1961

readable scales examined depicted the same age. However, on the basis of evidence from one fish only limited conclusions regarding this problem can be made. A more extensive study into this problem is planned using more specimens.

Absorption and age determinations. The majority of the scales sampled from chum salmon caught in streams and estuaries show evidence of absorption (loss of scale material) at the margin of the scale. When these scales are used to determine the age of the fish the reader must attempt to estimate the amount of absorption that has occurred. This estimate is generally based on the degree to which the margin of the scale differs in appearance from the normal. In other words, has the loss of scale material from the edge of the scale been great enough to remove one or more annuli? Generally no scientifically established method of measuring absorption is available.

It appears that errors of one or more years can be made when using partially absorbed scales for age determination. Further study of the effect of scale absorption on age determinations and of the possibility of using otoliths and other methods to supplement current procedures is in progress.

Summary

Differences in meristic characters have enabled us to identify the continental origin of chums taken at sea with the exception of those originating from the Bering Sea coast and Kodiak Island region. Scale characteristics are being examined for possible differences which can be used to supplement meristic characters.

This report places particular emphasis on the methods and assumptions required in the use of chum salmon scale characteristics for population differentiation and age determination studies.

A method of establishing a line of count and measurement that is consistent and also accounts for scale shape is described. Circuli counts and scale lengths differ with change in position of line of count or measurement on the scale.

Regeneration of scales may be difficult to detect in some cases, especially in the central area of the scale. Variation of scale characteristics with change in scale sampling area on the body is of sufficient magnitude to be a serious source of error in a study designed to separate Asian and North American chum salmon. The quality of the plastic scale impressions may affect the validity of scale racial data. Proof of the validity of age determinations made from chum salmon scales is given by agreement of scale age determinations with the known age of marked fish. Lack of knowledge of the time of annulus formation can result in errors of unknown magnitude in age determinations of chum salmon, especially those taken early in the season.

Age readings of 610 scales sampled from a single chum salmon specimen gave limited evidence supporting the assumption that all readable scales on chum salmon have the same number of annuli regardless of body position of the scale.

Age reading of partially absorbed scales are subject to errors of unknown magnitude. Studies designed to solve these problems are in progress.

KING CRAB STUDIES

by Herbert Shippen and Takashi Miyahara

The year 1961 saw continuation of rapidly increasing fishing pressures on eastern Bering Sea king crabs. In 1960 one Russian and two Japanese motherships were operated; in 1961 two Russian and five Japanese motherships took part in the fishery.

By utilizing available catch statistics and announced production targets, we can estimate the catch of Japanese king crab operations in the eastern Bering Sea in 1961 to be about 3.5 million male crabs. For the two Russian mothership expeditions we can only guess that a combined total of about two million crabs may have been taken. The estimated 5.5 million crabs removed by these two nations is probably conservative and represents at least a fourfold increase in the catch of king crab in the eastern Bering Sea in comparison with the level of fishing during the period from 1953 to 1958 (Fig. 35).

In addition to expansion of king crab fishing by Japan and Russia, there have also been increases in groundfish operations. Although these fleets are

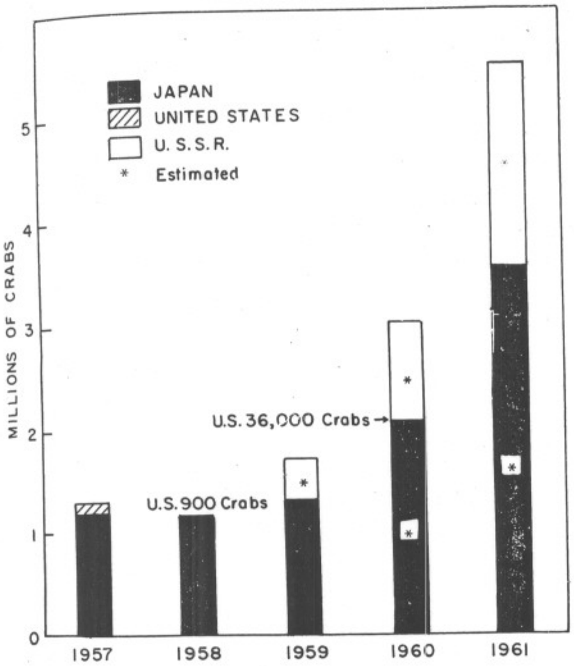

FIGURE 35. Commercial catch of adult male king crabs in eastern Bering Sea, 1957–1961.

primarily harvesting fish, we expect that substantial numbers of king crabs are also taken. Requests for catch data of all fishing operations in this area have been made to the governments of Japan and the Soviet Union.

United States' king crab research activities in the eastern Bering Sea were conducted from the 80–foot research trawler *Paragon* during July. The vessel was chartered by the Bureau of Commerical Fisheries, and after initially being used in salmon studies, spent four weeks in the Bering Sea sampling king crabs. Sixty stations were successfully completed where 3,775 male and 1,608 female crabs were sampled and measured; 2,790 male crabs were tagged and released —twice as many as we were able to tag last year.

In addition to tagging for growth, migration and mortality studies, meat content, ecological and oceanographic data were collected. Two research objectives which we had hoped to achieve during the 1961 charter period were, however, only partially completed due to the lack of vessel charter time. One of these objectives was to define the extent of distribution of adult male king crabs in the eastern Bering Sea by means of systematic sampling on the 20–mile grid pattern which we have used in past years. In order to obtain reliable estimates of population abundance and to insure random distribution of tagged crabs throughout the populations, it was necessary that the station pattern be extended sufficiently to include the area occupied by the stock. Preliminary examination of the 1961 station pattern catches indicates that crabs were probably distributed well beyond the area surveyed.

A second phase in which we fell short of the measure of success for which we had hoped was in the release of double-tagged crabs. The purpose of this experiment was to ascertain the rate at which tagged crabs die as a result of the tagging operation and the proportion of tagged crabs which lose their tags in the interval between tagging and time of molting. This knowledge is necessary for precise determination of the natural death rate of crabs, proportion of the population taken by the fishery, and the fraction of the stock which survives to the next year. We estimated that approximately 2,000 male crabs must be tagged in this experiment in order to assure significant return, but we were able to tag only 350. It is apparent that this experiment will require considerably more vessel time than we are presently able to allocate in view of the demands of other research problems.

Two Russian king crab mothership operations were observed northwest of Amak Island. This area is somewhat farther west than commercial operations have been observed in the past and is usually an area of concentration for recently molted crabs that have been found to contain less meat than old-shelled crabs. However, the 1961 samples showed a slightly higher proportion of old-shelled crabs in this area than in past years.

During 1961, we received tags from 539 crabs recovered by fishing operations in the eastern Bering Sea during 1960 and 1961. In August, 415 king crab tags recovered aboard the mothership *Tokei-maru* were returned to us from Japan. Tags from two king crabs recovered by a United States fishing vessel in 1960 near Unalaska Island were returned in June. In February, 122 tags were returned from king crabs recovered by the Russian mothership, *Vsevolod Sibertsev* during 1960 operations. Table 17 gives a summary of our king crab releases and returns to date.

In addition to returns noted in Table 17, we are quite certain that recoveries have been made by the *Shinyo-maru* operations in 1960 and 1961. These recoveries have not as yet been transmitted to us. Russian recoveries for 1961 have not yet been received. Further, tagged king crabs must have been taken by

TABLE 17. Summary of tag releases and returns*.

Tagging year	Number tagged	Returns during 1954	1955	1956	1957	1958	1959	1960	1961	TOTAL
1954	1,107	44	60	1	2	1	0	0	0	108
1955	1,351		32	53	35	18	12	6	2	158
1956	4,063			53	197	114	67	49	37	517
1957	13,795				39	192	235	182	151	799
1958	9,851					40	118	123	120	401
1959	4,447						41	77	81	199
1960	1,327								24	24
1961	2,790									
TOTAL		44	92	107	273	365	473	437	415	2,206

* The table is presented to show the magnitude of release and returns. Since each year's tagging experiment varied in sex, size, and area, and the recovery is the result of varying fishing intensity, the data are not strictly comparable.

Japanese and Russian groundfish fleets in the past several years but these have not yet been returned. Requests for the tags and recovery information have been made to the government agencies.

One of our studies utilizing data from king crab tag returns is that of the growth of adult male king crabs. At present the report is in the hands of the printers and is expected to be published in the near future. The completion of this phase of our work is a notable step since the yield of a stock is dependent upon growth.

The relationship of meat content to size and molting stage is closely related to the study of crab growth. This project was emphasized during the 1961 vessel charter period, and a large number of field observations was collected to fill in gaps and to extend the range of data from previous years.

A report on the movements of crabs as determined from tag releases and recoveries is being prepared for publication. A description of the methods employed in this study and a general summary of the results appeared in the Annual Report for 1960.

A major objective of our investigations is to determine the distribution of the king crab population in the eastern Bering Sea, to estimate crab abundance, and to arrive at some judgment as to the accuracy of our abundance estimate. Because of the problems of sampling, it has long been apparent that it was not feasible to attempt to assess the entire king crab population which consists of countless millions of planktonic individuals as well as the more finite numbers of older crabs. We must, therefore, define

TABLE 18. Eastern Bering Sea king crab abundance estimates 1957–1960. (Survey totals only, no additions from commercial catch prior to survey or other adjustment of survey totals.)

Year of survey	Date	Number of males: Length (mm.)	New and soft shell	Old and very old	TOTAL	Number of females
1957	June 25–July 25	<132.5	19,105,000	6,336,000	25,441,000	
		>132.5	5,375,000	7,782,000	13,157,000	
		TOTAL	24,480,000	14,118,000	38,598,000	35,081,000
1958 (1)	April 29–June 3	<132.5	15,049,000	1,191,000	16,240,000	
		>132.5	15,462,000	6,767,000	22,229,000	
		TOTAL	30,511,000	7,958,000	38,469,000	20,908,000
1958 (2)	June 8–July 11	<132.5	20,685,000	1,384,000	22,069,000	
		>132.5	10,646,000	6,790,000	17,436,000	
		TOTAL	31,331,000	8,174,000	39,505,000	43,987,000
1959	May 2–19	<132.5	10,544,000	341,000	10,885,000	
		>132.5	18,184,000	6,961,000	25,145,000	
		TOTAL	28,728,000	7,302,000	36,030,000	20,284,000
1960	August 2–30	<132.5	7,999,000	750,000	8,749,000	
		>132.5	3,170,000	5,775,000	8,945,000	
		TOTAL	11,169,000	6,525,000	17,694,000	18,439,480

the population with which we are dealing as the adult crabs of the eastern Bering Sea which are accessible by otter trawl at the time of sampling. Our sampling has been restricted primarily to the broad shelf which is the locality of commercial crabbing operations. Because of migrations and other movements, the composition of the crab population on this shelf appears to be quite variable so that the results of sampling, both with regard to distribution and abundance, should be considered relative to the time of year when samples were taken. The effects of the removal of large numbers of crabs by the fishery prior to the time of the sampling must also be considered in comparing one year with another.

Abundance estimates for each station pattern survey were made by expanding the catch at each station in relation to the area of ocean bottom swept by the otter trawl. In 1958 two surveys were made; in 1957, 1959, and 1960 only one. Abundance estimates based on these surveys are given in Table 18.

In Figure 36 the abundance estimates for various groups of crabs have been arranged in time sequence by the midpoint of the survey period. This arrangement suggests that for females and new-shelled males a large part of the variation between years may be due to seasonal movement into and out of the sampling area rather than to actual differences in abundance in the eastern Bering Sea. However, for the large old-shell males the number in the sampling area appears to be relatively constant during the season of sampling, suggesting that there may be no significant migration of these crabs during the late spring and summer months. This is of particular significance since these large old-shell males are the crabs generally selected by the fisheries.

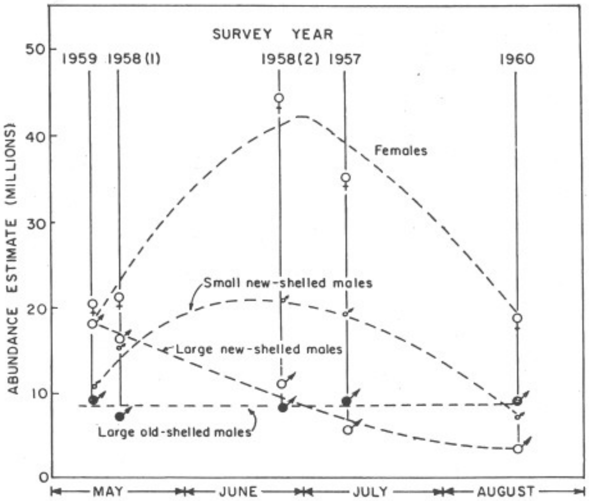

FIGURE 36. Bering Sea king crab abundance estimates, 1957–1960. (Large old-shelled estimates have been adjusted to compensate for commercial catches prior to the survey and for incomplete coverage of the station pattern in 1959.)

We have begun to make estimates of the level of yield which may be taken on a sustained basis from the eastern Bering Sea king crab stock. We believe that our present knowledge of the fishery and the population upon which it is based is sufficient for such calculations to be made. However, most of the factors which enter into yield calculations were determined for a period when the level of fishing was much less than we are experiencing at present.

Since it is probable that some of these factors may change as a result of the large increase in fishing during recent years, continued observations of the effects of the fishery upon the stocks are necessary.