Abundance and Size-Class Structure of Dungeness Crabs In or Near Frequently-Dredged Areas in the Columbia River Estuary

FINAL REPORT

by
George T. McCabe, Jr.
and
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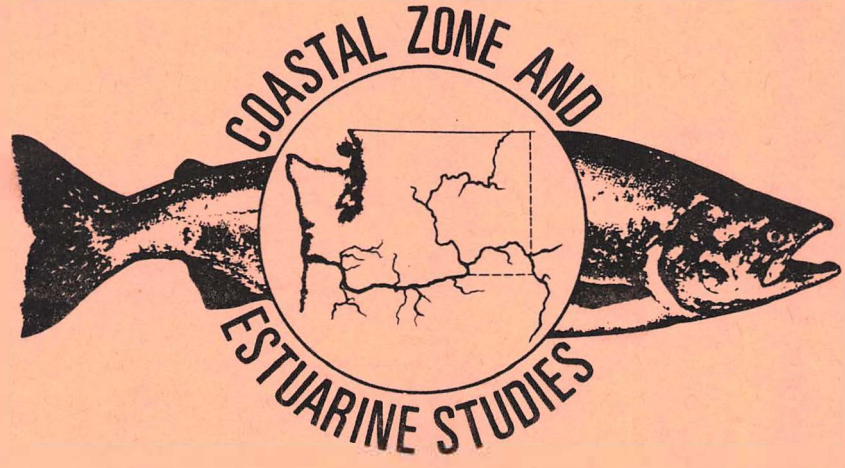

ABUNDANCE AND SIZE-CLASS STRUCTURE OF DUNGENESS CRABS IN OR NEAR FREQUENTLY-DREDGED AREAS IN THE COLUMBIA RIVER ESTUARY

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Final Report

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and

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INTRODUCTION

In October 1985, the National Marine Fisheries Service (NMFS) completed a 2-year study of Dungeness crabs, Cancer magister, in the Columbia River estuary (McCabe et al. 1986). The main objectives of the study, which was funded primarily by the Portland District, U.S. Army Corps of Engineers (COE), were to determine estuarine distribution, relative abundance, size-class structure, and location and timing of movements across the Columbia River bar (River Mile 0.7 to 2.8[1]) of Dungeness crabs. The 2-year study demonstrated that crab densities fluctuate annually in the estuary. For example, densities on the bar in the spring and summer of 1984 were less than 115 crabs/hectare (ha), whereas during the same period in 1985, densities exceeded 1,800 crabs/ha.

Because of the large annual fluctuations in crab densities at some frequently-dredged estuarine areas, the COE requested that NMFS continue to sample at some of the established stations. The objectives of the extended study were to describe the abundance and size-class structure of Dungeness crabs in or near frequently-dredged areas in the Columbia River estuary. These observations expanded the overall data base on Dungeness crabs in the estuary, specifically in areas subject to frequent dredging, and also provided additional information for COE crab entrainment studies. Results from the 3-year study were reported in McCabe et al. (1987a, 1987b) and McCabe and McConnell (1989). This final report is a summation and analysis of data collected from November 1983 through September 1988 at sites in or near frequently-dredged areas in the Columbia River estuary.

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[1] River Mile is used in this report because of its common usage in navigation charts.

METHODS

Sampling was done at sites in the Columbia River estuary from November 1983 through September 1988 (Fig. 1). Stations 3 (Ilwaco Channel), 6 (Chinook Channel), and 10 (Flavel Bar area) were sampled monthly. In November 1984, the location of Station 10 was moved about 1 mile to the west to avoid bottom obstructions at the original site; catch data for the original station are not included in this report. Sampling frequency at the bar stations (Stations 1, 2, 23, 24, 25, and 26) varied during the study. During the first 2 years (November 1983-October 1985), monthly sampling was done on the bar; however, during the subsequent 3 years, sampling was usually done biweekly from April through September or October when weather and oceanographic conditions permitted. Normal maintenance dredging on the bar is typically done during the April-October period. At times, particularly in 1988, we were unable to sample at Station 26 due to crab pots in the area.

Samples were collected with an 8-m semiballoon shrimp trawl that was generally towed for 5 minutes at each estuarine site during times of higher salinity (early flood to early ebb tide). Overall mesh size in the trawl was 38.1 mm (stretched), with a 12.7-mm mesh liner placed in the cod end of the net to prevent the escape of young-of-the-year (Y-O-Y) crabs. The distance traveled during a sampling effort was estimated using either a radar range-finder or Loran-C navigational equipment.

Usually individuals from a subsample of crabs (up to about 100) from each sampling effort were measured (mm) across the carapace anterior to the tenth anterolateral spines, weighed (g), and checked for eggs. Crabs not measured and weighed were counted and this number was added to the number in the subsample. When large numbers of early instar crabs (<20 mm) were captured, a minimum of 50 were measured and weighed. Size variations of the early instar crabs were much less than those of the larger crabs.

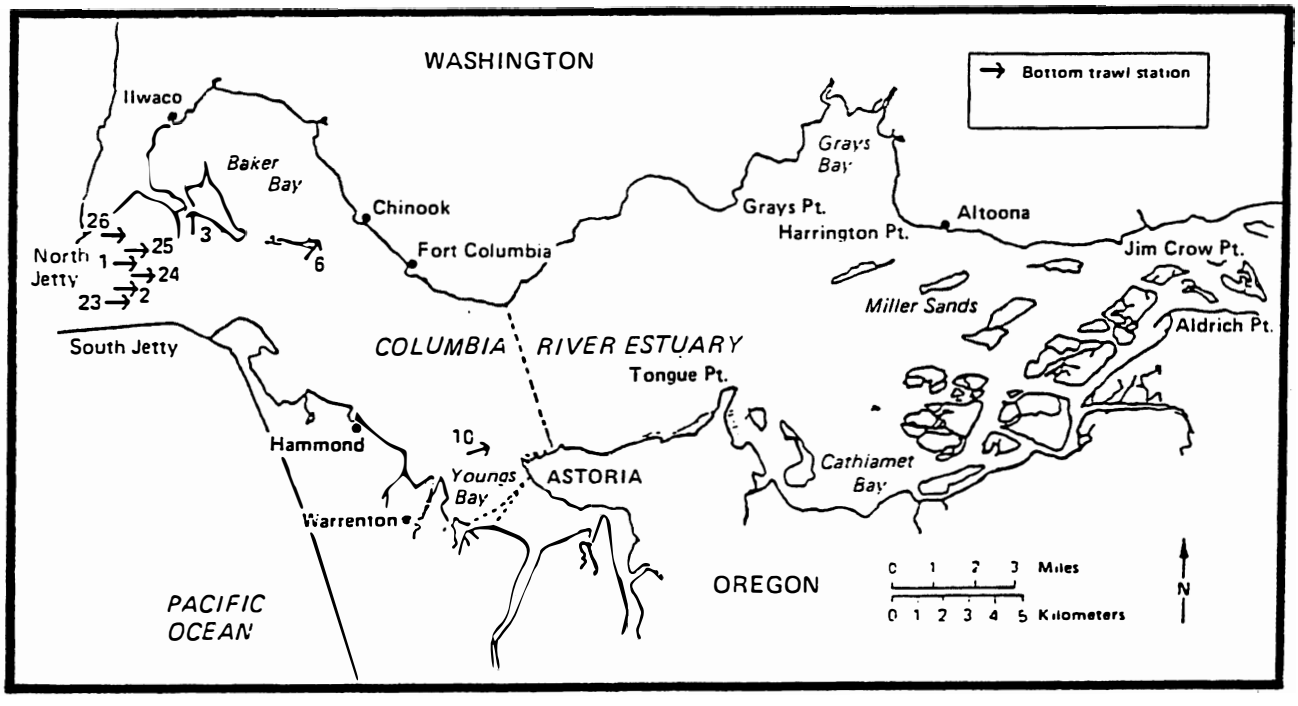

Figure 1.--Map of the Columbia River estuary, showing the Dungeness crab sampling stations.

Before each sampling effort, salinity (ppt) and temperature (°C) were measured at the surface and near the bottom using a Beckman RS5-3[2] salinometer and temperature probe.

By using catch data, the distance traveled during a trawl effort, and the fishing width of the trawl, which was estimated to be about 5 m by the manufacturer, we were able to estimate crab densities. Densities are reported as numbers of crabs/hectare (ha). For data analyses, crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm). Crabs were not separated into age classes, except for young Y-O-Y crabs, because we were unable to consistently assign age groups using length-frequency distributions. Different age groups often had overlapping carapace width distributions, particularly the older groups.

Statistical comparisons of monthly crab densities (by year) on the bar were done using the nonparametric Kruskal-Wallis test (Elliott 1977).

RESULTS

Estimated mean monthly crab densities (all size classes combined) on the Columbia River bar were generally relatively low during the April-October period (Fig. 2). With the exceptions of June and July 1985 and September 1986, estimated mean monthly densities were <200 crabs/ha. Densities on the bar varied both temporally and spatially during the study. Crab densities among years were significantly different for the months of June, July, August, and September (Kruskal-Wallis, $P < 0.01$). For detailed descriptions of crab catches at the individual bar stations see McCabe et al. (1986, 1987a, 1987b) and McCabe and McConnell (1989).

Crab densities by size class, month, and year were examined for the bar (Table 1). On the bar, mean monthly densities of Size Class I crabs tended to be higher in 1984

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[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

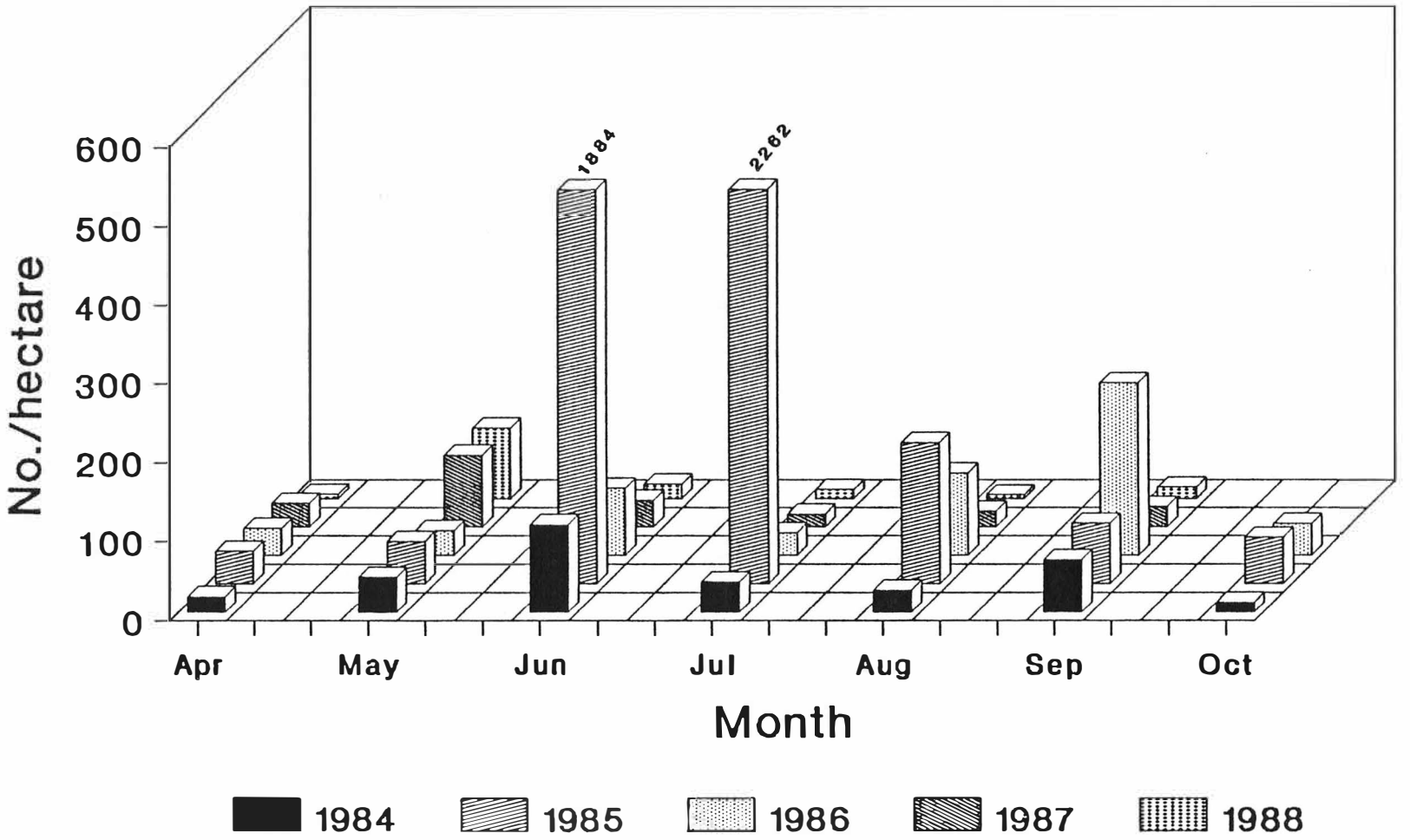

Figure 2.--Mean densities of Dungeness crabs (all size classes combined) on the Columbia River bar from April through October, 1984-88; each bar represents the average catch from 5 to 12 trawling efforts. Empty squares for a specific month indicate that no sampling was done.

Table 1.--Mean densities (number/ha) of Dungeness crabs by size class on the Columbia River bar from April through October, 1984-88; each number is the average catch from 5 to 12 trawling efforts. Crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm).

Month	Size Class	Year				
		1984	1985	1986	1987	1988
Apr	I	11	36	0	6	0
	II	1	0	2	0	0
	III	6	5	26	15	5
	IV	3	0	6	8	1
May	I	13	41	1	54	58
	II	3	2	4	0	0
	III	18	6	20	14	10
	IV	10	5	7	23	22
Jun	I	96	1,876	14	19	11
	II	0	0	16	0	0
	III	4	1	40	4	2
	IV	10	6	15	10	7
Jul	I	34	2,251	2	3	1
	II	0	0	0	0	0
	III	3	2	10	3	2
	IV	2	10	16	10	9
Aug	I	6	153	1	2	0
	II	0	16	1	0	0
	III	7	2	39	4	1
	IV	15	7	63	15	4
Sep	I	48	35	0	2	2
	II	0	33	10	0	0
	III	8	6	114	4	3
	IV	10	2	95	20	10
Oct	I	9	10	1	-	-
	II	0	28	8	-	-
	III	2	13	15	-	-
	IV	1	7	15	-	-

and 1985 than in 1986-88. Densities of Size Class I crabs were particularly high during June and July 1985 when mean densities were 1,876 crabs/ha and 2,251 crabs/ha, respectively. Virtually all Size Class I crabs collected on the bar from May through October (for all years) were Y-O-Y crabs; mean monthly densities of Y-O-Y crabs on the bar are shown in Table 2. Overall, Size Class II was the least abundant size group on the bar, with mean densities often being 0 crabs/ha. Size Classes III and IV were usually present in all months from April through October.

During each of the 5 years of bar sampling, Y-O-Y crabs began to enter the estuary as early instars or as megalops larvae that metamorphosed to first instar juveniles beginning in late April or May. With the exceptions of densities for June, July, and August 1985, mean densities for Y-O-Y crabs on the bar were <100 crabs/ha (Table 2).

Crab densities at the three stations upstream from the bar varied within a specific year and between years. At Station 3, crab densities tended to be lowest in April (Fig. 3). Crab densities at Station 3 were relatively high at times; in 10 of the 58 months sampled, densities exceeded 1,000 crabs/ha. At Station 6, crab densities tended to be lower in the February-May period than in other months (Fig. 4). The highest densities in the estuary from 1983 to 1988 were found at Station 6 in September and October 1985, when densities were >16,000 crabs/ha. Densities at Station 10 fluctuated annually as at Stations 3 and 6; however, densities tended to be lowest in September through January (Fig. 5). The highest density at Station 10 was found in June 1986 (1,244 crabs/ha).

The size-class structures of crabs at Stations 3, 6, and 10 are presented in Tables 3-5. The size-class structures at all three stations fluctuated temporally. A total of three early instar crabs (<20 mm carapace width) were collected at the three stations. At Stations 3 and 6, which are both located in Baker Bay, Size Classes II and III were overall the most abundant size classes (Tables 3 and 4). Size Class I crabs were more

Table 2.--Mean densities (number/ha) of Y-O-Y Dungeness crabs on the Columbia River bar from April through October, 1984-88; each number is the average catch from 5 to 12 trawling efforts.

Month	Year				
	1984	1985	1986	1987	1988
Apr	0	0	0	6	0
May	13	11	0	54	58
Jun	96	1,876	14	19	10
Jul	34	2,251	2	3	1
Aug	6	153	1	2	0
Sep	48	35	0	2	1
Oct	9	10	1	-	-

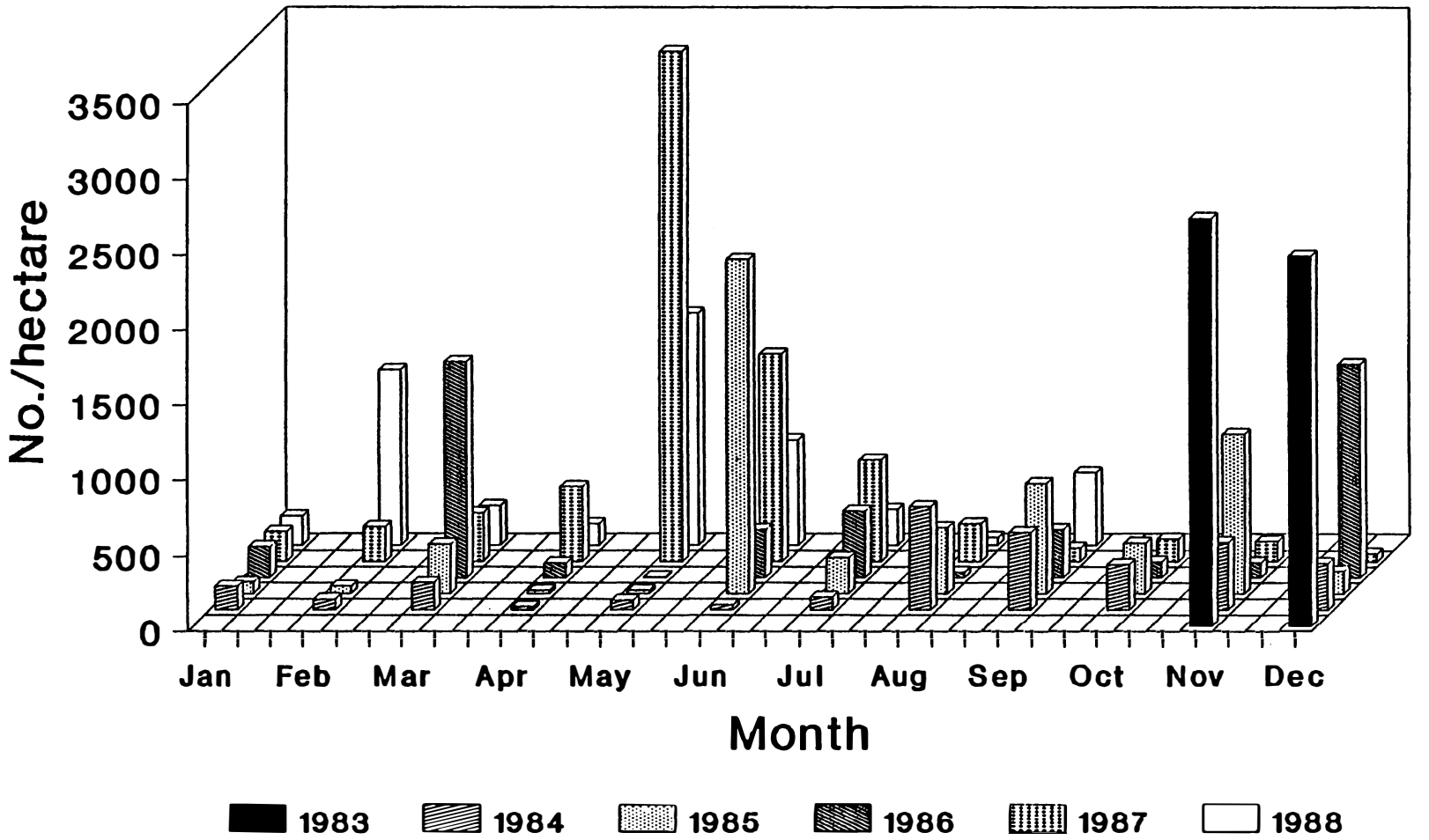

Figure 3.--Mean densities of Dungeness crabs (all size classes combined) in Ilwaco Channel (Station 3), Columbia River estuary, 1983-88; each bar represents one trawling effort. Empty squares for a specific month indicate that no sampling was done.

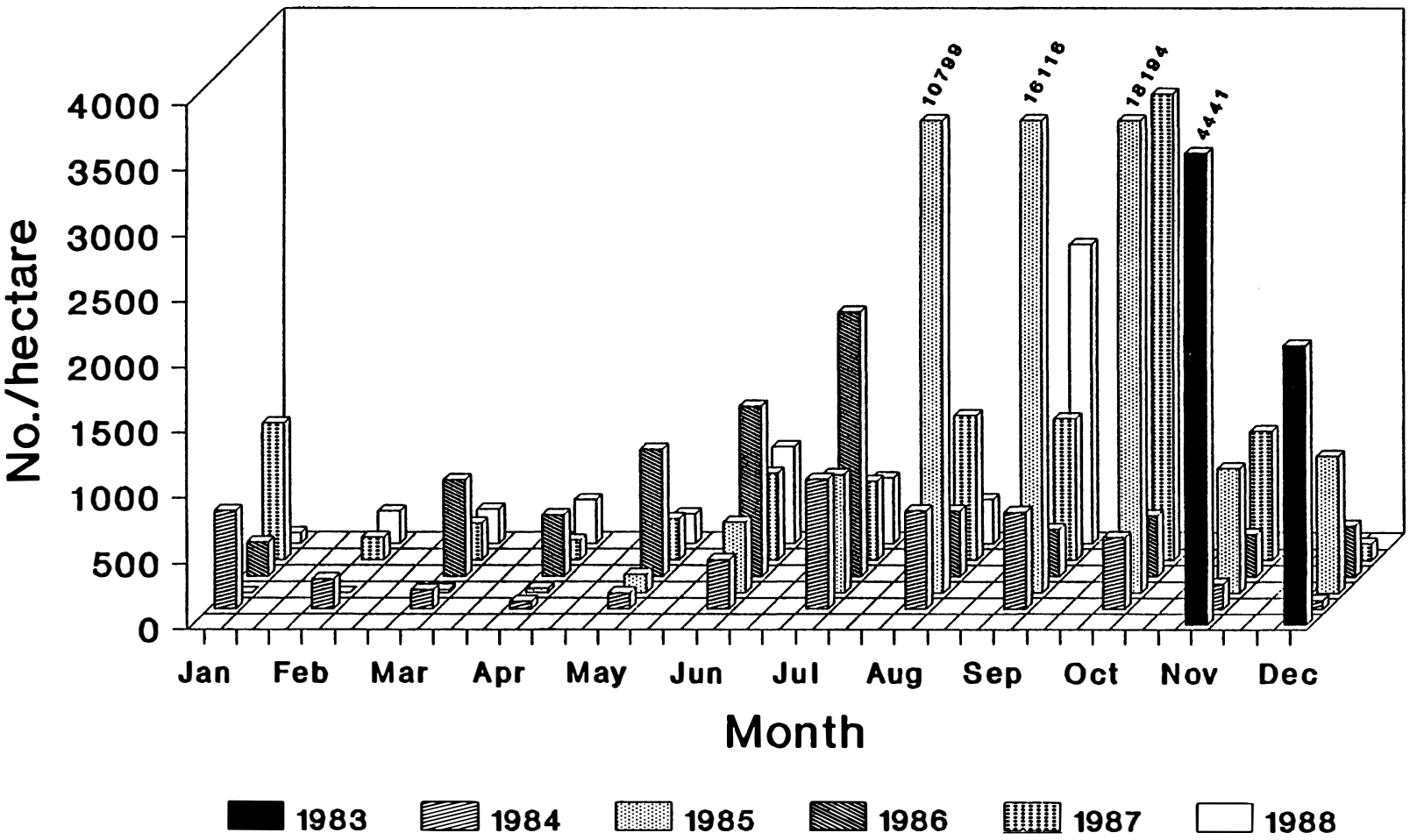

Figure 4.--Mean densities of Dungeness crabs (all size classes combined) in Chinook Channel (Station 6), Columbia River estuary, 1983-88; each bar represents one trawling effort. Empty squares for a specific month indicate that no sampling was done.

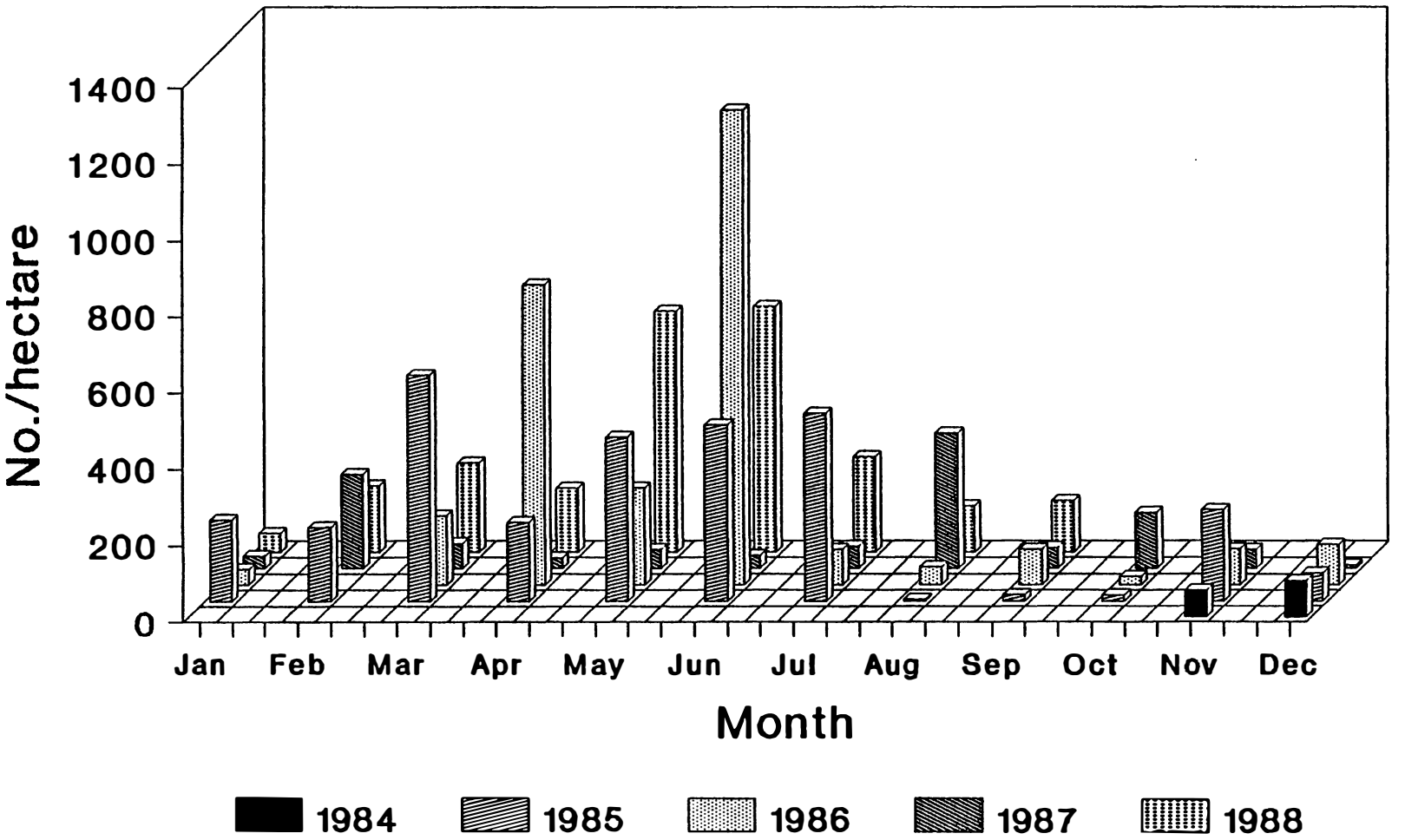

Figure 5.--Mean densities of Dungeness crabs (all size classes combined) in the Flavel Bar area (Station 10), Columbia River estuary, 1984-88; each bar represents one trawling effort. Empty squares for a specific month indicate that no sampling was done.

Table 3.--Densities (number/ha) of Dungeness crabs by size class in Ilwaco Channel (Station 3), Columbia River estuary, 1983-88; each number represents one trawling effort. Crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm).

Month	Size Class	Year					
		1983	1984	1985	1986	1987	1988
Jan	I	-	11	27	22	0	11
	II	-	142	54	173	146	125
	III	-	6	0	11	49	29
	IV	-	0	0	0	0	23
Feb	I	-	5	0	-	6	0
	II	-	62	32	-	156	941
	III	-	5	19	-	60	195
	IV	-	0	0	-	6	26
Mar	I	-	10	140	57	15	0
	II	-	170	190	1,375	230	222
	III	-	5	0	0	58	34
	IV	-	0	0	0	14	0
Apr	I	-	0	16	0	0	0
	II	-	22	5	91	449	108
	III	-	0	0	6	40	18
	IV	-	0	0	0	0	12
May	I	-	5	17	0	0	0
	II	-	59	6	6	2,471	1,311
	III	-	0	0	0	881	231
	IV	-	0	0	0	34	0
Jun	I	-	0	312	0	13	27
	II	-	36	1,886	302	588	465
	III	-	0	24	15	676	167
	IV	-	0	0	0	95	38
Jul	I	-	0	60	13	6	5
	II	-	86	180	400	238	135
	III	-	0	0	19	358	70
	IV	-	0	0	6	68	22

Table 3.--cont.

Month	Size Class	Year					
		1983	1984	1985	1986	1987	1988
Aug	I	-	0	0	0	6	0
	II	-	590	419	32	42	6
	III	-	86	19	6	150	28
	IV	-	7	0	0	48	17
Sep	I	-	6	0	0	0	0
	II	-	178	655	178	36	57
	III	-	273	50	100	31	293
	IV	-	57	22	39	20	128
Oct	I	-	0	0	0	17	-
	II	-	126	305	30	23	-
	III	-	138	32	48	68	-
	IV	-	42	0	30	40	-
Nov	I	27	86	17	0	0	-
	II	2,632	249	863	54	36	-
	III	54	108	183	12	66	-
	IV	0	5	0	36	30	-
Dec	I	48	162	22	0	6	-
	II	2,416	146	124	1,090	30	-
	III	0	5	5	269	18	-
	IV	0	0	0	57	0	-

Table 4.--Densities (number/ha) of Dungeness crabs by size class in Chinook Channel (Station 6), Columbia River estuary, 1983-88; each number represents one trawling effort. Crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm).

		Year					
Month	Size Class	1983	1984	1985	1986	1987	1988
Jan	I	-	0	0	7	0	0
	II	-	574	0	196	541	29
	III	-	170	0	47	439	21
	IV	-	0	0	7	61	29
Feb	I	-	0	0	-	0	0
	II	-	130	0	-	60	60
	III	-	81	0	-	103	144
	IV	-	16	0	-	5	42
Mar	I	-	0	6	0	0	0
	II	-	108	0	574	165	101
	III	-	39	12	162	85	121
	IV	-	0	6	0	28	38
Apr	I	-	0	14	0	0	6
	II	-	54	14	386	85	76
	III	-	6	7	77	31	140
	IV	-	0	0	0	31	108
May	I	-	7	58	7	30	0
	II	-	95	79	635	126	44
	III	-	20	0	311	132	140
	IV	-	0	0	13	24	38
Jun	I	-	0	38	29	0	7
	II	-	250	470	1,165	135	452
	III	-	122	25	101	378	189
	IV	-	0	0	0	149	88
Jul	I	-	29	54	15	0	0
	II	-	770	703	1,413	101	241
	III	-	187	93	525	264	167
	IV	-	0	46	62	236	93

Table 4.--cont.

Month	Size Class	Year					
		1983	1984	1985	1986	1987	1988
Aug	I	-	0	0	0	0	0
	II	-	245	6,698	232	451	30
	III	-	403	3,885	208	393	240
	IV	-	94	216	54	254	66
Sep	I	-	0	0	0	10	0
	II	-	345	6,865	184	494	365
	III	-	223	8,764	134	345	1,602
	IV	-	162	486	38	226	323
Oct	I	-	9	0	0	0	-
	II	-	288	4,559	202	1,479	-
	III	-	216	12,731	169	1,726	-
	IV	-	27	903	88	352	-
Nov	I	0	15	0	7	20	-
	II	3,504	77	451	101	88	-
	III	937	93	473	122	774	-
	IV	0	8	23	87	98	-
Dec	I	0	7	0	14	0	-
	II	1,365	41	706	182	19	-
	III	764	20	332	162	102	-
	IV	0	0	0	27	6	-

abundant at Station 3 than at Station 6, but Size Class IV crabs were more abundant at Station 6 than at Station 3. At Station 10, Size Class II was the most abundant, and Size Class IV was the least abundant (Table 5).

Salinities and temperatures were measured near the bottom throughout the study. McCabe et al. (1986) found that salinity and temperature, both individually and together, were poor predictors of crab densities for all size classes combined and for individual size classes. In no case was more than 24% of the variation explained by salinity or temperature. Salinity and temperature data for individual sampling efforts is available upon request.

DISCUSSION

Actual crab densities in the Columbia River estuary were probably higher than indicated by our trawl catches. The sampling efficiency of our 8-m semiballoon shrimp trawl for different size classes of Dungeness crabs in the Columbia River estuary is unknown. In Humboldt Bay, California, Gotshall (1978) estimated that his 4.9-m bottom trawl was about 50% efficient in collecting Dungeness crabs (combined Y-O-Y and older). Stevens and Armstrong (1984), who estimated crab populations in Grays Harbor estuary, Washington, used a sampling efficiency of 3.3% for early instar crabs collected with a 4.9-m semiballoon otter trawl.

During part of 1987 (half of July, August, and half of September) and virtually all of 1988, we were unable to sample at Station 26, the northernmost bar station. Mean crab densities for these periods probably would have been higher if Station 26 could have been sampled. Station 26 typically was a very productive crab station for the bar.

Our observations in the Columbia River estuary were similar to those made in Grays Harbor estuary by Stevens and Armstrong (1984), who noted widely fluctuating crab densities at individual stations. Two California researchers, Gotshall (1978) and Tasto (1983) also noted that annual crab populations can fluctuate widely.

Table 5.--Densities (number/ha) of Dungeness crabs by size class in the Flavel Bar area (Station 10), Columbia River estuary, 1984-88; each number represents one trawling effort. Crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm).

Month	Size Class	Year				
		1984	1985	1986	1987	1988
Jan	I	-	184	0	0	0
	II	-	11	14	0	5
	III	-	16	20	27	33
	IV	-	0	7	5	11
Feb	I	-	177	-	0	0
	II	-	10	-	36	38
	III	-	0	-	206	127
	IV	-	5	-	5	9
Mar	I	-	437	36	0	4
	II	-	152	131	7	185
	III	-	0	14	58	41
	IV	-	0	0	0	4
Apr	I	-	119	47	0	17
	II	-	86	713	5	108
	III	-	0	9	9	43
	IV	-	0	17	14	0
May	I	-	176	24	0	0
	II	-	248	225	5	556
	III	-	0	5	34	71
	IV	-	4	0	10	4
Jun	I	-	164	98	0	12
	II	-	296	1,131	10	631
	III	-	0	15	14	0
	IV	-	0	0	10	0
Jul	I	-	10	5	0	0
	II	-	477	76	21	220
	III	-	5	11	21	29
	IV	-	0	0	15	0

Table 5.--cont.

Month	Size Class	Year 1984	1985	1986	1987	1988
Aug	I	-	0	0	0	0
	II	-	5	33	162	84
	III	-	0	14	133	32
	IV	-	0	0	59	4
Sep	I	-	0	0	0	0
	II	-	11	68	4	56
	III	-	6	20	23	65
	IV	-	0	4	27	13
Oct	I	-	0	0	0	-
	II	-	5	9	23	-
	III	-	5	13	80	-
	IV	-	5	0	42	-
Nov	I	51	59	0	0	-
	II	5	54	11	4	-
	III	10	103	72	37	-
	IV	5	22	10	8	-
Dec	I	76	9	0	0	-
	II	11	17	0	0	-
	III	11	39	82	9	-
	IV	0	9	22	0	-

Densities of Size Class II (50-99 mm) and III (100-129 mm) crabs were particularly high at Stations 3 and 6 in Baker Bay at times. These shallow channels, which are lower water velocity areas, probably provide excellent feeding areas for crabs. Dungeness crabs consume fish and benthic invertebrates, such as amphipods, clams, isopods, and shrimp (Gotshall 1977; Stevens et al. 1982). Fishes are abundant in the shallow channel areas in Baker Bay during summer and fall (Bottom et al. 1984; Fox et al. 1984). Durkin and Emmett (1980) found that benthic invertebrate densities in Baker Bay were highest in June, September, and December, and lowest in March. During our study, the shrimp Crangon franciscorum was frequently observed in the trawl with Dungeness crabs. In Grays Harbor estuary, Washington, Crangon spp. were important in the diet of Dungeness crabs with a mean width of 79-81 mm (Stevens et al. 1982).

In November-December 1984, crab densities at Station 6 were extremely low in comparison to those same months in 1983 (Fig. 4). The lower densities in November-December 1984 may have partially resulted from hopper dredging operations that began prior to November sampling. In the absence of hopper dredging, densities at Station 6 might still have been lower than during fall 1983, but the decline might not have been as great. Crabs at Station 6 could have been affected both directly and indirectly by dredging activities through entrainment, reduction of food supply, and loss of suitable habitat. Crab densities at the other Baker Bay site (Station 3), which was not dredged during fall 1984, were also much lower in fall 1984 than during the preceding fall (Fig. 3).

CONCLUSIONS

Sampling on the bar and the three stations upstream from the bar (Stations 3, 6, and 10) clearly showed that densities of Dungeness crabs fluctuate temporally and spatially in the Columbia River estuary. High densities of crabs on the bar during the

spring and summer are extremely dependent on the immigration of early instar crabs or megalops larvae into the estuary. Although densities fluctuate annually, seasonal patterns have been identified at some sites. This information about the Columbia River estuary has and will continue to aid resource managers in making decisions about dredging schedules and methods to minimize impacts on Dungeness crabs.

This report does not constitute NMFS's formal comment under the Fish and Wildlife Coordination Act or the National Environmental Policy Act.

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