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MOVEMENTS OF TAGGED MALE TANNER CRABS, *Chionoecetes bairdi*,

LIBERATED OFF KODIAK ISLAND, ALASKA

By

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# MOVEMENTS OF TAGGED MALE TANNER CRABS, *Chionoecetes bairdi*, LIBERATED OFF KODIAK ISLAND, ALASKA[1]

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## ABSTRACT

From 1973 through 1978, 11,196 male Tanner crab, *Chionoecetes bairdi*, were tagged and released off of Kodiak Island, Alaska. A total of 1,961 tags were returned; 1,412 with accurate recovery data. Males tagged in the inshore bay areas tended to move into the open water offshore areas while those tagged offshore remained in the general area of tagging. Average movement for all recoveries was 24 km (15 mi) indicating that movements were not extensive. From the generalized movement models, there appears to be discrete stocks of crab in the Shelikof, Marmot-Chiniak, Eastside, and Southwest areas of Kodiak Island waters.

# Movement of Tagged Male Tanner Crab, *Chionoecetes bairdi*, Liberated off Kodiak Island, Alaska

## INTRODUCTION

The Tanner crab, *Chionoecetes bairdi* Rathbun, occurs from shallow nearshore areas to depths of 473 m (259 fm) (Rathbun 1925). *C. bairdi* ranges from Puget Sound, Washington (Slipp 1952) to the Aleutian Islands and Southeastern Bering Sea where it is the target species of a major fishery (Anon. 1979).

Many fishermen hold traditional beliefs concerning Tanner crab migrations and cite changes in catch over time in relation to depth as evidence of onshore-offshore movement. Prior to this study there had been no effort to look at movement patterns of *C. bairdi*.

Migration of the Tanner crab, *C. opilio*, has been studied in Atlantic Ocean waters around the Gaspé region of the Gulf of Saint Lawrence (Watson 1970; Watson and Wells 1972). Their results indicated that tagged males traveled relatively little, with 85% of the returns recaptured within 10 miles of release. Pereyra (1967) concluded that *C. tanneri* males, off the coast of Oregon, showed a seasonal depth shift in relative abundance whereas the female population was fairly stationary during all seasons, suggesting movement for reproductive purposes. Katoh et al. (1956) and Yoshida (1941) also observed bathymetric separation of the sexes for *C. opilio* in the Sea of Japan.

In recent years, the fishery has developed exponentially compared to the accumulated data on *C. bairdi* life history. While *C. bairdi* has accounted for about one quarter of the recent domestic crab harvest by United States fishermen (Donaldson 1980), the fisheries continue to be managed by historical fishing area. In most areas, data is insufficient to define discrete stocks (Anon. 1979).

Since migrations or displacement of aggregations of *C. bairdi* is necessary information for informed management decisions, this study was initiated, and conducted off of Kodiak Island, Alaska between 1973 and 1979.

## METHODS

Migration was studied by the release and recapture of tagged male crabs.

Male Tanner crab $\geq$ 110 mm carapace width (CW) were tagged and released between July 1973 and August 1975. Minimum tagging size was raised to 135 mm CW with the establishment of a minimum size limit in 1976.

Capture was accomplished utilizing 2.1 m x 2.1 m (7 ft x 7 ft) crab pots covered with 89 mm (3.5 in) mesh. Tag number, date, location, and depth

were recorded for crabs tagged from 1973 through 1975. Exoskeletal age and carapace width were recorded additionally beginning in 1976.

Tagging was accomplished using a combination of Floy disc, FD 67 "T" bar, and a modified FD 67 "T" bar known as the McBride tag. The Floy disc is a temporary tag which is lost during ecdysis. The FD 67 "T" bar and the modified FD 67 "T" bar are prototype permanent tags. Floy disc tags were used in all years, except 1977. Both FD 67 "T" bars and Floy discs were used in 1975. The modified 67 "T" bar was used exclusively in 1977.

Tagged crabs were recovered from the fishing industry. Recovery data collected included tag number, location and depth of capture, carapace width, and exoskeletal age. Only recaptures with accurate recovery information are used here.

Crabs were captured, tagged, and released at various bay and offshore locations depicted in Figure 1.

The most straightforward method of presenting migration data is pictorially by plotting individual release and recovery data and indicating length of freedom and direction of movement. I have chosen to present this information as an estimation of mean direction and velocity of dispersion and thereby assigning a degree of statistical confidence. Because of the volume of data generated and the large number of combinations of data, e.g., migrations by size groups, by area, a series of computer programs (CRABWALK), were developed (Appendix A).

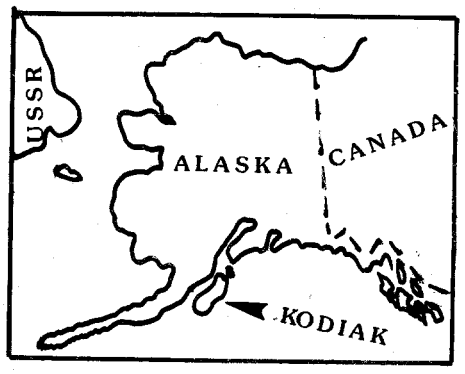
Distance of migration, direction, and depth change information is presented by year of release and by bay and offshore areas. I have collated all recovery data by specific geographical area for the duration of the study and discuss migrations by specific areas. Crabs were grouped by 30-day intervals at liberty. The average movement by each 30-day interval is presented. Changes in depth are represented by the percent of crabs which were recovered deeper, shallower, or remained at the same depth. Direction of movement and recovery location are depicted by an ellipse, computer calculated, that represents a 95% confidence interval of direction and recovery region. Information on the distribution of fishing effort was obtained from a fish ticket reporting system.

## RESULTS

### 1973

A total of 2,285 male crabs $\geq$ 110 mm CW was tagged and released between 15 July and 5 August (Table 1). Floy disc tags were used exclusively. The majority of tagging occurred in offshore areas, 2,024 releases, as opposed to bays, 261 releases. A total of 486 recoveries were made, 415 from offshore and 71 from bay tagged crabs. Catch data are available from 362 of the recoveries of 15.8% of the crabs tagged. Length of freedom

A Alitak Bay
C Chiniak Bay
E Eastside Area
K Kiliuda Bay
K-V Kupreanof-Viekoda Bay area
M-C Marmot-Chiniak Bay area
M-K Marmot-Kizhuyak Bay area
S Sitkalidak Bay
Sh Shelikof area
SW Southwest



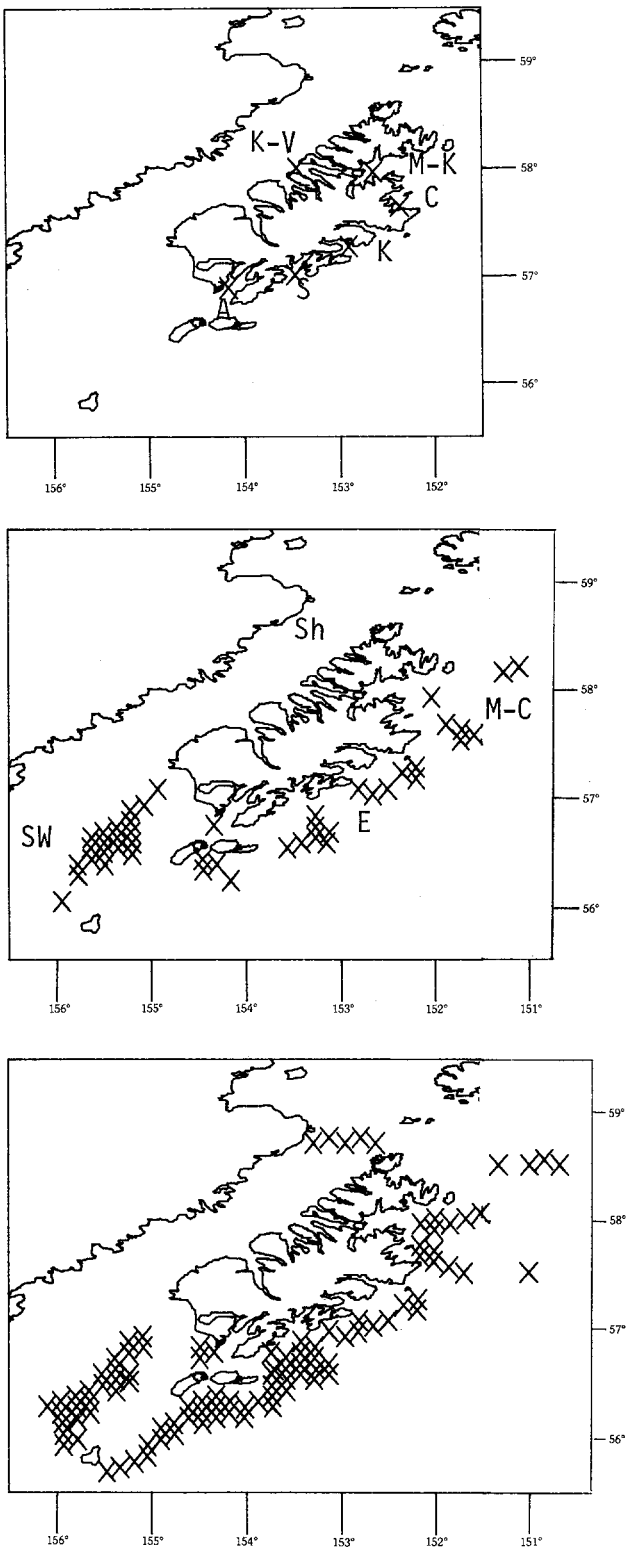




Figure 1. Tagged Tanner crab release sites (x) Kodiak, Alaska. Upper: bay sites, Middle: offshore sites 1973-1975, Lower: offshore sites 1976-1978.

Table 1. Number of tagged Tanner crab released and recovered off of Kodiak Island, Alaska 1973 - 1978.

| Tagging Dates | Number released in bays | Number recoveries | Usable recoveries | % of releases usable | Number released offshore | Number recoveries | Usable recoveries | % of releases usable | Total released | Total recovered | Total usable recoveries | % total releases usable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/15 - 8/5, 1973 | 261 | 71 | 51 | 19.5 | 2024 | 415 | 311 | 15.4 | 2285 | 486 | 362 | 15.8 |
| 6/28 - 7/26, 1974 | 374 | 57 | 38 | 10.2 | 1472 | 340 | 274 | 18.6 | 1846 | 397 | 312 | 16.9 |
| 7/15 - 7/27, 1975 | 430 | 68 | 54 | 12.6 | 502 | 142 | 78 | 15.5 | 932 | 210 | 130 | 13.9 |
| 11/8 - 11/12, 1975[1] | 408 | 31 | 22 | 5.4 | 766 | 84 | 63 | 8.2 | 1174 | 115 | 85 | 7.2 |
| 6/24 - 8/1, 1976 | 301 | 65 | 38 | 12.6 | 2023 | 434 | 274 | 13.5 | 2324 | 499 | 317 | 13.6 |
| 6/27 - 8/18, 1977 | 321 | 14 | 11 | 3.4 | 1351 | 167 | 147 | 10.9 | 1672 | 181 | 158 | 9.4 |
| 7/9 - 11/13, 1978 | 0 | - | - | - | 963 | 73 | 53 | 5.5 | 963 | 73 | 53 | 5.5 |
| | 2095 | 306 | 212 | 10.5 | 9101 | 1655 | 1200 | 13.2 | 11196 | 1961 | 1412 | 12.7 |

[1]FD 67 "T" tags

ranged from 26 to 1,376 days (Table 2). Crabs recovered within 1, 2, and 3 years of release represented 72.9, 18.8, and 7.5% of total recoveries, respectively. Three crabs, 0.8%, were captured in their fourth year of freedom.

Average migration (based on 2 or more crabs) ranged from 49.6 km (30.8 mi) for nine crabs free between 961 - 990 days, to 11.5 km (7.1 mi) for two crabs free 481 to 510 days (Table 2). Overall average distance migrated was 27.9 km (17.3 mi).

Direction of movement and a 95% confidence region for recoveries is represented in Figure 2 for bay and offshore tagged crabs. Bay tagged crab tended to move offshore while offshore tagged crab remained offshore and moved within the general geographic area of release. Depth change was variable with 176 (48.6%) crabs recaptured shallower than their release depth, 179 (49.4%) crabs were recaptured deeper, while 7 (1.9%) were recaptured at the same depth as released.

1974

During 1974, 1,846 male crabs $\geq$ 110 mm CW were tagged and released around Kodiak with Floy disc tags (Table 1). The majority of releases occurred in offshore areas, 1,472 as opposed to bay areas, 374.

A total of 397 tags was recovered (57 bay, 340 offshore). Catch data are available from 312 recoveries or 16.9% of all crabs tagged. Length of freedom ranged from 30 to 1,352 days (Table 2). Crabs recaptured within 1, 2, and 3 years of release represented 57.7, 37.5, and 4.8% of all recoveries, respectively.

The longest average movement was 83.5 km (51.9 mi) for four crabs free between 991 and 1,020 days. The shortest average movement was 12.0 km (7.5 mi) for two crabs free from 1,021 to 1,050 days (Table 2). Overall average distance of migration was 26.8 km (16.7 mi). Direction of movement and a 95% confidence region of recoveries is represented in Figure 3 for bay and offshore tagged crab. Movement in all offshore areas was localized to the area of release. Bay tagged crab tended to move offshore similar to the 1973 releases. One hundred seventy crab (54.5%) were recovered deeper than released, 108 crab (34.6%) were recovered shallower than released while 34 crab (10.9%) were recaptured at the same depth as released.

1975

Between 15 July and 12 November 2,106 crabs $\geq$ 110 mm CW were tagged and released around Kodiak Island (Table 1). The FD 67 "T" bar tag was used on 1,174 crab and the Floy disc was affixed to 932 crab. Sixty percent or 1,268 were tagged and liberated in offshore areas while 40%, 838, were tagged and liberated in bays. A total of 325 recoveries was made, 226 from offshore and 99 from bay tagged crab. Catch data are available from 215 of the recoveries or 10.2% of all crabs tagged.

Table 2. Distance moved from release site for Tanner crab captured at thirty-day intervals off of Kodiak Island, Alaska 1973-1978.

Average movement from release site in km and number of crab in ( ).

| Days of liberty | 1973 | 1974 | 1975 ADF&G | 1975 NMFS | 1976 | 1977 | 1978 | All years |
|---|---|---|---|---|---|---|---|---|
| One year | | | | | | | | |
| 1-30 | 23.7(3) | 17.1(1) | - (0) | - (0) | - (0) | - (0) | - (0) | 23.5(4) |
| 31-60 | 24.0(3) | 24.8(17) | 7.3(3) | - (0) | - (0) | 11.4(2) | 6.0(1) | 20.9(26) |
| 61-90 | 11.0(1) | 22.7(6) | 8.0(1) | - (0) | - (0) | 9.8(5) | 87.0(1) | 20.8(14) |
| 91-120 | 31.6(23) | 25.0(1) | - (0) | - (0) | - (0) | 9.7(7) | - (0) | 26.0(31) |
| 121-150 | 35.3(12) | 60.0(1) | 15.4(22) | - (0) | - (0) | 32.3(4) | - (0) | 24.4(39) |
| 151-180 | 17.9(21) | - (0) | 19.4(9) | - (0) | 17.5(9) | 15.3(11) | 19.0(1) | 17.2(51) |
| 181-210 | 26.9(21) | - (0) | 17.4(20) | - (0) | 18.4(46) | 17.7(38) | 19.5(4) | 19.5(131) |
| 211-240 | 30.8(39) | - (0) | 16.0(26) | - (0) | 18.5(57) | 15.9(34) | 17.3(27) | 20.1(183) |
| 241-270 | 27.9(106) | 43.3(24) | 12.3(19) | - (0) | 23.0(59) | 24.0(47) | 18.4(19) | 25.8(274) |
| 271-300 | 22.3(33) | 28.6(78) | 20.6(5) | - (0) | 25.8(38) | - (0) | - (0) | 26.3(154) |
| 301-330 | - (0) | 19.1(48) | - (0) | - (0) | 46.0(1) | - (0) | - (0) | 19.6(49) |
| 331-360 | - (0) | 14.3(4) | - (0) | - (0) | - (0) | - (0) | - (0) | 14.3(4) |
| Two years | | | | | | | | |
| 361-390 | - (0) | - (0) | - (0) | - (0) | 10.0(1) | - (0) | - (0) | 10.0(1) |
| 391-420 | 24.7(8) | - (0) | 4.0(1) | 30.0(1) | - (0) | - (0) | | 23.0(9) |
| 421-450 | 12.8(4) | 25.2(4) | 32.0(1) | 38.1(2) | - (0) | 47.0(1) | | 28.8(19) |
| 451-480 | - (0) | 19.6(5) | - (0) | 25.5(30) | 14.0(2) | - (0) | | 24.1(37) |
| 481-510 | 11.5(2) | 24.0(2) | - (0) | 14.9(36) | 39.5(2) | - (0) | | 17.7(42) |
| 511-540 | 56.0(1) | 28.5(14) | - (0) | 15.8(5) | 9.3(3) | 40.5(2) | | 25.7(25) |
| 541-570 | - (0) | 20.3(19) | 20.5(4) | - (0) | 8.5(1) | 20.0(2) | | 19.9(26) |
| 571-600 | - (0) | 24.8(12) | 25.4(8) | - (0) | 26.0(11) | 25.5(2) | | 25.4(33) |
| 601-630 | 31.7(3) | 24.0(25) | 20.5(2) | - (0) | 29.0(60) | 20.7(3) | | 26.8(99) |
| 631-660 | 23.2(29) | 24.3(34) | 41.0(1) | - (0) | 23.0(21) | - (0) | | 23.8(85) |

Table 2. Distance moved from release site for Tanner crab captured at thirty-day intervals off of Kodiak Island, Alaska 1973-1978 (cont.)

Average movement from release site in km and number of crab in ( ).

| Days at liberty | 1973 | 1974 | 1975 ADF&G | 1975 NMFS | 1976 | 1977 | 1978 | All years |
|---|---|---|---|---|---|---|---|---|
| 661-690 | 29.3(21) | - (0) | - (0) | - (0) | - (0) | - (0) | | 30.8(20) |
| 691-720 | 13.0(1) | - (0) | - (0) | - (0) | - (0) | - (0) | | 13.0(1) |
| 721-750 | - (0) | - (0) | - (0) | - (0) | - (0) | - (0) | | - (0) |
| Three years | | | | | | | | |
| 751-780 | - (0) | - (0) | - (0) | - (0) | - (0) | | | - (0) |
| 781-810 | 31.7(3) | - (0) | - (0) | 21.4(4) | - (0) | | | 25.6(7) |
| 811-840 | 49.0(1) | 19.0(1) | - (0) | - (0) | - (0) | | | 34.0(2) |
| 841-870 | 29.0(2) | - (0) | - (0) | 15.0(2) | - (0) | | | 19.5(4) |
| 871-900 | - (0) | - (0) | - (0) | - (0) | - (0) | | | - (0) |
| 901-930 | 17.0(1) | - (0) | 138.0(1) | - (0) | 31.0(1) | | | 62.0(3) |
| 931-960 | 23.5(2) | 41.3(3) | 55.0(1) | - (0) | 41.0(3) | | | 38.8(9) |
| 961-990 | 49.6(9) | 29.5(4) | - (0) | - (0) | 28.5(2) | | | 41.4(15) |
| 991-1020 | 43.1(7) | 83.5(4) | - (0) | - (0) | 34.0(1) | | | 55.8(12) |
| 1021-1050 | 38.5(2) | 12.0(2) | - (0) | - (0) | - (0) | | | 25.3(4) |
| 1051-1080 | - (0) | 30.0(1) | - (0) | - (0) | - (0) | | | 30.0(1) |
| Four years | | | | | | | | |
| 1343-1376 | 34.3(3) | - (0) | - (0) | - (0) | | | | 34.3(3) |
| N | 362 | 312 | 130 | 85 | 317 | 158 | 53 | 1,417 |
| $\frac{\Sigma}{N}$ = Km | 27.9 | 26.8 | 18.2 | 21.1 | 23.1 | 19.4 | 19.0 | 24.0 |

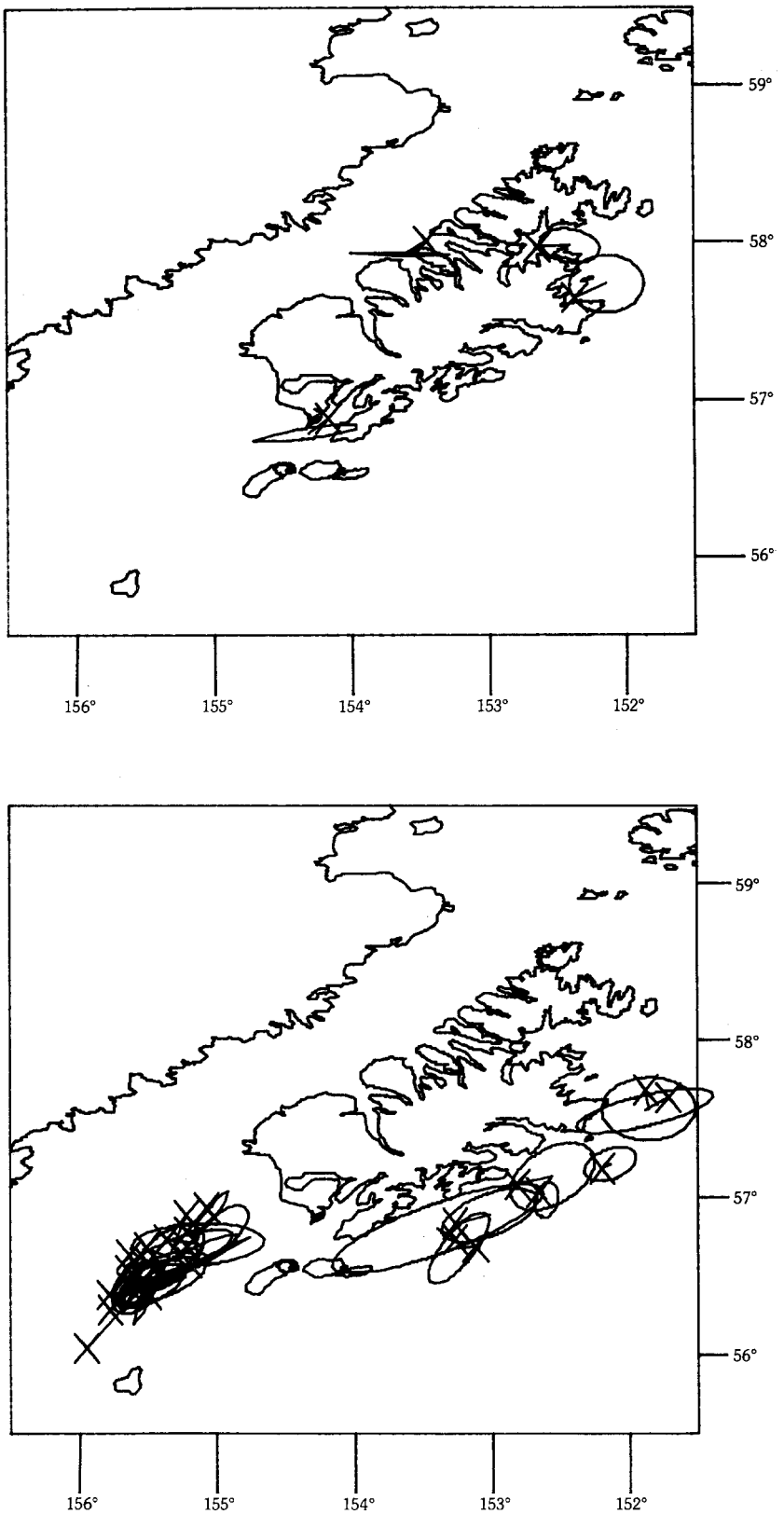



Figure 2. Movements of tagged Tanner crab released in 1973 at Kodiak, Alaska. Upper: bay recoveries (51), Lower: offshore recoveries (311). Ellipse represents 95% confidence region.

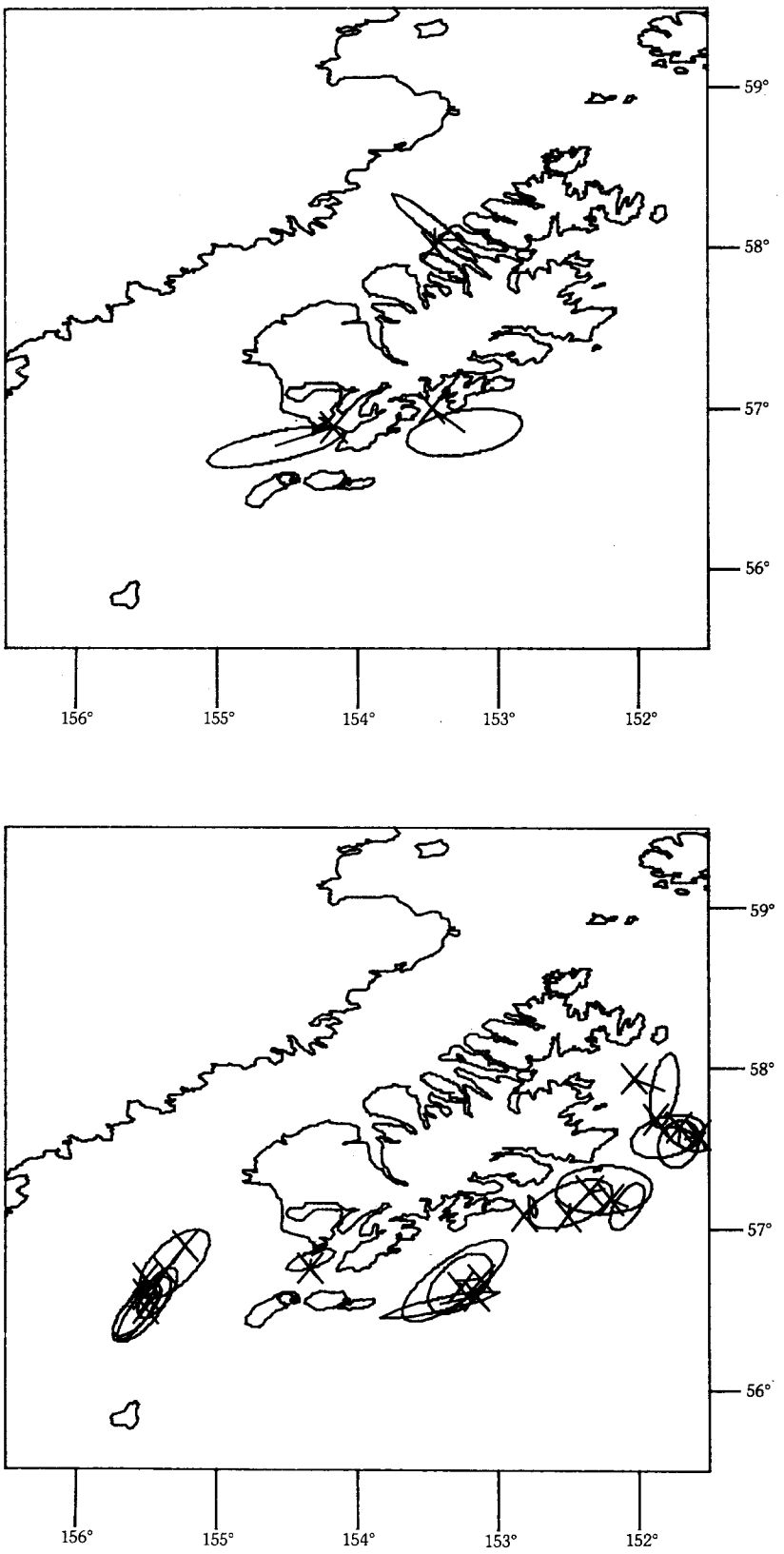



Figure 3. Movements of Tanner crab released in 1974 at Kodiak, Alaska. Upper: bay recoveries (38), Lower: offshore recoveries (274). Ellipse represents 95% confidence region.

Length of freedom ranged from 40 to 935 days (Table 2). Crabs recovered within 1, 2, and 3 years of release accounted for 48.8, 47.4, and 3.7%, respectively.

The longest average movement was 38.1 km (23.6 mi) for two crabs free from 421 to 450 days (Table 2). The shortest average movement was 7.3 km (4.5 mi) for three crab free from 31 to 60 days. Overall average distance of migration was 19.3 km (12.0 mi). There was little difference in the average distances of migration for FD 67 "T" bar tagged crab 21.1 km (13.1 mi), versus Floy discs 18.2 km (11.3 mi).

Direction of movement and a 95% confidence region of recoveries is represented in Figure 4 for bay and offshore tagged crab. Recoveries were restricted to the northeast and east sides of the island. Movement for offshore crab was localized around the area of release while bay tagged crab showed offshore movement. Forty-one (19.1%) crab were recaptured shallower than released, 164 (76.3%) were recaptured deeper, while 10 (4.7%) remained at the same depth.

1976

Between 24 June and 8 August 2,324 Floy disc tags were attached on crab ≥ 135 mm CW (Table 1). The change in size of crab tagged was due to an imposition of a minimum size limit at 135 mm CW. As in previous years the majority of tags were liberated in offshore areas, 2,023 tags (87%) as opposed to bays, 301 tags (13%).

A total of 499 recoveries were made, 434 from offshore tagged crab and 65 for bay tagged crab. Catch data are available from 317 recoveries or 13.6% of the total releases.

Length of freedom ranged from 166 to 994 days (Table 2). Crabs recovered within 1, 2, and 3 years of release represented 66.2, 31.5, and 2.2%, respectively, of total recoveries.

Average movement by 30-day periods ranged from 9.3 km (5.8 mi) for three crabs free from 511 to 540 days to 41.0 km (25.5 mi) for three crabs free from 931 to 960 days. The average distance migrated for all 317 crab was 23.1 km (14.4 mi).

Direction of movement and a 95% confidence region of recoveries is represented in Figure 5 for bay and offshore stations, respectively. Movement is basically the same as demonstrated for previous years. Additional tagging in the northwest area showed movement westerly from the release site. Two hundred nine (65.9%) crab were recovered shallower than released and 198 (34.1%) were recovered in deeper water.

1977

Between 27 June and 18 August 1,672 crabs ≥ 135 mm CW were tagged with the modified FD 67 "T" bar tag (Table 1). The majority, 80.8% (1,351), of the

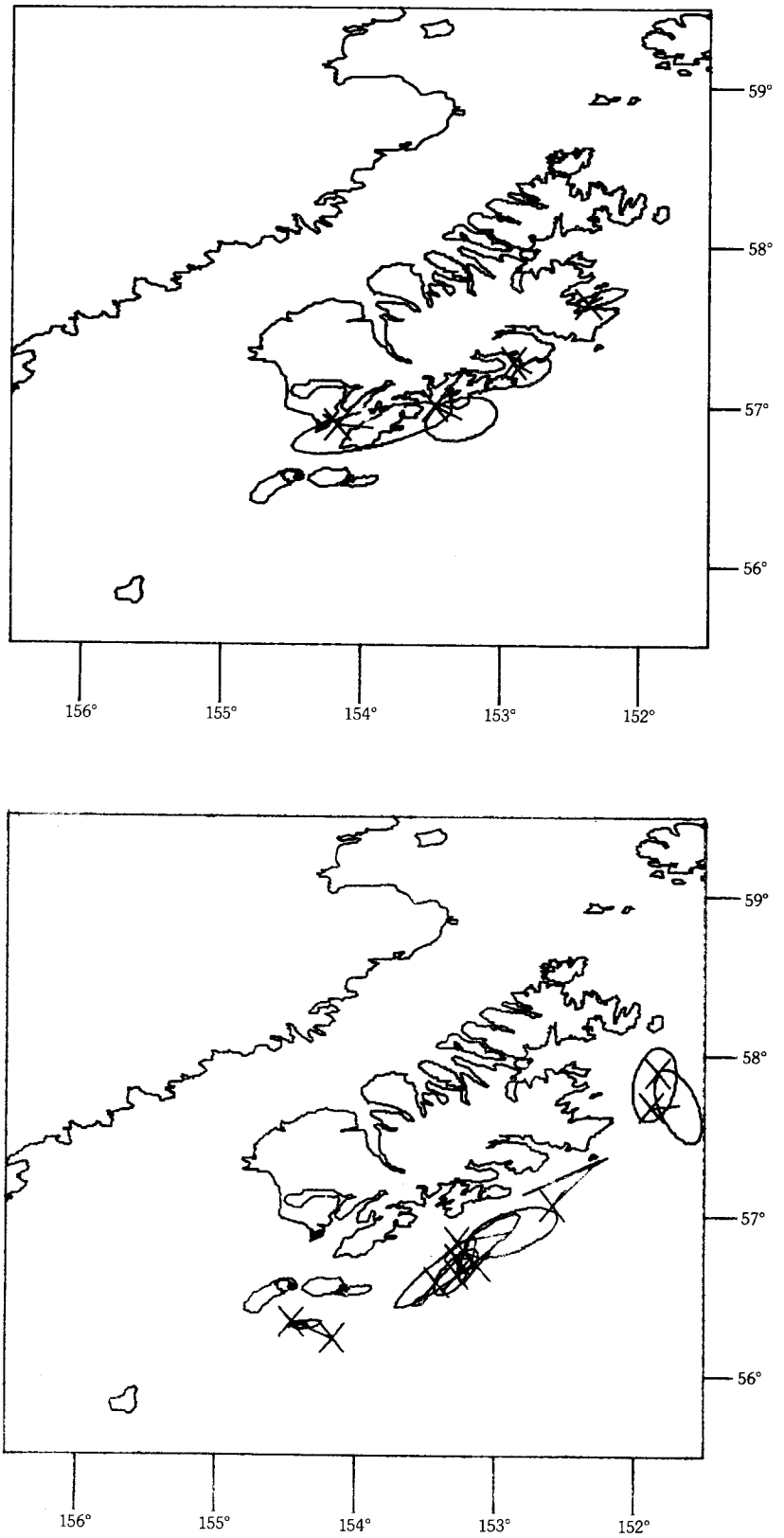



Figure 4. Movements of tagged Tanner crab released in 1975 at Kodiak, Alaska. Upper: bay recoveries (76), Lower: offshore recoveries (226). Ellipse represents 95% confidence region.

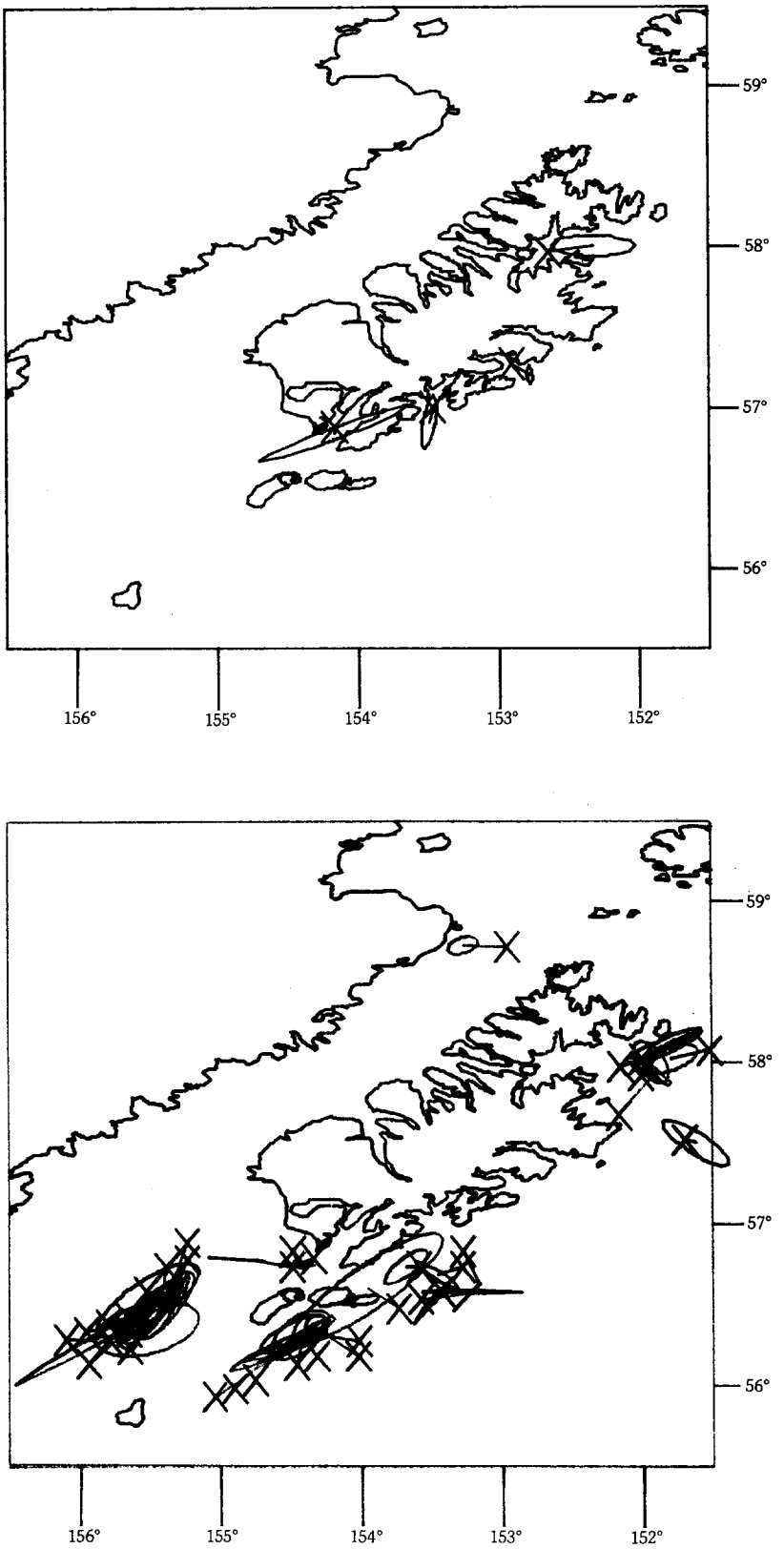



Figure 5. Movements of tagged Tanner crab released in 1976 at Kodiak, Alaska. Upper: bay recoveries (22), Lower: offshore recoveries (63). Ellipse represents 95% confidence region.

tags were liberated in offshore areas while 19.2% (321) were liberated in bays. A total of 181 tags was recovered (167 offshore, 14 bay). Catch data are available from 158 or 9.4% of the total releases.

Length of freedom ranged from 44 to 617 days (Table 2). The majority of the recoveries occurred within 1 year of release, 148 (93.7%) while 10 (6.3%) were recovered during the second year after release. Average movement ranged from 9.7 km (6.0 mi) for seven crab at liberty from 91 to 120 days to 40.5 km (25.2 mi) for two crab at liberty 511 to 540 days. The average distance migrated for all 158 crab was 19.4 km (12.1 mi).

Direction of movement and a 95% confidence region of recoveries is represented in Figure 6 for bay and offshore tagged crab, respectively. Movement patterns were consistent with those from previous years data where tagging took place. Most of the crab, 110 (69.6%) were recovered shallower than their release sites, 43 (27.2%) moved deeper, while 10 (6.3%) were recaptured at the same depth.

1978

A total of 963 crab $\geq$ 135 mm CW was tagged with Floy disc tags and released in the southern portion of the Kodiak area (Table 1). No tagging was done in bay areas. Seventy-three recoveries were made, 53 (5.5%) of the total releases with catch data. Length of freedom ranged from 55 to 263 days (Table 2). The longest average movement was 19.5 km (11.8 mi).

Direction of movement and a 95% confidence region of recoveries is represented in Figure 7 for offshore tagged crab. No crab were tagged in bay areas and there were no recoveries of offshore tagged crab in bays. Thirty-seven crab (70%) were recovered shallower than their release depth, 15 crab (28%) were recovered deeper, while one individual was recaptured at the same depth as released.

Bay Areas, 1973-1978

Tagging and recovery for bay areas, all years combined, is depicted on Figure 8. A total of 212 tagged crab with recovery data from all bays (Table 1) was obtained during the course of this study ranging from 52 from Sitkalidak Bay (S) to 17 for the Marmot-Kizhuyak (M-K) Bay area (see Figure 1 for individual bay locations). Movement from the midpoint of the release locations to the midpoint of the recovery locations was greatest in the Marmot-Kizhuyak Bay area, 33.6 km (20.9 mi) while the least movement occurred in Kiliuda (K) and Alitak (A) Bays, 14.4 km (8.9 mi). Movement of crabs tagged and released in the Kupreanof-Viekoda (K-V) Bay areas averaged 9.6 km (6.0 mi), Chiniak (C) Bay, 17.6 km (10.9 mi), and Sitkalidak Bay on the southeast side of Kodiak 22.3 km (13.9 mi). Maximum migration occurred in Alitak Bay, 62.4 km (38.8 mi). All bay tagged crab demonstrated an offshore movement with the exception of Kupreanof-Viekoda Bay area recoveries which demonstrated both offshore and onshore movement.

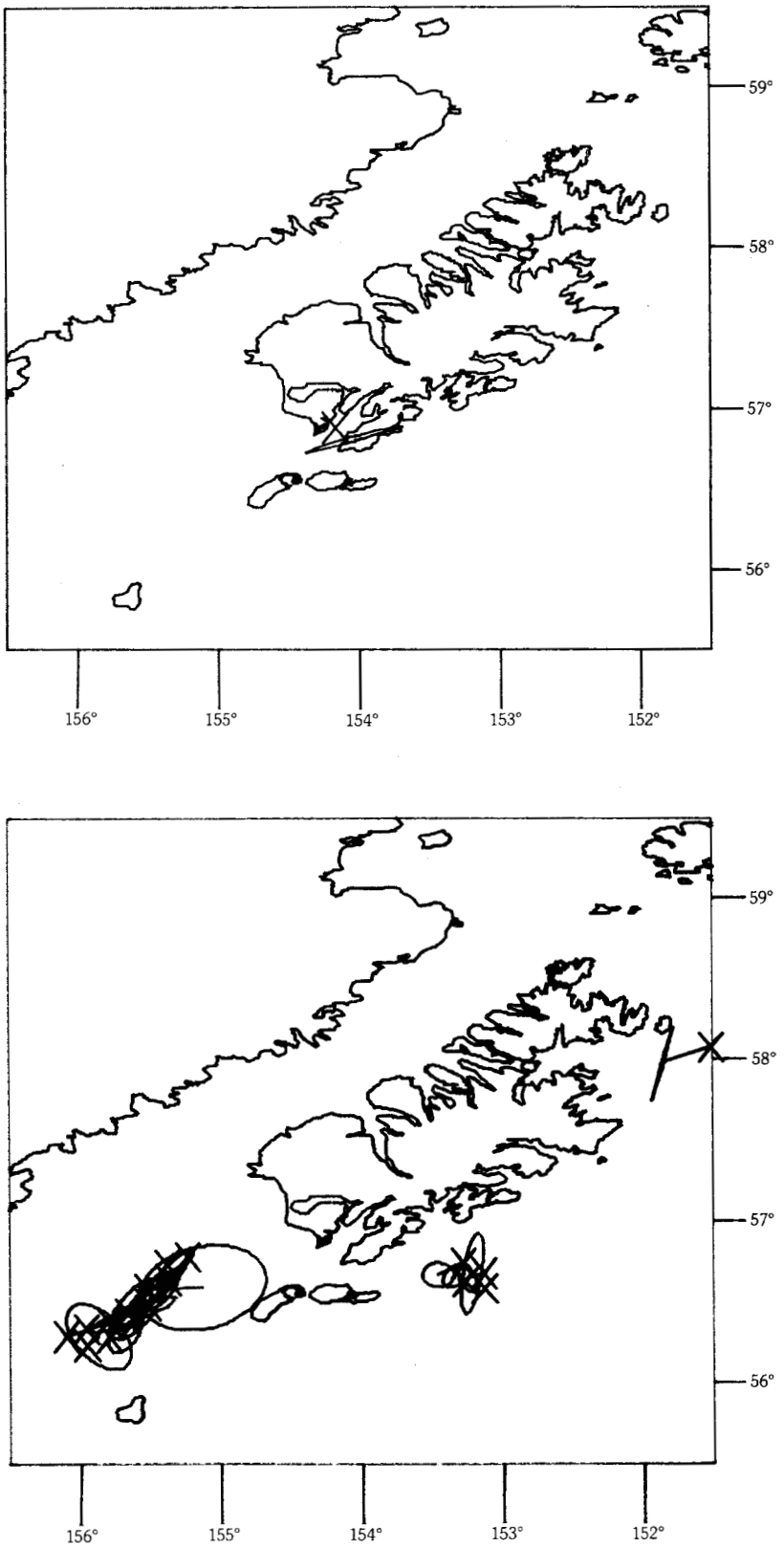



Figure 6. Movements of tagged Tanner crab released in 1977 at Kodiak, Alaska. Upper: bay recoveries (38), Lower: offshore recoveries (274). Ellipse represents 95% confidence region.

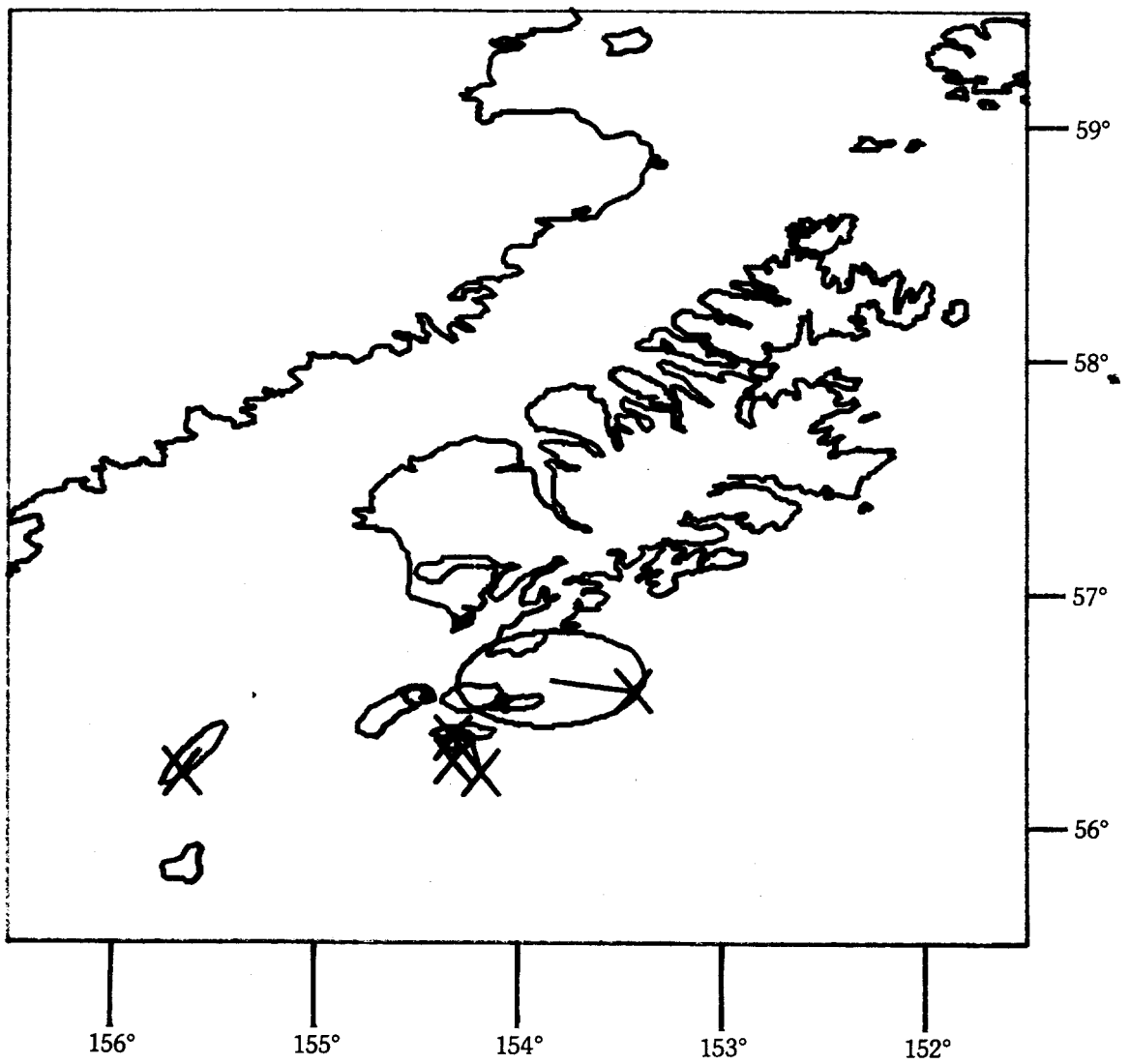



Figure 7. Movements of tagged Tanner crab released in 1978 at offshore Kodiak, Alaska (N=53). Ellipse represents 95% confidence region.

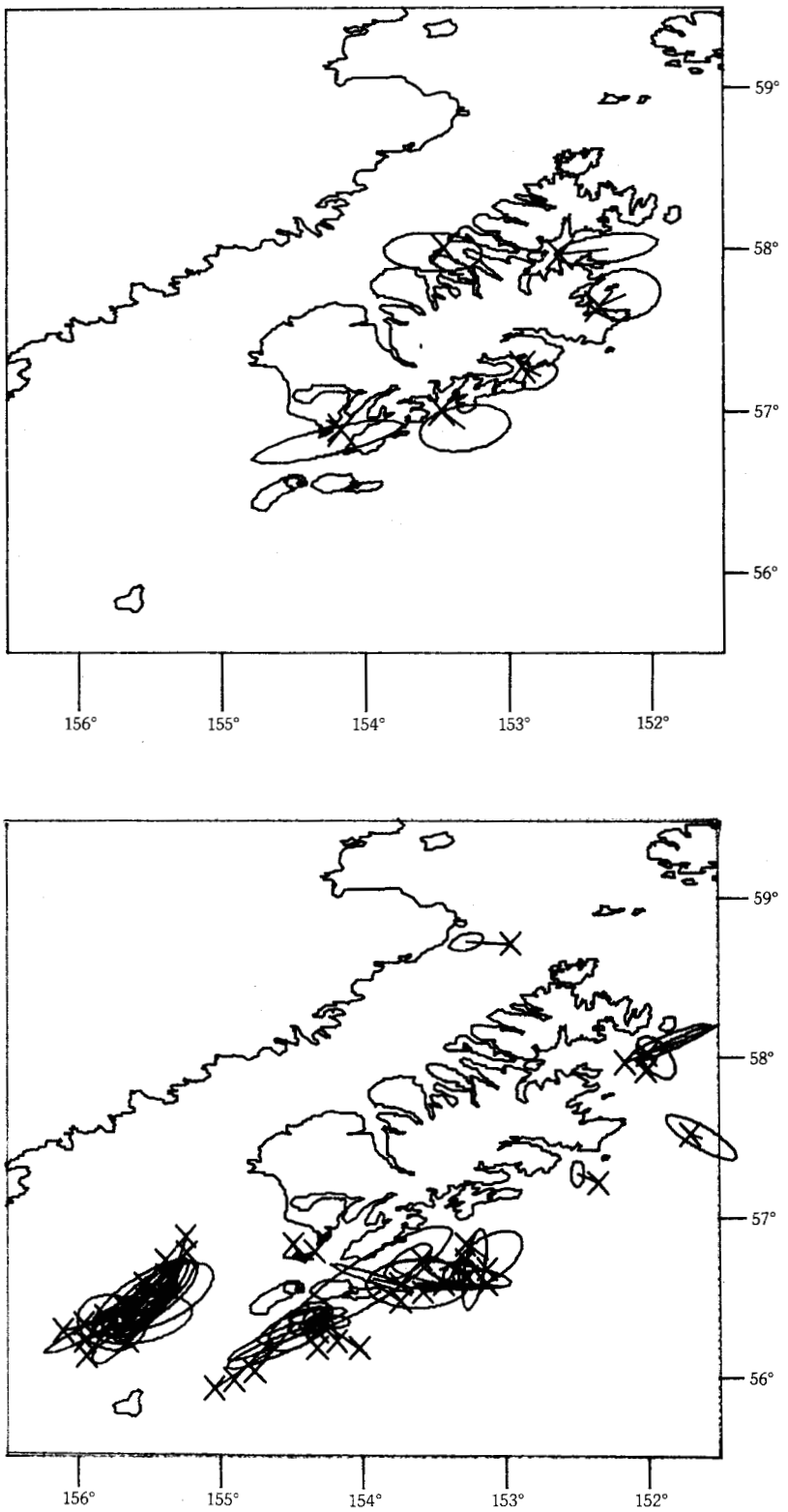



Figure 8. Movements of tagged Tanner crab released in 1973-1978 at Kodiak, Alaska. Upper: bay recoveries (212), Lower: offshore recoveries (1,200). Ellipse represents 95% confidence region.

Offshore Areas, 1973-1978

A total of 1,200 tagged crab with recovery data was obtained for crabs released from 1973 to 1978 (Table 1). Direction and magnitude of migration is depicted on Figure 8. Four stocks are apparent from this figure: (1) Marmot-Chiniak (M-C) area, 238 tags recovered; (2) Eastside (E), 494 tags recovered; (3) Southwest (SW), 453 tags recovered; and (4) Shelikof (Sh), 15 tags recovered. Crabs appear to move about in the general area of tagging and release with no immigration into bay areas. The westerly movement of crabs released in the northern portion of the Eastside and Shelikof areas is most likely due to a small number of tags released in those areas. The northerly movement in the southern portion of the Eastside area is most likely due to a lack of commercial fishing to the south of the release points.

The Marmot-Chiniak and Eastside stocks are separated by a deep gully 144 to 215 meters (80 to 120 fm) which may present a physical barrier separating crab into independent stocks. Likewise, the Eastside and Southwest stocks are separated by a large shallow area 18 to 36 meters (10 to 20 fm) running northeast-southwest which may also present a physical barrrier to movement.

## DISCUSSION

Obviously, tag recovery is dependent on the when and where of the commercial fisheries. From 1973 through 1978, 57,334.7 mt (124,809,323 lb) of Tanner crab were harvested off of Kodiak. These poundage figures approximate 49,934,730 crabs at 1.13 kg (2.5 lb) per crab. After release, tagged crabs are first susceptible to recapture in the fall fishery (August-December) for the king crab *Paralithodes camtschatica*. Tanner crab are captured incidental to king crab since the two species tend to occupy much of the same habitat. Tagged crabs are then subject to capture during a Tanner crab fishery. Opening dates of this fishery have varied from 1 November in 1973 and 1974 to 1 January in 1976 through 1978. During the 1973-74 season, effort levels and rates of harvest combined to close the season on 15 May. The 1974-75 season closed on 31 May. The 1975-76 and 1977 seasons closed on 30 April since research information indicated May as a peak month of reproduction. The 1978 season terminated on 16 April after the harvest limit was obtained.

During the early to late seventies (1973-1978) fishing effort expanded to cover all major production grounds of both king and Tanner crab. "In 1973, a major expansion of the Tanner crab fishery occurred due to an extremely short king crab season and favorable Tanner crab marketing conditions. The offshore areas of Cape Ikolik to Chirikof Island, Portlock Banks, Shelikof Strait, Chiniak Gully, and Albatross Bank were most explored (Anon. 1979)". Smaller vessels tend to fish the nearshore areas while larger crabbers tend to fish deeper offshore areas for the duration of the season.

The results of this study are influenced by the peculiarities in fishing patterns, however, recovery effort appears to have been reasonably well

dispersed over the year by area and should provide a reasonable picture of crab migration.

The majority of crabs tagged were sexually mature males. However, since there is not enough data to look at migration by cohort or specific size groups within the range of sizes tagged, the data was collated. I chose to represent migration for specific areas by collating data from individual tagging years. This was necessary because of variable tagging effort.

Migration data indicates that Tanner crab do not move extensively from their release sites. Watson (1970) and Watson and Wells (1972) found this to be true for *C. opilio* with an average movement of 11 miles for adult males. They also concluded that "it was impossible to determine any general pattern of movement". It appears that crabs can be separated into manageable stocks based on the fact that there appears to be little or no movement between designated geographic regions. The tagging results show that although there are examples of extensive movement for small numbers of crab, the average movement was only 24.1 km (15.0 mi) over the entire length of the study. Although length of freedom varied between less than 1 month to 3.8 years, no correlation between time and distance migrated is evident. There appears to be a definite offshore movement for crabs tagged in bay areas and intermingling with deeper offshore stocks. There is no evidence to suggest the reverse is true.

Crabs tagged in open ocean areas show no discernible patterns of movement when recovery effort encircled the release area.

What seems to be unfolding is a pattern of growth to maturity for males in bay areas with gradual movement offshore. Offshore crab appear to mature and remain in the offshore areas moving randomly within a defined geographic unit.

## CONCLUSIONS

After examination of the recovery data I believe the following conclusions are evident.

1) Male Tanner crab maturing in bay areas tend to move to deeper offshore waters and mix with offshore stocks.

2) Male Tanner crab maturing in offshore waters remain offshore and migrate randomly within a geographic area.

3) While individuals may range widely, average movement, 24 km (15 mi), is not extensive.

4) Distance of migration is not necessarily dependent on length of freedom.

5) Seasonal migrations may occur and further studies are necessary.

6) Capture of tagged crab up to 2 years (47.4% tagged in 1975) and 3 years (7.5% tagged in 1973) after tagging indicates extensive inter-molt periods for male crabs smaller than the present size limit.

7) High exploitation rates in offshore geographic areas may be partially compensated for by immigration of mature bay crab.

8) High exploitation rates in bay areas may be more serious since recruitment into the fishable size range is dependent on annual recruits to legal size with no apparent immigration of offshore crab.

9) For fishery management purposes, independent stocks of male Tanner crab off of Kodiak are definable.

## ACKNOWLEDGMENTS

I wish to acknowledge Matthew Dick, David Hicks, Rich Peterson, Mary Clemens, and Marilyn Kemerer for their contribution. A special thanks to Sharon Theis for her many hours on the keyboard.

## LITERATURE CITED


Anonymous. 1979. "Fishery management plan for the commercial Tanner crab fishery off the coast of Alaska". N.P.F.M.C., Anchorage, Ak.

Donaldson, W.E. 1980. Alaska Tanner crab investigations. Alaska Dept. Fish and Game Comp. Rep. Proj. No. 5-41-R, Comm. Fish. Res. Dev. Act. 122 pp.

Katoh, Genji, Ichiro Yamanaka, Akira Ochi, and Tetsuo Ogata. General aspects on trawl fisheries in the Japan Sea (In Japanese with English summary). Bull. Japan Sea Reg. Fish. Res. Lab. (Niigata, Japan), 4:1-331. Trans. avail., p. 293-305, Trans. Prog., Bur. Comm. Fish., Washington, D.C.

Pereyra, W. 1967. The bathymetric and seasonal abundance and general ecology of the Tanner crab, *Chionoecetes tanneri* Rathbun (Brachyura: Majidae), off the Northern Oregon Coast. U. of Wash. Thesis, 415 pp.

Rathbun, Mary J. 1925. The spider crabs of America. Bull. U.S. Nat. Mus., 129. 613 pp.

Slipp, J.W. 1952. Status of the crab, *Chionoecetes bairdi*, in the inshore waters of Washington and British Columbia. Wassman J. Biol. 10:235-239.

Watson, J. 1970. Tag recaptures and movements of adult male snow crabs, *Chionoecetes opilio* (O. Fabricius) in the Gaspé region of the Gulf of St. Lawrence. Fish. Res. Board Can. Tech. Rep. No. 204, 16 pp.

Watson, J. and P.G. Wells. 1972. Recaptures and movements of tagged crabs *(Chionoecetes opilio)* in 1970 from the Gulf of St. Lawrence. Fish. Res. Board Can. Tech. Rep. No. 349. 12 pp.

Yoshida, H. 1941. On the reproduction of useful crabs in North Korea. II. Suisham Kenkyushi. 36:116-123 (p. 116-121 trans. from Japanese by Hack hin Kim, Natl. Mar. Fish. Ser. Seattle).

APPENDIX A

# CRABWALK

## A Series of Computer Programs for Analysis of Crab Migration Data

by

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Alaska Tanner Crab Investigations

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APPENDIX A

CRABWALK, A series of computer programs for analysis of crab migration data.

## I. Introduction

This report documents the existence of "CRABWALK", a series of computer programs to assist in the analysis of crab migration data. The programs were developed in response to a need for timely analysis of data collected for the Tanner crab, *Chionoecetes bairdi*, off of Kodiak Island, Alaska. "CRABWALK" is a user oriented system composed of programs which allow editing of data, update of the data base, retrieval of user specified records, collation of migration data to users specifications, computation of migration variables for individuals or combinations to users specifications, calculation and plotting of recovery data with a degree of statistical significance, and reporting of this information in a variety of formats.

Although "CRABWALK" was written specifically for the Kodiak Tanner crab data base, it can be adapted readily for use in other geographic areas. Jones (1976) discusses the determination of movement parameters and presents some of the mathematical background used in this study to calculate migration parameters.

## II. System Design

A. Specifications: Migration or displacement of aggregations of a commercially exploited resource is necessary information for management of that resource. The main goal in defining migration(s) is to allow management of independent stocks, if they exist, so as to better utilize and protect the resource.

Because patterns of movement may change over time, depending on environmental as well as biological parameters, it is necessary that a means of analyzing migration data be available and timely. The manager also requires a way of assigning confidence in statistical terms to his definitions of independent stocks or schools.

Also, the manager may require an analysis by size group, sex or area which requires flexibility and timeliness.

The programs were written for the University of Alaska's Honeywell 6000 computer. Subroutines are available which calculate length at freedom, depth change, distance migrated and angle of movement for individuals. Additional subroutines combine the values from individual crab so as to estimate the mean of the stated variables according to the user's need. Ellipse programs calculate a 95% confidence region of dispersion, which can be graphically represented with the aid of a computer plotter.

B. Information Flow: The initial tasks are depicted on figure 1. A permanent file of release and recovery data is created which can be readily updated by accomplishing the following: 1) Release information is recorded in keypunchable format, 2) Release information is keyed into the computer creating a file of releases, 3) The file is then checked for accuracy and errors corrected, 4) A printout of NDATA file is then available, 5) Recovery information is recorded in keypunchable format, 6) Recovery information is keyed into computer and a new file of migration data consisting of release

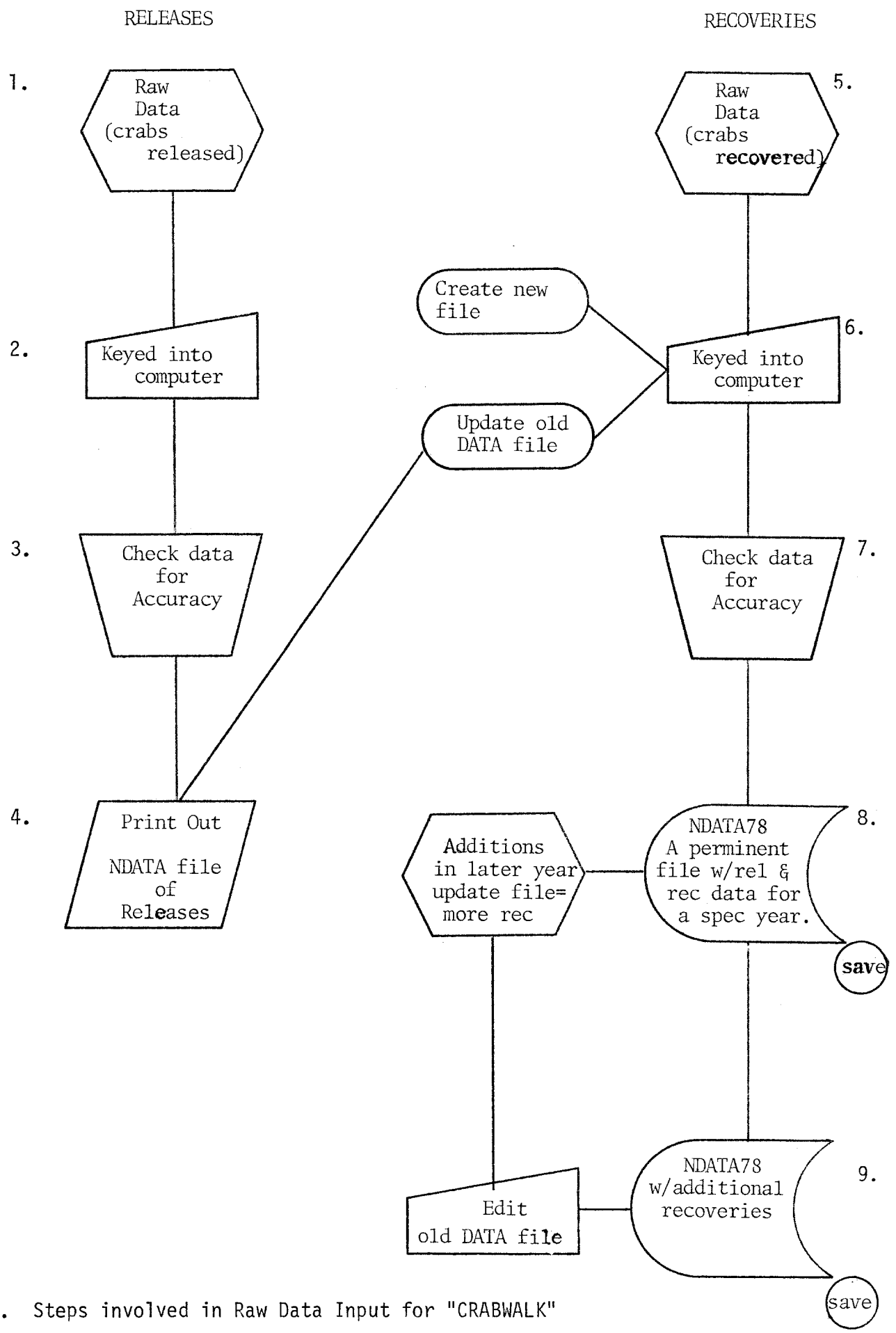


Figure 1. Steps involved in Raw Data Input for "CRABWALK"

and recovery information is created, 7) Recovery data keyed in is checked for accuracy, 8) NDATA "78" is created which is a permanent file of release and recovery data for a specific year of tagging, in this case 1978, 9) NDATA "78" is updated as additional recoveries of tagged crab are made.

C. Raw Data Input: In the Kodiak Tanner crab example, the release data file created, included release date, release station, tag number, carapace width, exoskeletal age, and latitude, longitude and depth of release. Recovery data keyed in included date, exoskeletal age, and latitude, longitude and depth of recovery.

A conversion table was created after McMullen (1967) to assign release and recovery sites to individual environmental zones (based on depth) and bay and offshore areas. This was done in order to allow release and recovery sites to be grouped into larger geographical units for analysis.

## III. COMPUTER IMPLEMENTATION

### A. Program

There are six (6) programs designed for the Honeywell 6000.

1. TESTPROG

Takes crab Recovery Data File and computes for each tag recovery various statistics (Depth Change, Days of Freedom, Distance Traveled, Angle Traveled, etc.). Then it creates a new "Save File" which contains all the original data plus the computed statistics for each tagged crab recovery.

2. WRITECAS/TORT

Takes the "Save File" and sorts it by Year by Station. Calls for a subprogram "Log" (Fort) and takes the sorted "Save File" and prints out an Edit listing of the "Save File".

3. AGGR3

Aggregates the Tag Recoveries in the Save File" By:
1. Release Year, By Station, By Months Out
2. Release Year, By Station, By Years Out
3. Release Year, By Station, By Total Period at Large

Computes the Mean Release Depth, the Mean Recovery Depth, the Mean Distance Traveled and the Mean Angle Traveled for each grouping.

4. AGGR4

Aggregates the Tag Recoveries in the "Save File" By:
1. Release Year, By Station, By Months Out, By Width Class, By Age Class
2. Release Year, By Station, By Years Out, By Width Class, By Age Class
3. Release Year, By Station, By Total Period, By Width Class By Age Class

Computes the Mean Release Depth, the Mean Recovery Depth, the Mean Distance Traveled and the Mean Angle Traveled for each grouping.

5. AGGR5

Aggregates the Tag Recoveries in the "Save File" By"
1. Bay, By Environmental Zone, By Catch Area, By Months Out
2. Bay, By Environmental Zone, By Catch Area, By Years Out
3. Bay, By Environmental Zone, By Catch Area, By Age Class

Computes the Mean Release Depth, the Mean Recovery Depth, the Mean Distance Traveled and the Mean Angle Traveled for each grouping.

6. SORT/FORT

Selects out those Tag Recovery-Crabs the Biologists chooses from the "Save File" (Generally Selects By Station, By Year). Calls for a Sub-program "Ellipse" which takes the Latitude and Longitude readings of selected recovered crabs and generates the necessary information to draw an ellipse for those recoveries. The ellipse statistics created are the length of the Major and Minor Axis, the Angle of the Major Axis from North and the Confidence Interval.

The structure of these programs is depicted in figure 2.

With the edited raw data in the form of printed paper you are ready to start keying it into the computer.

7. Sign Onto Computer Terminal:

a. Dial phone number for connection to computer (1-3293 or 1-3294)

b. Printer "on"

c. Connect by pressing phone receiver into "slot"

d. Press "cntl" and "A" keys simultaneously

You are not "on line" and can begin.

| Computer Response | Operator Response |
|---|---|
| UACN TSS date time etc | |
| USERID? | DGTAN (or other appropriate userid) |
| PASSWORD? | (appropriate password) |
| * | (system level) |
| UPDATE EXISTING FILE: | |
| * | LIST RETRIEVE<br>(if RETRIEVE program doesn't exist you must create it) |
| (lists RETRIEVE) | |
| * | EDIT 0 RETRIEVE |

| | |
|---|---|
| - | (edit program with series of<br>FVS:/ / find verify string<br>RVS:/ /:/ / replace verify string) |
| (prints what is between slashes in operator command)(also replaces) | |
| - | SAVE (or) RESAVE RETRIEVE |
| - | DONE |
| * | (back to system level) |
| * | JRUN RETRIEVE |
| CARD FORMAT, DISPOSITION | N,J<br>(N=normal card format 8, 16, 32 tab settings, J=system as opposed to Anch. system) |
| (snumb # & runs program) | (this program brings your old data file from tape to disk for access) |
| FUNCTION? | RELE |

<u>PROGRAMS:</u>

| | |
|---|---|
| * | LISTS TESTPROG |
| (lists testprog) | |
| * | EDIT 0 TESTPROG |
| - | FVS:/ /<br>RVS:/ /:/ /<br>(edit necessary portions of program: ie. circled on enclosed copies) |
| - | RESAVE TESTPROG |
| Data saved | |
| - | DONE |
| * | (create new files) |
| * | JRUN TESTPROG |
| CARD FORMAT, DISPOSITION | N,J |
| (runs program) | |
| FUNCTION? | HOLD<br>(this hold prog. run. Can print it out at any time in next 24 hours by knowing SNUMB #) |

```
*                                   LIST WRITECAS
(lists writecas)

*                                   EDIT 0 WRITECAS

-                                   (make changes)

-                                   RESAVE WRITECAS

Data Saved
-                                   DONE

*                                   LIST TORT
(lists tort)

*                                   EDIT 0 TORT
-                                   (make changes)

-                                   RESAVE TORT

Data Saved
-                                   DONE

*                                   JRUN WRITECAS
CARD FORMAT, DISPOSITION            N,J

(runs writecas)

FUNCTION?                           RELE

*                                   JRUN TORT

(runs tort)

FUNCTION?                           EPRINT 06

(prints output)

FUNCTION?                           RELE

*                                   JOUT (snumb # for TESTPROG)

FUNCTION?                           EPRING 06

(prints output)

FUNCTION?                           RELE

*
```

A. PROGRAMS

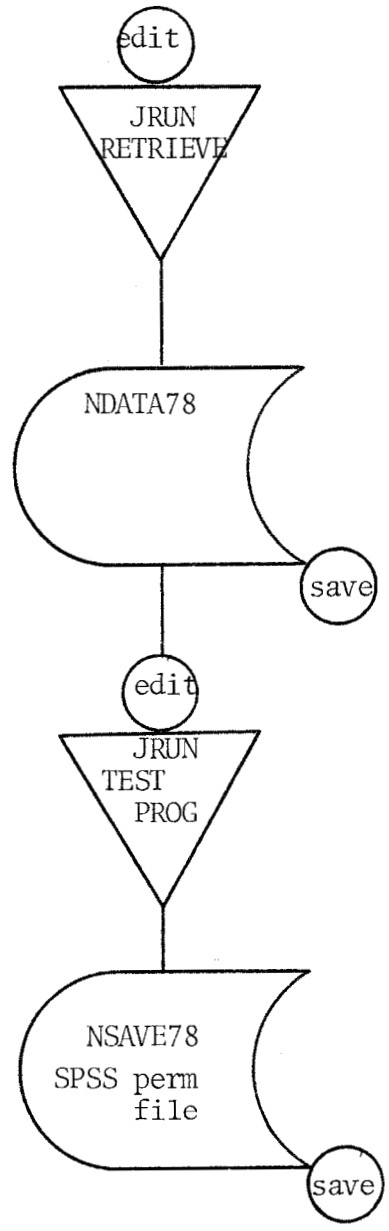


Figure 2. Structure of programs written for U. of A. Honeywell 6000 computer

con't

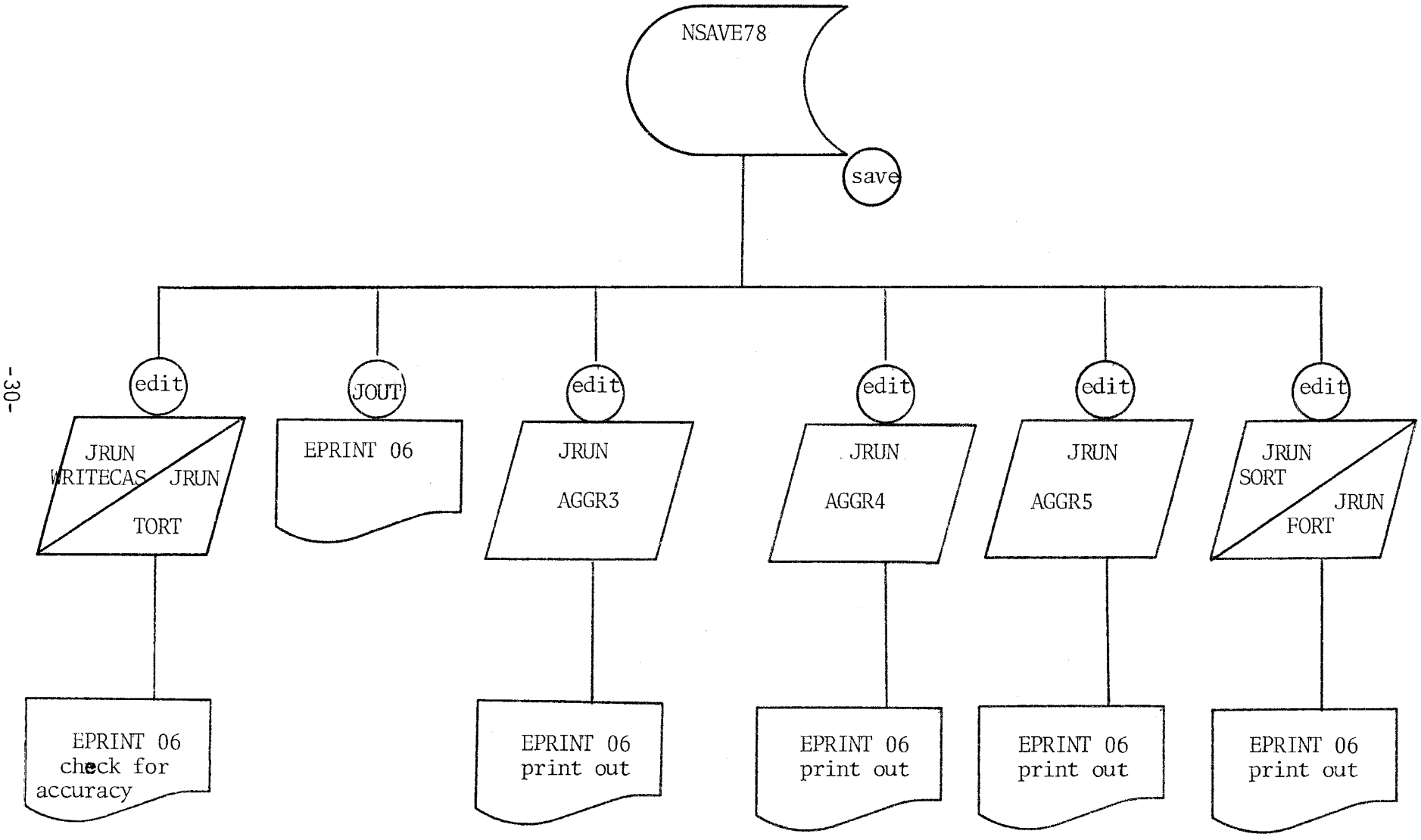


Figure 2 (continued)

CREATE A NEW FILE:

| | |
|---|---|
| * | EDIT N |
| enter<br>* | (hit return key) |
| - | SAVE(file name) |
| Date saved<br>- | DONE |
| * | |

Use the same format to LIST, EDIT & JRUN AGGR3, AGGR4, AGGR5, SORT & FORT programs.

CREATE NEW PROGRAM:

| | |
|---|---|
| * | CARD N |
| *<br>(it automatically numbers program lines) | AUTOX<br>(simply key in lines desired hitting a "return" at the end of each line) |
| | (hit return key twice after last line desired) |
| - | SAVE(program name) |
| - | DONE |
| * | |

MODIFY EXISTING FILES:

| | |
|---|---|
| * | ACCESS LS/file name |
| (prints out data on file named, ie. # of times accessed, # of LLinks, etc) | |
| * | ACCESS<br>(used to make changes: such as a new name, more llinks etc.) |
| FUNCTION? | MF |
| (asks question as to how you want to change file) | (hit return until you come to the question you want to change) |
| * | |

CREATE NEW NDATA FILE:

| | |
|---|---|
| * | EDIT N |
| enter<br>* | (key in new data)<br>(hit return twice after last data entry) |
| - | SAVE NDATA78 |
| Data Saved<br>- | DONE |
| * | |

B. ELLIPSE PROGRAMS:

The structure of ellipse program in shown in figure 3.

Ellipse programs were run under DGSALMON/ELLIPSE because "OUTIN" subroutine was inaccessible by DGTAN.

There are four (4) ellipse programs available designed for the Tektronic Plotter.

1. ONEMAP: Gives you one ellipse and a map of Kodiak. By putting in a data file with zero points or points 0,0 just a map can be printed.

2. ONEELLI: As the name implies it will plot the points in the file given and create an ellipse.

3 & 4. MULTMAP/MULTELLI: These programs are used when more than one data point file is used. In all cases the screen prompts the operator as to the "DATA FILE NAME" it requires.

   The ellipse subroutine that actually plots the ellipses, requires a minimum of three (3) different recovery coordinants for each station. Otherwise an error message is printed. If two or more recovery points are identical or there are too few points, the program doesn't abort. It continues and ends up plotting odd lines trailing off the page or other undesired results. In other words, the more points used to plot the ellipse, the more accurate and usable these programs.

5. Sign Onto Computer Terminal:

   There are three (3) on/off switches. One is on the phone terminal, one on the screen (located in back) and one on the plotter itself. Turn the first two "on". Dial the appropriate phone number and press phone into phone terminal recepacle. Press "cntl" and "A" keys simultaneously and proceed with USERID and PASSWORD.

B. ELLIPSE PROGRAMS

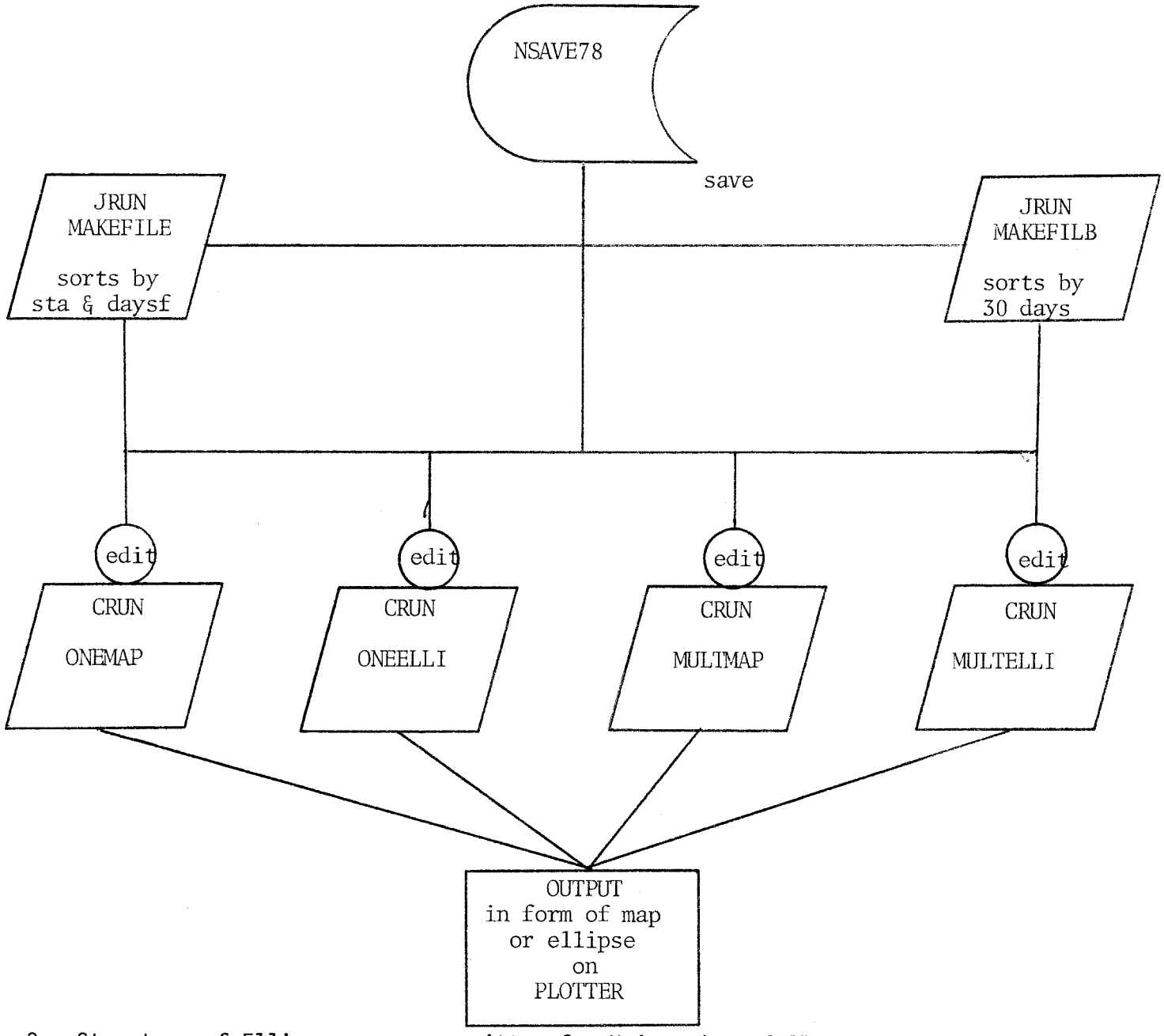


Figure 3. Structure of Ellipse programs written for University of Alaska Honeywell 6000 system.

It is best to leave the plotter "off" until most of the editing is done, program is run and you've keyed in the last command. $PLOT$ Before hitting the return key turn plotter on and set margins. The margins will remain "set" until plotter is turned "off". The error light on the plotter tends to "beep" on when there is any power fluctuation (le: turning a typewriter on/off when using same plug outlet) or errors in the program run. Usually, depending on type of error, the plotter finishes plotting and error is ignored. Sometimes, however, it will go "berserk" and waste a good piece of paper. Not to worry. Simply turn plotter "off" then "on" and reset margins. The error light should go off. Rerun program and continue.

C. ELLIPSES BY RELEASE STATION:

Each ocean station is run separate. Bay station recoveries are run by Bay, using common release coordinates for all release stations in each bay.

| | lat | long |
|---|---|---|
| KUPREANOF | 58005 | 153267 |
| MARMOT | 57580 | 152385 |
| CHINIAK | 57389 | 152221 |
| SITKALIDAK | 57001 | 153279 |
| ALITAK | 56529 | 154098 |
| KILIUDA | 57163 | 152542 |

```
*                                   LIST MAKEFILE

(lists makefile)

*                                   EDIT 0 MAKEFILE
                                    (make changes)

-                                   RESAVE MAKEFILE

Data Saved
-                                   DONE

*                                   (create FILE78 and FILE78A)

*                                   JRUN MAKEFILE

(program runs)

*                                   CONV FILE78=FILE78A
                                    (this converts data in FILE78 bcd
                                    to asc in order to edit it)

*
```

| | |
|---|---|
| 8 | LIST FILE78A<br>(create subfiles: ie: 8P058 by editing 0 FILE78A using series of deleting lines, printing lines you want saved, and deleting the rest of the file.) |
| * | EDIT 0 FILE78A |
| - | D;4 |
| (deletes four records) | |
| - | P;6 |
| (prints 6 records) | |
| - | D;* |
| (deletes rest of file plus last line printed so print one more than you want in subfile) | |
| end of file | |
| - | SAVE 8P058 |
| Data Saved | |
| - | DONE |
| * | |
| | (create as many subfiles as ellipes desired. If there are too many files in active file the computer will let you know you've exhausted you space. At system level type in_ |
| * | REMC AFT<br>(and continue creating subfiles) |

When you have all subfiles, choose type of ellipse program desired. Edit it to change xmin, xmax, ymin, ymax to appropriate degrees needed on printout. Leave (1, 2, 5, 5) coordinates the same as these are the dimensions of your box.

| | |
|---|---|
| * | CRUN ONEMAP<br>or CRUN ONEELLI<br>or CRUN MULTMAP<br>or CRUN MULTELLI |
| DATA FILE NAME? | 8P058<br>(or other file name and return key) |
| (runs program) | |

```
*                                        SX/PLOT/TEK,R

----------------------screen clears---------------------

=                                        $PLOT$
                                         (before hitting return key be sure
                                         plotter is on and margins are set)

----------------------plotter draws map----------------

=                                        Hit "Break" key

*                                        (ready to run another program)
```

Use the same format to LIST, EDIT, AND CRUN other ellipse programs.

To draw ellipses for other "categories" EDIT 0 MAKEFILE to sort by station, days free, etc. EDIT programs accordingly.

For ellipses containing data for more than one year files need to be converted to asc then combined, converted back to bcd to sort and back asc to edit. A new file name is created each time a conversion takes place and it does get confusing.

In Tanner Migration ellipses, so far, sorting by 30 day intervals was unsatisfactory due to small number of recovery points. Readable results were obtained when recoveries for years "76-78" were plotted in one ellipse for each station.

## IV. ACKNOWLEDGMENTS

CRABWALK was developed over a two-three year period by a number of people. Early system development and specification work was done by Marilyn Kemerer, Rich Peterson, and Bill Donaldson. Most of the programming was done by Kemerer. The digitized map of the Westward Region was obtained from Dave Somerton. The subroutine which calculates the probability ellipses was obtained from Guy Thornburgh. Further program debugging was done by Mary Ellen Harris and Larry Talley. Early production runs were made by Grace Stanley.

## V. LITERATURE CITED

Jones, R. 1976. The use of marking data in fish population analysis. FAO Fish. Tech. Paper No. 153, p. 16-18.

McMullen, John C. 1967. A preliminary study of king crab *Paralithodes camtschatica* ocean reproduction and the delineation of the Kodiak district continental shelf environmental zones. State of Alaska Inf. Leaflet No. 93, 15 p.

# VI. ATTACHMENTS

# A. PROGRAM SOURCE LISTINGS

```
 LIST MAKEFILE

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0030$:LIMITS:50,50K
0040NUMBERED:YES
0050RUN NAME:WRITE CASES PROCEDURE
0060GET FILE:NSAVE77
0070SORT CASES:STATION(A)
0080WRITE CASES:(F3.0,F2.0,F3.1,
0090::F3.0,F3.1,F2.0,F3.1,F3.0,F3.1)
0100::STATION,LATA,LATB,LONGA,LONGB,
0110::LATC,LATD,LONGC,LONGD
0120FINISH
0130$:PRMFL:FR,R,S,DGTAN/NSAVE77
0140$:PRMFL:43,W,S,DGTAN/FILE77
0150$:ENDJOB


*LIST MAKEFILB

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0030$:LIMITS:50,100K
0040NUMBERED:YES
0050RUN NAME:WRITE CASES PRODECURE
0060FILE NAME:73TAN78A
0061VARIABLE LIST:STATION,DAYSFREE,LATA,LATB,LONGA,LONGB,
0062::LATC,LATD,LONGC,LONGD
0063INPUT MEDIUM: TAPE
0064INPUT FORMAT:FIXED(F3.0,F4.0,F2.0,F3.1,F3.0,F3.1,F2.0,
0065::F3.1,F3.0,F3.1)
0066N OF CASES:UNKNOWN
0068READ INPUT DATA
0070SORT CASES:STATION(A) DAYSFREE(A)
0080WRITE CASES:(F3.0,F4.0,F2.0,F3.1,F3.0,F3.1,F2.0,
0090::F3.1,F3.0,F3.1)
0100::STATION,DAYSFREE,LATA,LATB,LONGA,LONGB,LATC,LATD,
0110::LONGC,LONGD
0120FINISH
0130$:PRMFL:08,R,S,DGTAN/73TAN78A
0140$:PRMFL:43,W,S,DGTAN/73TAN78B
0150$:ENDJOB


*
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 LIST RETRIEVE

0010$:IDENT:DGTAN,FILE RETRIEVE
0020$:UTILITY
0030$:FUTIL:01,02,SKIP,3F/,COPY/1F/
0040$:FRMFL:02,W,S,DGTAN/NDATA76
0050$:TAPE9:01,T1D,,X0137,,TANNER2
0060$:ENDJOB


*LIST TESTPROG

0010$:IDENT:DGTAN,TESTPROG
0020$:SELECT:SX/SPSS/EXEC
0030$:LIMITS:50,50K
0040NUMBERED:YES
0050RUN NAME:DONALDSON'S TANNER CRAB MIGRATION STUDY
0060FILE NAME:NSAVE78
0070VARIABLE LIST:STATION,TAGNO,RELSTAT,RECSTAT,RELMO,RELDAY,RELYR,
0080::RECMO,RECDAY,RECYR,RELBAY,RECBAY,RELZONE,RECZONE,
0090::RELCA,RECCA,LATA,LATB,LONGA,LONGB,LATC,LATD,LONGC,LONGD,
0100::RELWIDTH,RECWIDTH,RELAGE,
0110::RECAGE,RELDEPTH,RECDEPTH
0120INPUT MEDIUM:TAPE
0130N OF CASES:UNKNOWN
0140INPUT FORMAT:FIXED(F3.0,3F5.0,8F2.0,4F1.0,2(F2.0,F3.1,F3.0,F3.1),
0150::2F3.0,2F2.0,2F3.0)
0160RECODE::STATION(BLANK=-999)/TAGNO,RELSTAT,RECSTAT(BLANK=-99999)/
0170::RELMO,RELDAY,RELYR,RECMO,RECDAY,RECYR(BLANK=-99)/
0180::RELBAY,RECBAY(BLANK=-99)/
0190::RELZONE,RECZONE,RELCA,RECCA(BLANK=-9)/
0200::LATA,LATB,LONGA,LONGB,LATC,LATD,LONGC,LONGD(BLANK=-99)/
0210::RELWIDTH,RECWIDTH(BLANK=-999)/RELAGE,RECAGE(BLANK=-99)/
0220::RELDEPTH,RECDEPTH(BLANK=-999)
0230MISSING VALUES:STATION(-999)/TAGNO,RELSTAT,RECSTAT(-999)/
0240::RELMO,RELDAY,RELYR,RECMO,RECDAY,RECYR,RELBAY,RECBAY(-999)/
0250::RELZONE,RECZONE,RELCA,RECCA(-999)/
0260::LATA,LATB,LONGA,LONGB,LATC,LATD,LONGC,LONGD(-999)/
0270::RELWIDTH,RECWIDTH(-999)/RELAGE,RECAGE(-999)/
0280::RELDEPTH,RECDEPTH(-999)
0290COMPUTE:STATTAG=(100000*STATION)+TAGNO
0300COMPUTE:RL=(RELMO-14)/12
0310COMPUTE:RC=(RECMO-14)/12
0320COMPUTE:RLDATE=RELDAY-2447095+1461*(RELYR+4800+RL)/4
0330::+367*(RELMO-2-12*RL)/12-3*((RELMO+4900+RL)/100)/4
0340COMPUTE:RCDATE=RECDAY-2447095+1461*(RECYR+4800+RC)/4
0350::+367*(RECMO-2-12*RC)/12-3*((RECMO+4900+RC)/100)/4
0360COMPUTE:YRCHANGE=RECYR-RELYR
0370IF::(YRCHANGE EQ 0)DAYSFREE=RCDATE-RLDATE
0380IF::(YRCHANGE EQ 1)DAYSFREE=((365-RLDATE)+RCDATE)-365
0390IF::(YRCHANGE EQ 2)DAYSFREE=((YRCHANGE-1)*365)+(365-RLDATE)
0400::+RCDATE - 730
0410IF::(YRCHANGE EQ 3)DAYSFREE=((YRCHANGE-1)*365)+(365-RLDATE)
0420::+RCDATE-1095
0430IF::(YRCHANGE EQ 4)DAYSFREE=((YRCHANGE-1)*365)+(365-RLDATE)
0440::+RCDATE-1460
0450IF::(YRCHANGE EQ 5)DAYSFREE=((YRCHANGE-1)*365)+(365-RLDATE)
0460::+RCDATE-1825
0470COMPUTE:DEPTHCH=RECDEPTH-RELDEPTH
```

```
      MPUTE:MONTHOUT=TRUNC(DAYSFREE/30)+1
0490COMPUTE:YEARSOUT=TRUNC(DAYSFREE/365)+1
0500COMPUTE:STATYR=1000*(STATION)+RELYR
0510COMPUTE:LATCHG=((60.0*LATC+LATD)-(60.0*LATA+LATB))*1.85
0520COMPUTE:LONGCHG=((60.0*LONGC+LONGD)-(60.0*LONGA+LONGB))*(1.85)
0530::*COS(((60.0*LATA+LATB+60.0*LATC+LATD)/2)*.0002989)
0540COMPUTE:DIST=SQRT(LATCHG*LATCHG+LONGCHG*LONGCHG)
0550IF::(LONGCHG LE 0 AND LATCHG GE 0)ANGLE =
0560::ATAN(ABS(LATCHG)/ABS(LONGCHG))*180/3.1415
0570IF::(LONGCHG GE 0 AND LATCHG GE 0)ANGLE=
0580::180-(ATAN(ABS(LATCHG)/ABS(LONGCHG))*180/3.1415)
0590IF::(LONGCHG GE 0 AND LATCHG LE 0)ANGLE=
0600::180 + (ATAN(ABS(LATCHG)/ABS(LONGCHG))*180/3.1415)
0610IF::(LONGCHG LE 0 AND LATCHG LE 0)ANGLE=
0620::360-(ATAN(ABS(LATCHG)/ABS(LONGCHG))*180/3.1415)
0621COMPUTE:NANGLE=450-ANGLE
0621IF::(NANGLE GE 360)NANGLE=NANGLE-360
0621IF::(DIST EQ 0)NANGLE=999
0622COMPUTE:SINANGLE=SIN(NANGLE* .01745)
0623COMPUTE:COSANGLE=COS(NANGLE* .01745)
0630IF::(RELWIDTH  LT 124 AND  RELWIDTH  GT 0) WIDTHCLS=1
0640IF::(RELWIDTH LT 140 AND RELWIDTH GT 123)WIDTHCLS=2
0650IF::(RELWIDTH LT 166 AND RELWIDTH GT 139)WIDTHCLS=3
0660IF::(RELWIDTH GT 165) WIDTHCLS=4
0670IF::(RELAGE LT 13 AND RELAGE GT 0)AGECLASS=1
0680IF::(RELAGE GT 12)AGECLASS=2
0690COMPUTE:WIDTHAGE=10*(WIDTHCLS)+AGECLASS
0700COMPUTE:YEAR=RELYR+1900
0710VAR LABELS:TAGNO, TAG NUMBER/RELSTAT, RELEASE STATION/
0720::RECSTAT, RECOVERY STATION/RELMO, RELEASE MONTH/
0730::RELDAY, RELEASE DAY/RELYR, RELEASE YEAR/RECMO, RECOVERY
0740::MONTH/RECDAY, RECOVERY DAY/RECYR, RECOVERY YEAR/
0750::RELBAY, RELEASE BAY/RECBAY, RECOVERY BAY/
0760::RELZONE, RELEASE ZONE/RECZONE, RECOVERY ZONE/
0770::RELCA, RELEASE CATCH AREA/RECCA, RECOVERY CATCH AREA/
0780::LATA, RELEASE LATITUDE/LONGA, RELEASE LONGITUDE/
0790::LATC, RECOVERY LATITUDE/
0800::LONGC, RECOVERY LONGITUDE/RELWIDTH, RELEASE WIDTH/
0810::RECWIDTH, RECOVERY WIDTH/RELAGE, RELEASE AGE/
0820::RECAGE, RECOVERY AGE/
0830::RELDEPTH, RELEASE DEPTH/RECDEPTH, RECOVERY DEPTH/LATCHG,
0840::LATITUDE CHANGE/LONGCHG, LONGITUDE CHANGE/DIST, DISTANCE/
0850::DEPTHCH, DEPTH CHANGE/DAYSFREE, DAYS OF FREEDOM
0860VALUE LABELS:RELBAY (1)MARMOT (2)KUPREANOF (3)CHINIAK
0870::(4)TONKI (5)ALITAK (6)SITKALIDAK (7)PERENOSA
0880::(8)KILIUDA (9)OCEAN STATIONS/WIDTHCLS (1)98-123MM
0890::(2)124-139MM (3)140-165MM (4)166MM & UP/AGECLASS
0900::(1)NEW (2)OLD AND VERY OLD
0905MISSING VALUES:ALL(0)
0910READ INPUT DATA
0920SORT CASES:STATYR(A) DAYSFREE(A) WIDTHAGE(A)
0930AGGREGATE:GROUPVARS=STATYR,MONTHOUT,WIDTHCLS,AGECLASS/
0940::VARIABLES=RELDEPTH,RECDEPTH,DIST,NANGLE/AGGSTATS=VALIDN,
0950::SUM,MEAN,SD,MAX,MIN
0960SAVE FILE:INITIALIZE
0970FINISH
0980$:PRMFL:08,R,S,DGTAN/NDATA78
0990$:PRMFL:FW,W,S,DGTAN/NSAVE78
1000$:ENDJOB
```

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LIST WRITECAS

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0030$:LIMITS:50,75K
0040NUMBERED:YES
0050RUN NAME:WRITE CASES PROCEDURE
0060GET FILE:NSAVE78
0070SORT CASES:STATYR(A) TAGNO(A)
0090WRITE CASES:(F4.0,F3.0,F5.0,F3.0,F2.0,F2.0,
0100::F3.1,F3.0,F3.1,F2.0,F2.0,F2.0,F2.0,F3.1,
0110::F3.0,F3.1,F2.0,F2.0,F2.0,F3.0,F3.0,F4.0,
0120::F4.0,F4.0,F3.0)
0130::YEAR,STATION,TAGNO,RELWIDTH,RELAGE,LATA,LATB,LONGA,
0140::LONGB,
0150::RELMO,RELDAY,RELYR,LATC,LATD,LONGC,LONGD,RECMO,RECDAY,
0160::RECYR,RELDEPTH,RECDEPTH,DEPTHCH,DAYSFREE,DIST,NANGLE
0170FINISH
0180$:PRMFL:FR,R,S,DGTAN,NSAVE78
0190$:FILE:43,D1S
0200$:FFILE:43,NOSLEW
0210$:OPTION:FORTRAN
0220$:FORTY
0230$:SELECTA:TORT
0240$:EXECUTE
0250$:FILE:01,D1
0260$:FFILE:01,NOSLEW
0270$:SYSOUT:06,ORG
0280$:ENDJOB


*
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LIST TORT

```
C      ---PURPOSE---TO CREATE A LISTING OF DONALDSON'S TANNER
C      CRAB TAG RECOVERY AND MIGRATION DATA.
C
C      ---WRITTEN BY---MARILYN KEMERER,ADFG, 1/23/78
C
C      ---DESCRIPTION--
C
       DIMENSION TEXT(500)
       INTEGER STATION,TAGNO,RELSTAT,RECSTAT,RELMO,RELDAY,RELYR,
      &RECMO,RECDAY,RECYR,RELBAY,RECBAY,RELZONE,RECZONE,
      &RELCA,RECCA,LATA,LATB,LONGA,LONGB,LATC,LATD,LONGC,LONGD,
      &RELWIDTH,RECWIDTH,RELAGE,RECAGE,RELDEPTH,RECDEPTH,YEAR,
      &DEPTHCH,DAYSFREE,DIST,ANGLE
C
C      ---WRITE HEADINGS
C
       WRITE(6,60)
   60 FORMAT(36X,'KODIAK TANNER CRAB TAG RECOVERY AND ',
      &'MIGRATION DATA'//)
       WRITE(6,61)
   61 FORMAT(5X,'REL    REL    TAG    REL    REL RELEASE   RELEASE',
      &'   RELEASE   RECAPT   RECAPT    RECAPT   REL   REC  DEPTH',
      &'   DAYS   DIST  ANGLE')
       WRITE(6,62)
   62 FORMAT(5X,'YEAR   STAT  NUMBER WIDTH  AGE   LAT',
      &'      LONG      DATE      LAT      LONG      DATE   DEPTH',
      &'  DEPTH  CHG   FREE   (KM)  MOVED')
       WRITE(6,63)
   63 FORMAT(5X,'____   ____  ______ _____  ___ _______',
      &'   _______   _______   _____   _______   _________',
      &' _____ _____ _____  ____   ____  _____')
C
C
C      ---ENTERING DATA PROCEDURE
C
       REWIND 01
   10 READ(1,20,END=40)YEAR,STATION,TAGNO,RELWIDTH,RELAGE,
      &LATA,LATB,LONGA,LONGB,RELMO,RELDAY,RELYR,LATC,LATD,LONGC,
      &LONGD,RECMO,RECDAY,RECYR,RELDEPTH,RECDEPTH,DEPTHCH,
      &DAYSFREE,DIST,ANGLE
   20 FORMAT(I4,I3,I5,I3,I2,I2,I3,I3,I3,I2,I2,I2,I2,I3,I3,I3,
      &I2,I2,I2,I3,I3,I4,I4,I4,I3)
C
C      ---PRINTOUT PROCEDURE
C
   70 WRITE(6,80)YEAR,STATION,TAGNO,
      &RELWIDTH,RELAGE,LATA,LATB,LONGA,LONGB,RELMO,RELDAY,RELYR,
      &LATC,LATD,LONGC,LONGD,RECMO,RECDAY,RECYR,RELDEPTH,RECDEPTH,
      &DEPTHCH,DAYSFREE,DIST,ANGLE
   80 FORMAT(5X,I4,3X,I3,3X,I5,3X,I3,3X,I2,3X,I2,1X,I3,
      &3X,I3,1X,I3,2X,I2,1X,I2,1X,I2,3X,I2,1X,I3,3X,I3,1X,I3,
      &2X,I2,1X,I2,1X,I2,2X,I3,3X,
      &I3,3X,I4,3X,I4,3X,I4,3X,I3)
       GO TO 10
   40 STOP
       END
```



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```
 LIST AGGR3

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0035$:LIMITS:50,75K,,10K
0040NUMBERED:YES
0050RUN NAME:DONALDSONS CRAB MIGRATION PROGRAM #3
0060GET FILE:NSAVE78
0070AGGREGATE:GROUPVARS=STATYR, MONTHOUT/VARIABLES=RELDEPTH,
0080::RECDEPTH, DIST, ANGLE/AGGSTATS=VALIDN,SUM,MEAN,SD,MAX,MIN
0090OPTIONS:3
0100STATISTICS:2
0110AGGREGATE:GROUPVARS=STATYR,YEARSOUT/VARIABLES=RELDEPTH,RECDEPTH,
0120::DIST, ANGLE/AGGSTATS=VALIDN,SUM,MEAN,SD,MAX,MIN
0130OPTIONS:3
0140STATISTICS:2
0150AGGREGATE:GROUPVARS=STATYR/VARIABLES=RELDEPTH,RECDEPTH,DIST,
0160::ANGLE/AGGSTATS=VALIDN,SUM,MEAN,SD,MAX,MIN
0170OPTIONS:3
0180STATISTICS:2
0190FINISH
0200$:PRMFL:FR,R,S,DGTAN/NSAVE78
0210$:ENDJOB


*LIST AGGR4

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0025$:LIMITS:50,75K,,25K
0030NUMBERED:YES
0040RUN NAME:DONALDSON'S CRAB MIGRATION PROGRAM AGGR #4
0050GET FILE:NSAVE76
0060AGGREGATE:GROUPVARS=STATYR,MONTHOUT,WIDTHCLS,AGECLASS/
0070::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0080::SUM,MEAN,SD,MAX,MIN
0090OPTIONS:3
0100STATISTICS:1,2
0110AGGREGATE:GROUPVARS=STATYR,YEARSOUT,WIDTHCLS,AGECLASS/
0120::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0130::SUM,MEAN,SD,MAX,MIN
0140OPTIONS:3
0150STATISTICS:1,2
0160AGGREGATE:GROUPVARS=STATYR,WIDTHCLS,AGECLASS/
0170::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0180::SUM,MEAN,SD,MAX,MIN
0190OPTIONS:3
0200STATISTICS:1,2
0210FINISH
0220$:PRMFL:FR,R,S,DGTAN/NSAVE76
0225$:FILE:43,NULL
0230$:ENDJOB


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```
 LIST SORT

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0030NUMBERED:YES
0040RUN NAME:TANNER CRAB MIGRATION MAPPING
0050GET FILE:NSAVE7B
0060SORT CASES:STATION(A) YEAR(A) TAGNO(A)
0070WRITE CASES:(F3.0,F4.0,F5.0,2(F2.0,F3.1,F3.0,F3.1),F4.0)
0080::STATION,YEAR,TAGNO,LATA,LATB,LONGA,LONGB,
0090::LATC,LATD,LONGC,LONGD
0100FINISH
0110$:LIMITS:05,43K,,,500
0120$:PRMFL:FR,R,S,DGTAN/NSAVE7B
0130$:PRMFL:43,W,S,DGTAN/SAVE78A
0140$:FFILE:43,NOSLEW
0150$:ENDJOB


*LIST FORT

0010$:IDENT:DGTAN,MIGRANT
0020$:OPTION:FORTRAN
0030$:FORTY
0040$:LIMITS:05,,,1000
0050$:SELECTA:INDELIPS
0060$:EXECUTE
0070$:LIMITS:05,75K,,10K
0080$:PRMFL:02,R,S,DGTAN/SAVE78A
0090$:SYSOUT:06,ORG
0100$:ENDJOB


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```
LIST AGGR5 :

0010$:IDENT:DGTAN,MIGRANT
0020$:SELECT:SX/SPSS/EXEC
0025$:LIMITS:50,75K,,10K
0030NUMBERED:YES
0040RUN NAME:DONALDSON'S CRAB MIGRATION PROGRAM AGGR #5
0050GET FILE:NSAVE78
0060AGGREGATE:GROUPVARS=RELCA,RELZONE,RELBAY,MONTHOUT/
0070::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0080::SUM,MEAN,SD,MAX,MIN
0090OPTIONS:3
0100STATISTICS:1,2
0110AGGREGATE:GROUPVARS=RELCA,RELZONE,RELBAY,YEARSOUT/
0120::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0130::SUM,MEAN,SD,MAX,MIN
0140OPTIONS:3
0150STATISTICS:1,2
0160AGGREGATE:GROUPVARS=RELCA,RELZONE,RELBAY/
0170::VARIABLES=RELDEPTH,RECDEPTH,DIST,ANGLE/AGGSTATS=VALIDN,
0180::SUM,MEAN,SD,MAX,MIN
0190OPTIONS:3
0200STATISTICS:1,2
0210FINISH
0220$:PRMFL:FR,R,S,DGTAN/NSAVE78
0230$:ENDJOB

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*LIST INDELIPS

0010C      SUBROUTINE ELLIPSE (XI,YI,RMAJ,RMIN,ANGLE,MEANX,MEANY)
0020C
0030C      XX,YY=ARRAYS OF X AND Y POINTS
0040C      ICNT=THE NUMBER OF POINTS
0050C      FVALUE=CONFIDENCE OF ELLIPSE E.G. 95 PERCENT REQUIRES A FVALUE OF "1.96
0060C      MEANX,MEANY=CENTER POINT OF THE DATA
0070C      ANGLE=ROTATION ANGLE OF THE TRANSFORMED AXIS(DEGREES)
0080C      MAJOR=LENGTH OF X AXIS
0090C      MINOR=LENGTH OF Y AXIS
0100C
0110       DIMENSION YEAR(1000), STATION(1000), TAGNO(1000),
0120      &LATA(1000),LATB(1000),LONGA(1000),LONGB(1000),LATC(1000),
0130      &LATD(1000),LONGC(1000),LONGD(1000),XX(1000),YY(1000)
0140       REAL XX,YY,MEANX,MEANY,MAJOR,MINOR,LATC,LATD,LONGC,LONGD,
0141      &LATA,LATB,LONGA,LONGB,RELLAT,RELLONG,
0142      &MRL,BC,XREM,MRLO,DE,YREM,
0150      &YEAR,STATION,ANGLE,AA,BB,XREMAIN,CC,DD,YREMAIN
0160       INTEGER ICNT,IB,ID,IC,IG
0170       I=1
171       N1=0
0180       RELLAT=0
0190       RELLONG=0
0200     5 READ(02,10)STATION(I),YEAR(I),TAGNO(I),
0210      &LATA(I),LATB(I),LONGA(I),LONGB(I),LATC(I),LATD(I),LONGC(I),
0220      &LONGD(I)
0230    10 FORMAT(F3.0,F4.0,F5.0,2(F2.0,F3.1,F3.0,F3.1)F4.0)
0240       E=STATION(I)
0250       GO TO 16
0260    15 READ(02,10,END=19)STATION(I),YEAR(I),TAGNO(I),
0270      &LATA(I),LATB(I),LONGA(I),LONGB(I),LATC(I),LATD(I),
0280      &LONGC(I),LONGD(I)
0290       IF(STATION(I) .NE. E) GO TO 20
0300    16 RELLAT=RELLAT +((LATA(I)*60)+LATB(I))
0310       RELLONG=RELLONG +((LONGA(I)*60)+LONGB(I))
0320       XX(I)=((LATC(I)*60.0)+LATD(I))/.55
0330       YY(I)=((LONGC(I)*60.0)+LONGD(I))
0340       I=I+1
0350       IF(I .GT. 1000) GO TO 20
0360       GO TO 15
361     19 N1=99
0370    20 I=I-1
0380       ICNT=I
0390       FVALUE=1.96
391       WRITE(6,30)
392    30 FORMAT(/////34X,'ELLIPSE')
393       WRITE(6,31)
394    31 FORMAT(//6X,'RELEASE  RELEASE  TAG      RECOVERY  RECOVERY',
395      &'      XX LAT  YY LONG')
396       WRITE(6,32)
397    32 FORMAT(6X,'STATION   YEAR    NUMBER  LATITUDE  LONGITUDE',
398      &'     CONVER  CONVER')
399       WRITE(6,38)
400    38 FORMAT(6X,'_______  _______  ______  ________  _________',
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```
     &     '_______  ________')
      DO 33 J=1,I
      WRITE(6,34)STATION(J),YEAR(J),TAGNO(J),LATC(J),LATD(J),
     &LONGC(J),LONGD(J),XX(J),YY(J)
   34 FORMAT(8X,F4.0,4X,F5.0,3X,F6.0,2X,F3.0,1X,F4.1,2X,F4.0,
     &1X,F4.1,3X,F7.1,2X,F7.1)
   33 CONTINUE
C
      MRL=((RELLAT/ICNT)*55)/60
      IC=IFIX(MRL)
      BC=FLOAT(IC)
      XREM=(MRL-BC)*60
      MRLO=(RELLONG/ICNT)/60
      IG=IFIX(MRLO)
      DE=FLOAT(IG)
      YREM=(MRLO-DE)*60
      COUNT=FLOAT(ICNT)
      IF(COUNT.LE.1.) CALL ERROR(1)
      IF(FVALUE.LE.0.) CALL ERROR(2)
      IF(COUNT.LE.1.) GO TO 42
      SUMX=0.
      SUMY=0.
      SUMXSQ=0.
      SUMYSQ=0.
      SUMXY=0.
      DO 1111 I=1,ICNT
      SUMX=SUMX+XX(I)
      SUMY=SUMY+YY(I)
      SUMXSQ=SUMXSQ+XX(I)**2
      SUMYSQ=SUMYSQ+YY(I)**2
 1111 SUMXY=SUMXY+XX(I)*YY(I)
      CALL MVSD(SUMX,COUNT,SUMXSQ,MEANX,VARX,SDX)
      CALL MVSD(SUMY,COUNT,SUMYSQ,MEANY,VARY,SDY)
      COVARXY= (SUMXY-((SUMX*SUMY)/COUNT))/(COUNT-1.)
      DOG=SQRT((VARX+VARY)**2-4.*(VARX*VARY-COVARXY**2))
      LAMDA1=(VARX+VARY+DOG)/2.
      THETA=1.5708
      IF(LAMDA1.EQ.VARY) GO TO 641
      SLOPE=COVARXY/(LAMDA1-VARY)
      THETA=ATAN(SLOPE)
  641 SUMXT=0.
      SUMYT=0.
      SUMXTSQ=0.
      SUMYTSQ=0.
      DO 111 I=1,ICNT
      XT=(XX(I)-MEANX)*COS(THETA)+(YY(I)-MEANY)*SIN(THETA)
      YT=(YY(I)-MEANY)*COS(THETA)-(XX(I)-MEANX)*SIN(THETA)
      SUMXT=SUMXT+XT
      SUMYT=SUMYT+YT
      SUMXTSQ=SUMXTSQ+XT**2
  111 SUMYTSQ=SUMYTSQ+YT**2
      CALL MVSD(SUMXT,COUNT,SUMXTSQ,MEANXT,VARXT,SDXT)
      CALL MVSD(SUMYT,COUNT,SUMYTSQ,MEANYT,VARYT,SDYT)
      IF(SDXT.LE.0..OR.SDYT.LE.0.) CALL ERROR(3)
      MAJOR=SDXT*FVALUE
      MINOR=SDYT*FVALUE
      ANGLE=THETA*180./3.1416
```

```
      AA=(MEANX*.55)/60
      IB=IFIX(AA)
      BB=FLOAT(IB)
      XREMAIN=(AA-BB)*60
      CC=MEANY/60
      ID=IFIX(CC)
      DD=FLOAT(ID)
      YREMAIN=(CC-DD)*60
      STARTX = MEANX + MAJOR * COS(THETA)
      STARTY = MEANY + Major * cos(theta)
      WRITE(6,41)
   41 FORMAT(///19X,'THE',
     &'                                    ANGLE')
      WRITE(6,35)
   35 FORMAT(5X,'NO.        CO-ORDINATES OF',
     &'       LENGTH   LENGTH   MAJOR')
      WRITE(6,36)
   36 FORMAT(5X,'OF       ELLIPSE CENTER POINT   MAJOR',
     &'     MINOR    FROM    ELLIPSE')
      WRITE(6,37)
   37 FORMAT(5X,'TAGS     LATITUDE LONGITUDE    AXIS',
     &'      AXIS     NORTH   FVALUE')
      WRITE(6,39)
   39 FORMAT(5X,'____     ____________________   ______',
     &'   ______   _____   _______')
      WRITE(6,40)ICNT,IB,XREMAIN,ID,YREMAIN,MAJOR,MINOR,ANGLE,
     &FVALUE
   40 FORMAT(5X,I4,4X,I2,1X,F4.1,3X,I3,1X,F4.1,5X,F5.1,4X,F5.1,
     &3X,F6.1,3X,F4.2)
   42 E=STATION(I+1)
      I=1
      RELLAT=0
      RELLONG=0
      BACKSPACE 2
      IF (N1.EQ.0) GO TO 15
      STOP
      END
      SUBROUTINE MVSD (SUM,SSIZE,SUMSQD,AMEAN,VAR,SD  )
      IF (SSIZE.EQ.0..OR.SSIZE.EQ.1.) GO TO 101
      AMEAN=SUM/SSIZE
      SUMSQS=SUMSQD-(SUM**2/SSIZE)
      VAR=SUMSQS/(SSIZE-1.)
      IF (VAR.LE.0.) GO TO 101
      SD=SQRT(VAR)
      GO TO 102
  101 CONTINUE
      AMEAN=SUM
      SUMSQS=SUMSQD
      VAR=0.
      SD=0.
  102 CONTINUE
      RETURN
      END
      SUBROUTINE ERROR (II)
      PRINT,'FATAL ERROR IN ELLIPSE'
      GO TO (10,20,30),II
   10 PRINT, 'COUNT IS LESS THAN OR EQUAL TO 0'
      RETURN
   20 PRINT,'FVALUE IS LESS THAN OR EQUAL TO 0'
      RETURN
   30 PRINT,'STD.DEV. OF THE DATA IS LESS THAN OR EQUAL TO ZERO'
      RETURN
      END
```

```
 L NSAVEXX
$fil  nsavexx     01/30/80                                                                                                                  $vls
lonsc        000000000001^00000^00000^00000lonsd        000000000001^00000^00000^00000relwidth    000000000001^00000^00000^00000recwid
widthage     000000000001^00000^00000^00000wear         000000000001^00000^00000^00000$sls  000001nsavexx     000001$vlb  000005tas
$vlb  00000drele  ase   lati  tude                                   $vlb  00000frele  ase   lons  itud  e
0a0000chin  iak                     0u0000tonk  i                    0v0000alit  ak                    0w0000sitk  alid  ak
$obs  chin  iak
0d00002mv^0025u0003wda003wda000x00001d00001u*0001600001400001u*00014^00014^0000u00000u00000m00000m00001p00001n800024s0000x00001p0000
0d00002mv^0027&0003wda003wda000x00001d00001u*0001600001500001u*00014^00014^0000u00000u00000m00000m00001p00001n800024s0000x00001p0000
0d00002mv^0026]0003wda003wda000x00001d00001u*0001600001 5^0001u*00014^00014^0000u00000u00000m00000m00001p00001n800024s0000x00001p0000
0d00002mv^002di0003wda003wd1000x00001d00001u*0001600001600001u*00014^00014^0000u00000u00000m00000m00001p00001n800024s0000x00001p0000
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0d00002mw0002d%0003wda003wdp000x00001d 0001u*00014^0001d^0001u*00014^00014^0000u00000w00000m00000m00001p00001m+00024s00017zoio1p0000
0d00002mw0002e@0003wda003wda000x00001d 0001u*0001600001700001u*00014^00014^0000u00000u00000m00000m00001p00001m+00024s00017zoio1p0000
0d00002mw0002e.0003wda003wda000x00001d 0001u*0000d00000v00001u+00014^00014^0000u00000u00000m00000m00001p00001m+00024s00017zoio1p0000
0d00002mw0002e<0003wda003wda000x00001d 0001u*0000d00001f+0001u+00014^00014^0000u00000u00000m00000m00001p00001m+00024s00017zoio1p0000
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0d00002mw0002d=0003wda003wdi000x00001d 0001u*0000a00000m00001uu00014^00014^0000u00000u00000m00000m00001p00001m+00024s00017zoio1p0000
*
```

```
LIST MULTMAP

DGSALMON/ELLIPSE
MAPPTS
(2F7.2)
1,2 5,5
-156.5,-151.5,55.5,59.5
$$$USER
(I3,2(F2.0,F3.1,F3.0,F3.1))
```

```
 LIST ONEELLI

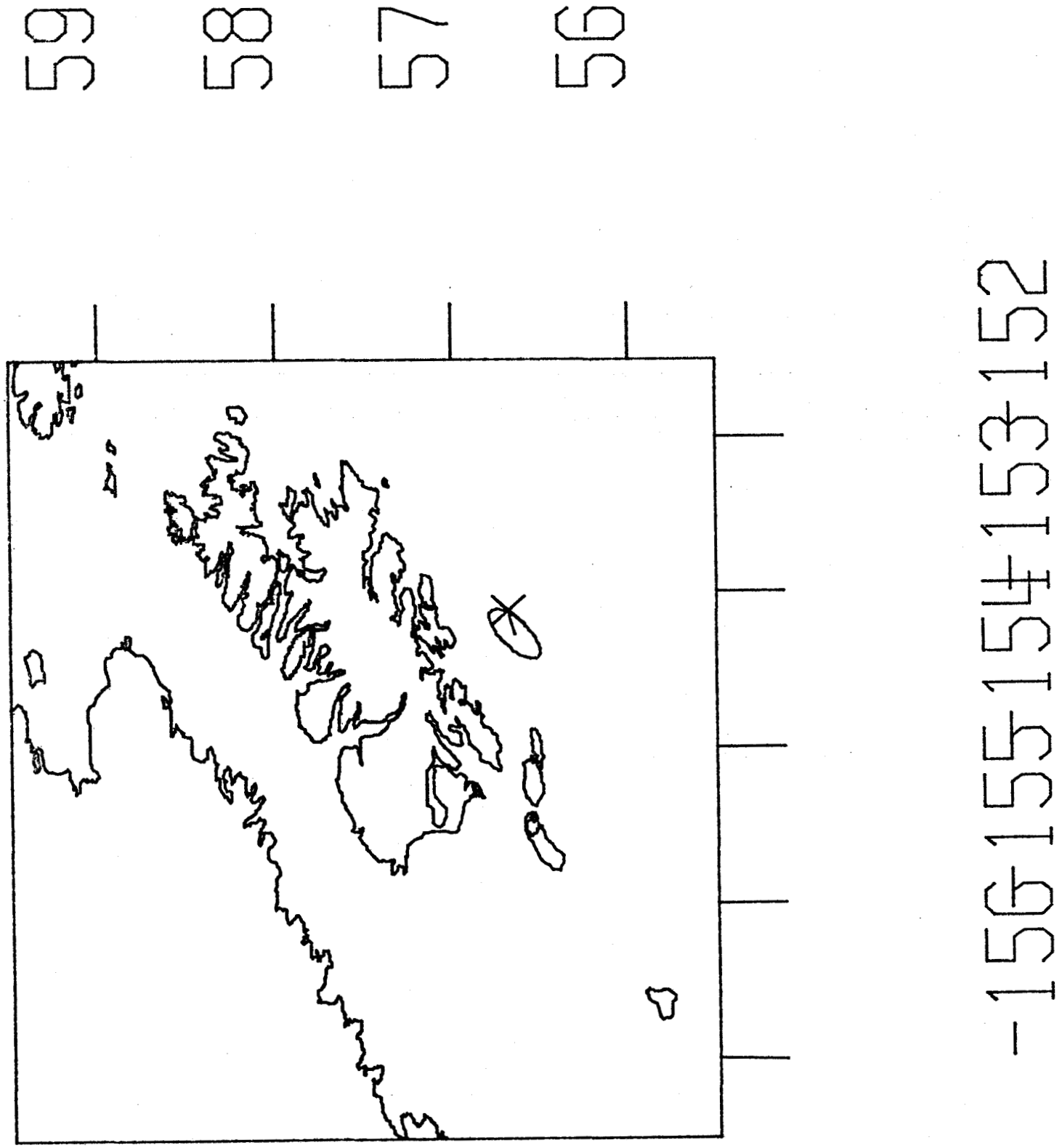
EDIT
OLD
$*$USER
RESAVE DUMMY
DONE
DGSALMON/ELLIPSE
MAPPTSAB
(2F7.2)
1,2 5,5
-156.5,-151.5,55.5,59.5
DUMMY
(I3,2(F2.0,F3.1,F3.0,F3.1))
$*$NULL


*LIST ONEMAP

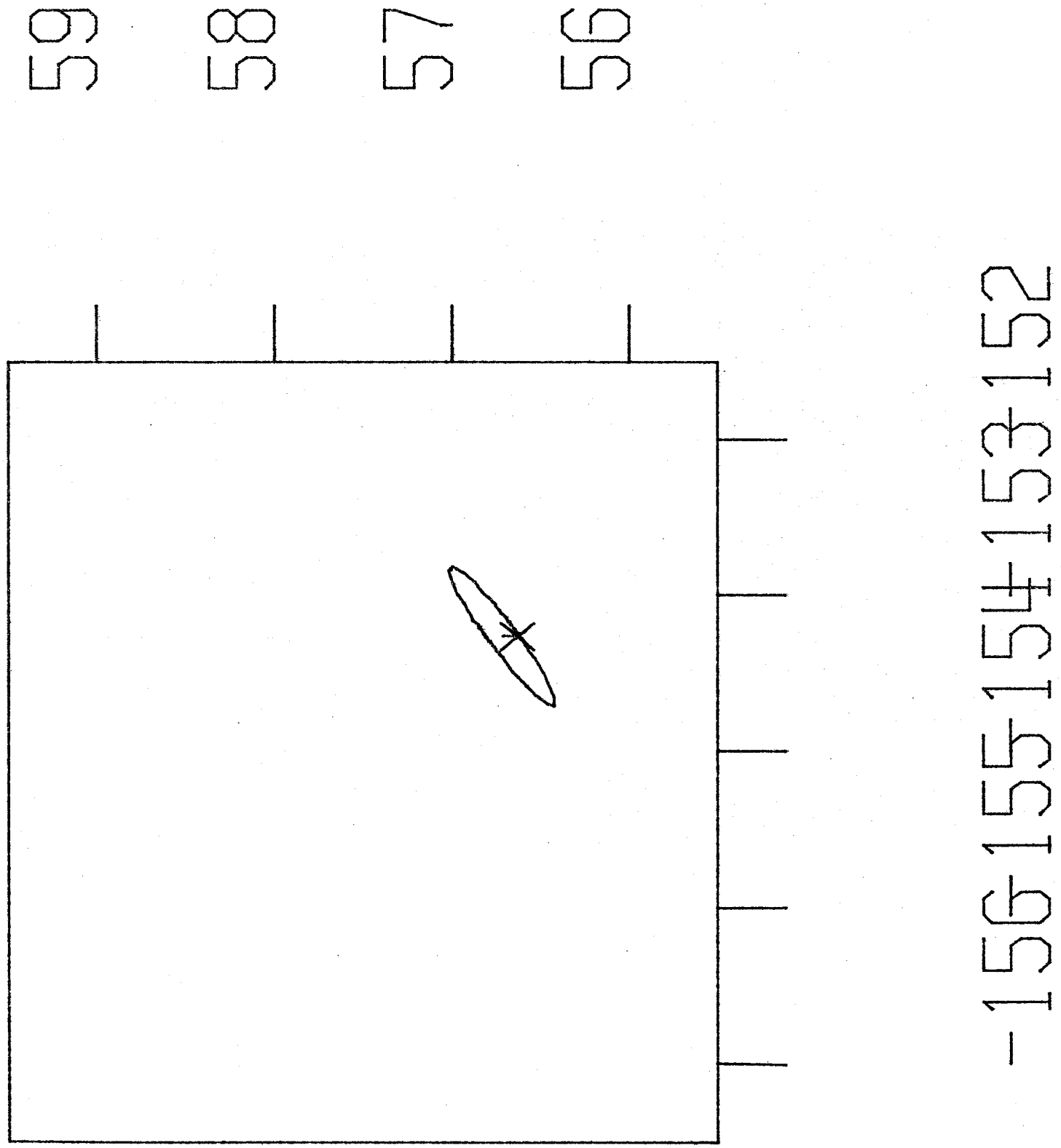
EDIT
OLD
$*$USER
RESAVE DUMMY
DONE
DGSALMON/ELLIPSE
MAPPTS
(2F7.2)
1,2 5,5
-156.5,-151.5,55.5,59.5
DUMMY
(I3,2(F2.0,F3.1,F3.0,F3.1))
$*$NULL


*
```

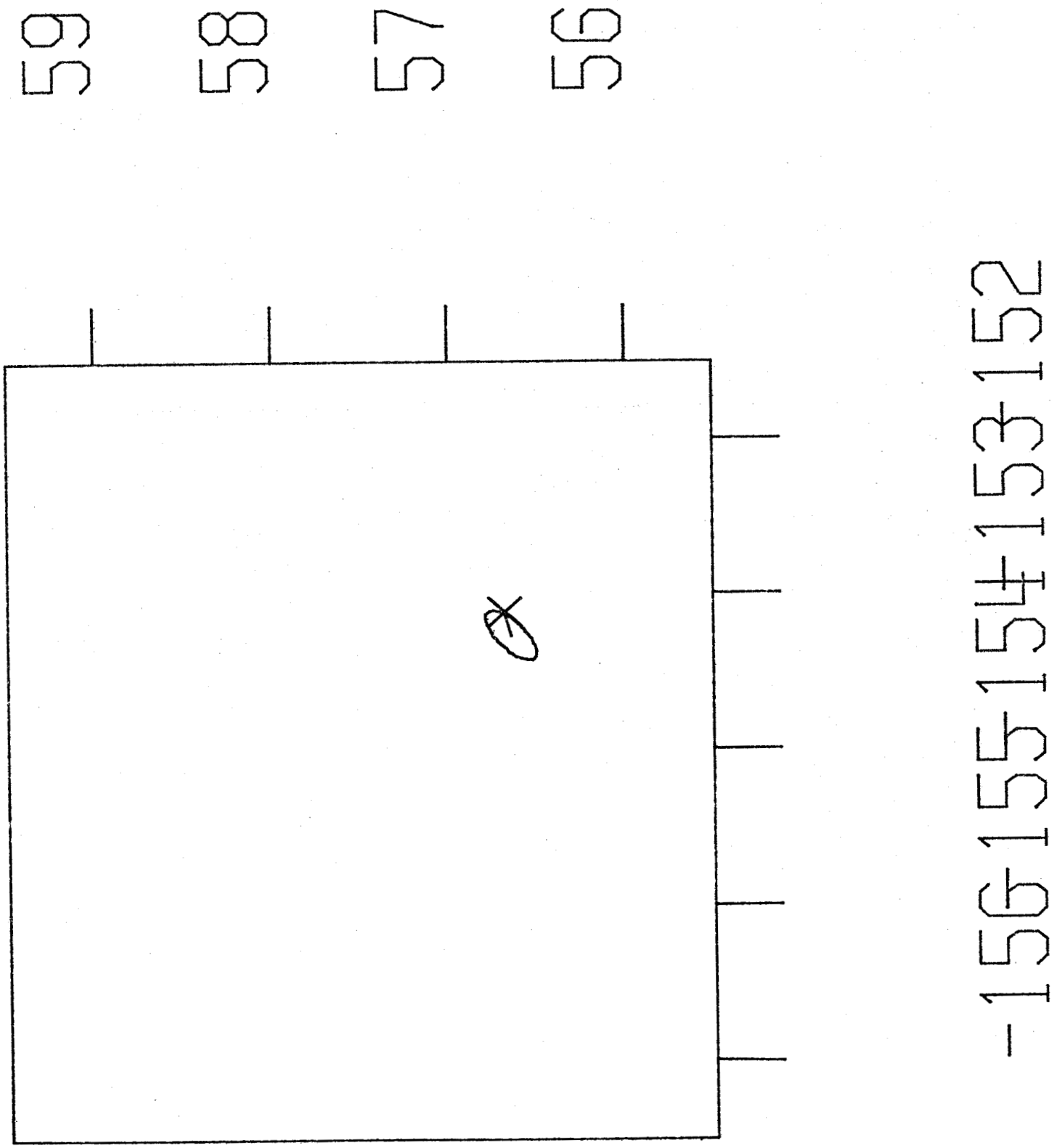
# B. ELLIPSE EXAMPLES



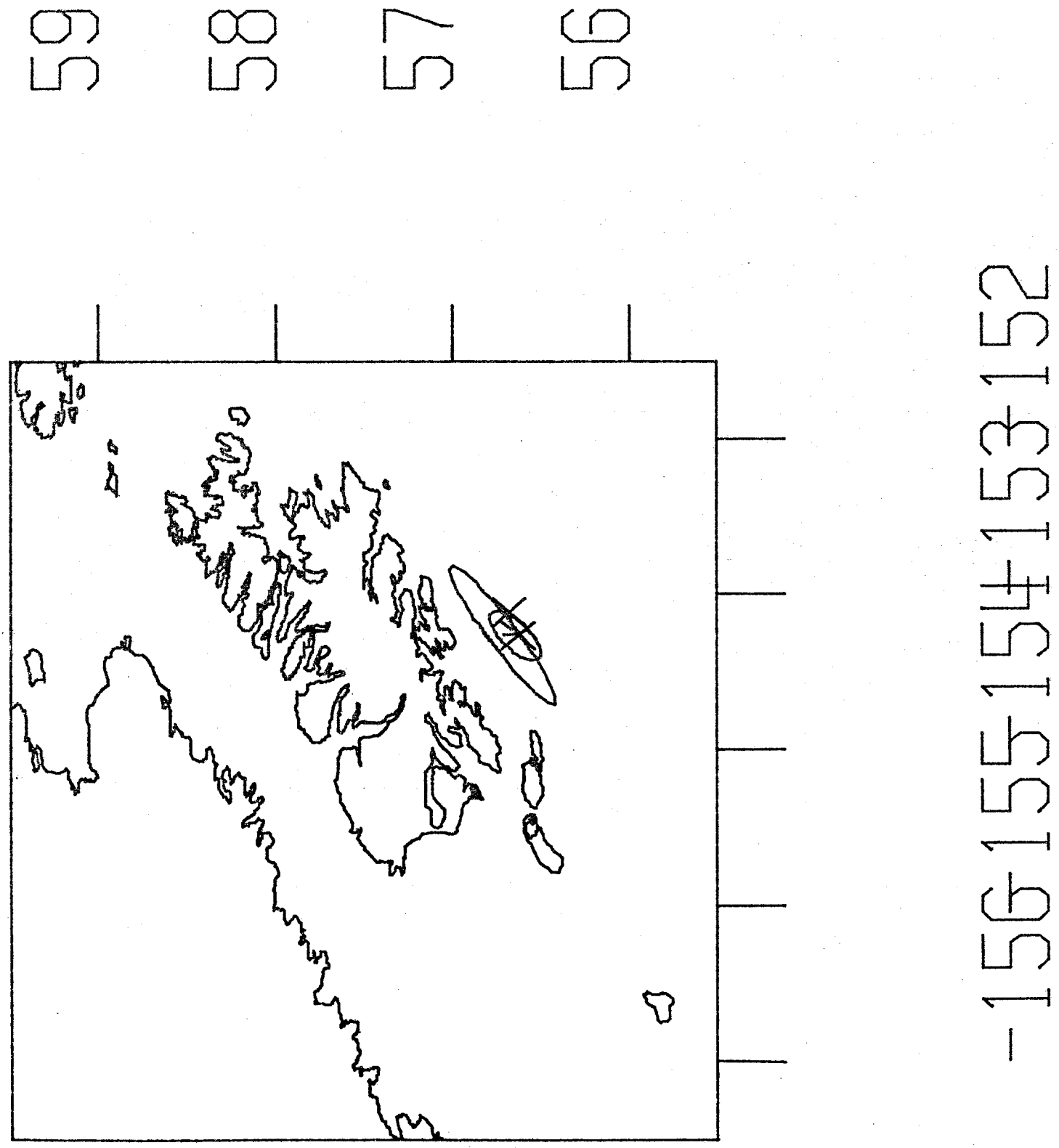

1. Example output from ONEMAP, Station 619 Kodiak.



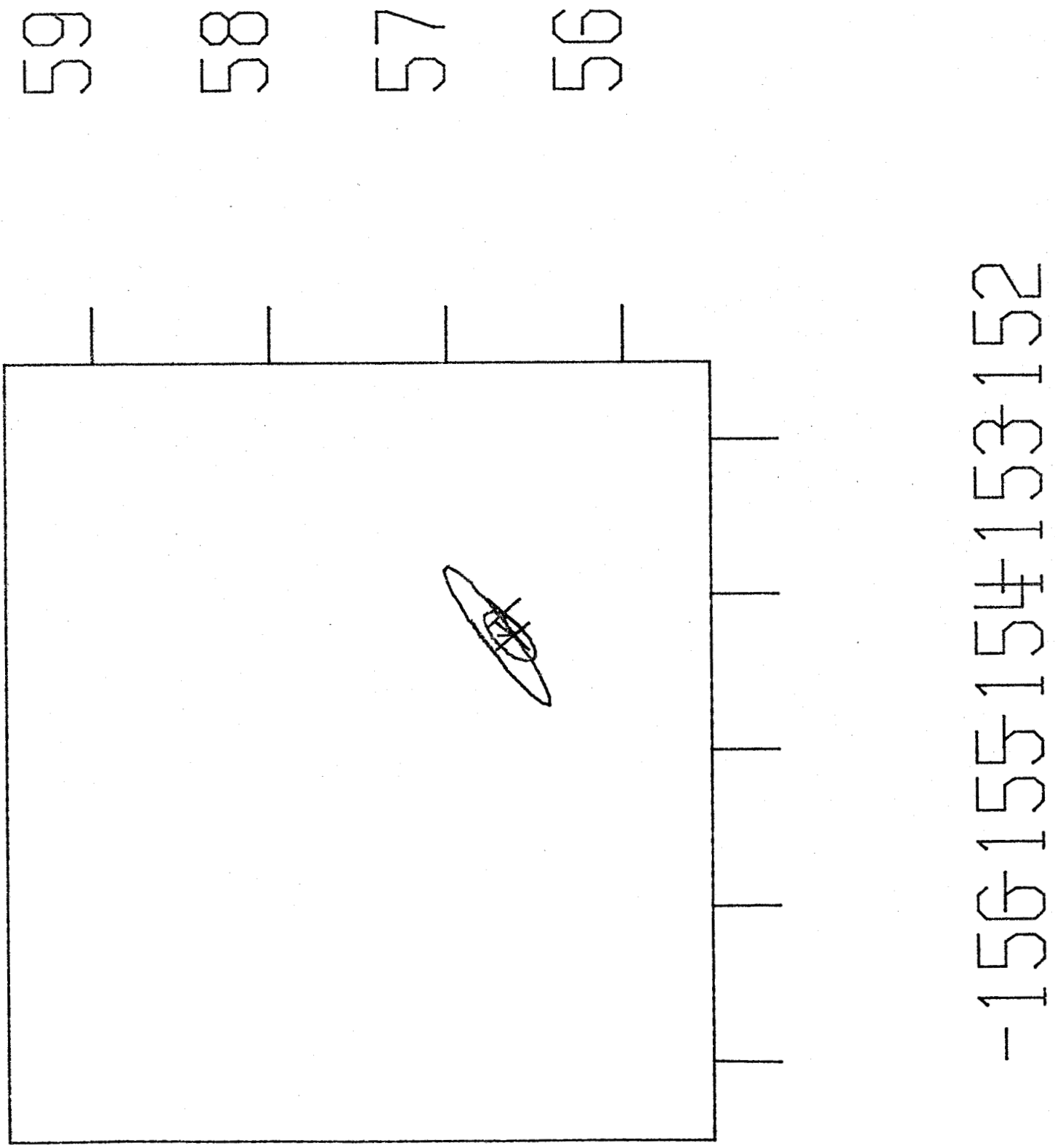

2a. Example Output from ONEELLI Station 620 Kodiak




2b. Example Output from ONEELLI, Station 619 Kodiak




3. Example Output from MULTMAP, Stations 619 and 620 Kodiak




4. Example Output from MULTELLI, Stations 619 and 620 Kodiak

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