Juvenile Pacific Salmon (*Oncorhynchus* spp.) Trawl Survey on the South Coast of British Columbia, October 27 to November 3, 2016

Yeongha Jung, Amy M. Tabata, Kelsey L. Flynn and Jackie R. King

Pacific Biological Station
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, British Columbia
V9T 6N7, Canada

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JUVENILE PACIFIC SALMON (*ONCORHYNCHUS* SPP.) TRAWL SURVEY ON THE SOUTH COAST OF BRITISH COLUMBIA, OCTOBER 27 TO NOVEMBER 3, 2016

by

Yeongha Jung, Amy M. Tabata, Kelsey L. Flynn, and Jackie R. King

Pacific Biological Station
Fisheries and Oceans Canada, 3190 Hammond Bay Road
Nanaimo, British Columbia, V9T 6N7, Canada

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Fisheries and Oceans Canada (DFO) conducted a surface trawl survey from October 27 to November 3, 2016 on the CFV *Frosti*. This study targeted juvenile Pacific Salmon (*Oncorhynchus* spp.) in southern British Columbia (BC). There were 364,385 individuals caught from 20 species in 37 tows. Rockfishes was the most abundant species with 96% of the total catch. Juvenile salmon species caught in decreasing abundance by count were: Chinook Salmon, Chum Salmon, Pink Salmon, Coho Salmon and Sockeye Salmon, with catch distribution varied based on species. Biological samples for genetic stock composition, otoliths, pathogen analyses, energy density estimation, stable isotope analyses and coded wire tags were returned to the Pacific Biological Station (DFO, Nanaimo, BC). Associated information on the physical oceanography (37 locations), water samples for chemistry and chlorophyll *a* along with zooplankton samples (37 locations) were returned to the Institute of Ocean Sciences (DFO, Sidney, BC).

RÉSUMÉ

Jung, Y, Tabata, A.T., Flynn, K.L., and King, J.R. 2025. Juvenile Pacific Salmon (*Oncorhynchus* spp.) Trawl Survey on the South Coast of British Columbia, October 27 to November 3, 2016. Can. Data Rep. Fish. Aquat. Sci. 1439: vi + 31 p.

Pêches et Océans Canada a effectué un relevé au chalut de surface entre octobre 27 to novembre 3, 2016 sur le CFV *Frosti*. Cette étude ciblait le saumon du Pacifique juvénile (*Oncorhynchus* spp.) dans le sud de la Colombie-Britannique (C.-B.). 364,385 individus de 20 espèces ont été capturés au cours de 37 traits. Le sébastes était l'espèce la plus abondante avec 96% de la prise totale. Les espèces de saumon juvénile capturées par ordre décroissant d'abondance par comptage étaient les seuivantes: saumon quinnat juvéniles, saumon kéta juvéniles, saumon rose juvéniles, saumon coho juvéniles et saumon rouge juvéniles, avec la répartition des prises variait selon les espèces. Les échantillons biologiques pour la composition génétique des stocks, les otolithes, des analyses de pathogènes, des analyses de densité énergétique, des analyses d'isotopes stables et les micromarques magnétisées codées ont été retournés à la Station biologique du Pacifique (MPO, Nanaimo, C.-B.). Les informations associées sur l'océanographie physique (37 sites) les échantillions d'eau pour la chimie et la chlorophylle *a* ainsi que les échantillons de zooplancton (37 sites) ont été retournés à l'Institut des sciences de la mer (MPO, Sidney, C.-B.).

1 INTRODUCTION

Fisheries and Oceans Canada (DFO) conducted a trawl survey, targeting juvenile Pacific Salmon (*Oncorhynchus* spp.) from October 27 to November 03, 2016 on the CFV *Frosti*. The main objectives of this survey were:

1. to determine the abundance, condition, distribution, and genetic stock composition of juvenile Pacific Salmon present off the north and west coast of Vancouver Island;
2. the associated physical oceanography; and
3. the distribution and biomass of zooplankton.

This survey was part of an ongoing suite of surveys (1997-2016) which was led by the High Seas Salmon Program at the Pacific Biological Station, Nanaimo, British Columbia (BC) in support of research on Pacific Salmon ocean ecology. These surveys were conducted annually since 1997 (Welch et al. 2002), initially from the Gulf of Alaska to the southern continental shelf of BC, albeit with differences in location, survey area and timing each year.The survey is focused on juvenile Pacific Salmon, specifically Chum Salmon (*O. keta*), Chinook Salmon (*O. tshawytscha*), Coho Salmon (*O. kitsutch*), Pink Salmon (*O. gorbuscha*) and Sockeye Salmon (*O. nerka*). The survey is focused on juvenile Pacific Salmon. This data report documents the biological, oceanographic, and zooplankton data and samples collected.

2 METHODS

2.1 SURVEY LOCATIONS

Fishing, oceanographic, and zooplankton sampling occurred off the west coast of Vancouver Island, including Queen Charlotte Strait, Quatsino Sound, Esperanza Inlet, and Juan de Fuca Strait (Figure 1).

2.2 FISHING OPERATIONS

The CFV *Frosti* deployed a Cantrawl model 250 midwater trawl net (approximately 90 m long x 30 m wide x 15 m high; (Cantrawl Nets Ltd., Richmond, Canada; Appendix Table A and Appendix Figure B). This three-bridle midwater net had a codend liner with 12.7 mm mesh (stretched) to retain smaller species. On this survey, the mean trawl net opening was 30 m wide by 12 m high, or an area of 360 m^2.

Tow speed averaged 7.6 km/hr, and varied between 5.4 to 9.1 km/hr speed over ground, depending on the wind, tide, and current. The target headrope depths were 0 m, 15 m, and 30 m. Warp length ranged from 100 m to 200 m (Appendix C). Tow duration was 30 min with the time starting when the Jet 5 m^2 trawls doors were locked and the net started fishing.

2.3 CATCH PROCESSING

All fish were sorted to species and counted. If the catch of a species was too large to effectively count within a reasonable timeframe, the species' catch was weighed (kg) and a subsample was counted and weighed to extrapolate an estimated catch count. The catch (count) of juvenile Pacific Salmon by species was divided by swept volume (km^3) to calculate catch per unit effort (CPUE).

2.4 BIOLOGICAL SAMPLING

All Pacific Salmon specimens were measured for fork length (mm) and weight (g), sex determined, and presence of sea lice recorded. Pacific Salmon were divided into juveniles and adults based on their fork lengths. All Pacific Salmon species that were < 350 mm in length were considered juveniles, except for Coho Salmon whose length threshold as juveniles was < 400 mm. Additional collections included: fin clips for genetic stock identification (GSI), additional salmon tissues for molecular identification of pathogens, muscle tissue for energy density estimation, stable isotope analyses or proximate analyses, otoliths, adipose fin status (i.e. clipped vs. non-clipped), and coded wire tags (CWTs). Other fish species were measured for length (mm) and weight (g) as time permitted.

2.5 OCEANOGRAPHY

A Sea-Bird SBE25 CTD (conductivity-temperature-depth; Sea-Bird Scientific, Bellevue, WA) was used for oceanographic profiles at 37 locations (Figure 1, Appendix D). A Niskin bottle at 10 m from the surface was used for nutrient and chlorophyll (chl *a*) collections. Seawater samples for nitrate, phosphate, and silicate were placed in acid-washed glass test tubes and frozen. Seawater samples for chl *a* estimation were filtered with 25 mm GF/F glass fibre filter disks under vacuum, not exceeding 5 inHg (inch of mercury). Filter disks were then placed in polypropylene scintillation vials and frozen. Both the nutrient and chl *a* samples were frozen and maintained at -18℃. Nutrient and chl *a* samples were sent for analyses at the Institute of Ocean Sciences (DFO, Sidney, BC).

2.6 ZOOPLANKTON

At 37 locations (Figure 1, Appendix D), vertical tows to sample zooplankton were conducted to approximately 250 m or within 10 m of the bottom with two 60 cm diameter, 253 μm mesh nets mounted in a bongo-drum style frame, one of which was equipped with a flow meter. Zooplankton collected from one bongo net were preserved in 10% formalin and sent to the zooplankton laboratory at the Institute of Ocean Sciences (DFO, Sidney, BC) for species enumeration. The zooplankton sample from the other bongo net was sorted into four size fractions by successively sieving through 8.0, 1.7, 1.0, and 0.25 mm screens. Individual size fractions were frozen for future stable isotope, energy density, or proximate analyses and sent to the Pacific Biological Station (DFO, Nanaimo, BC) for processing or archiving.

3 RESULTS

3.1 FISHING OPERATIONS

This survey conducted 37 trawl net tows off the north and west coast of Vancouver Island (Figure 1, Appendix C) with 37 trawls completed successfully. There were 0 unusable tows.

3.2 CATCH COMPOSITION

Total catch for the survey from usable tows was 364,385 fish, with 1,852 (or 1%) juvenile Pacific Salmon. Detailed catch composition for each tow is included in Appendix E. For each species captured during the survey, the number of tows in which the species was present, total catch count, maximum tow catch count, and mean tow catch count in usable tows is presented in Table 1. The top three abundant species caught by count were Rockfishes (n=350,042), Pacific Herring (n=8,753), then Opalescent Inshore Squid (n=2,848; Table 1). Juvenile Pacific Salmon species caught, in order of abundance by count, were: Chinook Salmon, Chum Salmon, Pink Salmon, Coho Salmon and Sockeye Salmon. The survey targeted juvenile Pacific Salmon so the catches of adult Pacific Salmon should be interpreted with care.

The location and catch per unit effort (CPUE, count/km^3) of juvenile salmon is shown in Figure 2. Juvenile Chinook Salmon were caught throughout the survey region, and in higher abundance in Quatsino Sound, Esperanza Inlet, off Clayquot and Barkley Sounds and in Juan de Fuca Strait. Juvenile Chum Salmon were captured in high abundance in Queen Charlotte Strait, Quatsino Sound and Juan de Fuca Strait, and sporadically in the remaining survey area. Juvenile Coho Salmon were captured in low numbers throughout the survey area. Juvenile Pink Salmon were caught primarily in Queen Charlotte Strait and Juan de Fuca Strait. Few juvenile Pink Salmon were expected given that Pink Salmon have alternating large and small return years. Juvenile Sockeye Salmon were localized within their migratory corridors through Queen Charlotte Sound and Juan de Fuca Strait.

3.3 BIOLOGICAL SAMPLES

Samples were collected for GSI (n=784), otoliths (n=788), pathogen analyses (n=186), energy density and stable isotope analyses (n=878). CWTs (n=70) when present and detected were retained. These biological samples are located at the Pacific Biological Station, Fisheries and Oceans Canada (Nanaimo, BC).

3.4 LENGTH AND WEIGHT

Length frequencies and length-weight relationships are presented for juvenile Pacific Salmon species in Figures 3 to 7. Double log transformed length-weight regressions coefficients for Chinook and Coho Salmon were the highest, and were the lowest for Pink Salmon. A larger

coefficient typically represents better condition, whereas a smaller coefficient typically represents worse condition. Lengths and weights of 15 species were recorded (Table 2). The length frequencies for species with greater than 50 length measurements (Opalescent Inshore Squid, Pacific Herring, Sablefish and Rockfishes) are presented in Figure 8.

Within juvenile Pacific salmon, Coho Salmon had the largest maximum length (299 mm) and weight (332 g), whereas Sockeye Salmon had the smallest maximum length (173 mm) and weight (58 g).

3.5 OCEANOGRAPHY

CTD casts and water samples were completed at 37 sites with cast depths ranging from 33 m to 215 m (Appendix D). Oceanographic data from the CTD casts and nutrient analysis of the water samples are archived online within the Water Properties Data Inventory (Institute of Ocean Sciences, DFO, Sidney, BC) under cruise number 201640.

3.6 ZOOPLANKTON

Vertical bongo tows were conducted at 37 stations to depths ranging from 33 m to 225 m (Appendix D). Zooplankton enumeration data are archived in the zooplankton database (Institute of Ocean Sciences, DFO, Sidney, BC) under cruise number 201640.

4 DISCUSSION

This juvenile Pacific Salmon trawl survey collected valuable information on distribution, abundance, condition, and genetic stock composition for juvenile Pacific Salmon off the north and west coast of Vancouver Island. Overall, juvenile Chinook Salmon and juvenile Chum Salmon were most abundant, whereas juvenile Sockeye Salmon were least abundant. Distributions varied by species and life stage. This survey data supplements historic juvenile Pacific Salmon surveys that have been reported in Fisheries and Oceans Canada's State of the Pacific Ocean, and are being incorporated into longer term and broader scope research projects.

5 ACKNOWLEDGEMENTS

We would like to thank the Captain John Roach, and crew of the CFV *Frosti*. Marc Trudel was the High Seas Salmon Program Lead in 2016. Mary Thiess was the Chief Scientist. We appreciate the expertise of additional science staff who participated in the survey, in particular Hugh Maclean who conducted oceanographic sampling.

6 REFERENCES

Welch, D.W., Morris, J.F.T., and Demers, E. 2002. CCGS *W.E. Ricker* Gulf of Alaska salmon survey, March - April, 1997. Can. Data Rep. Fish. Aquat. Sci. 1101: 19 p.

7 TABLES

Table 1. All captured species (or taxonomic group), ordered by total catch count, showing number of tows in which the species occurred, total catch count, maximum catch count, and mean catch count per tow for usable tows during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. Rockfish catch is estimated from subsample and they are juveniles with average length of 98.48 mm.

Common Name	Scientific Name	Tows	Count	Max	Mean
Rockfishes	*Sebastes*	6	350,042	350,000	58,340
Pacific Herring	*Clupea pallasii*	19	8,753	8,317	461
Opalescent Inshore Squid	*Doryteuthis opalescens*	20	2,848	900	142
Chinook Salmon (Juveniles)	*Oncorhynchus tshawytscha*	34	1,017	80	30
Sablefish	*Anoplopoma fimbria*	22	745	630	34
Chum Salmon (Juveniles)	*Oncorhynchus keta*	21	408	65	19
Pink Salmon (Juveniles)	*Oncorhynchus gorbuscha*	13	273	91	21
Coho Salmon (Juveniles)	*Oncorhynchus kisutch*	17	108	21	6
Chum Salmon (Adults)	*Oncorhynchus keta*	10	55	20	6
Sockeye Salmon (Juveniles)	*Oncorhynchus nerka*	8	46	21	6
Chinook Salmon (Adults)	*Oncorhynchus tshawytscha*	8	42	26	5
Shiner Perch	*Cymatogaster aggregata*	3	17	8	6
Jack Mackerel	*Trachurus symmetricus*	6	11	3	2
Prowfish	*Zaprora silenus*	5	6	2	1
Pacific Pomfret	*Brama japonica*	3	5	3	2
Wolf Eel	*Anarrhichthys ocellatus*	3	3	1	1
Whitebait Smelt	*Allosmerus elongatus*	2	3	2	2
Coho Salmon (Adults)	*Oncorhynchus kisutch*	1	1	1	1
Pacific Saury	*Cololabis saira*	1	1	1	1
Smelts	*Osmeridae*	1	1	1	1

Table 2. Lengths and weights for each species (arranged descending by the number of length measurements for each by species) sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. Tows = number of tows. Type = Type of length measurement (FL = Fork Length, TL = Total Length, SL = Standard Length, ML = Mantle Lenth, BD = Bell Diameter). Measured = number of length measurements. Weighed = number of weight measurements.

		Length (mm)					Weight (g)			
Common Name	Tows	Type	Measured	Min	Max	Mean	Weighed	Min	Max	Mean
Chinook Salmon	34	FL	1,059	74	530	207	807	30	1,881	145
Chum Salmon	23	FL	463	169	773	282	172	55	268	131
Opalescent Inshore Squid	20	ML	402	12	120	31				
Pink Salmon	13	FL	273	198	270	230	103	88	227	128
Pacific Herring	15	FL	224	78	240	135				
Sablefish	22	FL	159	221	291	251				
Rockfishes	6	TL	136	28	165	91				
Coho Salmon	17	FL	102	219	569	301	94	143	894	332
Sockeye Salmon	8	FL	46	135	203	173	46	35	90	58
Shiner Perch	2	TL	9	75	83	78				
Prowfish	5	TL	6	35	262	108				
Pacific Pomfret	3	FL	5	45	51	49				
Whitebait Smelt	2	FL	4	56	144	100				
Wolf Eel	3	TL	4	525	603	563				
Pacific Saury	1	FL	1	150	150	150				

8 FIGURES

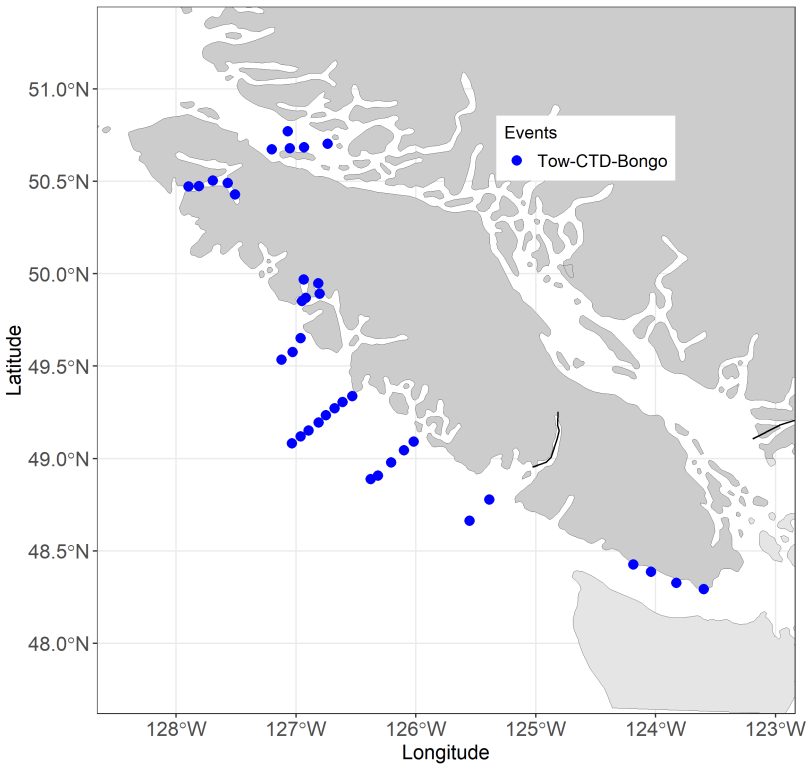

Figure 1. Location of survey events (fishing tows, CTD casts and zooplankton bongo casts) during the juvenile Pacific Salmon trawl survey from October 27 to November 03, 2016 on the CFV *Frosti*.

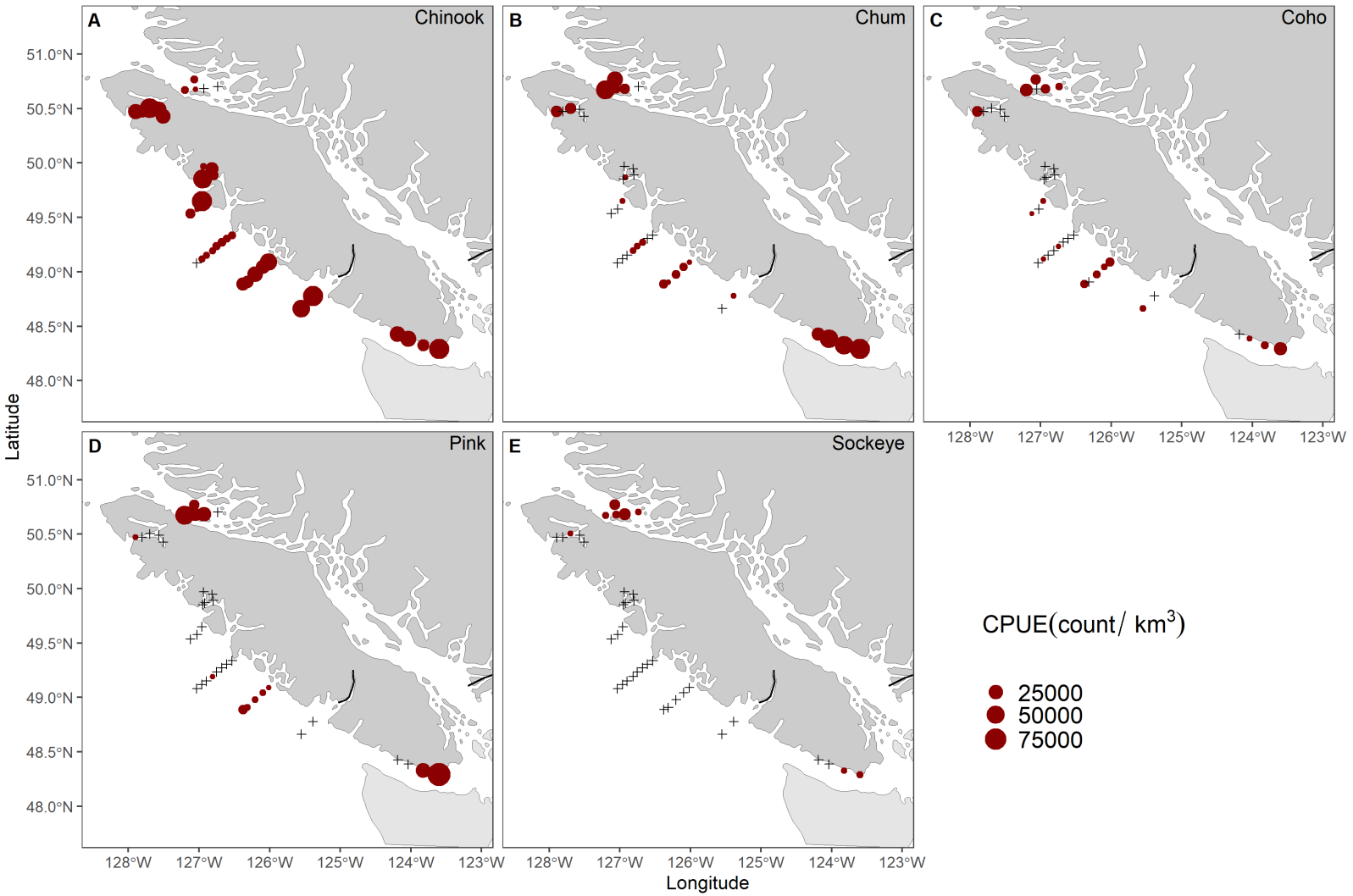

Figure 2. Juvenile Pacific Salmon (*Oncorhynchus* spp.) catch (count) per unit effort (CPUE; count/km^3) for each tow. Circles are proportional to maximum abundance, and zero catches are shown with a cross (+).

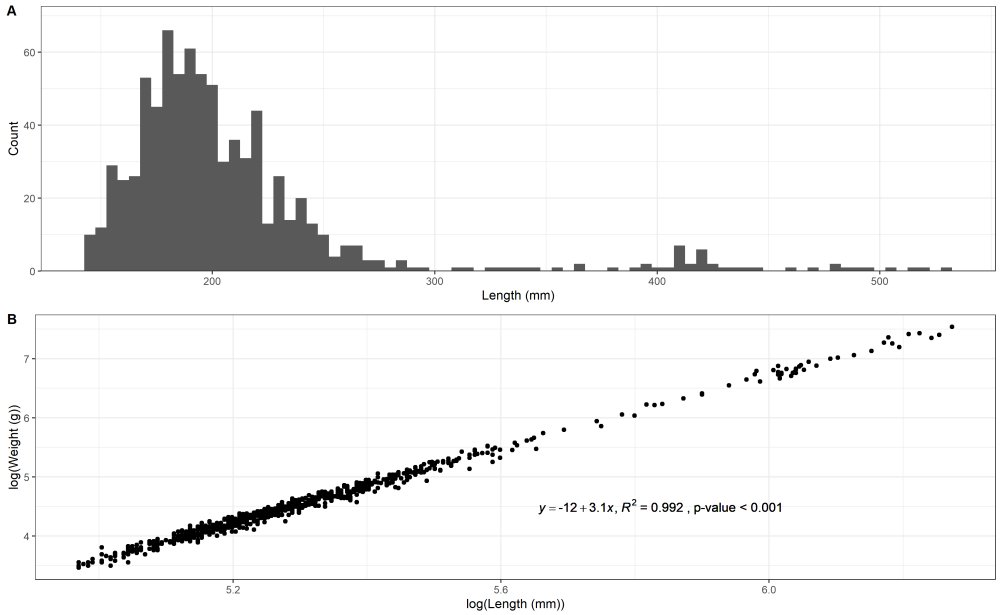

Figure 3. *A.* Chinook Salmon (*Oncorhynchus tshawytscha*) length frequency plot as sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. *B.* Double log-transformed length-weight regression with outliers removed, using a Bonferroni outlier test.

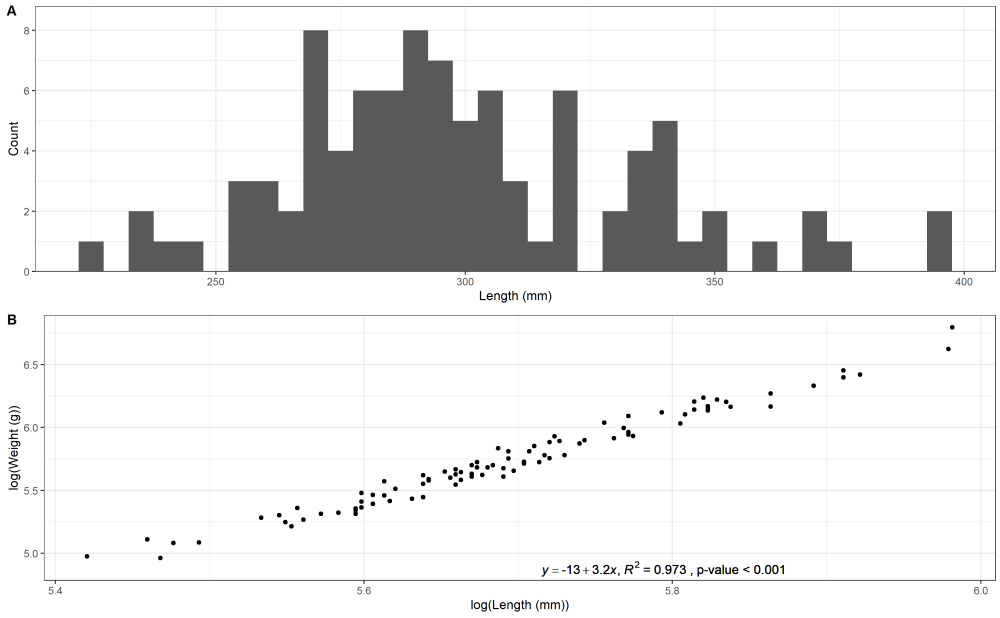

Figure 4. **A.** Coho Salmon (*Oncorhynchus kisutch*) length frequency plot as sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. **B.** Double log-transformed length-weight regression with outliers removed, using a Bonferroni outlier test.

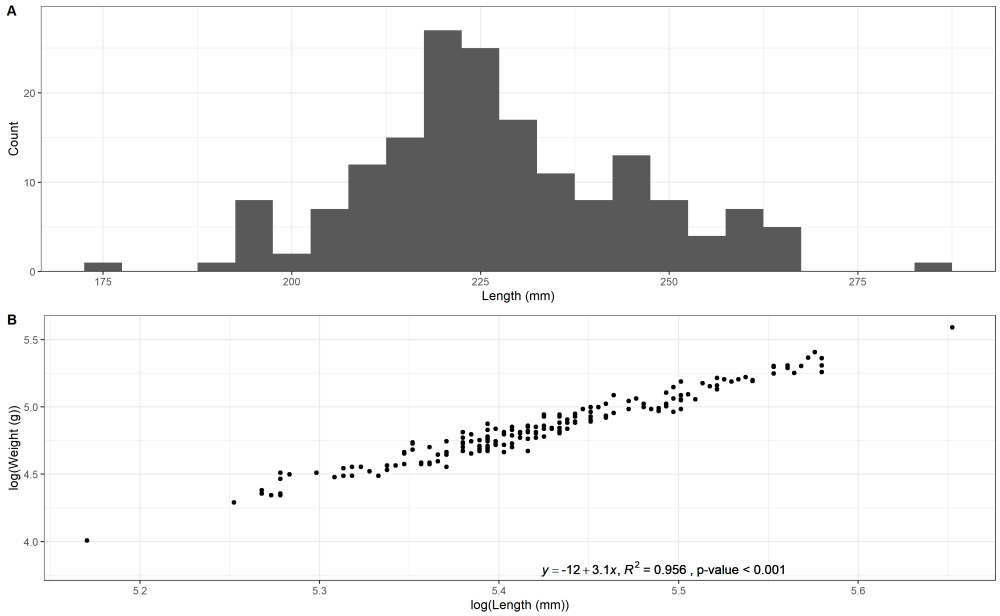

Figure 5. **A.** Chum Salmon (*Oncorhynchus keta*) length frequency plot as sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. **B.** Double log-transformed length-weight regression with outliers removed, using a Bonferroni outlier test.

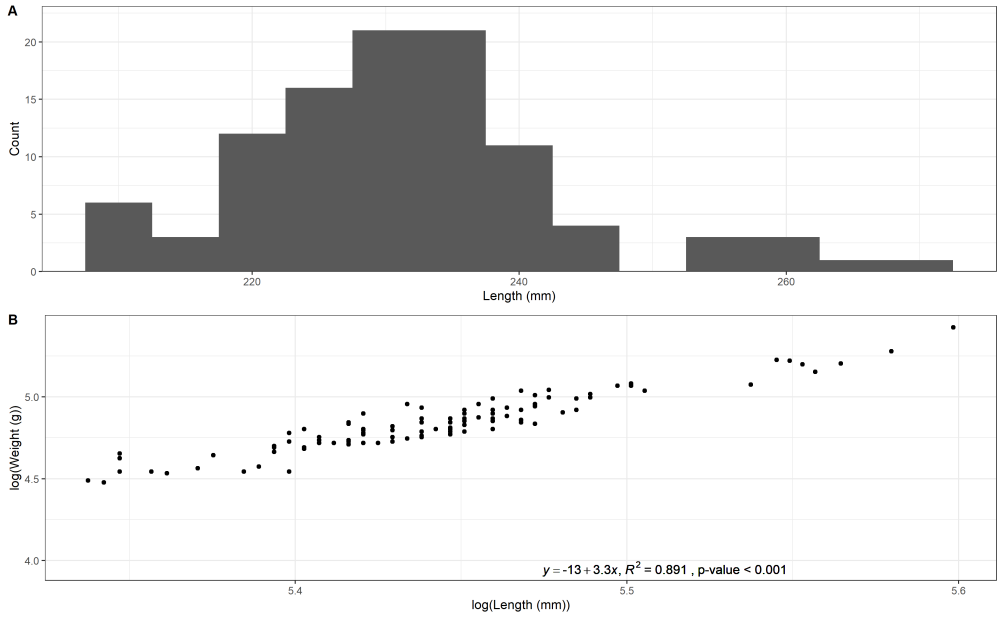

Figure 6. **A.** Pink Salmon (*Oncorhynchus gorbusha*) length frequency plot as sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. **B.** Double log-transformed length-weight regression with outliers removed, using a Bonferroni outlier test.

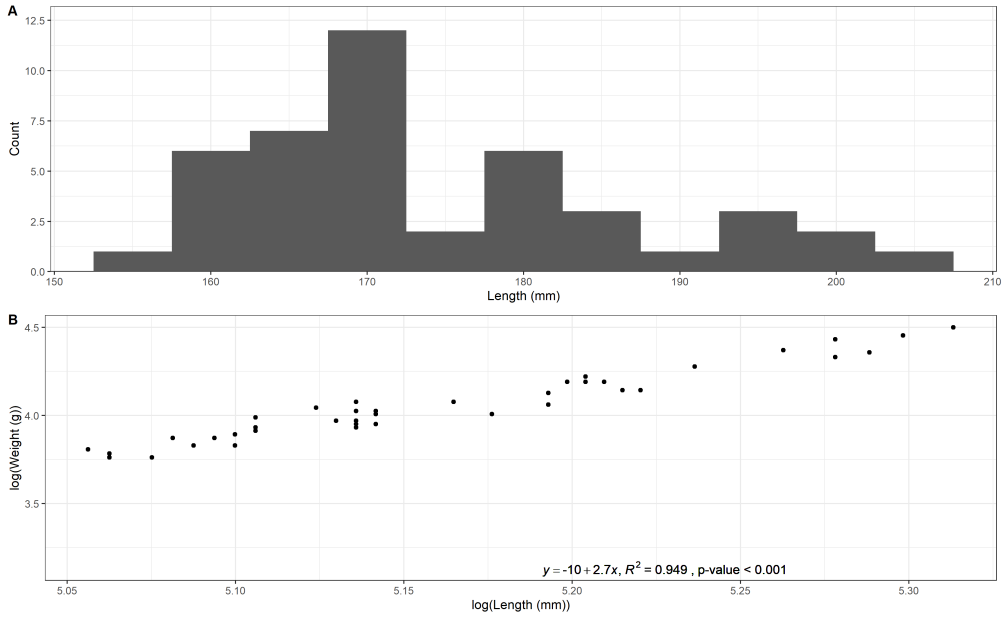

Figure 7. **A.** Sockeye Salmon (*Oncorhynchus nerka*) length frequency plot as sampled during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. **B.** Double log-transformed length-weight regression with outliers removed, using a Bonferroni outlier test.

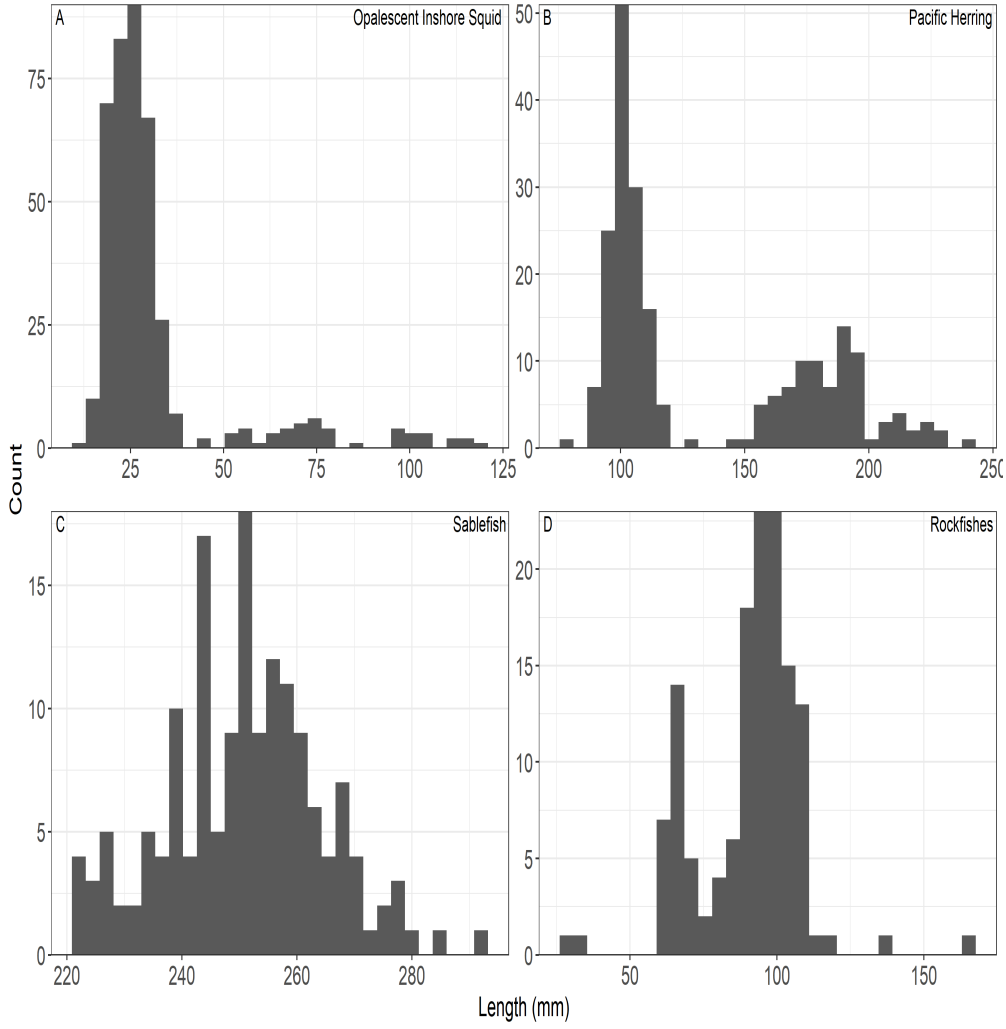

Figure 8. Length (mm) frequency plots for common species sampled (n>50 samples) during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016. **A.** Opalescent Inshore Squid (*Doryteuthis opalescens*), length = Mantle Length, **B.** Pacific Herring (*Clupea pallasii*), length = Fork Length, **C.** Sablefish (*Anoplopoma fimbria*), length = Fork Length, **D.** Rockfishes (*Sebastes*), length = Total Length.

APPENDIX A CANTRAWL 250 NET SPECIFICATIONS

Table A.1. Net specifications for the CanTrawl 250 net used during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016.

Part	Size	Material
Doors	2 m^2	Jet
Door Legs	12.2 m (6.67 fm)	1 inch Spectra rope
Bridles	45.72 m (25 fm)	5/8 Wire Rope
Head Line	76.2 m (41.7 fm)	1 1/8 inch Tenex
Foot Rope	76.2 (41.7 fm)	1/2 chain
Mesh incl. Codend	3.8 cm (1.5 inch)	Knotted nylon
Codend Liner	12.7 mm (0.5 inch)	210/20 knotless liner

APPENDIX B CANTRAWL 250 NET DIAGRAM

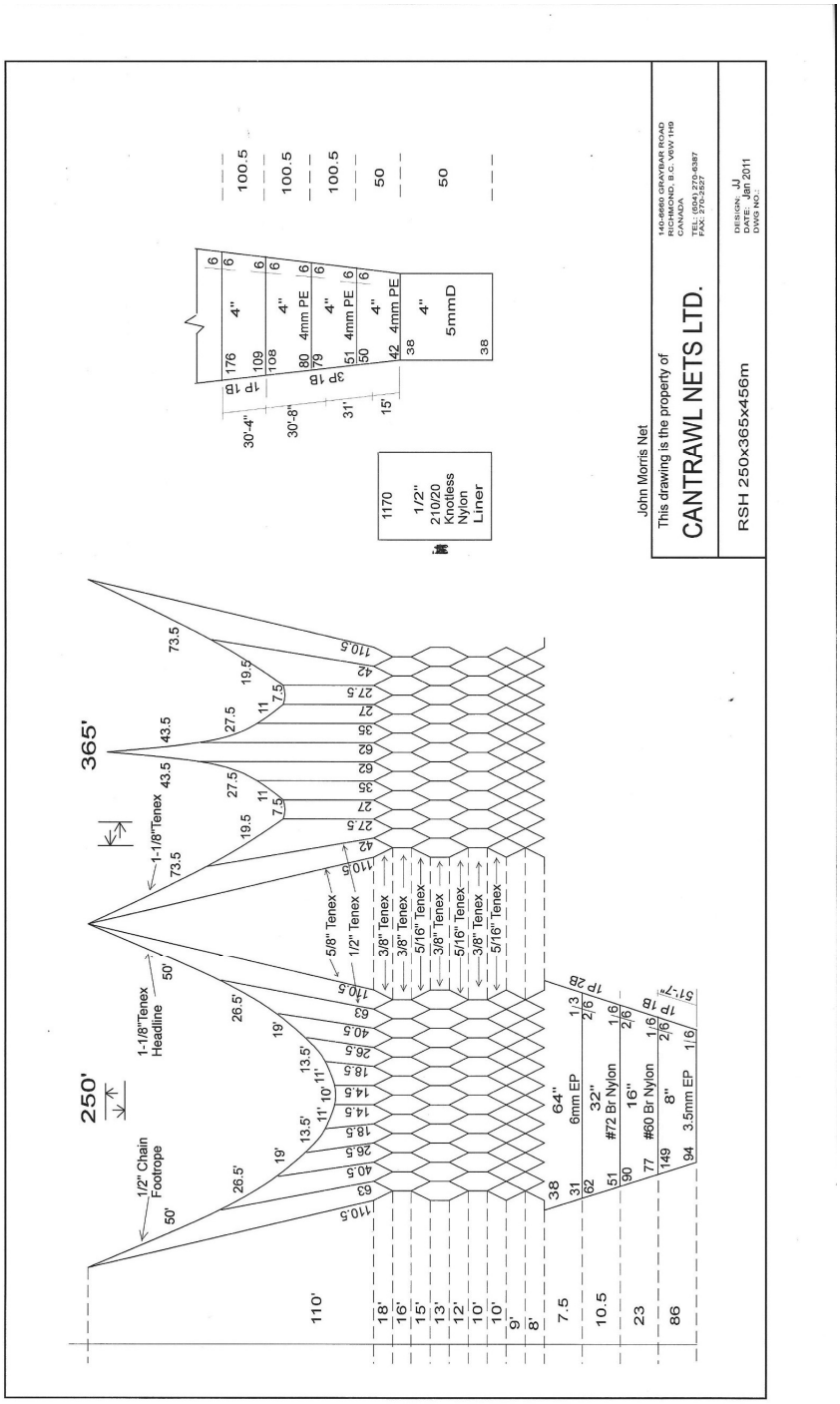

Figure B.1. Net diagram for CanTrawl 250 trawl net used during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016.

APPENDIX C TRAWL BRIDGE LOG DATA

Table C.1. Bridge log information for trawl tows during the juvenile Pacific Salmon trawl survey aboard the CFV *Frosti*, October 27 to November 03, 2016.

Station Name	JF01	JF02	JF03	JF04	IVI01	IVI02
Tow	1	2	3	4	5	6
Date (Pacific)	2016-10-27	2016-10-27	2016-10-27	2016-10-27	2016-10-28	2016-10-28
Start Time (Pacific)	11:00:00	13:22:00	15:25:00	17:07:00	13:30:00	16:12:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	48° 17' 35" N	48° 19' 37" N	48° 23' 13" N	48° 25' 37" N	48° 46' 41" N	48° 39' 43" N
Start Longitude	123° 35' 56" W	123° 49' 37" W	124° 02' 17" W	124° 11' 10" W	125° 23' 17" W	125° 33' 07" W
End Latitude	48° 17' 31" N	48° 20' 10" N	48° 23' 49" N	48° 26' 10" N	48° 45' 18" N	48° 41' 20" N
End Longitude	123° 38' 10" W	123° 51' 43" W	124° 04' 55" W	124° 14' 35" W	125° 25' 16" W	125° 34' 59" W
Direction of Tow (deg)	268	291	289	283	223	323
Vessel Speed (km/h)	5.4	5.6	6.9	8.5	7.0	7.4
Distance Towed (km)	2.74	2.78	3.43	4.32	3.52	3.76
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	100	200	100	200	100	200
Target Headrope Depth (m)	0	30	0	30	0	30
Start Bottom Depth (m)	157	163	69	81	94	94
End Bottom Depth (m)	168	136	63	60		92
Usable	Y	Y	Y	Y	Y	Y

Station Name	VI01	VI02	VI03	VI04	VI05	EP05
Tow	7	8	9	10	11	12
Date (Pacific)	2016-10-29	2016-10-29	2016-10-29	2016-10-29	2016-10-29	2016-10-30
Start Time (Pacific)	08:30:00	10:19:00	12:35:00	14:57:00	16:45:00	08:17:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	49° 05’ 28" N	49° 02’ 38" N	48° 58’ 41" N	48° 54’ 25" N	48° 53’ 20" N	49° 07’ 07" N
Start Longitude	126° 01’ 01" W	126° 05’ 53" W	126° 12’ 18" W	126° 18’ 54" W	126° 22’ 41" W	126° 57’ 43" W
End Latitude	49° 06’ 43" N	49° 04’ 37" N	49° 00’ 43" N	48° 56’ 20" N	48° 55’ 01" N	49° 08’ 53" N
End Longitude	126° 03’ 43" W	126° 07’ 30" W	126° 14’ 10" W	126° 20’ 42" W	126° 24’ 22" W	126° 59’ 53" W
Direction of Tow (deg)	305	332	329	328	327	323
Vessel Speed (km/h)	8.0	8.3	8.7	8.3	7.4	8.1
Distance Towed (km)	4.02	4.17	4.41	4.19	3.72	4.13
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	100	200	100	150	100	100
Target Headrope Depth (m)	0	30	0	15	0	0
Start Bottom Depth (m)	97	179	41	57	96	139
End Bottom Depth (m)	99	131	42	57	95	144
Usable	Y	Y	Y	Y	Y	Y

Station Name	VI06	EP06	VI07	EP01	EP02	EP03
Tow	13	14	15	16	17	18
Date (Pacific)	2016-10-30	2016-10-30	2016-10-30	2016-10-30	2016-10-30	2016-10-30
Start Time (Pacific)	08:17:00	10:00:00	10:00:00	11:49:00	13:36:00	15:29:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	49° 20’ 13" N	49° 04’ 52" N	49° 18’ 22" N	49° 16’ 19" N	49° 14’ 02" N	49° 11’ 38" N
Start Longitude	126° 31’ 52" W	127° 01’ 59" W	126° 36’ 36" W	126° 40’ 44" W	126° 45’ 00" W	126° 48’ 43" W
End Latitude	49° 20’ 46" N	49° 06’ 47" N	49° 20’ 06" N	49° 17’ 42" N	49° 15’ 58" N	49° 13’ 16" N
End Longitude	126° 35’ 06" W	127° 04’ 05" W	126° 39’ 04" W	126° 43’ 52" W	126° 46’ 44" W	126° 50’ 53" W
Direction of Tow (deg)	284	326	317	304	329	319
Vessel Speed (km/h)	8.0	8.1	8.7	9.1	8.1	8.0
Distance Towed (km)	4.04	4.11	4.39	4.56	4.13	3.98
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	200	150	100	100	150	100
Target Headrope Depth (m)	30	15	0	0	15	0
Start Bottom Depth (m)	141	190	158	46	93	114
End Bottom Depth (m)	141	195	151	47	76	119
Usable	Y	Y	Y	Y	Y	Y

Station Name	EP04	VI08	VI09	VI10	IVI03	IVI04
Tow	19	20	21	22	23	24
Date (Pacific)	2016-10-30	2016-10-31	2016-10-31	2016-10-31	2016-11-01	2016-11-01
Start Time (Pacific)	16:51:00	08:20:00	10:22:00	12:06:00	08:33:00	09:33:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	49° 09’ 04" N	49° 32’ 06" N	49° 34’ 34" N	49° 39’ 00" N	49° 56’ 49" N	49° 53’ 28" N
Start Longitude	126° 53’ 38" W	127° 07’ 19" W	127° 01’ 37" W	126° 57’ 36" W	126° 48’ 47" W	126° 48’ 04" W
End Latitude	49° 10’ 19" N	49° 33’ 22" N	49° 36’ 18" N	49° 37’ 34" N	49° 55’ 01" N	49° 52’ 01" N
End Longitude	126° 56’ 31" W	127° 10’ 34" W	127° 03’ 32" W	126° 55’ 48" W	126° 47’ 31" W	126° 50’ 10" W
Direction of Tow (deg)	304	301	324	141	156	223
Vessel Speed (km/h)	8.3	9.1	7.8	6.9	7.2	7.2
Distance Towed (km)	4.20	4.54	3.96	3.43	3.67	3.67
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	200	100	150	100	100	150
Target Headrope Depth (m)	30	0	15	0	0	15
Start Bottom Depth (m)	123	133	107	47	159	242
End Bottom Depth (m)	122	139	109	45	180	197
Usable	Y	Y	Y	Y	Y	Y

Station Name	IVI05	IVI06	IVI07	IVI08	IVI09	IVI10
Tow	25	26	27	28	29	30
Date (Pacific)	2016-11-01	2016-11-01	2016-11-01	2016-11-02	2016-11-02	2016-11-02
Start Time (Pacific)	11:54:00	13:39:00	15:42:00	08:39:00	10:10:00	11:55:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	49° 52’ 05" N	49° 58’ 08" N	49° 51’ 07" N	50° 25’ 41" N	50° 29’ 24" N	50° 30’ 14" N
Start Longitude	126° 55’ 08" W	126° 56’ 10" W	126° 57’ 00" W	127° 30’ 32" W	127° 34’ 12" W	127° 41’ 42" W
End Latitude	49° 54’ 00" N	49° 56’ 13" N	49° 51’ 54" N	50° 27’ 50" N	50° 30’ 40" N	50° 29’ 46" N
End Longitude	126° 55’ 59" W	126° 55’ 52" W	126° 54’ 18" W	127° 31’ 52" W	127° 36’ 18" W	127° 44’ 42" W
Direction of Tow (deg)	344	174	66	339	313	256
Vessel Speed (km/h)	7.4	7.0	7.0	8.5	6.7	7.2
Distance Towed (km)	3.70	3.57	3.54	4.30	3.41	3.65
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	100	200	100	100	150	100
Target Headrope Depth (m)	0	30	0	0	15	0
Start Bottom Depth (m)	225	179	185	164	224	125
End Bottom Depth (m)	263	190	96	188	122	115
Usable	Y	Y	Y	Y	Y	Y

Station Name	IVI11	IVI12	QCST01	QCST02	QCST03	QCST04
Tow	31	32	33	34	35	36
Date (Pacific)	2016-11-02	2016-11-02	2016-11-03	2016-11-03	2016-11-03	2016-11-03
Start Time (Pacific)	13:34:00	15:19:00	08:27:00	10:19:00	11:45:00	13:45:00
Net	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250	CanTrawl 250
Duration (min)	30	30	30	30	30	30
Start Latitude	50° 28’ 23" N	50° 28’ 16" N	50° 40’ 19" N	50° 40’ 44" N	50° 41’ 02" N	50° 42’ 07" N
Start Longitude	127° 48’ 29" W	127° 53’ 46" W	127° 12’ 11" W	127° 03’ 04" W	126° 55’ 55" W	126° 44’ 06" W
End Latitude	50° 29’ 02" N	50° 28’ 05" N	50° 40’ 23" N	50° 40’ 34" N	50° 40’ 19" N	50° 43’ 59" N
End Longitude	127° 51’ 11" W	127° 56’ 53" W	127° 09’ 18" W	126° 59’ 49" W	126° 52’ 48" W	126° 45’ 43" W
Direction of Tow (deg)	291	265	88	95	110	331
Vessel Speed (km/h)	6.7	7.4	6.7	7.6	7.8	7.8
Distance Towed (km)	3.41	3.70	3.39	3.82	3.91	3.94
Net Opening Height (m)	12	12	12	12	12	12
Net Opening Width (m)	30	30	30	30	30	30
Warp Length (m)	200	100	150	150	100	200
Target Headrope Depth (m)	30	0	0	15	0	30
Start Bottom Depth (m)	140	168	66	110	150	98
End Bottom Depth (m)	166	215	48	112	151	92
Usable	Y	Y	Y	Y	Y	Y

Station Name	QCST05
Tow	37
Date (Pacific)	2016-11-03
Start Time (Pacific)	16:16:00
Net	CanTrawl 250
Duration (min)	30
Start Latitude	50° 46’ 12" N
Start Longitude	127° 04’ 08" W
End Latitude	50° 47’ 02" N
End Longitude	127° 07’ 08" W
Direction of Tow (deg)	294
Vessel Speed (km/h)	7.6
Distance Towed (km)	3.85
Net Opening Height (m)	12
Net Opening Width (m)	30
Warp Length (m)	100
Target Headrope Depth (m)	0
Start Bottom Depth (m)	157
End Bottom Depth (m)	202
Usable	Y

APPENDIX D CTD CASTS AND ZOOPLANKTON TOWS

Table D.1. CTD casts and vertical bongo tow times and depths during the juvenile Pacific Salmon trawl survey from October 27 to November 03, 2016 on the CFV *Frosti*.

				CTD			BONGO		
Date	Station	Latitude	Longitude	Start Time (PDT)	Bottom Depth (m)	Gear Depth (m)	Start Time (PDT)	Bottom Depth (m)	Gear Depth (m)
2016-10-27	JF01	48° 17' 35" N	123° 35' 56" W	10:22	170	160	10:39	170	160
2016-10-27	JF02	48° 19' 37" N	123° 49' 37" W	05:40	140	130	12:59	140	130
2016-10-27	JF03	48° 23' 13" N	124° 02' 17" W	07:45	55	45	15:06	55	45
2016-10-27	JF04	48° 25' 37" N	124° 11' 10" W	09:34	74	64	16:44	74	64
2016-10-28	IVI01	48° 46' 41" N	125° 23' 17" W	01:17	90	88	08:28	98	88
2016-10-28	IVI02	48° 39' 43" N	125° 33' 07" W	03:40	97	87	10:49	97	87
2016-10-28	VI01	49° 05' 28" N	126° 01' 01" W	05:48	97	87	13:00	97	87
2016-10-28	VI02	49° 02' 38" N	126° 05' 53" W	08:15	177	167	15:32	177	167
2016-10-29	VI03	48° 58' 41" N	126° 12' 18" W	00:48	43	33	07:53	43	33
2016-10-29	VI04	48° 54' 25" N	126° 18' 54" W	02:42	58	48	09:50	58	48
2016-10-29	VI05	48° 53' 20" N	126° 22' 41" W	04:52	96	86	12:06	96	86
2016-10-29	VI06	49° 20' 13" N	126° 31' 52" W	07:07	142	132	14:24	142	132
2016-10-29	VI07	49° 18' 22" N	126° 36' 36" W	09:05	157	147	16:22	157	147
2016-10-30	EP01	49° 16' 19" N	126° 40' 44" W	00:42	50	40	07:49	50	40
2016-10-30	EP02	49° 14' 02" N	126° 45' 00" W	02:23	91	81	09:32	91	81
2016-10-30	EP03	49° 11' 38" N	126° 48' 43" W	04:08	114	104	11:20	114	104
2016-10-30	EP04	49° 09' 04" N	126° 53' 38" W	05:53	123	113	13:06	123	113
2016-10-30	EP05	49° 07' 07" N	126° 57' 43" W	07:46	149	139	15:02	149	139
2016-10-30	EP06	49° 04' 52" N	127° 01' 59" W	10:51	190	180	17:40	235	225
2016-10-31	VI08	49° 32' 06" N	127° 07' 19" W	00:35	135	135	07:56	135	125
2016-10-31	VI09	49° 34' 34" N	127° 01' 37" W	02:43	108	98	09:54	108	98
2016-10-31	VI10	49° 39' 00" N	126° 57' 36" W	04:40	47	37	11:46	47	37
2016-11-01	IVI03	49° 56' 49" N	126° 48' 47" W	00:53	159	149	08:09	159	149
2016-11-01	IVI04	49° 53' 28" N	126° 48' 04" W	03:23	216	206	10:43	226	216
2016-11-01	IVI05	49° 52' 05" N	126° 55' 08" W	04:28	192	182	11:21	192	182
2016-11-01	IVI06	49° 58' 08" N	126° 56' 10" W	05:57	194	184	13:16	194	184
2016-11-01	IVI07	49° 51' 07" N	126° 57' 00" W	07:54	138	128	15:11	138	128
2016-11-02	IVI08	50° 25' 41" N	127° 30' 32" W	00:58	166	156	08:17	166	156

Date	Station	Latitude	Longitude	CTD			BONGO		
				Start Time (PDT)	Bottom Depth (m)	Gear Depth (m)	Start Time (PDT)	Bottom Depth (m)	Gear Depth (m)
2016-11-02	IVI09	50° 29' 24" N	127° 34' 12" W	02:30	178	168	09:46	178	168
2016-11-02	IVI10	50° 30' 14" N	127° 41' 42" W	04:17	117	107	11:30	117	107
2016-11-02	IVI11	50° 28' 23" N	127° 48' 29" W	05:52	135	125	13:06	135	125
2016-11-02	IVI12	50° 28' 16" N	127° 53' 46" W	07:29	225	215	14:51	225	215
2016-11-03	QCST01	50° 40' 19" N	127° 12' 11" W	00:53	69	59	08:01	69	59
2016-11-03	QCST02	50° 40' 44" N	127° 03' 04" W	02:36	103	93	09:47	103	93
2016-11-03	QCST03	50° 41' 02" N	126° 55' 55" W	04:16	75	65	11:26	75	65
2016-11-03	QCST04	50° 42' 07" N	126° 44' 06" W	06:10	100	90	13:19	100	90
2016-11-03	QCST05	50° 46' 12" N	127° 04' 08" W	08:43	218	208	15:56	218	208

APPENDIX E CATCH DATA

Table E.1. Catch (counts) of species (or taxonomic groups where species identification could not be made with certainty) captured during the juvenile Pacific Salmon trawl survey from October 27 to November 03, 2016 on the CFV *Frosti*. Rockfish catch is estimated from subsample and they are juveniles with average length of 98.48 mm.

Tow	1	2	3	4	5	6	7	8	9	10	11
Station ID	JF01	JF02	JF03	JF04	IVI01	IVI02	VI01	VI02	VI03	VI04	VI05
Chinook Salmon (Adults)		7		26		1	1		2		
Chinook Salmon (Juveniles)	64	15	42	51	80	60	62	35	51	24	25
Chum Salmon (Adults)	2				2		20		20	4	
Chum Salmon (Juveniles)	65	51	65	31	1		1	5	7	1	7
Coho Salmon (Adults)			1								
Coho Salmon (Juveniles)	19	3	1			2	8	2	5		5
Pink Salmon (Juveniles)	91	28					1	2	2	2	8
Sockeye Salmon (Juveniles)	2	1									
Jack Mackerel				1				3	1		
Opalescent Inshore Squid		13	12	143	510		130	130	265	900	
Pacific Herring			1	1	3	5			22	73	1
Pacific Pomfret				1			3				
Pacific Saury											
Prowfish								1		1	
Rockfishes											
Sablefish	2			1				1	1	2	14
Shiner Perch											
Smelts				1							
Whitebait Smelt				2	1						
Wolf Eel			1		1			1			
TOTAL	245	118	123	258	598	68	226	180	376	1007	60

Tow	12	13	14	15	16	17	18	19	20	21	22
Station ID	EP05	VI06	EP06	VI07	EP01	EP02	EP03	EP04	VI08	VI09	VI10
Chinook Salmon (Adults)											
Chinook Salmon (Juveniles)	3	4		5	7	6	3	3	13	1	80
Chum Salmon (Adults)											1
Chum Salmon (Juveniles)					3	2	2				1
Coho Salmon (Adults)											
Coho Salmon (Juveniles)	1					1			1		1
Pink Salmon (Juveniles)							1				
Sockeye Salmon (Juveniles)											
Jack Mackerel			2	3							1
Opalescent Inshore Squid			2				72	4	2		160
Pacific Herring					251						18
Pacific Pomfret											1
Pacific Saury											
Prowfish			1	2							
Rockfishes			2		350000						
Sablefish	11	6		31	1	10	5	3	2	630	3
Shiner Perch											
Smelts											
Whitebait Smelt											
Wolf Eel											
TOTAL	15	10	7	41	350262	19	83	10	18	631	266

Tow	23	24	25	26	27	28	29	30	31	32	33
Station ID	IVI03	IVI04	IVI05	IVI06	IVI07	IVI08	IVI09	IVI10	IVI11	IVI12	QCST01
Chinook Salmon (Adults)					2				2	1	
Chinook Salmon (Juveniles)	26	12	41	2	69	44	40	80	20	40	4
Chum Salmon (Adults)			1		1						
Chum Salmon (Juveniles)			1					15		17	65
Coho Salmon (Adults)											
Coho Salmon (Juveniles)										14	21
Pink Salmon (Juveniles)										1	65
Sockeye Salmon (Juveniles)								1			2
Jack Mackerel											
Opalescent Inshore Squid	62		7	5	24	390		15	2		
Pacific Herring		2	2	8332	34	7		1			
Pacific Pomfret											
Pacific Saury										1	
Prowfish										1	
Rockfishes	36	2				1			1		
Sablefish								1		1	
Shiner Perch	8	1				8					
Smelts											
Whitebait Smelt											
Wolf Eel											
TOTAL	132	17	52	8339	130	450	40	113	25	76	157

Tow	34	35	36	37
Station ID	QCST02	QCST03	QCST04	QCST05
Chinook Salmon (Adults)				
Chinook Salmon (Juveniles)	1			4
Chum Salmon (Adults)		2	2	
Chum Salmon (Juveniles)	8	13		47
Coho Salmon (Adults)				
Coho Salmon (Juveniles)		9	3	12
Pink Salmon (Juveniles)	24	36		12
Sockeye Salmon (Juveniles)	4	21	2	13
Jack Mackerel				
Opalescent Inshore Squid				
Pacific Herring				
Pacific Pomfret				
Pacific Saury				
Prowfish				
Rockfishes				
Sablefish	1	1	17	1
Shiner Perch				
Smelts				
Whitebait Smelt				
Wolf Eel				
TOTAL	38	82	24	89