DISTRIBUTION AND RELATIVE ABUNDANCE OF LARVAE OF KING CRAB, *PARALITHODES CAMTSCHATICA*, IN THE SOUTHEASTERN BERING SEA, 1969-70

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ABSTRACT

During the spring and summer of 1969 and 1970, larvae of the king crab, *Paralithodes camtschatica*, were abundant in plankton samples from the southeastern Bering Sea. Abundance was highest near shore and generally lowest in the central and western parts of the study area. As the season progressed, the center of abundance moved northeastward along the Alaska Peninsula toward the head of Bristol Bay. This change in distribution was apparently related to water current patterns.

This report is based on collections of larvae of king crab, *Paralithodes camtschatica*, made by the Auke Bay Fisheries Laboratory, National Marine Fisheries Service, Auke Bay, Alaska, in the spring and summer of 1969 and 1970 in the southeastern Bering Sea. The larvae were collected during studies of migrating salmon and exploratory fishing for shellfish. In this report, I describe the distribution and relative abundance of the king crab larvae in the southeastern Bering Sea in 1969 and 1970 and relate seasonal changes in the distribution of the larvae to current patterns.

The only reports on distribution and abundance of king crab larvae in the study area are those by Takeuchi (1962, 1968) and Rodin.[2] Takeuchi sampled with various types of plankton nets from Japanese crab processing ships off the Black Hills-Port Moller area in 1957, 1958, and 1960. He found more king crab larvae off Port Moller than the Black Hills area, but because his sampling was restricted in area, he could not determine where the larvae had been released or where they dispersed. Rodin's study encompassed a greater area than Takeuchi's but was of shorter duration (less than 1 mo as compared with an average of nearly 2 mo). Rodin speculated, however, that king crab larvae were released primarily in the Port Moller area.

My study provided further evidence that a major area of release of king crab larvae occurs in the Black Hills-Port Moller area and the larvae generally disperse northeastward along the Alaska Peninsula toward the head of Bristol Bay.

MATERIALS AND METHODS

A total of 249 plankton tows were made in the southeastern Bering Sea from May to September 1969, and 237 were made from March to September 1970. Ten-minute oblique hauls were taken from the bottom to the surface during daylight with paired bongo nets (Posgay, Marak, and Hennemuth, 1968), each with a mouth area of 0.03 m^2 and nylon netting of 0.333-mm mesh. Tows were made at a speed of about 3 knots without regard to tide stage. The plankton samples were preserved in 5% Formalin[3] and seawater immediately after they were collected.

Although flowmeters were inside each sampler to determine the amount of water strained, mechanical difficulties prevented an accurate measure for most tows. However, the data have been converted to numbers of larvae under 10 m^2 of sea surface, as an index sufficiently precise to determine the general distribution and relative abundance of the larvae. Because the correlation between the two nets fished simultaneously was high (r = 0.979) and it is desirable to use whole numbers, I summed the catch of the two nets in

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[2]Rodin, V. E. 1966. Soviet investigation in 1965 to determine the status of king crab (*Paralithodes camtschatica* (Tilesius)) stocks in southeastern Bering Sea. Unpubl. manuscr., 12 p. Auke Bay Fisheries Laboratory, National Marine Fisheries Service, NOAA, Auke Bay, AK 99821.

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

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each tow rather than use the average in my analysis. The terms "positive tow" and "negative tow" are used to describe plankton tows that contained king crab larvae and those that did not. The station locations and developmental stages of king crab larvae captured for the positive tows are given in Table 1; the locations of both positive and negative tows are indicated in the charts showing distribution of larvae (Figures 1 to 7). Charts showing distribution and abundance of larvae were made by plotting the number of larvae under 10 m² of sea surface at each station and then drawing isopleths. Identification of the larval stages was based on descriptions given by Marukawa (1933), Sato and Tanaka (1949), and Kurata (1964).

TABLE 1.—Station location and number and stage of development of king crab larvae captured for each positive tow collected in the southeastern Bering Sea, 1969 and 1970.

Date	Depth (m)	Station location		Larval stage					
				Zoea					
		Lat. N	Long. W	I	II	III	IV	Glaucothoe	Total
1969									
May									
18	55	55°00′	165°00′	39	32	5	—	—	76
19	45	58°00′	163°22′	1	—	1	—	—	2
20	75	56°20′	162°12′	10	—	—	—	—	10
26	116	55°20′	165°45′	—	1	7	—	—	8
26	107	55°40′	165°10′	—	4	10	7	—	21
27	116	55°40′	165°47′	—	—	6	4	—	10
29	44	57°40′	163°22′	—	1	—	—	—	1
June									
3	45	56°20′	161°00′	5	18	8	4	—	35
3	63	57°00′	160°57′	4	13	6	—	—	23
3	63	57°00′	159°43′	49	60	1	—	—	110
3	47	57°40′	159°38′	5	1	1	—	—	7
4	57	57°40′	160°53′	8	1	—	—	—	9
4	47	58°00′	160°51′	4	2	—	—	—	6
4	40	58°00′	162°07′	1	—	—	—	—	1
5	75	56°20′	162°12′	—	2	2	—	—	4
17	19	56°03′	160°58′	—	—	—	2	—	2
18	63	57°00′	160°57′	—	—	—	2	—	2
19	63	57°00′	159°43′	2	23	20	6	—	51
19	47	57°40′	159°38′	2	9	—	—	—	11
19	57	57°40′	160°53′	2	3	1	—	—	6
19	47	58°00′	160°51′	—	3	5	—	—	8
20	46	57°40′	162°08′	1	2	—	—	—	3
20	60	57°00′	162°10′	—	—	1	1	—	2
24	66	56°40′	160°59′	—	1	—	4	—	5
24	68	56°30′	160°59′	—	—	2	1	—	3
24	45	56°20′	161°00′	—	—	1	6	—	7
26	68	56°30′	160°59′	—	—	3	7	—	10
27	29	56°54′	159°08′	—	—	—	1	—	1
27	36	57°00′	159°07′	—	—	—	1	—	1
27	45	57°09′	159°05′	—	—	2	3	—	5
27	51	57°20′	159°04′	—	2	9	5	—	16
28	51	57°29′	159°03′	—	5	42	7	—	54
28	44	57°40′	159°01′	—	—	11	—	—	11
28	35	57°49′	159°00′	—	1	8	1	—	10
28	37	57°55′	158°59′	—	—	5	1	—	6
29	43	58°00′	158°58′	—	—	4	1	—	5
July									
1	45	58°10′	160°50′	—	—	—	1	—	1
1	47	58°00′	160°51′	—	—	3	2	—	5
2	63	57°00′	160°57′	—	—	—	4	—	4
4	25	57°31′	158°54′	—	—	—	1	—	1
4	29	57°41′	158°17′	—	—	—	—	1	1
4	35	57°47′	158°23′	—	—	—	1	—	1
7	22	58°33′	159°31′	—	—	—	—	1	1
7	23	58°29′	159°32′	—	—	—	—	3	3
7	28	58°14′	159°30′	—	—	—	1	—	1
8	35	57°55′	158°33′	—	—	—	4	—	4
8	36	57°44′	158°20′	—	—	—	6	—	6
9	51	57°20′	159°04′	—	—	1	4	—	5
9	45	56°20′	161°00′	—	—	—	—	1	1
13	63	57°00′	159°43′	—	—	—	4	—	4
14	47	57°40′	159°38′	—	—	2	29	—	31
14	57	57°40′	160°53′	—	—	—	1	—	1
1970									
March									
29	111	55°08′	165°12′	1	—	—	—	—	1

TABLE 1.—Continued.

Date	Depth (m)	Station location: Lat. N	Station location: Long. W	Larval stage: Zoea I	Zoea II	Zoea III	Zoea IV	Glaucothoe	Total
1970—Continued									
May									
9	60	55°00′	164°35′	399	20	2	—	—	421
13	73	56°40′	163°23′	1	—	—	—	—	1
13	75	56°20′	162°48′	1	3	—	—	—	4
14	47	55°40′	162°50′	16	9	—	—	—	25
14	76	56°00′	162°14′	26	2	—	—	—	28
14	75	56°20′	162°12′	2	—	—	—	—	2
15	65	56°40′	162°11′	1	—	—	—	—	1
15	65	57°00′	161°34′	1	—	—	—	—	1
16	65	57°20′	161°32′	2	—	—	—	—	2
16	55	57°20′	160°56′	1	—	—	—	—	1
16	58	57°20′	160°18′	11	2	—	—	—	13
16	63	57°00′	159°43′	1	—	—	—	—	1
17	35	56°40′	159°45′	9	1	—	—	—	10
17	58	56°40′	160°22′	9	—	—	—	—	9
17	58	57°00′	160°20′	12	1	—	—	—	13
17	63	57°00′	160°57′	7	—	—	—	—	7
18	66	56°40′	160°59′	14	2	—	—	—	16
18	86	56°40′	161°35′	20	1	—	—	—	21
18	61	56°20′	161°37′	40	10	2	—	—	52
19	45	56°20′	161°00′	163	106	—	—	—	269
19	25	56°20′	160°25′	5	3	—	—	—	8
22	73	56°10′	162°14′	11	4	—	—	—	15
22	52	56°06′	161°53′	4	1	—	—	—	5
22	70	56°26′	161°59′	16	7	—	—	—	23
23	71	56°40′	161°22′	3	1	—	—	—	4
23	60	56°26′	161°33′	35	17	—	—	—	52
24	22	57°07′	160°52′	1	—	—	—	—	1
24	47	56°19′	161°04′	9	2	—	—	—	11
24	70	56°31′	161°17′	36	22	—	—	—	58
24	83	56°43′	161°30′	3	1	—	—	—	4
24	64	56°55′	161°42′	6	2	—	—	—	8
24	51	57°07′	161°55′	4	—	—	—	—	4
25	36	58°02′	161°33′	1	—	—	—	—	1
25	22	58°13′	160°08′	1	—	—	—	—	1
26	45	57°41′	159°50′	2	1	—	—	—	3
26	45	57°29′	159°37′	3	1	—	—	—	4
26	51	57°17′	159°25′	2	1	—	—	—	3
26	47	57°06′	159°12′	5	12	—	—	—	17
26	21	56°54′	159°00′	—	2	—	—	—	2
28	89	55°52′	163°17′	1	—	—	—	—	1
28	59	55°39′	163°04′	1	—	—	—	—	1
29	111	55°33′	165°36′	—	1	1	—	—	2
29	111	55°21′	165°24′	—	12	4	—	—	16
29	111	55°08′	165°12′	—	2	1	—	—	3
29	91	54°56′	164°59′	—	13	1	—	—	14
29	43	54°43′	164°47′	2	5	2	—	—	9
June									
8	111	55°08′	165°12′	1	36	36	1	—	74
15	48	56°19′	161°00′	1	7	15	5	—	28
21	49	56°22′	161°00′	—	4	3	—	—	7
21	42	56°17′	161°00′	—	4	2	4	—	10
25	27	56°09′	161°00′	—	—	5	11	—	16
25	21	56°07′	160°52′	—	—	2	8	—	10
26	47	56°19′	161°04′	—	1	—	1	—	2
26	70	56°31′	161°17′	—	2	—	—	—	2
26	83	56°43′	161°30′	—	—	2	—	—	2
26	64	56°55′	161°42′	—	2	1	—	—	3
26	51	57°07′	161°55′	1	—	—	—	—	1
27	47	57°06′	159°12′	—	—	15	18	—	33
27	51	57°17′	159°25′	—	2	38	16	—	56
27	45	57°29′	159°37′	—	3	23	7	—	33
27	45	57°41′	159°50′	—	4	34	4	—	42
27	42	57°54′	159°42′	—	—	15	9	—	24
27	22	57°59′	157°55′	—	—	—	1	—	1
27	33	58°04′	158°25′	—	—	—	1	—	1
28	22	58°13′	160°08′	—	—	—	2	—	2
28	41	58°38′	162°16′	—	—	—	1	—	1
29	40	58°22′	163°24′	—	1	—	—	—	1
30	59	55°39′	163°04′	—	—	1	1	—	2
30	28	55°27′	162°52′	—	—	—	1	—	1
July									
1	111	55°33′	165°36′	—	—	—	—	1	1

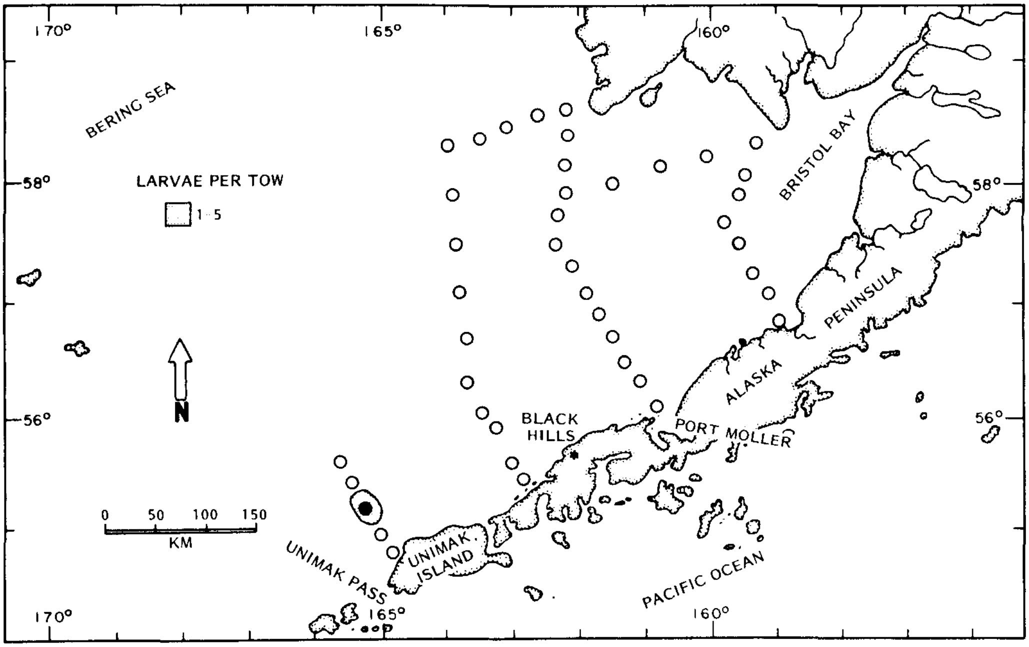

FIGURE 1.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 29 March-30 April 1969 and 1970. Solid circle indicates larvae were present at station.

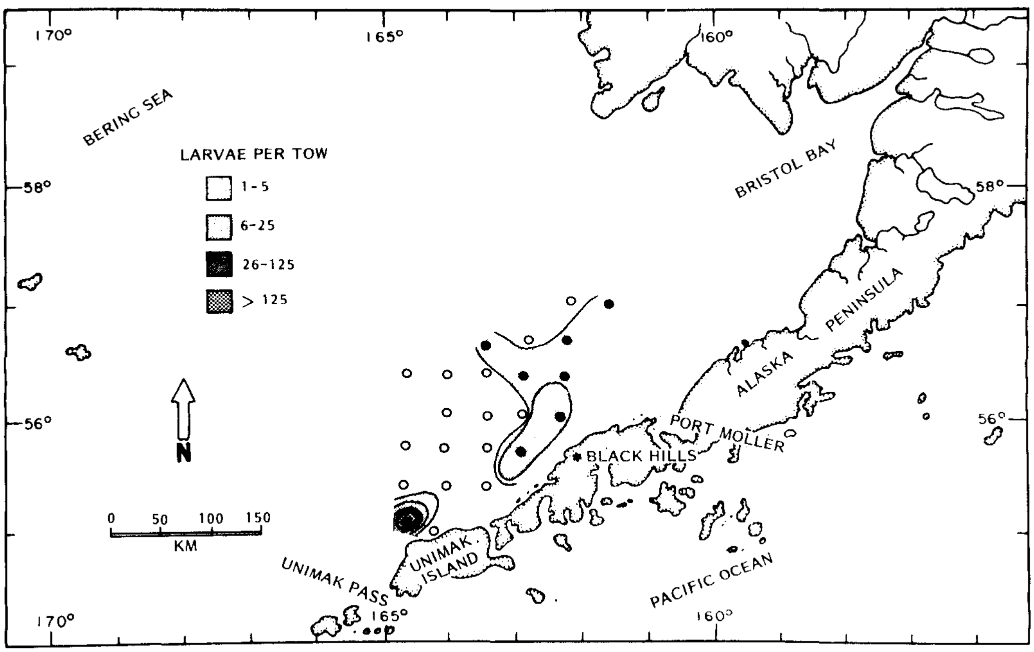

FIGURE 2.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 1-15 May 1969 and 1970. Solid circles indicate larvae were present at station.

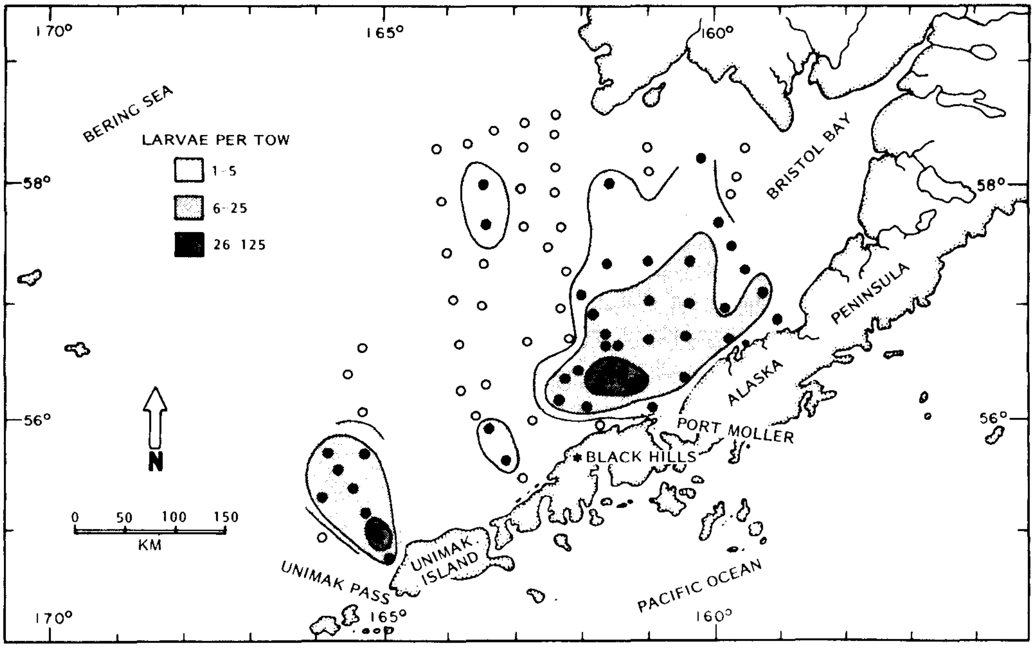

FIGURE 3.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 16-31 May 1969 and 1970. Solid circles indicate larvae were present at station.

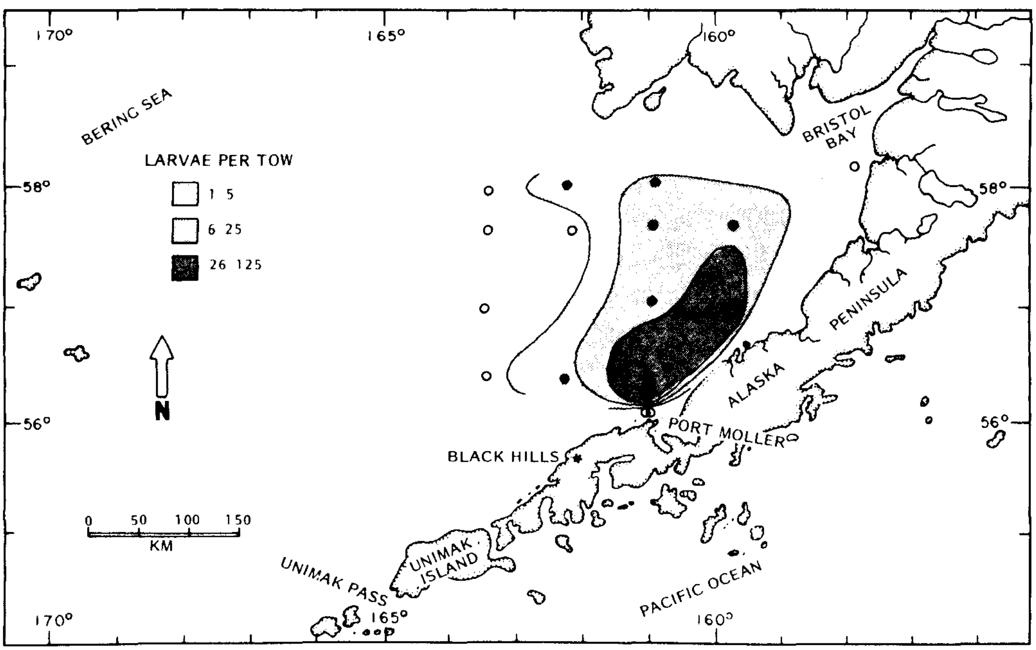

FIGURE 4.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 1-15 June 1969 and 1970. Solid circles indicate larvae were present at station.

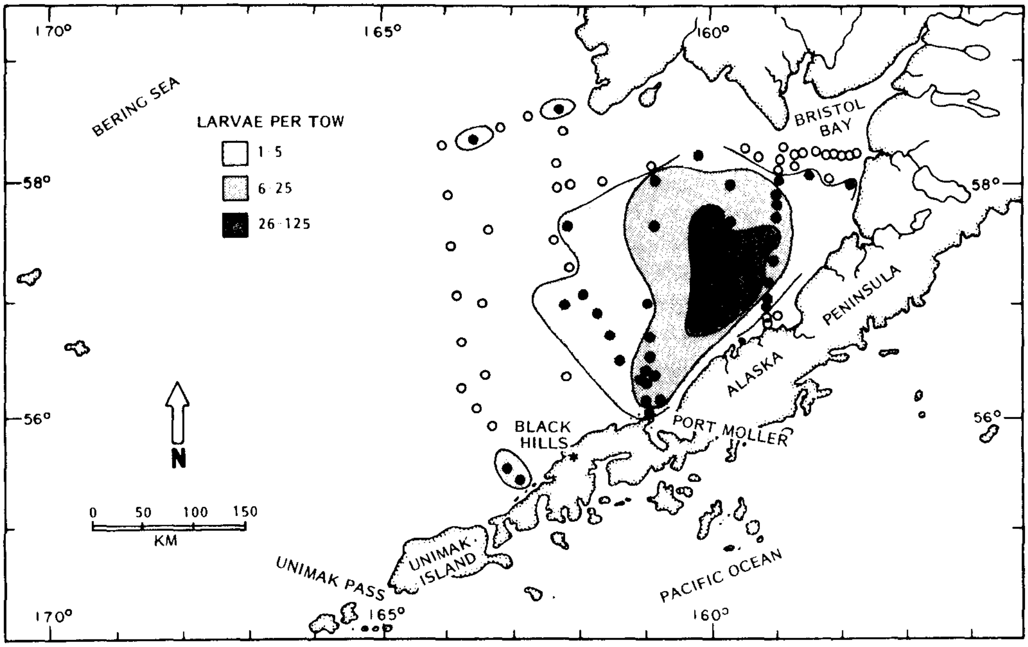

FIGURE 5.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 16-30 June 1969 and 1970. Solid circles indicate larvae were present at station.

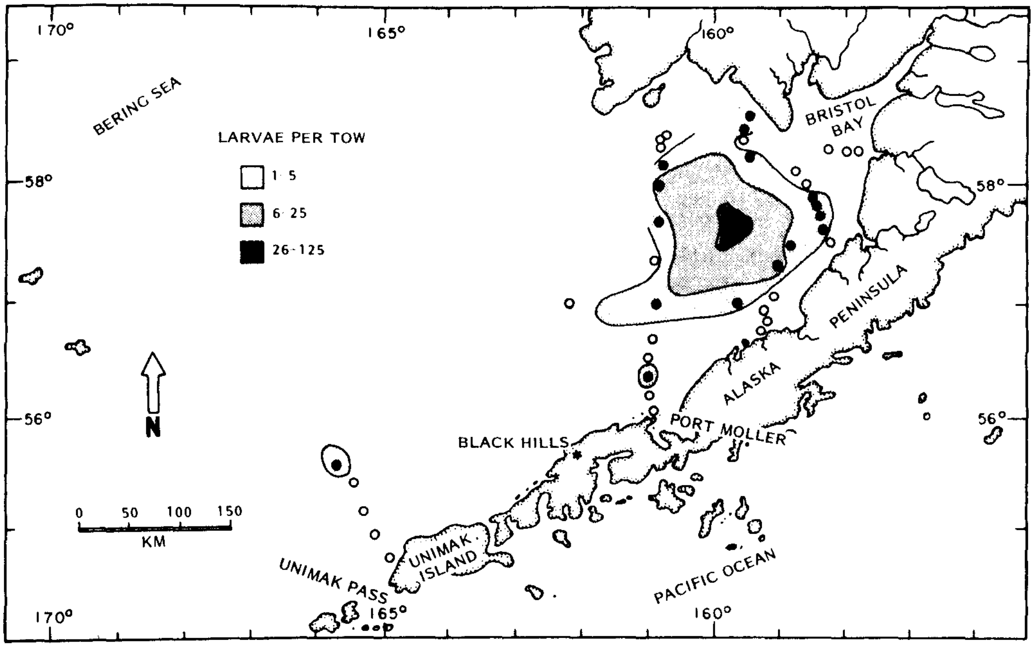

FIGURE 6.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 1-15 July 1969 and 1970. Solid circles indicate larvae were present at station.

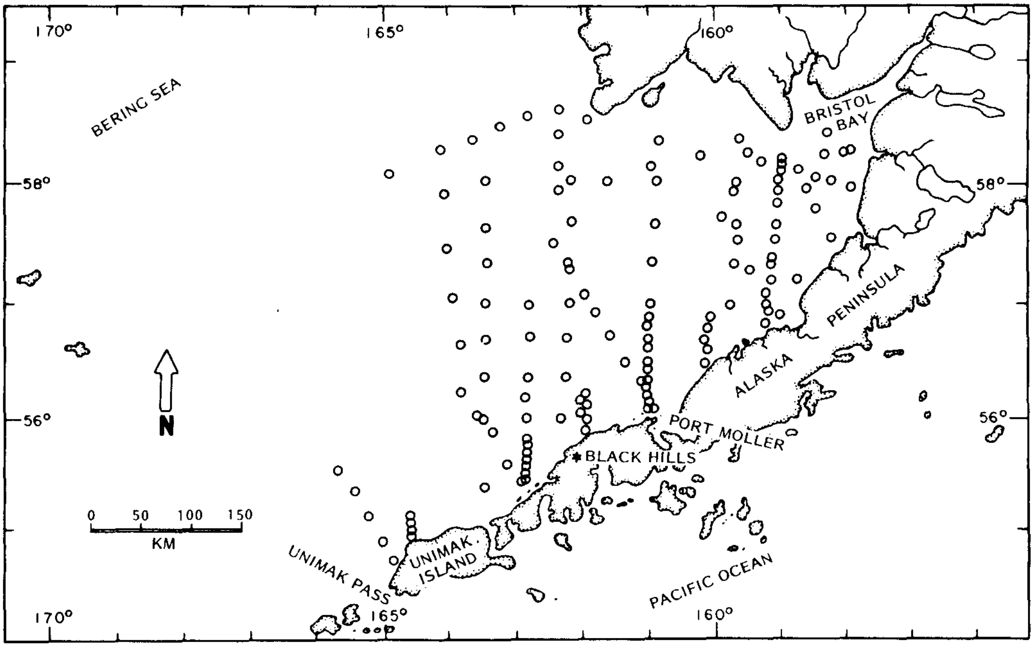

FIGURE 7.—Distribution and relative abundance of king crab larvae sampled at stations in the southeastern Bering Sea, 16 July-21 September 1969 and 1970.

DISTRIBUTION AND RELATIVE ABUNDANCE

Although sampling locations and dates were different each year, I determined that I could combine the data for both years for consideration of distribution and abundance. For each semimonthly period, I tabulated the degree squares (the areas bordered by 1° of latitude and longitude) that were sampled in both years. This resulted in 14 degree squares, 7 each for the latter half of May and June. For each of the two semimonthly periods, the median catch per tow was computed and the degree squares were ranked "good" or "poor" on the basis of whether their catch per tow was greater or lesser than the median. In this manner it was possible to compare degree squares without considering the actual abundance of larvae. The degree square data indicated that in every instance except one the same degree squares for each year were consistently good or poor.

I assumed therefore that the distributions were not random and that the data for the two sampling years could be combined for analyzing larval distribution.

The combined data on distribution of larvae in 1969 and 1970 are presented by time periods (usually semimonthly) between 29 March and 21 September (Figures 1 to 7). Most of the larvae were in the southern and eastern portions of the study area and within these areas were most abundant close to shore. The largest catches (more than 1,000 larvae under 10 m² of sea surface) were made near Unimak Pass and Port Moller; the smallest (usually fewer than 10 larvae under 10 m² of sea surface) were generally made in the more central and western parts of the area.

The distribution and abundance of larvae in the Black Hills-Port Moller area increased gradually toward the head of Bristol Bay. During the first half of May (Figure 2), larvae were found off the Black Hills area; 2 wk later (Figure 3), these larvae apparently had been carried northeastward along the coast and became mixed with larvae released off the Port Moller area. As the season continued, the center of abundance shifted farther toward the head of the bay (Figures 4 and 5). This trend continued until mid-July (Figure 6), when no more larvae were taken (Figure 7).

The seasonal progression of occurrence of larvae off Unimak Island is less clear. A small concentration of larvae was found in this area in early May (Figure 2); 2 wk later they were most abundant to the northwest toward the open sea (Figure 3). Too few samples were taken in the Unimak Island area after May to determine the extent of the drift of larvae.

The four zoeal stages that king crab larvae pass through before molting to the glaucothoe (settling) stage were all represented in my samples (Table 1). The percentage of larvae in each zoeal stage is shown by semimonthly intervals in Figure 8. A comparison of this figure with Figures 1 to 7 shows that the progression of larval stages corresponded closely with the seasonal progression of larval distribution. For instance, the abundant larvae found early in the season off Unimak Island and Port Moller were mostly stage I. As the areas of greatest abundance moved toward the head of the bay, the percentage of later larval stages in the samples increased, and by July most of the larvae were stage IV (Figure 8).

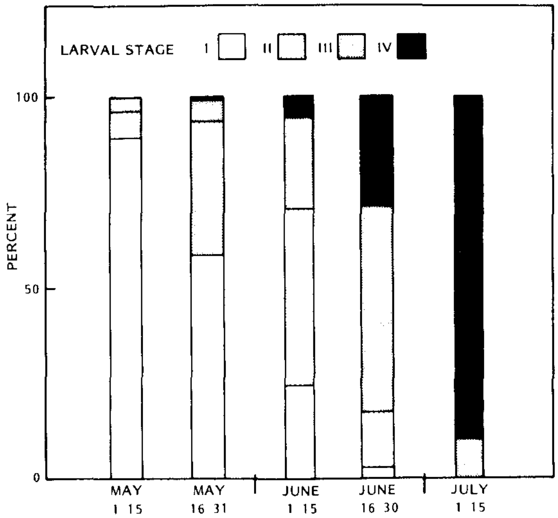

FIGURE 8.—Percentages of four zoeal stages of king crab larvae sampled at stations in the southeastern Bering Sea, 1969 and 1970. Data for 1969 and 1970 combined by semimonthly periods (see Figures 3 to 7).

LARVAL RELEASE AREAS

Areas of relatively high abundance of stage I larvae are generally assumed to be the areas where the larvae were released by the female. This proved to be true in the present study: stage I larvae were abundant near Unimak Island and the Black Hills-Port Moller area where female king crabs with empty egg cases were also abundant (Figure 9). (The egg cases remain attached to the pleopods of the female for some time after the larvae have been released.) The

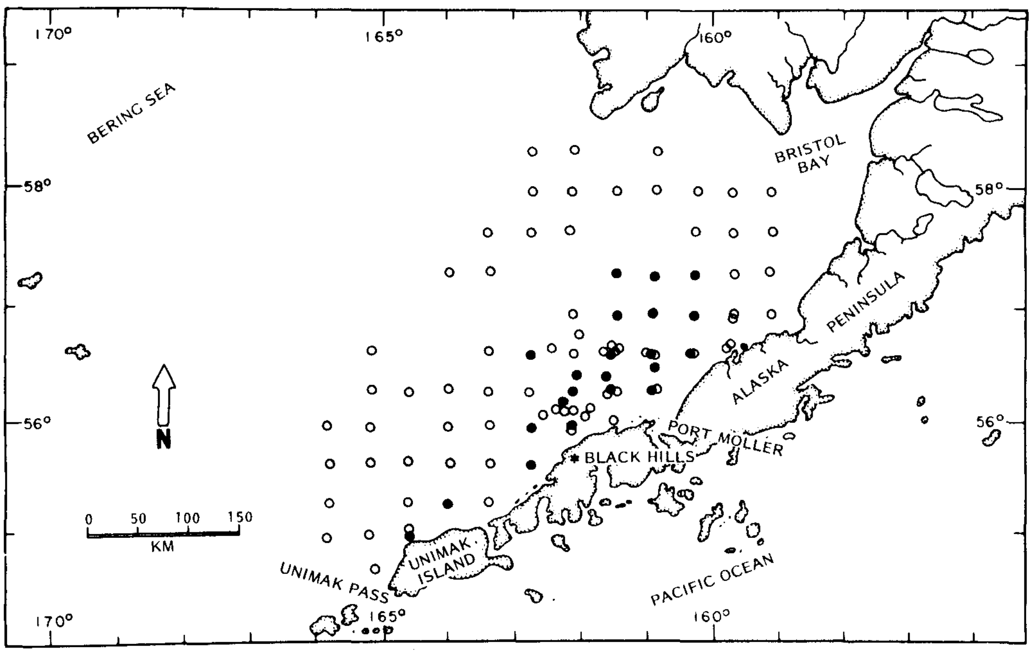

FIGURE 9.—Trawling stations (circles) in the southeastern Bering Sea where female king crabs were taken in May 1969 and 1970. Stations with crabs with empty egg cases are designated by solid circles.

distribution of egg-bearing king crabs with empty egg cases shown in Figure 9 was determined from trawling in May 1969 and 1970 (data combined). Weber (1967) also reported that in Bristol Bay, king crabs usually release their larvae in May.

RELATION BETWEEN DISTRIBUTION OF LARVAE AND CURRENT PATTERNS

My observations of the dispersal of stage I larvae from the release areas generally agree with the known patterns of water currents in the study area. Hebard (1959) found that in the southeastern Bering Sea water moved counterclockwise toward Bristol Bay along the Alaska Peninsula and away from Bristol Bay in the more northern parts of the southeastern Bering Sea. Under these conditions larvae released in the Black Hills-Port Moller area would be carried northeastward along the Alaska Peninsula toward the head of Bristol Bay. The seasonal shift of larvae shown in Figures 1 to 7 corresponds closely with this pattern of water movement.

Because of differences in water currents, the direction of seasonal shift of larvae is different in the Unimak Island area than it is to the east. Oceanographic studies in this area, summarized by Dodimead, Favorite, and Hirano (1963), show that water from the Gulf of Alaska flows northward through the interisland passages of the Aleutian Islands in the southeastern Bering Sea. Such a flow pattern through Unimak Pass is consistent with the apparent northward movement of king crab larvae from the Unimak Island area (Figure 3).

On the basis of his findings on water currents in the southeastern Bering Sea, Hebard (1959) postulated that recruitment of king crab larvae into the Bering Sea may occur through the island passages of the Aleutian Islands, especially Unimak Pass. If this is so, then the possibility exists that the stock of king crabs in Bristol Bay is derived to some extent from larvae released south of the Alaska Peninsula. Unfortunately, plankton was not collected south of Unimak Pass during the present study, and the question of recruitment of king crab larvae into Bristol Bay from areas south of the Alaska Peninsula must await a more detailed investigation.

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