1960

turns from the USSR are needed to complete the pink distribution picture. Northwestern Alaskan pinks were shown to be present only to 173° West Longitude, but some high seas returns from central Aleutian tagging may have been en route to northwestern Alaska also.

No silver or king salmon tagged in 1960 have been recovered.

Two kings tagged in the Bering Sea north of Adak in 1959 were recovered in 1960. One was taken near Karaginski on the east Kamchatka coast and the other approximately 200 miles northwest of tagging location.

One king salmon tagged near Adak in 1958 was recovered approximately 400 miles south of Attu.

A steelhead tagged September, 1958, southwest of Kodiak Island was recovered February, 1960, in a fish hatchery at Alsea, Oregon. This fish had been fin-clipped and released from the same hatchery approximately 5 months before it was caught and tagged near Kodiak.

Supplement

Since submission of the report on U. S. high seas tagging for 1960, an additional 28 tags were received from the USSR and 21 from Japan. Only 3 tags had been received from Asian coastal areas when the report was written, so the recent 49 returns are an important addition. Table A summarizes these returns by year and area of tagging and by general area of recovery.

KING CRAB INVESTIGATIONS

By T. Miyahara

The eastern Bering Sea king crab fisheries from 1953 through 1958 were relatively stable. Crabs were taken by both Japanese and United States fisherman, but the bulk of the annual catch of 1.2 to 1.6 million adult male king crabs was taken by the Japanese with the factory-mothership *Tokei-maru*. During this period, their annual production quota was 59,850 cases of king crab meat.

In 1959, the eastern Bering Sea king crabs were subject to increased fishing pressures. The full degree of increase is not yet known, but it has been reported that in addition to the increase to 70,000 cases of the Japanese quota, the Russians also began a mothership-type operation for eastern Bering Sea king crabs.

In early April of 1960, a Russian mothership with a fleet of about twelve tangle-net pick-up boats (Kawasaki type) and two or three exploratory-net setting vessels of about 100 feet in length arrived off Amak Island. Shortly thereafter, the *Tokei-maru*, with an 80,000 case quota, arrived with her usual fleet of eight Kawasaki boats and three net setting-exploratory vessels. United States fishermen also actively fished for king crabs in the area with a total of seven trawlers. In May 1960, a second Japanese operation was licensed by the Japan Fisheries Agency to catch and freeze king crabs, herring and bottom fish.

In addition to the kind crab fleets mentioned above, the Soviet bottom fish fleet, composed of an 11,000 ton mothership, 10 or 12 refrigerator ships and approximately 40 trawlers, and the Japanese bottom fish fleets, composed of five motherships, each of about

TABLE 18. Summary of tag releases and recoveries [1].

Tagging Year	Number tagged	Recoveries during							
		1954	1955	1956	1957	1958	1959	1960[2]	Total
1954	1,107	44	60	1	2	1	0		108
1955	1,351		32	53	35	18	12	6	156
1956	4,063			53	197	114	67	49	480
1957	13,795				39	192	235	182	648
1958	9,851					40	118	123	281
1959	4,447						41	77	118
1960	1,327							0	0
Total	35,941	44	92	107	273	365	473	437	1,791

[1] The table is presented to show the magintude of releasses and recoveries. Since each year's tagging experiment varied in sexes, size, and area, the data are not directly comparable.

[2] Incomplete.

10,000 tons, and a total of approximately 130 trawlers, are assumed to be taking some king crabs. The extent of these fishing efforts is so great that even the incidental catch of king crabs could be of major magnitude.

In view of this increased fishing intensity, need for early determination of the effect on the king crab population is emphasized.

During the 1960 field season, a vessel was chartered as in each year since 1955. The 80 foot halibut schooner *Paragon* fished at a series of stations to collect data needed for studies on growth, abundance, migrations, mortalities, and environmental conditions. Although the vessel was used for king crab studies for only one month, 70 stations were covered. All crabs caught were measured and males tagged and released. Table 18 summarises by years the numbers of king crabs tagged, released and recovered.

Tagging experiments have been highly useful in the study of growth. A draft report[1] covering the growth of adult male king crabs was presented for review at the 1959 Annual Meeting of the International North Pacific Fisheries Commission. After review and changes, it is now ready for publication.

Although king crab growth rates developed have not been related to actual age, it is tentatively estimated that four-year-old crabs would be approximately 80 mm. in carapace length. Based on this estimate, a comparison of our age-growth relationship with those presented by other researchers, namely, Marukawa[2], Nakazawa[3] and Wang[4], is presented in Figure 38. Since they presented their results in terms of carapace width, all curves are so shown, although present researchers generally use the more definite and accurate length dimension.

Wide differences in growth rates are indicated, and though the difference may in part be due to geographic separation, it does appear possible that there

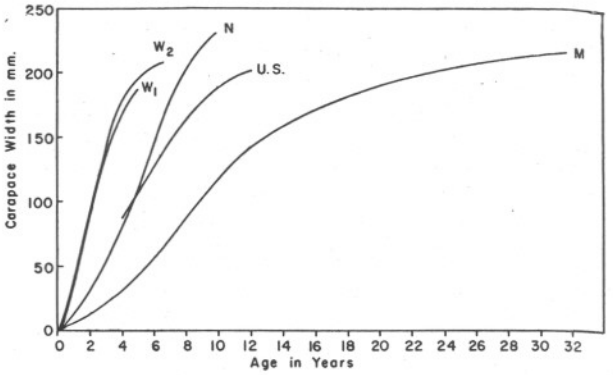

FIGURE 38. King crab growth curves. W_1 and W_2 derived from Wang (1937) for crabs from northern Hokkaido and Sakhalin, respectively; curve N from Nakazawa (1912) and curve M from Marukawa (1933), all from published reports. Curve U.S. from United States King Crab Investigation results.

are some errors in interpretation and demonstrates the difficulties in estimating growth of king crabs.

Marukawa's growth curve, based on molting increments exhibited by reared crabs and modes in a size frequency distribution, indicates very slow growth. McKay and Weymouth[1], in reviewing Marukawa's work, point out the possibility that early modes in the size frequency distribution are instars rather than year classes and the later modes are probably due to chance irregularities. We concur with the reviewers, since progressions of modes in a series of size frequencies taken throughout a year indicates greater difference between year classes than is shown by the modes in Marukawa's frequency distribution. That the later modes are due to chance irregularities is suspected, since our observations of increments resulting from one molt would span from three to six modes. If some of the early modes were considered as instars rather than year classes, the lower portion of Marukawa's curve would be steeper and would shift the remainder of the curve to the left. Consideration of fewer age classes in the larger sizes would also steepen the curve and it would approach maximum size more rapidly.

Nakazawa's curve lies intermediate between that of Marukawa and Wang, and somewhat similar to ours. The major difference is in the slope of the curve above 100 mm. Nakazawa's report unfortunately does not include data which would allow more detailed comparison. However, he assumes an annual molt, which is contrary to our findings and which

[1] Weber, Douglas D. and Takashi Miyahara. 1959. Estimated growth of the Southeastern Bering Sea adult male king crab population. INPFC Doc. No. 318, 15 p.

[2] Marukawa, Hisatoshi. 1933. Biological and fishery research on Japanese king crab *Paralithodes camtschatica* (Tilesius). *Journal of the Imperial Fisheries Experimental Station*, Tokyo, No. 14, Paper No. 37, 152 p. In Japanese with English abstract.

[3] Nakazawa, Kiichi. 1912. A study on the Hokkaido king crab (Hokkaidosan tarabagani no kenkyu). Tokyo, *Dobutsugaku Zasshi* (Zoological Magazine) vol. 24, No. 279, pp. 1–13. In Japanese.

[4] Wang, Yi-Kuan. 1937. On the stock of the crab, *Paralithodes camtschatica* (Tilesius) in the seas of Hokkaido and Saghalin. *Bulletin of the Japanese Society of Scientific Fisheries*, vol. 5, No. 5, pp. 291–294. In Japanese with English synopsis.

[1] MacKay, Donald C.G. and Frank W. Weymouth. 1935. The growth of the Pacific edible crab, *Cancer magister* Dana. *Journal of the Biological Board of Canada*, vol. 1, No. 3, pp. 191-212.

could very easily account for the fast growth rate of the larger sizes. It is interesting to note that Nakazawa's curve for the first two years is essentially the same as that postulated for juvenile crabs by U. S. researchers in the 1959 annual report.

Wang shows rapid growth based on size frequency distributions and also on the progression of modes in samples taken in three successive years. The smallest mode observed was at 45 mm. which he concludes are crabs one year old. There is, however, general agreement among most investigators that at age one, crabs are about 7 to 10 mm. in carapace width. Our studies indicate that at least one and possibly two years span of time is required for an 8 or 9 mm. crab to grow to 45 mm.

In summary, it appears that Marukawa's assignment of ages to the range of male king crab sizes is high and and that Wang's may be low.

The tagging experiments have provided additional information on other phases of the king crab investigations. Examination of data on tags recovered during the year of release provides information on rates of movement.

Movement rates calculated from the straight line distances and numbers of days between release and recovery, show ranges of 0 to 10.6 miles per day with a mean of 1.3 miles per day.

Tag release and recovery information has also been analyzed to assess the degree of movement from one area to another. In the analysis, the eastern Bering Sea king crab fishing area has been divided into six sub-areas. For this purpose, recoveries made within the year of release have not been considered, since they would not all have had time to move into other areas. The actual number of tag returns made in any area is the result of two influences, (1) the intensity of fishing in the areas, and (2) the movement of crabs into the areas fished. From the total number of recoveries made from releases in each sub-area and the total units of fishing effort expended over the entire area, a ratio of tag recoveries to units of effort was calculated. This ratio was then applied to the actual amount of effort in each area to calculate expected recoveries which were then compared with actual recoveries in each area.

The areas considered, the calculated expected and actual recoveries from tags released in each area, are presented in Figure 39. Arrows indicate the release to recovery relationships, and the numbers within each area are the expected (upper numeral) and the actual (lower numeral) recoveries. All expected and actual

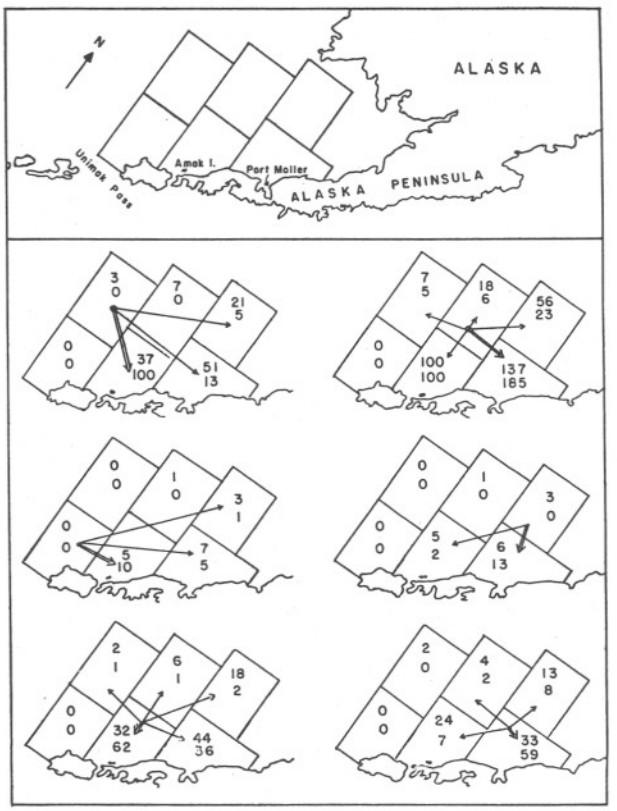

FIGURE 39. Dispersion of tagged male king crabs from various release areas. Arrows indicate the relation of tag release to recovery areas. The upper number in each area is the calculated expected and the lower, the actual number of tags recovered in each area.

return values are included in the figure, although fishing effort and/or returns in some cases have been insufficient to have significance.

Except in a few instances, the actual recoveries deviate from the expected, indicating that tagged crabs migrated to some areas more heavily than to others. The values indicate that crabs appear to congregate in two localities; one inshore off Amak Island and another inshore off Port Moller. It is noted that releases made in the Amak Island area and the areas to the northwest and west appear to be most strongly represented in the Amak area, while releases from other areas are most strongly recovered in the Port Moller area. It is obvious that the present fishery which is concentrated in the Amak Island and Port Moller areas is catching crabs from the entire area covered by the United States station pattern surveys.

Trawl surveys for the purpose of developing estimates of distribution and abundance have been a major phase of study and various aspects of the 1958 surveys

were analyzed. Particular emphasis has been placed on the 1958 surveys since area coverage was most complete.

The data show that occurrences of the smallest male crabs taken in the surveys are limited to the northeastern part of the station pattern, while the distribution of larger crabs is more widespread, appearing as concentrations in other portions of the survey area. This suggests that recruits may come from the more shallow peripheral areas where large numbers of juvenile crabs have been observed.

Abundance estimates for the total number of crabs in the southeastern Bering Sea were obtained by expanding each survey catch per unit area covered by the trawl. The estimated abundance of king crabs on the grounds during May of 1958 was 59,377,000, of which 20,908,000 were females, 30,511,000 were recently molted males, and 7,958,000 were old shell males. Of the old shell males, 1,191,000 were less than 132.5 mm. carapace length and 6,767,000 were greater. A tentative assessment of the reliability of the estimates suggests that at the .80 level of confidence, the estimate for total number of crabs is within 29 per cent of the actual number.

Pertinent in evaluating catch and production is information on the varying amount of meat in crabs. This variability which appears to be associated with the molting cycle is significant. The live weight and total meat weight of 22 new shell and 30 old and very-old shell adult male king crabs were sampled during 1958 through 1960. The live weights, meat weights and percentage recovery by size are plotted on Figures 40 and 41. The data show that there is little difference between live weights of the new and of the old and very-old shelled crabs. The total meat weight, however, shows greater difference. Expressed in percentages of meat weight to live weight, the mean recovery was 21.2 for new shell crabs and for old and very-old shell crabs, the recovery was 31.6 per cent.

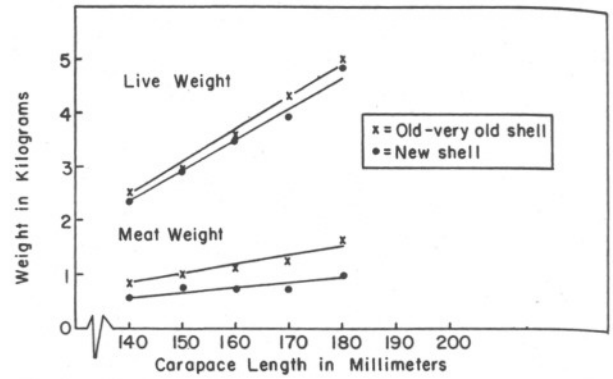

FIGURE 40. Mean live and meat weights by carapace length of old-very old and new shell adult male king crabs. Line is fitted by inspection.

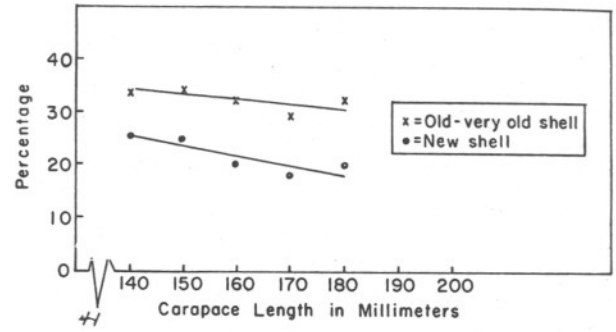

FIGURE 41. Recovery in terms of percentage meat to live weights of commercial size male crabs. Line is fitted by inspection.

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