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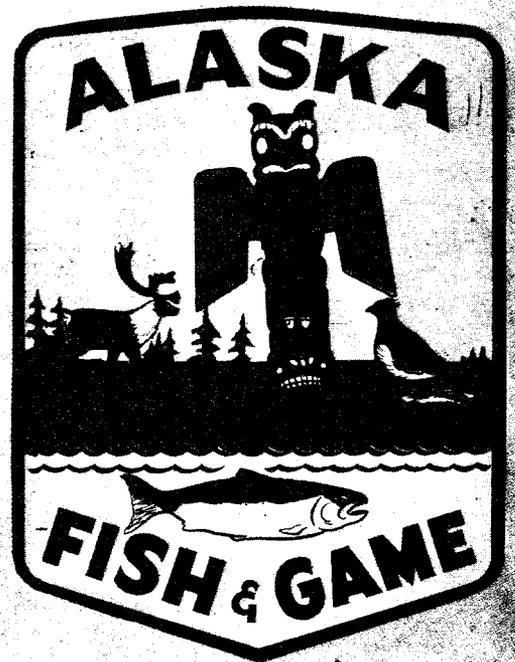
MOVEMENTS OF TAGGED KING CRABS
Paralithodes camtschatica (Tilesius) IN
THE KODIAK ISLAND - LOWER COOK INLET
REGION OF ALASKA, 1954 - 1963

By:

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ABSTRACT

During the period 1954 to 1962, 21,078 juvenile and adult king crabs of both sexes, between 75 and 190 mm. in carapace length, were marked with permanent tags and released at numerous locations in the Kodiak Island - Lower Cook Inlet region of Alaska. Subsequent migration data were obtained from the recovery of 6,922 tagged crabs reported by the commercial fishing fleet. During late winter and early spring adult male crabs traveled from deep to shallow water generally moving landward. This movement is related to spawning, which is known to occur in less than 40 fathoms of water during March, April and early May. After breeding, crabs return to deep water until the next spawning season. The king crabs existing in the Kodiak Island-Lower Cook Inlet area appear to be organized into six populations. Movements of mature females are similar to those of the adult male. Juvenile king crabs probably do not travel as extensively as adults until their fifth or sixth year.

INTRODUCTION

Commercial exploitation of Alaska's king crab stocks has increased considerably during the past decade, particularly in the Kodiak Island-Lower Cook Inlet region. In 1951, the commercial catch in this area was 20 thousand crabs. By 1963 production had increased to 5.7 million crabs. Intelligent management of this resource is essential for maximum sustained harvest and depends on a thorough knowledge of the crab's life history.

This paper presents migration data of 21 tag and recapture studies conducted in the Kodiak Island - Lower Cook Inlet area from 1954 to 1963, by the Alaska Department of Fish and Game and the U.S. Bureau of Commercial Fisheries. Migration data of both agencies has been combined in this report to provide one convenient summary of crab movements. Preparation of this manuscript was facilitated by the memorandum of understanding initiated in 1961 between the United States Fish and Wildlife Service and the Alaska Department of Fish and Game whereby the Alaska Department of Fish and Game assumed responsibility for the recovery of all federally tagged crabs in the Kodiak Island area. The presentation of this data has been simplified and shortened by omitting voluminous catch information. Although individual

area catches are not presented here they have been analyzed and are on file.^{1/}

Several limitations are inherent in a tag and recapture program. The most important single point to consider is that the majority of tag recoveries are necessarily from the commercial fishing fleet and cannot be regarded as random samples of the various populations under investigation. More specifically, fishing effort is typically concentrated. Areas of harvest change with the seasons, deep water in summer and shallow water in the spring. Consequently, at any one time a portion of the investigated king crab stocks on the submerged continental shelf were not being sampled and crab movements could have occurred which were not detected by tag returns. This was especially true in ocean areas where a sporadic fishery exists only during the summer months when weather is relatively calm. Shoreward areas of the continental shelf have been more intensively fished and explored with the result that certain areas have proved historically to be more productive than others.

Another limiting factor is that only adult male king crabs greater than 7 inches in carapace width are retained by the United States commercial fishery. Although females and sub-legal sized males have been tagged in the Kodiak area, concentrations of those crabs are avoided by the fishermen and little data has been obtained from tag returns to define their movements.

Japanese and Russian biologists were the first to study king crab movements. They conducted tagging and recapture programs on Asiatic stocks at least as early as 1922 (Marukawa, 1933; Vinogradov, 1945). Tagging on American stocks began in the Eastern Bering Sea in 1954 precipitated as a result of increased Japanese and American fishing in this location following World War II. William C. Herrington, Special Assistant for Fisheries and Wildlife to the Under Secretary, requested for the United States to the International North Pacific Fisheries Commission on February 6, 1954 that a study of king crab in the Bering Sea be initiated. The Bureau of Commercial Fisheries Biological Laboratory in Seattle, Washington (then Pacific Salmon Investigations) was assigned this study for the United States. Migration data collected by both countries since 1954 are reported by the International North Pacific Fisheries Commission in it's annual reports for the years 1955 through 1961. Other tagging investigations of king crabs in Alaska were initiated near the Shumigan Islands by the Bureau of Commercial Fisheries (Hayes and Montgomery, 1963), and also by the University of Southern California in Cook Inlet (Bright, Durham and Knudsen, 1961).

METHODS

History of King Crab Tagging

Prior to 1954, tagging programs were conducted exclusively with temporary tags because permanent tags had not been developed. In 1954,

^{1/} Alaska Department of Fish and Game - Subport Building, Juneau, Alaska

Ed Huizer, while studying king crab molting for the Alaska Department of Fisheries, successfully determined how to tag king crabs so that the tags would be retained throughout successive molts (Alaska Fisheries Board and Alaska Department of Fisheries, 1955). Simultaneously he developed the first isthmus loop tag using hollow, colored, plastic tubing. Crabs marked with these tags have since remained free in the ocean for periods in excess of six years before being captured (Powell, 1964). The design of the loop tag has been modified several times during its continued use by the United States since 1954 with the exception of 1960 when carapace darts were used (Powell, 1964). The history of the development of king crab tags is described in detail by Gray (1964).

Tagging in the Vicinity of Kodiak Island

Tagging programs in the Kodiak Island area of Alaska from 1954 through 1957 were pilot studies conducted on a small scale. Their value consists primarily in the background information they provide for subsequent investigations. During this period, tagged crabs were liberated in small numbers at several locations. Returns were limited by the absence of an extensive commercial fishery.

Most crabs were tagged aboard chartered fishing vessels and liberated immediately after being caught. Exceptions were those releases in Chiniak Bay (1959), Marmot Bay (1959), and the Twoheaded Island district (1960). These crabs were retained in circulating sea water for one to three days before release.

Specimens for tagging are captured primarily with large baited pots superior to trawls because less injury is incurred.

After 1958 tagging programs were enlarged and improved. More tagged crabs were released in each area with emphasis on the commercially valuable adult male, and more advanced tagging and recovery techniques were employed. Even greater returns resulted due to increased effort by the expanding commercial fishery. In addition, better tag materials were used resulting in reduced tag loss.

The result of improved plastic tubing and legend disc is seen by comparing recoveries from the 1958 and 1959 tagging programs in Chiniak Bay. In 1958, 2,467 crabs were tagged and released. Five years later, 13 percent had been recovered. In 1959, 3,260 crabs were marked with improved materials only. Four years later 35 percent had been recaptured. The increased rate of tag recovery is attributed primarily to reduced tag loss resulting from improved tag materials. Fishing intensity is not considered a major contributing factor since both studies were conducted in Chiniak Bay which is small and where harvest remained relatively stable.

From 1954 to 1959 male and female king crabs larger than 75 mm. in carapace length were tagged and released within the bays. As the commercial fleet expanded, boats ventured further seaward making it possible to extend tagging programs to ocean areas near the continental slope. The majority of all crabs tagged during 1960 to 1961 were released in ocean

areas (Table 1). All were adult males over 135 mm. in carapace length.

Tag Recovery

All tagged crabs were recovered by the commercial fishery. Accurate capture information and high percent recovery were made possible by continual close personal contact with fishermen and cannery employees. At the more accessible canneries routine personal interviews were conducted with fishermen as their boats were unloaded. At isolated canneries and factory ships cooperating people were visited frequently by biologists to insure continued assistance. A cash reward of two dollars was paid for each tagged crab turned in. All boats were supplied with research charts, tag recovery forms, and special web sacs for holding tagged crabs separate from the catch.

RESULTS

Commercial Harvest

The Kodiak Island - Lower Cook Inlet region of Alaska is divided into 203 different statistical areas from which commercial catches are recorded daily. The larger more seaward areas are clearly seen in Figure 1. Major king crab fisheries exist in the following locations: Alitak, Twoheaded-Trinity, Chiniak-Marmot, and Lower Cook Inlet. Figure 2 shows the number of crabs caught in the major fisheries of Kodiak Island and Lower Cook Inlet by season for the period 1959-1963.

Movements

King crabs walk in constant contact with the seabed of the continental shelf and are captured from depths seldom exceeding 150 fathoms and often as shallow as 5 fathoms. The three conspicuous bottom regions of the continental shelf adjacent to Kodiak Island to which king crab migrations may be related are illustrated in Figure 3. Figures 4 and 5 show recovery locations for each of the major tagging programs listed in Table 1. A discussion of specific migrations follows.

Juvenile king crabs. Few juvenile king crabs (under 100 mm. in carapace length) have been tagged and only a small amount of data is available to define their movements. A general outline of juvenile movements determined by close observation of the commercial fishery and life history studies is presented below:

Planktonic larvae hatch from eggs in the spring and before settling to the bottom undergo metamorphosis to the adult crab form (Marukawa, 1933). The movements of crabs during planktonic larval stages are determined by the combined effects of wind, tide and water current (Hebard, 1959).

Table 1. King crab tagging projects conducted by U. S. Bureau of Commercial Fisheries and Alaska Department of Fish and Game with annual recoveries, 1954-1963. Kodiak Island-Lower Cook Inlet, Alaska.

area	Release		Number of tagged crabs released		Number & percent of tagged crabs recovered through April, 1963		Number of tagged crabs recovered each year or portion of a year (through April 1963) following tagging, beginning with month of release					
	agency	date	males	females	males	females	first	second	third	fourth	fifth	sixth
Seaward from Marmot Bay	USBCF	July-Sept. 1962	1504	-	185 12%	-	185	-	-	-	-	-
Seaward from Chiniak Bay	USBCF	July-Sept. 1962	1344	-	172 13%	-	172	-	-	-	-	-
South of Sitkinak Bay	USBCF	July-Sept. 1962	325	-	118 36%	-	118	-	-	-	-	-
South of Tugidak Is.	USBCF	July-Sept. 1962	561	-	85 15%	-	85	-	-	-	-	1
East of Chirikof Is.	USBCF	July-Sept. 1962	680	-	55 8%	-	55	-	-	-	-	1
Alitak Bay	ADF&G	August 1961	5976	-	3861 65%	-	1943	1918	-	-	-	-
Lower Cook Inlet	USBCF	September 1961	659	-	67 ¹ / ₁₀ 10%	-	Data not available					
Cape Douglas	ADF&G	July 1961	373	-	123 33%	-	55	68	-	-	-	-
Twoheaded Island	ADF&G	October 1960	800	-	285 37%	-	275	10	0 ² / ₀	-	-	-
Chiniak Bay	ADF&G	September 1959	3268	-	1140 35%	-	468	323	232	117	-	-
Marmot Bay	ADF&G	September 1959	647	-	128 20%	-	30	23	48	27	-	-

Table 1 (Continued)

Area	Release agency	date	Number of tagged crabs released		Number & percent of tagged crabs recovered through April, 1963		Number of tagged crabs recovered each year or portion of a year (through April 1963) following tagging, beginning with month of release.						
			males	females	males	females	first	second	third	fourth	fifth	sixth	
Chiniak Bay	ADF&G	June 1958	2467	-	332 13%	-	262	32	15	12	11	-	
Alitak Bay	ADF&G	Jan. 1958	105	-	16 15%	-	10	6	0	0	0	-	
Marmot Bay	ADF&G	Nov. 1957	318	-	79 25%	-	0	17	40	20	2	0	
Chiniak Bay	ADF&G	Oct. 1957	53	-	7 13%	-	3	2	2	0	0	0	
Alitak Bay	ADF&G	Feb. 1957	29	163	3	1	0	1	1	1	0	1	1
			192		4								
Perenosa Bay	ADF&G	March & July 1956	200	81	31	11	27	5	4	2	4	0	
			281		42								
					15%								
Chiniak Bay	ADF&G	March 1956	17	-	0	-	0	0	0	0	0	0	
Alitak Bay	ADF&G	Sept. 1956	257	143	49	2	8	24	7	10	1	1	
			400		51								
					13%								
Marmot Bay	ADF&G	Oct. 1955	203	763	44	124	90	62	8	3	3	2	
			966		168								
					17%								
Chiniak Bay	ADF&G	Dec. 1954	106	36	3	1	0	2	1	1	0	0	
			142		4								
					3%								
Totals			19892	1186	6783	139	3819 ^{3/}	2526 ^{3/}	358	193	21	4	
			21078		6922								
					30%								

^{1/} Number of tagged crabs recovered through June, 1963.

^{2/} Carapace dart tags were not retained through ecdysis.

^{3/} 67 recoveries from the Bureau of Commercial Fisheries Lower Cook Inlet program in 1961 are divided equally between the first and second year after release.

Young crabs which have settled to the seabed begin their existence as solitary individuals living under rocks and debris. In their second and third year of life, crabs begin to congregate and move actively. After reaching puberty and at about 100 to 110 mm. in carapace length (5-6 years of age) crabs are believed to extend their range and begin an annual cycle of movements typical of the adult.

It appears that the shallows near land predominate as settling and rearing areas for juveniles and that ocean areas are inhabited primarily by adults.

Adult female king crabs. One thousand one hundred eighty six mature female king crabs were tagged during 1954 to 1958 in the Kodiak Island - Lower Cook Inlet area. One hundred thirty nine of these tagged crabs have been recaptured and analysis of the data indicates that movements are similar to those of their male counterparts. Observations of the commercial fishery show that mature male and female king crabs travel in segregated but not widely separated groups except during the spawning season.

Adult male king crabs. The distribution of adult male king crabs is most closely related to depth and time of year. Related environmental and physiological factors are believed instrumental in regulating movements.

During late winter and early spring adult male crabs move from the depths to shallow water and appear to use the valleys or depressions in the ocean floor as travel routes (Figure 3). This movement is termed the "spawning migration" since it is correlated with breeding which is known to occur in less than forty fathoms of water during March, April and early May. The direction of the spawning migration depends upon the location of the shallow areas, and the distance upon bottom configurations of each particular area involved.

After breeding, crabs return to deep water where they remain for approximately another six months until the next spawning season.

Tag return data shows that separate crab stocks exist in the Kodiak Island - Cook Inlet area. Five boundary lines have been drawn to illustrate this separation and are shown in Figures 4 and 5. The recovery data shows that tagged crabs liberated in one area are rarely recovered in another. A discussion of migrations for specific areas is discussed next.

Chiniak - Marmot. Since 1958, two major tagging programs have been conducted in the Chiniak-Marmot location, northeast of Kodiak Island. During 1958 and 1959, 5,735 king crabs were tagged and released near shore in Chiniak Bay (Figure 4), and in 1962, 2,848 legal-sized crabs were tagged in two ocean areas seaward from the existing commercial fisheries in Chiniak and Marmot Bays (35 miles southeast of Cape Chiniak in Chiniak Gully and 25 miles east of Marmot Island (Figure 5). By 1963, a total of 1,829 tagged crabs had been recovered from these programs. The locations of recovery for periods January through June, and July through December are illustrated in Figures 4 and 5. Tag recoveries which were recovered during January through June resulting from both inshore and ocean releases were normally taken near shore from shallow depths of less than 50 fathoms. Many of the recoveries were

captured on the shallow bank (25 to 50 fathoms) seaward from Chiniak and Marmot Bays, between the two offshore tagging locations. These recoveries indicate that breeding movements to shallow ocean areas and to shallow bay areas occur from January to April. Crabs tagged in ocean areas travel to both inshore and ocean shallows to spawn but are relatively more abundant in the shallow ocean areas. Recoveries also suggest that as bay crabs grow they become more nomadic and venture seaward to adopt ocean living. In recent years, with boats fishing the entire continental shelf in this area, crabs released inshore have been captured 60 miles seaward, and conversely, crabs tagged in the ocean on the edge of the continental slope have been recaptured 60 miles shoreward.

Inshore Marmot Bay, 1959. In 1959, 647 tagged crabs, predominately juveniles and young adults, were liberated in the inshore Marmot-Kizhuyak Bay area (Figure 4). By 1963, 128 crabs had been recaptured, indicating a typical annual migratory cycle from deep to shallow water but unlike crabs in other areas of Kodiak Island did not venture seaward but rather confined their movements to the bay system inshore or traveled westward into nearby Shelikof Straits.

Alitak. In 1961, 5,976 tagged crabs were released in the Alitak location and within 2 years 3,861 crabs had been recovered. All but 26 crabs were recovered in the Alitak location. Straying movements outside this fishery are minor and omitted from Figure 4 to avoid confusion. Twenty-five of the so-called strays were recovered in the area immediately east of the arbitrary line connecting Chirikof Island, Sitkinak Island and Aliulik Peninsula, and the other to the west across Shelikof Strait (Figure 4). In both these adjacent areas sizeable commercial fisheries exist, suggesting that if more straying had occurred a greater number of recoveries would have been captured. Tag returns indicate that the populations of king crabs are not entirely isolated but that a certain amount of intermingling occurs at the peripheries, particularly in the Sitkinak Island district. Over a longer period of time a greater amount of intermingling may occur between adjacent groups possibly dependent to some extent upon intensity of harvest.

The Alitak program has contributed much to our knowledge of annual migrations primarily because it supports a large fishery and has large adjacent fisheries. Alitak, like Lower Cock Inlet, is dissimilar to other locations in this region by having an expanse of shallow water. Migrating crabs must, therefore, travel farther (often 50 miles) in order to reach deep or shallow water. Areas of deep water are more readily accessible in the other locations.

In the early years of commercial harvest in Alitak catches were limited during July-December because boats were too small to fish offshore in deep water. In the 1959-1960 fishing season, the commercial catch during July-December (when king crabs are in deep water, see the locations of tag returns from this area in Figure 4) was 179,283 crabs and during the period January through June (when the crabs inhabit shallow water near shore and are available to the small crab boats) was 671,851 crabs. The trend was reversed when larger vessels began to fish offshore. In the 1962-63 fishing season during the period July through December the commercial catch was 1,156,587 crabs from ocean areas and during the period January through June

was only 203,970 crabs from inshore areas.

Lower Cook Inlet. Crab movements in Lower Cook Inlet were determined from recoveries of the Cape Douglas tagging of 1961. Tagging a few miles east of Cape Douglas immediately south of the inlet in 95 fathoms revealed that migrations are similar to those of Alitak in that they are localized with deep-to-shallow and reverse movements occurring definite times of the year. Crabs which occupied deep water in summer, later occupied the northern shallows around Augustine Island and in Kachemak Bay as well as the western shallows along the Alaskan Peninsula. Crabs were harvested from shallow water during February through June.

Recoveries one year after tagging were made at the location of release indicating further that the crabs returned to the deep water location of liberation or that some had remained in deep water the entire year, or a combination of both.

The migration of this body of crabs reveals that stocks are available to both fleets of Kodiak Island registration area and Cook Inlet area.

Other tagging programs. Results of the Twoheaded Island tagging of October 1960 show large scale shoreward movements to shallow water beginning December (Powell, 1964). Tag recoveries from adjacent Trinity Islands and Chirikof Island also reveal shoreward movements of ocean crabs further supporting inshore-offshore movements rather than alongshore travel. Lack of an ocean fishery in this location makes it difficult to study movements in ocean areas.

ACKNOWLEDGEMENTS

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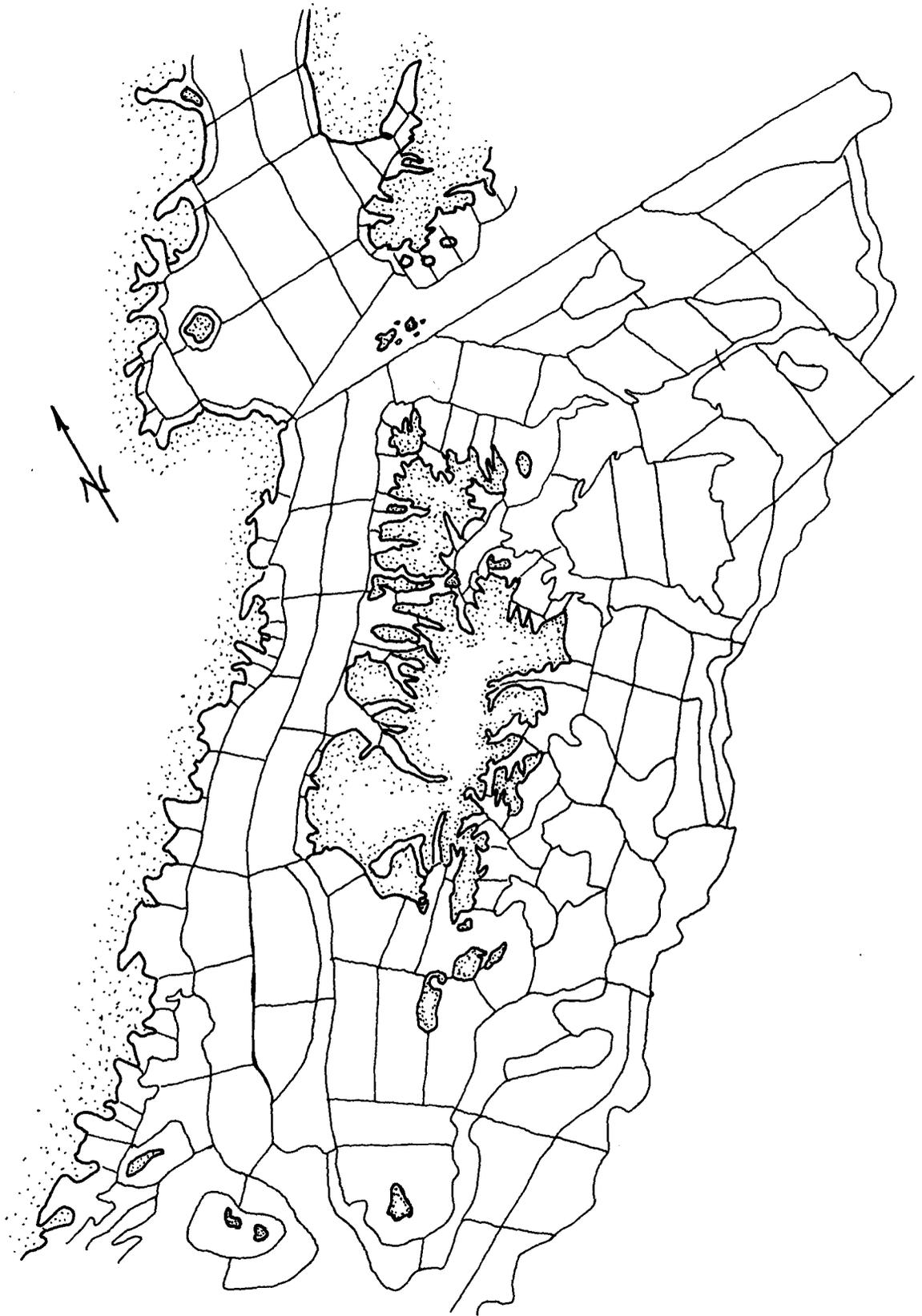


Figure 1.--Statistical catch areas of Kodiak Island - Lower Cook Inlet region of Alaska.

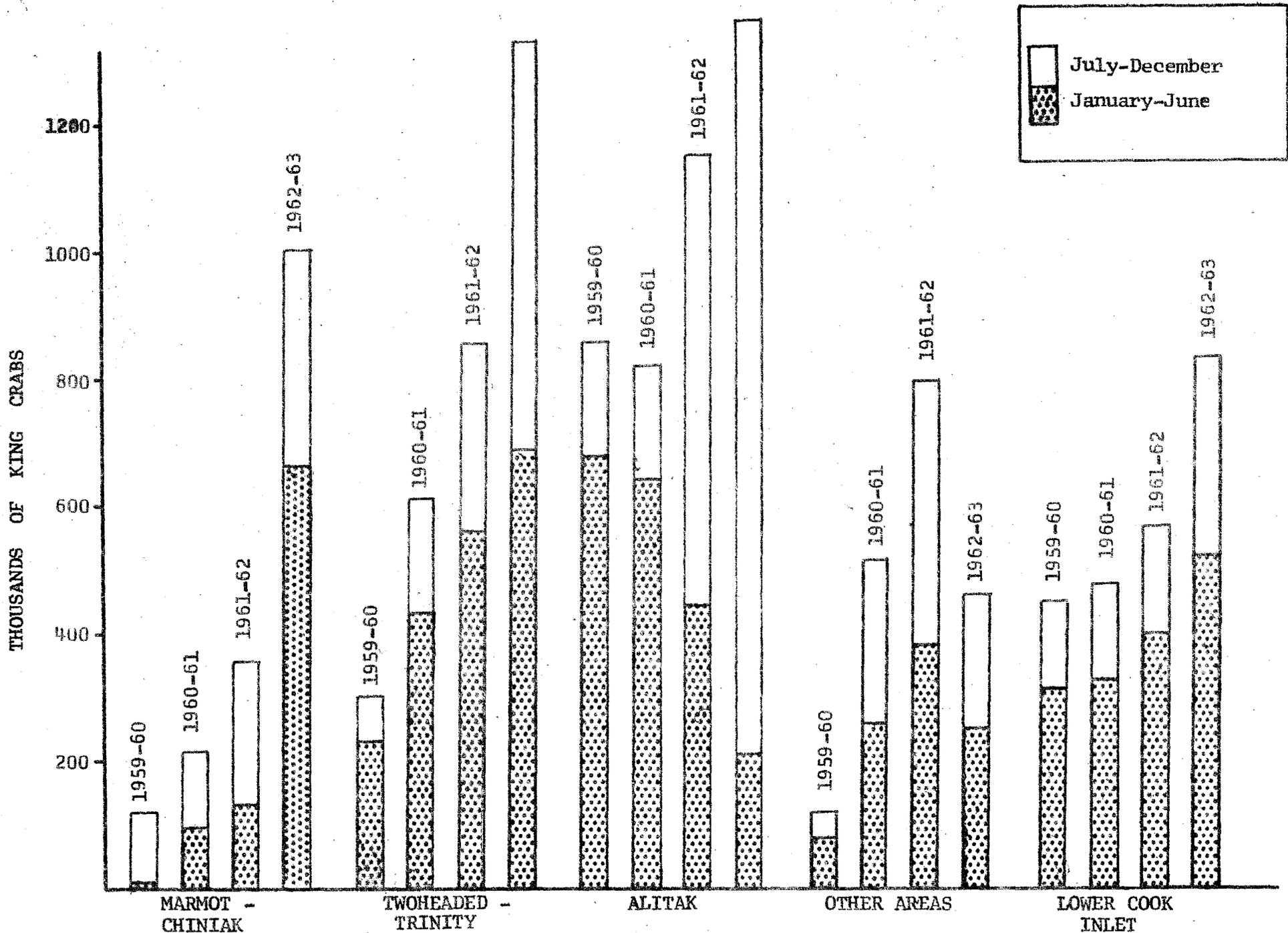


Figure 2. Commercial catch of king crabs from Kodiak Island - Lower Cook Inlet region by season and major production area, 1959-1963.

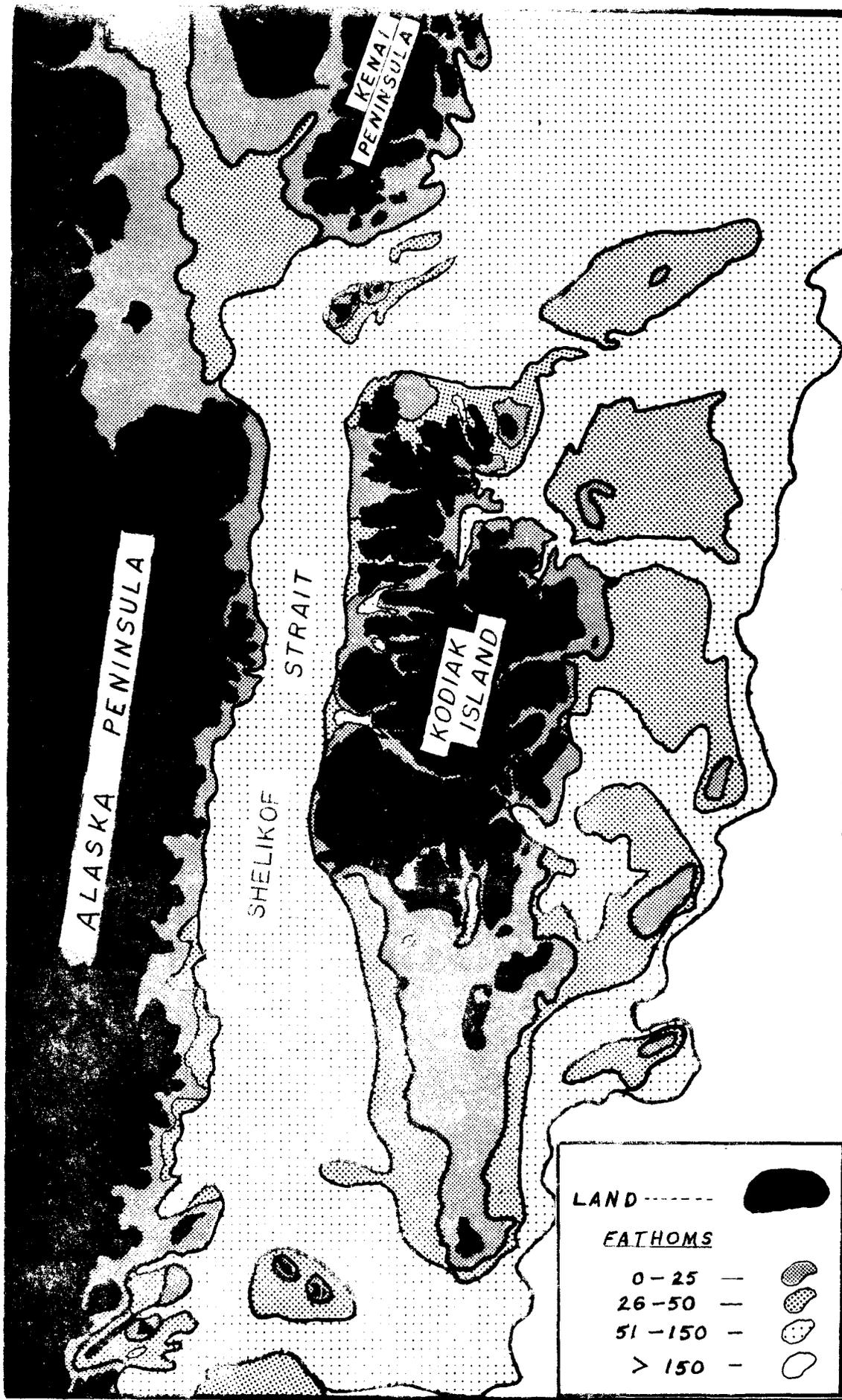


Figure 3. Submerged continental shelf of Kodiak Island, illustrating major depth regions.

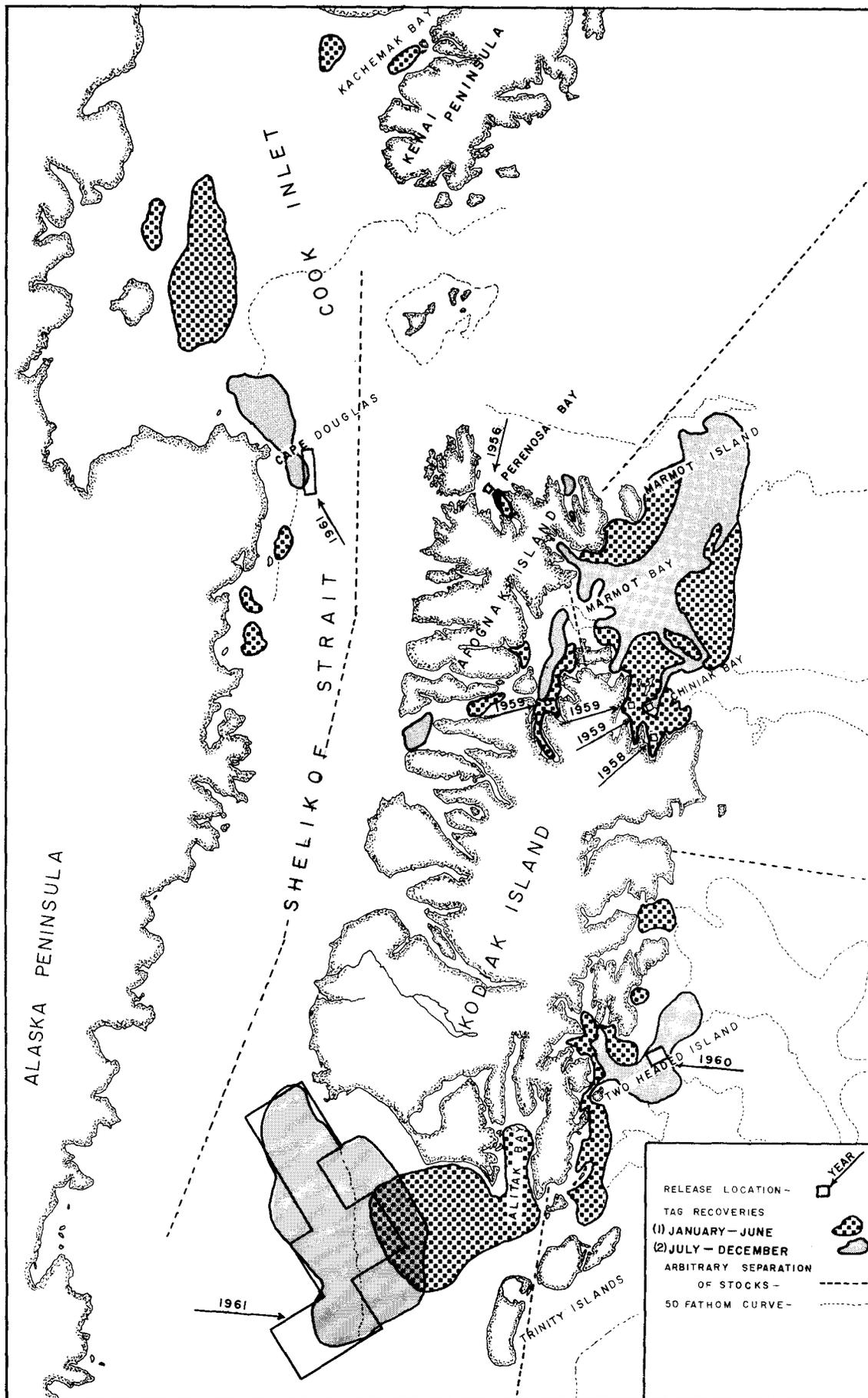


Figure 4.--Migratory pattern showing direction and distance from inshore release locations, Kodiak Island - Lower Cook Inlet, 1954-1961, illustrating segregation of stocks.

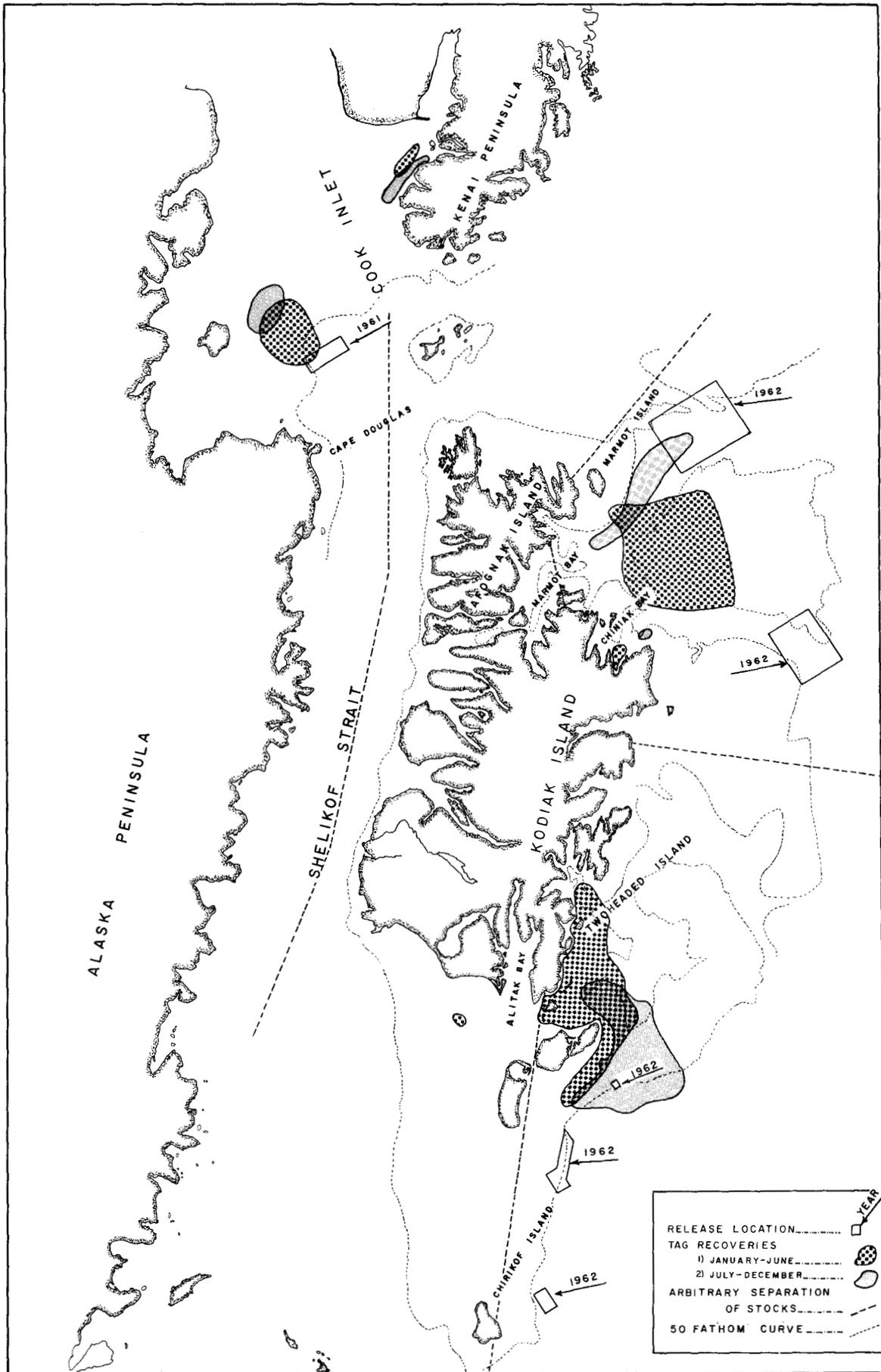


Figure 5.--Migratory pattern showing direction and distance from offshore release locations, Kodiak Island - Lower Cook Inlet, 1961-1962, illustrating segregation of stocks.

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