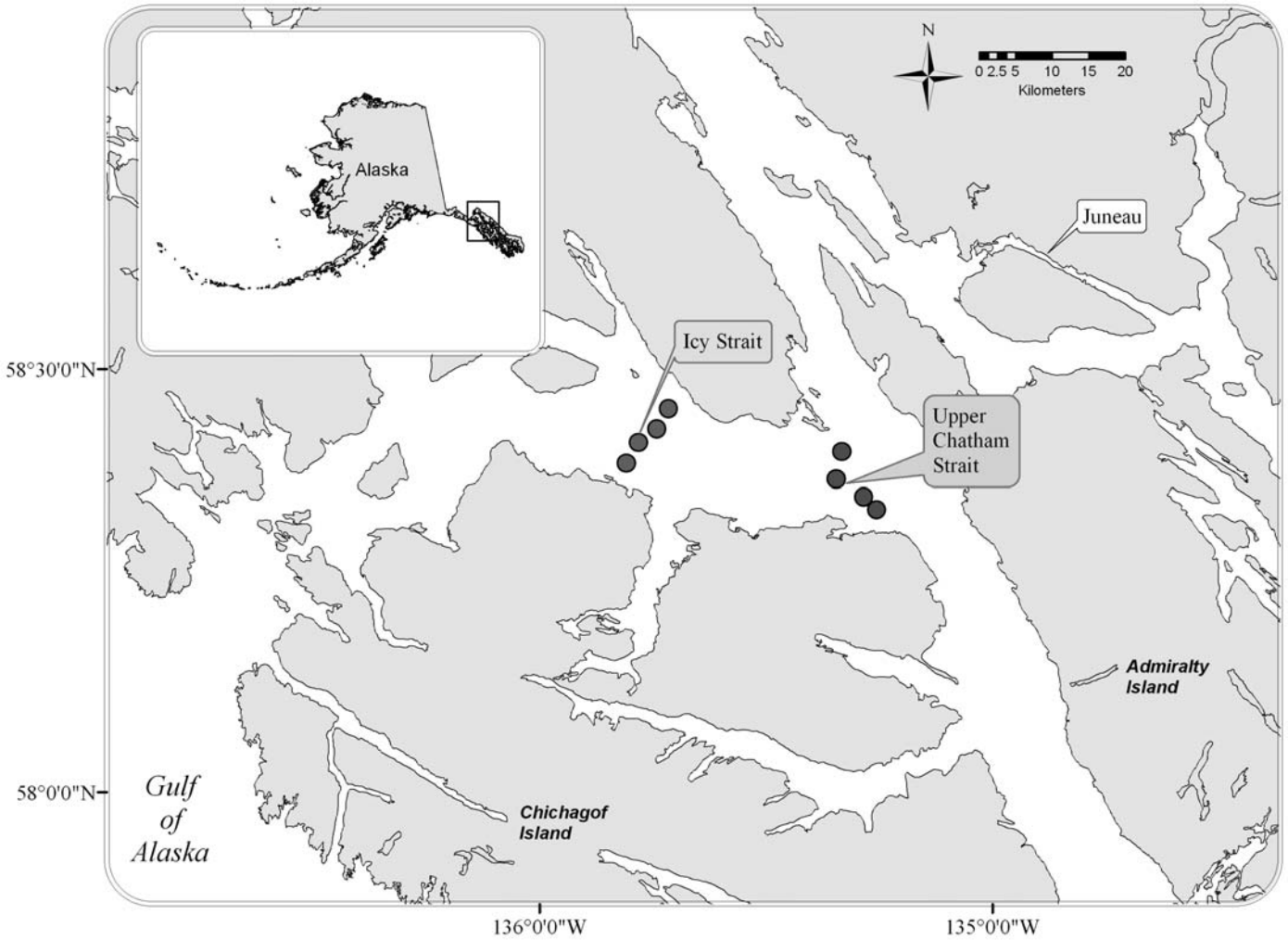

Figure 1.—Stations sampled in marine waters of the northern region of southeastern Alaska, July 2007. Transect and station coordinates are shown in Table 1.

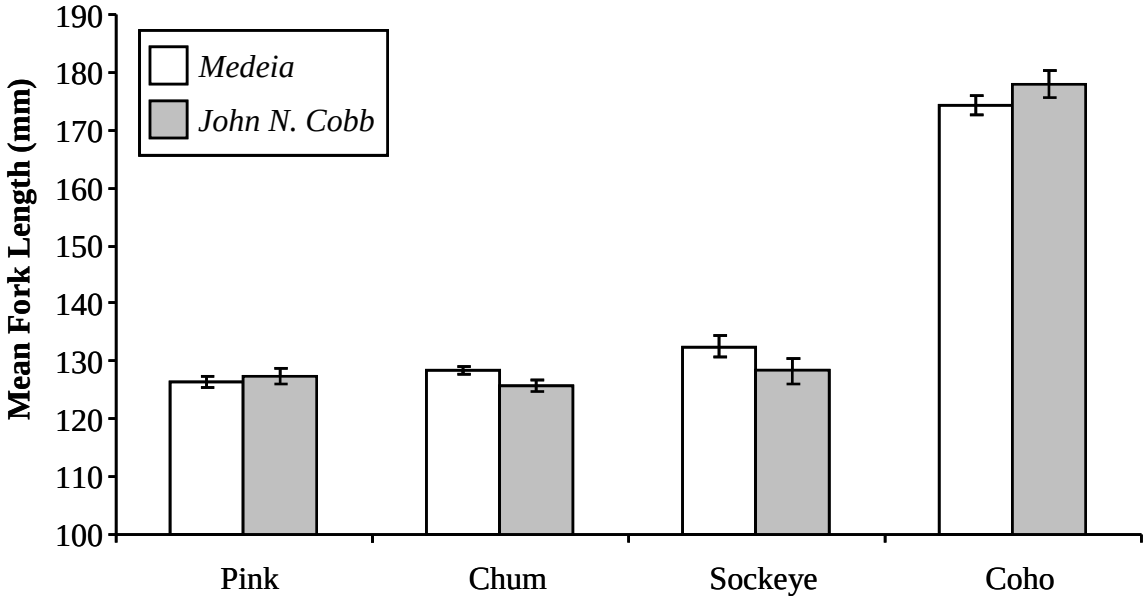

Figure 2.—Average fork lengths (mm) and standard error of four species of juvenile salmon captured in 28 paired trawl hauls by the ADF&G vessel *Medeia* and the NOAA ship *John N. Cobb* in marine waters of the northern region of southeastern Alaska, July 2007.