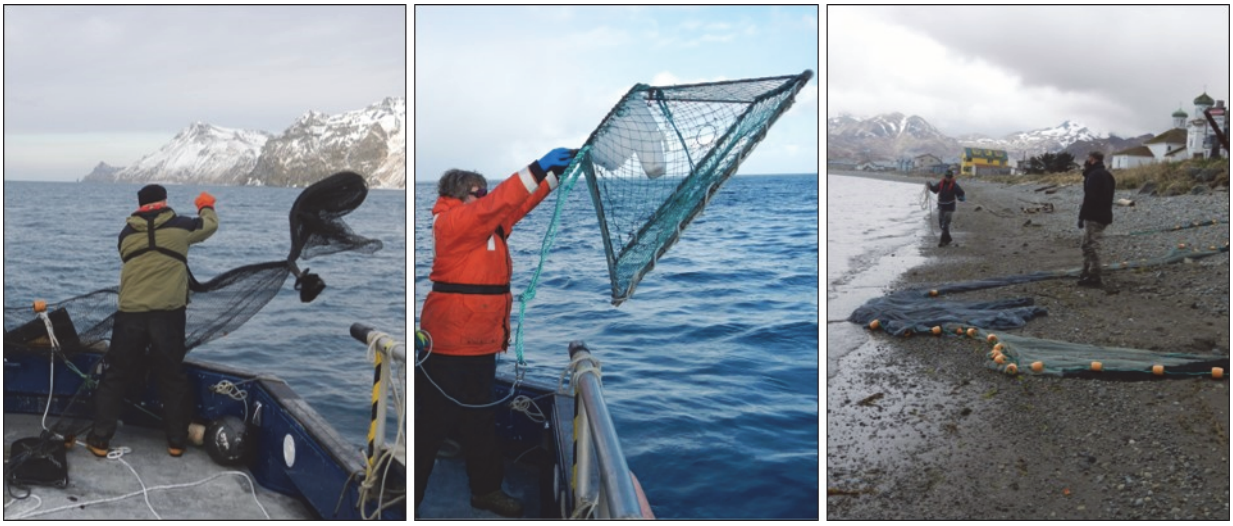
APPENDIX C
MARINE BIOTA IN ILIULIUK BAY

Marine Biota in Iliuliuk Bay, Alaska

Project Report



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Overview

Fish and invertebrates were sampled with a bottom trawl, crab pots, and a beach seine in Iliuliuk Bay, Alaska during winter (February 21-22, spring (May 16-17), summer (August 2-4), and fall (October 12-13) of 2017. Sampling was conducted by Chris Hoffman, Mike Rouse, Matt Ferguson, and Chris Floyd with the U.S. Army Corps of Engineers (USACE) Alaska District and by Darcie Neff with Alaska BioMap. Sampling took place from both the 43' F/V *Miss Alyssa* and a rigid-hulled inflatable boat (RIB), each skippered by Jimmer McDonald of Mac Enterprises.

Objectives

1. Identify seasonal presence and relative abundance of marine biota in select areas in Iliuliuk Bay that may be affected by proposed dredging and placement of dredged material.
2. Provide the USACE with a summary report of findings that supplement environmental analysis documents regarding proposed dredging operations in Iliuliuk Bay.

Study area

Sampling occurred at 22 sites among 7 areas in Iliuliuk Bay (Fig. 1, Table 1). Areas 1 through 6 were offshore, ranging from depths of 15 to 66 m. Each of the five deepest offshore areas (i.e., 1-5) were selected as potential locations for the disposal of dredged material and included up to one trawl transect and two crab pot sites per season. The shallowest offshore area (i.e., 6) encompassed the proposed location of dredging and included up to one trawl transect and four crab pot sites per season. Area 7 encompassed a nearshore location < 5 m deep that could be affected by an altered wave environment due to dredging; this area included two beach seine sites that were sampled only in spring and summer.

Methods

***Bottom trawl*:** Fish and invertebrates were sampled during daylight hours at water depths from 15 to 60 m with a bottom trawl in areas 1 through 6. Tows were made at 6 sites, for a total of 22 sets (Fig. 1, Table 1). Area 4 was not trawled in spring, and the trawl in area 6 during fall was aborted when an enormous boulder estimated at > 1 m^3 was caught. The trawl net was 5.2 m

long, which included a 1.7-m long codend of 3.2-mm stretch mesh protected by an outer skirt of 29-mm stretch mesh. The mouth of the net was 2.6 m wide, 1.2 m deep, and connected to two weighted otter doors (33 cm by 61 cm) – one per side. The doors were attached to a 6.3-m long bridle of 1.3-cm braided line, which was attached to the F/V *Miss Alyssa* with a 1.6-cm polypropylene tow line. Minimum scope ratio of the tow line was kept to at least 3:1. Once on the bottom, the trawl was towed for 10 minutes (min). Three exceptions to the 10 min protocol occurred: T6 in winter was the first tow of the project and was fished for only 5 min, T3 in fall lasted only about 3 min because the trawl got snagged on derelict crab line, and T6 in fall was terminated after about 4 min due to the boulder incident. Overall, the trawl was fished at speeds ranging from 2.1 to 3.4 kts over ground, resulting in an average transect distance of 0.81 km. Tow direction was determined by the skipper based on tide, currents, wind, and sea state.

***Crab pots*:** Fish and invertebrates were sampled at depths of 15 to 66 m with crab pots in areas 1 through 6. Pots were baited with whole herring and soaked for 24 to 26 hours at 14 sites, for a total of 46 sets (Fig. 1, Table 1). The ten deepest pot sites were not fished during fall due to weather-related safety concerns. Pots had a ~1.2 m^2 footprint with pyramid-shaped frames made of metal rebar and covered with ~5 cm^2 netting. Pots were deployed and retrieved from the F/V *Miss Alyssa* during daylight hours.

***Beach seine*:** Fish and invertebrates were sampled in water < 5 m deep and < 15 m from shore with a beach seine in area 7. Seine hauls were made at two sites in spring and summer, for a total of four sets (Fig. 1, Table 1). Neither seine site was fished in winter or fall due to unseinable shoreline wave action and time constraints, respectively. Seine length was 37-m long with variable mesh, tapering from 5 m wide at the center to 1 m wide at the ends. The two end panels were each 10 m long with 32-mm stretch mesh, the two intermediate panels were each 4 m long with 6-mm square mesh, and the bunt was 9 m long with 3.2-mm square mesh. The seine was equipped with a leadline and a floatline so that the bottom edge of the net would maintain contact with the bottom substrate and the top would float on the water surface. Two braided nylon lines, 25-30 m long, were attached to the seine – one per end. The seine was set as a round haul from the RIB. One line was held on the beach while the net was paid out from the RIB in a semi-circle to a second position on the beach about 18 m from the starting point. The net was

brought onto shore by pulling together on both lines from shore. Seining was conducted during daylight hours at a tidal level of about 0.0 m relative to mean lower low water.

***Catch*:** After retrieval of each gear type, the entire catch was sorted, identified to lowest taxon, and counted. A sub-sample (up to 50 individuals) of each fish species was measured to the nearest millimeter total length or fork length, depending on species. Fishes were identified in the field to the lowest possible taxon based on crew knowledge and reference to Mecklenburg et al. (2002). Fish life stage (i.e., young-of-the-year – YOY, juvenile, and adult) was field-assigned based on ontogenetic characteristics (e.g., development, coloration, and markings) and length. Refinements to adult life stage assignments were made in the office based on species-specific estimates of length-at-first-maturity (FishBase 2018). Invertebrates were photographed and identified in the field to the lowest possible taxon based on crew knowledge and reference to Jensen (1995). Aaron Baldwin, an expert in Alaskan marine invertebrates, kindly reviewed the photographs and provided confirmation as well as numerous refinements to our field identifications.

***Habitat*:** Water temperature (°C) and salinity (practical salinity unit, PSU) were measured with a CastAway® CTD in each area. The CTD was deployed to bottom depths at trawl and pot sites and to a depth of 0.5 m at seine sites. Beach slope and substrate composition were visually estimated at seine sites. Seaweeds captured during sampling were photographed and later identified to species by Mandy Lindeberg.

Data analysis

Catch data were expressed by absolute (i.e., total catch and species richness) and relative (i.e., catch-per-unit-effort - CPUE and percent frequency of occurrence - FO) metrics. Total catch was the total number of individuals captured. Species richness is the total number of unique species or taxa captured. Catch-per-unit-effort represents the relative abundance of a species or taxon; it was calculated by dividing total catch by number of sets (e.g., trawl tows). Percent FO represents how common a species or taxon is; it was calculated by dividing the number of sets where a species or taxa was present by the total number of sets made, and then multiplying by 100.

Results

***Fish catch*:** A total of 740 fish representing at least 31 species were captured with a mean CPUE of 10.3 (n = 72 sets; Table 2). Three species – rock sole, pink salmon, and English sole – accounted for 70% of the total fish catch. Catch varied by gear type, with overall fish abundance and richness of both bottom trawl and beach seine exceeding that of crab pots. Mean fish CPUE of seine sets greatly exceeded that of both trawl and pot sets. Trawl catch was dominated by rock sole. Indeed, rock sole was the most abundant and the most frequently captured species in trawls, but it should be noted that 82% of trawl-caught rock sole were captured in one trawl during fall. Pot and seine catch were dominated by yellow Irish lord and pink salmon. Fish catch also varied by season (Table 3). Mean CPUE and species richness were lowest in winter and highest in fall and summer, respectively. In winter, yellow Irish lord dominated the catch. In spring, yellow Irish lord remained the most frequently occurring species, but YOY pink salmon were the most abundant. In both summer and fall, rock sole had the highest mean CPUE and FO.

Fish catch differed between offshore and nearshore areas and among offshore areas (Table 4). Only four species – rock sole, sturgeon poacher, Pacific cod, and Pacific halibut – were captured in both offshore and nearshore areas. Among offshore areas, the two deepest areas (1 and 2) were markedly depauperate, with a combined mean CPUE of 0.5 fish and a total of two species. In contrast, the four shallower offshore areas (3-6) had a combined mean CPUE of 6.5 and a total of 20 species. Finally, the single nearshore area (7) had a mean CPUE of 104.8 and 17 species.

Juveniles and YOY were the most abundant life stages, accounting for more than 87% of the total fish catch (Table 5). Most species (88%) were also represented in part by juvenile or younger individuals; only four species – yellow Irish lord, crescent gunnel, red Irish lord, and yellowfin sole – were captured exclusively as adults. The frequency of each life stage differed by gear; trawl, pot, and seine catch were dominated by juveniles (84% of fish), adults (100%), and YOY (51%). A total of 616 fish were measured for length (Table 6). Overall, fish length ranged from 8 to 550 mm, with a mean of 117.5 mm and a median of 67 mm. Notably, no adult pink salmon were measured; in order to minimize damage to both the beach seine and the catch, adult salmon were quickly removed and released prior to bringing the net completely on shore.

***Invertebrate catch*:** A total of 1,636 invertebrates representing at least 65 species were captured with a mean CPUE of 22.7 (n = 72 sets; Table 7). Five species – puppet margarites, northern lacuna, and green urchin, Oregon hairy triton, and wrinkled dove snail – accounted for 68.5% of the total invertebrate catch. Catch differed among gear types, with most invertebrate species (65%) captured exclusively by bottom trawl. As a result, total invertebrate catch, mean CPUE, and species richness of trawls greatly exceeded that of both crab pots and beach seines. The most common species in trawl, pot, and seine sets were green urchin, Oregon hairy triton, and dungeness crab.

Invertebrate catch also differed between offshore and nearshore areas and among offshore areas (Table 8). A total of 62 invertebrate species were captured in offshore areas, compared to 4 in the nearshore. Among offshore areas, the shallowest area (6) had the most diverse invertebrate assemblage. Area 6 had a mean CPUE of 57.3 invertebrates compared to a combined, mean CPUE of 10.8 in the deeper offshore areas. Area 6 also had 33 species, 55% of which were captured in no other area. Although invertebrate CPUE and richness were highest in area 6, it should be noted that the area's CPUE was not consistently high; more than 83% of the total catch in area 6 was captured in the summer trawl.

***Habitat*:** A total of 24 CTD casts were made, comprising 23 offshore and 1 nearshore. Offshore casts were made in each area per season, with the exception of area 1 in spring. Overall, offshore bottom temperature and salinity ranged from 4.4 to 8.8° C and 31 to 32 PSU (Fig. 2). By season, mean offshore temperature was coldest in winter (4.7° C, n = 6) and warmest in summer (8.1° C, n = 6). In summer, offshore temperature was coldest in the deepest area (7.3° C in area 2) and warmest in the shallowest area (8.8° C in area 6). In the nearshore, temperature and salinity were 7.7° C and 21 PSU in spring (Fig. 2).

Substrate and gradient were similar at the two beach seine sites. Substrate was composed mostly of sand (85 – 90%), followed by gravel at the western site (S7a) and both gravel and small cobble along a ~2 m wide shoreline band at the eastern site (S7b). Beach slope in the seined area was estimated at < 5% at both sites.

Red seaweeds were incidentally captured in the trawl net at three areas. At the shallowest trawl site, T6, both sieve kelp (*Agarum clathratum*) and cup and saucer (*Constantinea rosa-*

marina) were present throughout the year. During winter, one specimen each of sieve kelp and Scagel's skein (*Scagelia occidentale*) were also collected at T5 and T3, respectively.

Summary

Our sampling represents seasonal snapshots of the marine assemblages in Iliuliuk Bay. The presence or absence of any given species at any given time and place can be affected in part by the patchy and seasonally variable distribution of some species, sampling effort, and gear effectiveness. Nonetheless, at least 96 fish and invertebrate taxa were captured by bottom trawl, crab pot, and beach seine across 7 sampling areas during 2017. By gear, overall fish abundance and richness of both trawl and seine exceeded that of pots. Whereas, total invertebrate catch, mean CPUE, and species richness of trawls greatly exceeded that of both pots and seine. By season, mean fish CPUE and species richness were lowest in winter and highest in fall and summer, respectively. By general area, fish catch was more abundant in the nearshore than the offshore, but total species richness was comparable. In contrast, invertebrate catch was markedly more abundant and rich offshore than nearshore. Among offshore areas, fish and invertebrate catch were relatively depauperate in the two deepest areas. Low observed diversity in areas 1 and 2 could indeed be representative of the fauna in these two areas, but it is also possible that the bottom trawl fished less effectively at depths of ~60 m.

References

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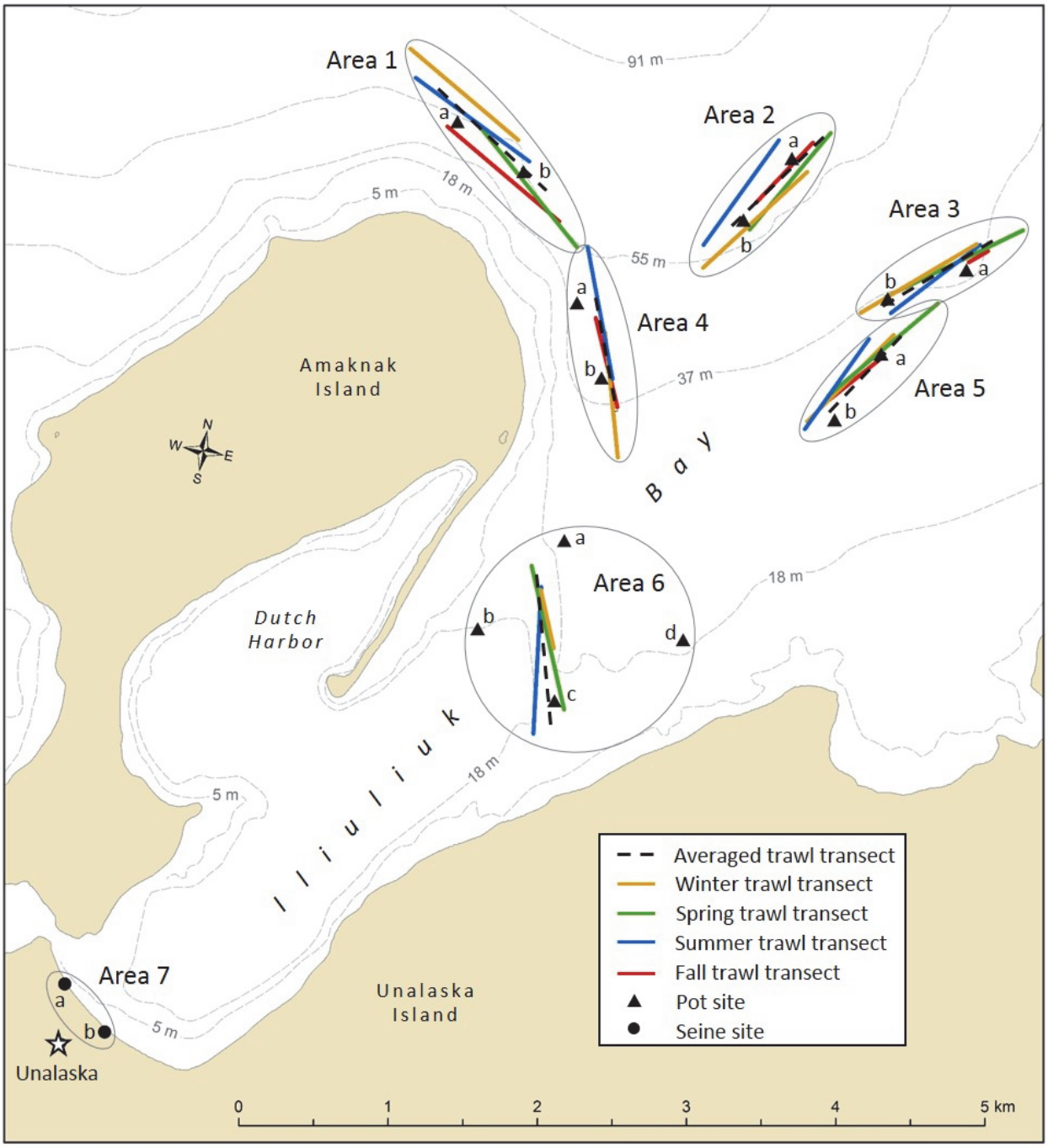

Figure 1. Seven areas sampled for marine fish and invertebrates in Iliuliuk Bay, Alaska in winter, spring, summer, and fall of 2017. The six offshore areas (1-6) were each sampled by bottom trawl along one transect and crab pots at two or four sites. The nearshore area (7) was sampled by beach seine at two sites. See Table 1 for site details.

Table 1. Bottom trawl (n = 6), crab pot (n = 14), and beach seine (n = 2) sites sampled during winter, spring, summer, and fall 2017 among 7 areas in Ililiuk Bay, Alaska. Trawl coordinates and depth (m) are averaged along transects and across seasons. Areas and sites are shown in Fig. 1.

			Location					Season				# of
Area	Gear	Site	Lat (N)	Long (W)	Lat (N)	Long (W)	Depth	W	Sp	Su	F	sets
1	trawl	T1	53.9339	166.5172	53.9294	166.5045	59	x	x	x		3
	pot	P1a	53.9325	166.5147			56	x	x	x		3
	pot	P1b	53.9303	166.5071			57	x	x	x		3
2	trawl	T2	53.9289	166.4854	53.9350	166.4791	60	x	x	x	x	4
	pot	P2a	53.9341	166.4805			66	x	x	x		3
	pot	P2b	53.9299	166.4842			59	x	x	x		3
3	trawl	T3	53.9263	166.4689	53.9315	166.4588	35	x	x	x	x	4
	pot	P3a	53.9295	166.4609			36	x	x	x		3
	pot	P3b	53.9269	166.4682			37	x	x	x		3
4	trawl	T4	53.9236	166.4976	53.9170	166.4933	42	x		x	x	3
	pot	P4a	53.9231	166.4993			45	x	x	x		3
	pot	P4b	53.9190	166.4954			39	x	x	x		3
5	trawl	T5	53.9194	166.4731	53.9249	166.4667	33	x	x	x	x	4
	pot	P5a	53.9235	166.4678			33	x	x	x		3
	pot	P5b	53.9191	166.4713			29	x	x	x		3
6	trawl	T6	53.9064	166.4980	53.8980	166.4941	15	x	x	x	x	4
	pot	P6a	53.9089	166.4960			23	x	x	x	x	4
	pot	P6b	53.9027	166.5030			19	x	x	x	x	4
	pot	P6c	53.8993	166.4939			15	x	x	x	x	4
	pot	P6d	53.9044	166.4822			20	x	x	x	x	4
7	seine	S7a							x	x		2
	seine	S7b							x	x		2
							Number of sets	20	21	22	9	72

Table 2. Total catch, catch-per-unit-effort (CPUE, unit = set), and percent frequency of occurrence (FO) of fishes captured with bottom trawl, crab pot, and beach seine in Iliuliuk Bay, Alaska during 2017. The top CPUE and FO values for each gear type are bolded. Fishes are listed in descending order of abundance based on total catch among all sets.

				Trawl		Pot		Seine	
Common name	Scientific name	Family	Catch	CPUE	FO	CPUE	FO	CPUE	FO
Rock sole	*Lepidopsetta* spp.	Pleuronectidae	272	**11.4**	**36**			5.5	100
Pink salmon	*Oncorhynchus gorbuscha*	Salmonidae	146					**36.5**	**100**
English sole	*Parophrys vetulus*	Pleuronectidae	106					26.5	100
Sturgeon poacher	*Podothecus accipenserinus*	Agonidae	31	0.1	9			7.3	75
unidentified flatfish		Pleuronectidae	25	0.6	14			2.8	50
Pacific cod	*Gadus macrocephalus*	Gadidae	21	0.1	9	< 0.1	4	4.0	50
Yellow Irish lord	*Hemilepidotus jordani*	Cottidae	21			**0.5**	**35**		
Pacific sand lance	*Ammodytes personatus*	Ammodytidae	20					5.0	50
Masked greenling	*Hexagrammos octogrammus*	Hexagrammidae	15					3.8	25
Snake prickleback	*Lumpenus sagitta*	Stichaeidae	14					3.5	50
unidentified sculpin	*Myoxocephalus* sp.	Cottidae	13					3.3	75
Starry flounder	*Platichthys stellatus*	Pleuronectidae	7					1.8	50
unidentified ronquil		Bathymasteridae	7					1.8	25
Highbrow sculpin	*Triglops metopias*	Cottidae	5	0.2	9				
Crescent gunnel	*Pholis laeta*	Pholidae	4					1.0	25
Red Irish lord	*Hemilepidotus hemilepidotus*	Cottidae	4	0.1	9	< 0.1	2		
Great sculpin	*M. polyacanthocephalus*	Cottidae	3	0.1	9	< 0.1	2		
Pacific halibut	*Hippoglossus stenolepis*	Pleuronectidae	3	0.1	9			0.3	25
Roughspine sculpin	*Triglops macellus*	Cottidae	3	0.1	9				
unidentified poacher		Agonidae	3					0.8	50
Dolly Varden	*Salvelinus malma*	Salmonidae	2					0.5	25
Kelp greenling	*Hexagrammos decagrammus*	Hexagrammidae	2					0.5	25

Table 2 continued.

Common name	Scientific name	Family	Catch	Trawl		Pot		Seine	
				CPUE	FO	CPUE	FO	CPUE	FO
unidentified snailfish		Liparidae	2	0.1	5				
Armorhead sculpin	*Gymnocanthus galeatus*	Cottidae	1	< 0.1	5				
Arrowtooth flounder	*Atheresthes stomias*	Pleuronectidae	1	< 0.1	5				
Dark rockfish	*Sebastes ciliatus*	Scorpaenidae	1	< 0.1	5				
Dover sole	*Microstomus pacificus*	Pleuronectidae	1	< 0.1	5				
Northern sculpin	*Icelinus borealis*	Cottidae	1	< 0.1	5				
Ribbed sculpin	*Triglops pingelii*	Cottidae	1	< 0.1	5				
Searcher	*Bathymaster signatus*	Bathymasteridae	1	< 0.1	5				
Slim sculpin	*Radulinus asprellus*	Cottidae	1	< 0.1	5				
Sockeye salmon	*Oncorhynchus nerka*	Salmonidae	1					0.3	25
Walleye pollock	*Gadus chalcogrammus*	Gadidae	1	< 0.1	5				
Yellowfin sole	*Limanda aspera*	Pleuronectidae	1	< 0.1	5				
		Total catch	740	215		25		419	
		Number of sets	72	22		46		4	
		Mean CPUE	10.3	9.8		0.5		104.8	
		Number of species	31	19		4		17	

Table 3. Catch, catch-per-unit-effort (CPUE, unit = set), and percent frequency of occurrence (FO) of fishes captured in Iliuliuk Bay, Alaska during winter (n = 20 sets), spring (n = 21), summer (n = 22), and fall (n = 9) of 2017. Fishes are listed in descending order of abundance based on total catch across all seasons. The top CPUE and FO values within each season are bolded.

	Catch metrics by season											
	Winter			Spring			Summer			Fall		
Common name	Catch	CPUE	FO	Catch	CPUE	FO	Catch	CPUE	FO	Catch	CPUE	FO
Rock sole	3	0.2	5	14	0.7	14	36	**1.6**	**23**	219	**24.3**	**33**
Pink salmon				113	**5.4**	10	33	1.5	9			
English sole				81	3.9	10	25	1.1	9			
Sturgeon poacher				1	0.0	5	30	1.4	18			
unidentified flatfish				11	0.5	10	13	0.6	9	1	0.1	11
Pacific cod	1	0.1	5	1	< 0.1	5	17	0.8	14	2	0.2	11
Yellow Irish lord	11	**0.6**	**35**	9	0.4	**38**	1	0.0	5			
Pacific sand lance				2	0.1	5	18	0.8	5			
Masked greenling							15	0.7	5			
Snake prickleback							14	0.6	9			
unidentified sculpin				8	0.4	5	5	0.2	9			
Starry flounder							7	0.3	9			
unidentified ronquil				7	0.3	5						
Highbrow sculpin							5	0.2	9			
Crescent gunnel							4	0.2	5			
Red Irish lord							1	< 0.1	5	3	0.3	22
Great sculpin	1	0.1	5	1	< 0.1	5				1	0.1	11
Pacific halibut							2	0.1	9	1	0.1	11
Roughspine sculpin							2	0.1	5	1	0.1	11
unidentified poacher				3	0.1	10						
Dolly Varden							2	0.1	5			
Kelp greenling							2	0.1	5			
unidentified snailfish							2	0.1	5			
Armorhead sculpin										1	0.1	11

Table 3 continued.

	Catch metrics by season											
	Winter			Spring			Summer			Fall		
Common name	Catch	CPUE	FO	Catch	CPUE	FO	Catch	CPUE	FO	Catch	CPUE	FO
Arrowtooth flounder										1	0.1	11
Dark rockfish							1	< 0.1	5			
Dover sole										1	0.1	11
Northern sculpin							1	< 0.1	5			
Ribbed sculpin							1	< 0.1	5			
Searcher							1	< 0.1	5			
Slim sculpin										1	0.1	11
Sockeye salmon							1	< 0.1	5			
Walleye pollock							1	< 0.1	5			
Yellowfin sole				1	< 0.1	5						
Total catch and CPUE	16	0.8		252	12.0		240	10.9		232	25.8	
Species richness	4			10			24			10		

Table 4. Total catch, catch-per-unit-effort (CPUE, unit = set), percent frequency of occurrence (FO), and species richness of fishes captured at 7 total offshore and nearshore areas of Iliuliuk Bay, Alaska during 2017. Fishes are listed in descending order of abundance based on total catch across all areas. The top CPUE and FO values in each area are bolded. Areas are listed in Table 1 and shown in Fig. 1.

		Offshore												Nearshore	
	Total	1		2		3		4		5		6		7	
Common name	catch	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO
Rock sole	272					**1.1**	**20**	**22.6**	11	**3.2**	**40**	0.2	5	5.5	100
Pink salmon	146													**36.5**	**100**
English sole	106													26.5	100
Sturgeon poacher	31					0.1	10			0.1	10			7.3	75
unidentified flatfish	25					0.3	10	0.1	11	1.0	10			2.8	50
Pacific cod	21					0.1	10	0.1	11	0.2	10	0.1	5	4.0	50
Yellow Irish lord	21	**0.3**	**30**	**0.6**	**40**			0.3	**22**	0.4	30	**0.3**	**21**		
Pacific sand lance	20													5.0	50
Masked greenling	15													3.8	25
Snake prickleback	14													3.5	50
unidentified sculpin	13													3.3	75
unidentified ronquil	7													1.8	25
Starry flounder	7													1.8	50
Highbrow sculpin	5					0.1	10			0.4	10				
Crescent gunnel	4													1.0	25
Red Irish lord	4					0.1	10			0.2	10	0.1	5		
Great sculpin	3									0.1	10	0.1	11		
unidentified poacher	3													0.8	50
Pacific halibut	3									0.2	20			0.3	25
Roughspine sculpin	3					0.2	10	0.1	11						
Dolly Varden	2													0.5	25
unidentified snailfish	2											0.1	5		
Kelp greenling	2													0.5	25

Table 4 continued.

		Offshore												Nearshore	
		1		2		3		4		5		6		7	
Common name	Catch	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO
Armorhead sculpin	1							0.1	11						
Arrowtooth flounder	1					0.1	10								
Dark rockfish	1											0.1	5		
Dover sole	1									0.1	10				
Northern sculpin	1					0.1	10								
Ribbed sculpin	1											0.1	5		
Searcher	1									0.1	10				
Slim sculpin	1			0.1	10										
Sockeye salmon	1													0.3	25
Walleye pollock	1									0.1	10				
Yellowfin sole	1									0.1	10				
Mean water depth (m)	-	57		61		36		42		32		18		< 5	
Number of sets	72	10		10		10		9		10		19		4	
Total catch	740	3		7		22		211		62		16		419	
Mean CPUE	10.3	0.3		0.7		2.2		23.4		6.2		0.8		97.3	
Species richness	31	1		2		8		5		12		8		104.8	

Table 5. Percentage of fish captured per life stage (i.e., young-of-the-year, juvenile, and adult) across and among 3 gear types (i.e., bottom trawl, crab pot, and beach seine) in Iliuliuk Bay, Alaska during 2017. Fishes are listed in descending order of abundance based on total catch among all sets.

	All gear types			Trawl			Pot	Seine		
Common name	YOY	Juv	Adult	YOY	Juv	Adult	Adult	YOY	Juv	Adult
Rock sole		90	10		90	10			95	5
Pink salmon	79		21					79		21
English sole		100							100	
Sturgeon poacher	74	26		50	50			76	24	
unidentified flatfish	100			100				100		
Pacific cod	81	10	10	33	67		100	100		
Yellow Irish lord			100				100			
Pacific sand lance	90	5	5					90	5	5
Masked greenling	80	13	7					80	13	7
Snake prickleback		100							100	
unidentified sculpin	62	38						62	38	
Starry flounder		100							100	
unidentified ronquil	100							100		
Highbrow sculpin		100			100					
Crescent gunnel			100							100
Red Irish lord			100			100	100			
Great sculpin		33	67		50	50	100			
Pacific halibut		100			100				100	
Roughspine sculpin		100			100					
unidentified poacher	100							100		
Dolly Varden		100							100	
Kelp greenling	100							100		
unidentified snailfish		100			100					
Armorhead sculpin		100			100					
Arrowtooth flounder		100			100					

Table 5 continued.

	All gear types			Trawl			Pot	Seine		
Common name	YOY	Juv	Adult	YOY	Juv	Adult	Adult	YOY	Juv	Adult
Dark rockfish		100			100					
Dover sole		100			100					
Northern sculpin		100			100					
Ribbed sculpin		100			100					
Searcher		100			100					
Slim sculpin		100			100					
Sockeye salmon		100							100	
Walleye pollock	100			100						
Yellowfin sole			100			100				
Percent of total catch	31.4	56.2	12.4	5.7	84.1	10.1	100.0	51.3	39.9	8.8

Table 6. Length metrics (i.e., number measured, mean length, range of lengths) and three life stages (i.e., young-of-the-year, juvenile, and adult) of fishes caught in Iliuliuk Bay, Alaska during 2017. Presence of a life stage in bottom trawl (T), crab pot (P), or beach seine (S) is indicated with an x. Length is in millimeters and is either total length (TL) or fork length (FL), depending on species. Fishes are listed in descending order of abundance based on total catch.

		YOY						Juvenile						Adult						
Common name	Catch	n	Avg	Range	T	P	S	n	Avg	Range	T	P	S	n	Avg	Range	T	P	S	
Rock sole	272							166	151.8	36-298	x		x	26	354.1	307-445	x		x	TL
Pink salmon	146	103	45.4	30-83			x							0					x	FL
English sole	106							106	60.3	34-136			x							TL
Sturgeon poacher	31	23	42.4	29-49	x		x	8	89.6	45-115	x		x							TL
unidentified flatfish	25	25	29.3	21-43	x		x													TL
Pacific cod	21	17	67.4	54-89	x		x	2	299.0	263-335	x			2	512.5	475-550		x		FL
Yellow Irish lord	21													21	407.4	298-470		x		TL
Pacific sand lance	20	18	67.8	58-86			x	1	104.0	104-104			x	1	140.0	140-140			x	FL
Masked greenling	15	11	63.4	57-71			x	2	196.5	170-223			x	1	256.0	256-256			x	TL
Snake prickleback	14							14	116.8	79-285			x							TL
unidentified sculpin	13	8	19.6	15-22			x	5	37.6	34-42			x							TL
Starry flounder	7							7	345.3	255-402			x							TL
unidentified ronquil	7	7	15.6	15-16			x													TL
Highbrow sculpin	5							5	63.4	54-78	x									TL
Crescent gunnel	4													4	137.5	130-140			x	TL
Red Irish lord	4													4	325.3	288-340	x	x		TL
Great sculpin	3							1	252.0	252-252	x			2	472.5	425-520	x	x		TL
Pacific halibut	3							3	102.7	63-170	x		x							TL
Roughspine sculpin	3							3	74.7	65-83	x									TL
unidentified poacher	3	3	24.0	23-25			x													TL
Dolly Varden	2							2	177.5	167-188			x							FL
Kelp greenling	2	2	58.0	57-59			x													TL
unidentified snailfish	2							2	10.0	8-12	x									TL
Armorhead sculpin	1							1	210.0	210-210	x									TL

Table 6 continued.

		YOY						Juvenile						Adult						
Common name	Catch	n	Avg	Range	T	P	S	n	Avg	Range	T	P	S	n	Avg	Range	T	P	S	
Arrowtooth flounder	1							1	156.0	156-156	x									TL
Dark rockfish	1							1	84.0	84-84	x									TL
Dover sole	1							1	117.0	117-117	x									TL
Northern sculpin	1							1	34.0	34-34	x									TL
Ribbed sculpin	1							1	81.0	81-81	x									TL
Searcher	1							1	87.0	87-87	x									TL
Slim sculpin	1							1	85.0	85-85	x									TL
Sockeye salmon	1							1	80.0	80-80			x							FL
Walleye pollock	1	1	66.0	66-66	x															FL
Yellowfin sole	1													1	370.0	370-370	x			TL
Total catch and lengths	740	218	45.7	15-89	x		x	336	119.2	8-402	x		x	62	360.5	130-550	x	x	x	

Table 7. Catch, catch-per-unit-effort (CPUE, unit = set), percent frequency of occurrence (FO), and species richness of invertebrates captured with bottom trawl, crab pot, and beach seine in Iliuliuk Bay, Alaska during 2017. Species are listed in descending order of abundance based on total catch among all sets.

				Trawl		Pot		Seine	
Common name	Scientific name	Family	Catch	CPUE	FO	CPUE	FO	CPUE	FO
Puppet margarites	*Margarites pupillus*	Turbinidae	278	**12.6**	9				
Northern lacuna	*Lacuna vincta*	Littorinidae	273	12.4	9				
Green urchin	*Strongylocentrotus droebachiensis*	Strongylocentrotidae	264	10.4	**41**	0.8	17		
Oregon hairy triton	*Fusitriton oregonensis*	Ranellidae	206	0.7	23	**4.1**	**41**		
Wrinkled dove snail	*Amphissa columbiana*	Columbellidae	100	4.5	5				
Widehand hermit crab	*Elassochirus tenuimanus*	Paguridae	77	3.0	23	0.2	9		
Steven's hermit crab	*Pagurus stevensae*	Paguridae	46	2.3	5				
Common sand dollar	*Echinarachinus parma*	Echinarachniidae	41	1.8	18	< 0.1	2		
unidentified sand shrimp	*Crangon* sp.	Crangonidae	26	1.0	36			0.8	**50**
Grey brittlestar	*Ophiura lutkenii*	Ophiuridae	24	1.0	32	0.1	7		
Pacific lyre crab	*Hyas lyratus*	Majidae	24	< 0.1	5	0.5	11		
Pacific red hermit crab	*Elassochirus gilli*	Paguridae	22	1.0	14				
unidentified mysid		Order Mysida	27	1.2	14				
unidentified tunicate		Class Ascidiacea	20	< 0.1	5	0.4	9		
Splendid hermit crab	*Labidochirus splendescens*	Paguridae	18	0.8	27				
Dungeness crab	*Cancer magister*	Cancridrae	16	0.1	5			**3.3**	**50**
Crystal jelly	*Aequorea victoriae*	Aequoreidae	14	0.6	9				
Pacific wingfoot snail	*Gastropteron pacificum*	Gastropteridae	14	0.6	14				
unidentified hermit crab		Paguridae	13	0.5	14	< 0.1	2	0.3	25
Common argid shrimp	*Argis alaskensis*	Crangonidae	8	0.4	18				
Tanner crab	*Chionoecetes bairdi*	Majidae	8			0.2	7		
Bluespine hermit crab	*Pagurus kennerlyi*	Paguridae	7	0.3	14				
Rough patch shrimp	*Pandalus stenolepis*	Pandalidae	6	0.3	5				
Sponge hermit crab	*Pagurus brandtii*	Paguridae	6	0.3	9				
Townsend's eualid	*Eualus townsendi*	Thoridae	6	0.3	5				

Table 7 continued.

Common name	Scientific name	Family	Catch	Trawl		Pot		Seine	
				CPUE	FO	CPUE	FO	CPUE	FO
Bering hermit crab	*Pagurus beringensis*	Paguridae	5	0.2	5				
Cemented sandmason tubeworm	*Neosabellaria cementarium*	Sabellariidae	5	0.2	5				
Pygmy rock crab	*Glebocarcinus oregonensis*	Cancridrae	5	0.2	14				
Rose sea star	*Crossaster papposus*	Solasteridae	5	0.2	9				
unidentified anenome	*Metridium* sp.	Metridiidae	5	0.2	5				
Alaskan hermit crab	*Pagurus ochotensis*	Paguridae	4	0.2	18				
Fat whelk	*Neptunea ventricosa*	Buccinidae	4			0.1	7		
Silky buccinum	*Buccinum scalariforme*	Buccinidae	4			0.1	4		
Greenland cockle	*Serripes groenlandicus*	Cardiidae	3	0.1	9				
Lined chiton	*Tonicella lineata*	Tonicellidae	3	0.1	5				
Sunflower star	*Pycnopodia helianthoides*	Asteriidae	3	< 0.1	5	< 0.1	4		
unidentified chiton		Tonicellidae	3	0.1	5				
unidentified copepod		Subclass Copepoda	3	0.1	5				
unidentified sponge		Order Poecilosclerida	3			0.1	4		
Giant plumose anenome	*Metridium farcimen*	Metridiidae	2	0.1	9				
Green falsejingle	*Pododesmus machrochisma*	Anomiidae	2	< 0.1	5	< 0.1	2		
Helmet crab	*Telmessus cheiragonus*	Cheiragonidae	2					0.5	25
Sea peach	*Halocynthia aurantium*	Pyuridae	2			< 0.1	4		
Smooth pink scallop	*Chlamys rubida*	Pectinidae	2	0.1	5				
Smooth scallop sponge	*Mycale adhaerens*	Mycalidae	2	0.1	5				
Stiletto shrimp	*Heptacarpus stylus*	Hippolytidae	2	0.1	5				
Western calcareous tubeworm	*Pseudochitinopoma occidentalis*	Serpulidae	2	< 0.1	5	< 0.1	2		
Black spined star	*Lethasterias nanimensis*	Asteriidae	1			< 0.1	2		
Daisy brittlestar	*Ophiopholis kennerlyi*	Ophiactidae	1			< 0.1	2		
Giant acorn barnacle	*Balanus nubilus*	Balanidae	1			< 0.1	2		
Graceful decorator crab	*Oregonia gracilis*	Oregoniidae	1	< 0.1	5				

Table 7 continued.

Common name	Scientific name	Family	Catch	Trawl CPUE	Trawl FO	Pot CPUE	Pot FO	Seine CPUE	Seine FO
Graceful kelp crab	*Pugettia gracilis*	Epialtidae	1	< 0.1	5				
Hairy crab	*Hapalogaster grebnitzkii*	Lithodidae	1	< 0.1	5				
Hundred-line cockle	*Nemocardium centifilosum*	Cardiidae	1	< 0.1	5				
Iceland cockle	*Clinocardium ciliatum*	Cardiidae	1	< 0.1	5				
Orange finger sponge	*Neoesperiopsis rigida*	Isodictyidae	1			< 0.1	2		
Pagurus trigonochirus	*Pagurus trigonochirus*	Paguridae	1	< 0.1	5				
Rainbow sea star	*Orthasterias koehleri*	Asteriidae	1	< 0.1	5				
Ribbed whelk	*Neptunea lyrata*	Buccinidae	1			< 0.1	2		
Rostrate barnacle	*Balanus rostratus*	Balanidae	1	< 0.1	5				
Shield limpet	*Lottia pelta*	Lottiidae	1	< 0.1	5				
unidentified amphipod		Suborder Gammaridea	1	< 0.1	5				
unidentified bryozoan		Phylum Bryozoa	1	< 0.1	5				
unidentified crab	*Hyas* sp.	Oregoniidae	1			< 0.1	2		
unidentified krill		Euphausiidae	1	< 0.1	5				
unidentified scallop		Pectinidae	1			< 0.1	2		
unidentified sea cucumber		Order Dendrochiotida	1	< 0.1	5				
unidentified snail	*Velutina* sp.	Velutinidae	1	< 0.1	5				
		Total catch	1636	1302		315		19	
		Number of sets	72	22		46		4	
		Mean CPUE	22.7	59.2		6.8		4.8	
		Species richness	65	53		22		4	

Table 8. Total catch, catch-per-unit-effort (CPUE, unit = set), percent frequency of occurrence (FO), and species richness of invertebrates captured at 7 total offshore and nearshore areas of Iliuliuk Bay, Alaska during 2017. Invertebrates are listed in descending order of abundance based on total catch across all areas. The top CPUE and FO values at each area are bolded. Gear types and sites per area are listed in Table 1 and shown in Fig. 1.

		Offshore												Nearshore	
		1		2		3		4		5		6		7	
Common name	Catch	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO
Puppet margarites	278											**14.6**	11		
Northern lacuna	273											14.4	11		
Green urchin	264	4.1	**70**			0.1	10	0.9	44	0.5	20	11.0	16		
Oregon hairy triton	206	**9.0**	50	**7.2**	**70**	**1.2**	**20**	1.9	**67**	0.1	10	0.7	16		
Wrinkled dove snail	100											5.3	5		
Widehand hermit crab	77	0.1	10	0.1	10	0.1	10	**3.3**	11	0.6	10	2.0	**21**		
Steven's hermit crab	46											2.4	5		
Common sand dollar	41					0.2	10			**3.5**	20	0.2	11		
unidentified sand shrimp	26			0.2	10	0.3	**20**	0.2	11	1.4	**30**	0.1	5	0.8	50
Grey brittlestar	24			0.1	10	0.4	10	1.3	44	0.6	**30**	0.1	5		
Pacific lyre crab	24			0.1	10					0.1	10	1.2	**21**		
Pacific red hermit crab	22											1.2	16		
unidentified mysid	27					0.1	10			2.6	20				
unidentified tunicate	20	1.3	20	0.2	10			0.4	11			0.1	5		
Splendid hermit crab	18					0.2	10	0.4	11	0.5	**30**	0.4	5		
Dungeness crab	16									0.3	10			3.3	50
Crystal jelly	14	0.1	10							1.3	10				
Pacific wingfoot snail	14					0.8	10			0.6	20				
Common argid shrimp	8					0.1	10	0.6	11	0.2	20				
Tanner crab	8					0.4	10			0.1	10	0.2	5		
Bluespine hermit crab	7							0.1	11	0.1	10	0.3	5		
Rough patch shrimp	6											0.3	5		
Sponge hermit crab	6					0.1	10					0.3	5		

Table 8 continued.

		Offshore												Nearshore	
		1		2		3		4		5		6		7	
Common name	Catch	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO
Townsend's eualid	6											0.3	5		
unidentified hermit crab	6											0.3	5		
Bering hermit crab	5											0.3	5		
Cemented sandmason tubeworm	5							0.6	11						
unidentified anenome	5											0.3	5		
Pygmy rock crab	5											0.3	16		
Rose sea star	5											0.3	11		
Alaskan hermit crab	4			0.1	10			0.1	11	0.2	20				
Fat whelk	4	0.2	20			0.2	10								
Silky buccinum	4			0.1	10	0.3	10								
Greenland cockle	3									0.3	20				
Lined chiton	3											0.2	5		
Sunflower star	3					0.1	10					0.1	11		
unidentified chiton	3											0.2	5		
unidentified copepod	3									0.3	10				
unidentified sponge	3	0.3	20												
Giant plumose anenome	2							0.1	11	0.1	10				
Green falsejingle	2	0.1	10	0.1	10										
Helmet crab	2													0.5	25
Sea peach	2	0.2	20												
Smooth pink scallop	2	0.2	10												
Smooth scallop sponge	2	0.2	10												
Stiletto shrimp	2											0.1	5		
Western calcareous tubeworm	2	0.1	10									0.1	5		
Black spined star	1	0.1	10												

Table 8 continued.

		Offshore												Nearshore	
		1		2		3		4		5		6		7	
Common name	Catch	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO	CPUE	FO
Daisy brittlestar	1							0.1	11						
Giant acorn barnacle	1	0.1	10												
Graceful decorator crab	1					0.1	10								
Graceful kelp crab	1											0.1	5		
Hairy crab	1											0.1	5		
Hundred-line cockle	1							0.1	11						
Iceland cockle	1									0.1	10				
Orange finger sponge	1	0.1	10												
Pagurus trigonochirus	1			0.1	10										
Rainbow sea star	1											0.1	5		
Ribbed whelk	1			0.1	10										
Rostrate barnacle	1	0.1	10												
Shield limpet	1											0.1	5		
unidentified amphipod	1											0.1	5		
unidentified bryozoan	1	0.1	10												
unidentified crab	1	0.1	10												
unidentified krill	1			0.1	10										
unidentified scallop	1	0.1	10												
unidentified sea cucumber	1							0.1	11						
unidentified snail	1											0.1	5		
Mean water depth (m)	-	57		61		36		42		32		18		<5	
Number of sets	72	10		10		10		9		10		19		4	
Total catch	1636	166		85		48		93		136		1089		19	
Mean CPUE	22.7	16.6		8.5		4.8		10.3		13.6		57.3		4.8	
Species richness	65	18		12		16		15		20		32		4	

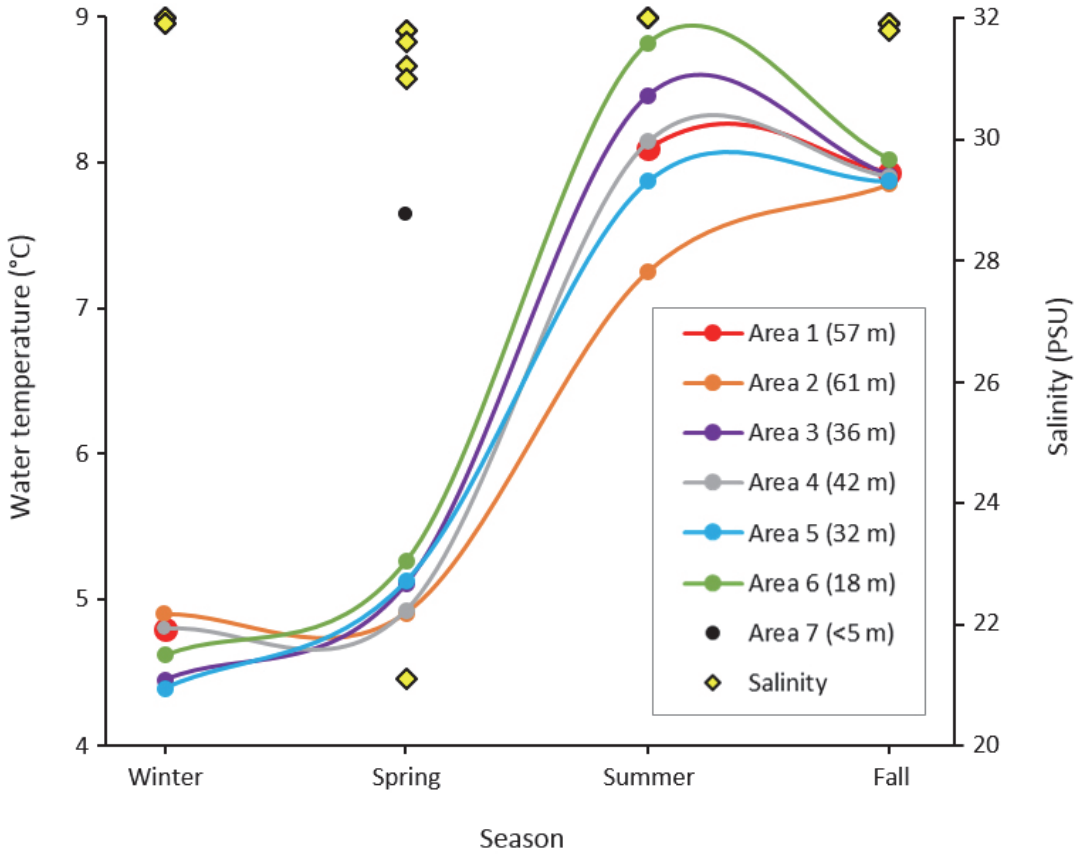

Figure 2. Seasonal water temperature (° C, circles) and salinity (practical salinity unit – PSU, yellow diamonds) during 2017 in Iliuliuk Bay, Alaska at seven sampling areas characterized by different mean water depths. Sampling areas are shown in Fig. 1 and detailed in Table 1.