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Herring tagging in western Gulf of Maine[1]

by

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ABSTRACT

In May of 1976 the Maine Department of Marine Resources conducted a
tagging project along the Maine coast. To date, 24,000 herring have been
tagged. There has been a 2.2% return rate for tagged herring recovered more
than three miles from where tagged or out for more than two weeks, and a 6.3%
return rate for all recoveries. Results from the first year of this
project can be summarized as follows: (1) tag returns indicate that
there are three coastal regions that have more or less indigenous
populations within them during summer and fall, with few fish tagged
in one region recovered in another (Casco Bay, east of Casco Bay to
Penobscot Bay, and east of Penobscot Bay); (2) returns within these
areas appeared to be random fairly soon after tagging (this could
indicate herring schools must be continuously reforming and breaking
up); (3) considerable numbers of herring tagged along th coast in
summer and fall were in Massachusetts Bay during winter (we had 56
returns from there); (4) laboratory experiments indicate two year old
herring can be tagged with low initial tagging mortality (less than 10%);
(5) in an experiment run at and by a cannery in Southwest Harbor, 80% of
30 tagged herring planted in the cannery were recovered; (6) there was
about a 9% (F = .09) seasonal fishing mortality in Casco Bay last year
if the estimates and assumptions used in calculations were correct.

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[1] This document was taken from the Annual Report of the Department of Marine Resources
of the State of Maine to the Maine Sardine Council which financed this tagging project.

INTRODUCTION

In May of 1976 the Department of Marine Resources of the State of Maine conducted a herring tagging project along the Maine coast to determine whether these fish remain along the coast all year or move seasonally to other areas.

MATERIALS AND METHODS

The herring were tagged with Floy FDM-68 tagging guns and FD-67 tags. The tags had a yellow #20 vinyl tubing section one inch long with legend "$1 ME DMR xxxxx", connected to a .75 inch monofilament section. Floy "thin" needles were used to tag all herring after July instead of the standard diameter needles.

All our handling procedures were organized to keep scale loss at a minimum and still tag adequate numbers of herring for the time invested. Fish were obtained as stop seine and weir fishermen pursed them out of their holding pockets by putting our holding pocket (12 foot long sides and six feet deep) next to the purse, sinking both sets of corks and pulling fish in with a large dip net (3 foot diameter hoop). After attaching two 16 foot poles to keep the pocket open, it was towed away from the seine pocket.

As soon as we were clear of the commercial fishing operations we began tagging (Fig. 1). About 30 herring were concentrated in a large dip net, which was then attached to the boat, and then both "taggers" leaned over the side of our 13 foot Boston whaler and grabbed and tagged fish as fast as possible. The only time a fish was out of the water was when it was being tagged, a period of about three seconds. Using this method, two people tagged as many as 3,000 fish in four hours.

Tags were applied near the forward edge of the dorsal fin so the tag went diagonally between the interneurals, with the exterior portion of the tag pointing backward for minimal water resistance. ICNAF Research Document 76/VI/101 by Wayne Stobo gives a more detailed explanation of tag application techniques and equipment.

RESULTS

As of 20 April 1977, 24,000 herring have been tagged. Approximately 15,000 were two years old, 7,500 were three years old, and 1;500 were older. All fish three years old and older were tagged east of Penobscot Bay (Fig. 2).

1. Long Term Recoveries:

Tag returns indicate that there are three coastal regions that have more or less indigenous populations within them during summer and fall, with few tagged fish in one region recovered in another: Casco Bay, east of Casco Bay to Penobscot Bay, and east of Penobscot Bay (Figures 3 to 6). Of herring tagged in Casco Bay and recovered more than 3 miles from where tagged or out more than two weeks, 44 out of 49 herring (90%) were recovered in Casco Bay; of those tagged east of Casco Bay to Penobscot Bay (excluding the Isle au Haut tagging since it was in a border region), 66 out of 69 (96%) were recovered in that region; and of those tagged east of Penobscot Bay, 199 out of 213 (93%) were recovered in that region.

That they remain in these relatively small areas in summer and fall is interesting, especially when one realizes that they can swim more than 15 miles a day (Casco Bay is less than 20 miles across).

In winter a considerable portion of fish from all three of these areas moved south of Gloucester. There were 55 returns from the Massachusetts Bay area and one from Point Judith (Table 1). Once we know what the age composition of these catches was we will be able to compare return rates for this area as compared to the Maine coastal fishery and will have more understanding of how important fish from Maine are to the Gloucester fishery.

2. Short Term Recoveries:

Recoveries a week or two after release were often at several locations in opposite directions. For instance, herring released at Bar Harbor on 4 and 5 August were: (1) recovered in Frenchman Bay until 31 August; (2) recovered at Isle au Haut on 16 August; (3) recovered at Eastport on 18 August; (4) and one was recovered at Jeffreys Ledge on 24 August. This seems to indicate that herring taken from one school do not necessarily remain in that school. Very likely schools are continuously fragmenting and reconstituting.

This process can be observed in miniature within a fisherman's "shut-off." When the fish are relaxed there are always small bunches breaking away from the main school and going in different directions.

What the fisherman "sees" when he watches a school of herring is the average movement. He doesn't see the movements of the small bunches, which may be considerably different from the average of all fish.

3. Estimates of Tagging Mortality:

If we know what percent of herring died within a couple of weeks as a result of being tagged, know the recovery rate of tagged herring which are caught, and know enough about herring movements, we can make good estimates of fishing mortality and population size.

We are currently trying to estimate herring mortality associated with tagging using aquarium experiments. In the only test completed so far, 93 of 107 tagged fish (87%) and 187 of 196 untagged fish (95%) lived for 33 days after handling (Appendix 1).

I tried to duplicate field conditions as closely as possible, but the herring were undoubtedly subject to fewer stresses related to their capture (such as being pursed). They were subject to aquarium stresses, however. My estimate is that about 80% of herring survive initial tagging stresses in our field operations.

4. Estimates of Tag Recovery Rate:

To estimate success of recovery at canneries we are introducing tagged fish in small amounts to selected canneries. At the Southwest Harbor plant the recovery rate was 24 out of 30 tags (80%). Tags were introduced 3 per day there.

5. A Preliminary Estimate of Population Size and Fishing Mortality of Herring in Casco Bay:

If tagged herring are as likely to be caught as untagged herring in an area, we can tell how many herring of a given age there were in that area. We need to know four things:

    a) the number of tagged fish available for recapture;

    b) the number of tagged fish recaptured;

    c) the number of fish caught of the given age;

    d) the distribution of fish caught of the given age.

Number of fish of a given age in an area =

    Number of tagged fish available for recapture x Number of fish caught that age
    Number of tagged fish recaptured

    a) Number of tagged herring available for recapture after 6 September

        Number of herring tagged in Casco Bay   2000 II's
        Estimated initial survival (see Appendix 1)   80%
        Estimated number of tagged fish available   1600

    b) Number of tagged herring recaptured after 6 September

        Number of tags recovered   42
        Estimated recovery rate in canneries   80%
        Estimated number of tagged herring recaptured   53

c) Number of two year olds caught:

Total catch in Casco Bay after 6 September was 1110.6 metric tons (MT). The National Marine Fisheries Service (NMFS) estimated there were, on the average, 18,100 herring/MT in western Maine last year (west of Port Clyde). Assuming the herring in Casco Bay in late summer and fall were the same size as fish in all of western Maine over the entire season the number of fish caught in Casco Bay after 6 September: 18,100 x 1110.6 ≃ 20,000,000 herring.

In western Maine two year olds made up 76% of the catch. Assuming this was true for Casco Bay there were 15,300,000 two year old herring caught in Casco Bay last year after 7 September.

d) The distribution of tagged and untagged herring:

I've assumed tagged herring were randomly distributed in Casco Bay as of 7 September; the tag returns don't indicate otherwise. For the same reason I've assumed that no herring entered Casco Bay during summer and fall.

If the proportion of tagged herring leaving Casco Bay is the same as the proportion of untagged fish this should have no effect on estimation of population size on 6 September.

The fishing mortality can be determined by the ratio of:

Number of tagged fish recaptured
Number of tagged fish available for recapture

The lowest value of fishing mortality possible is when there was no initial tagging mortality and all the tags of tagged fish are recovered. In this case:

fishing mortality of two years olds from 6 September to the end

of the season = $\dfrac{42}{2000}$ = 2.1%

The total catch in Casco Bay was 2877 MT and the catch after 6 September was 1111 MT, so the total catch in Casco Bay is equal to 2.6 times the catch after 6 September. If natural mortality remained about the same throughout the fishing season, and if there was little movement of herring into Casco Bay after 6 September:

fishing mortality of two year olds over the entire season = 2.1% x 2.6 = 5.5%

With the assumptions I think are most accurate (80% tagging survival and 80% plant recovery);

fishing mortality over the entire season = 8.5%.

With estimates of 40% tagging survival and 50% plant recovery;

fishing mortality over the entire season = 27%.

A 6

So, if our assumptions are correct, fishing mortality in Casco Bay was at least 5.5% (F = .05); unlikely to have been much more than 30% (F = .35); and was most probably 9% (F = .09).

LITERATURE CITED

Jensen, A.J.C. 1955. Danish herring tagging experiments inside the scan. Rapp. Cons. Explor. Mer, 140(2):30-32.

Watson, John E. 1963. A method for tagging immature herring. U.S. Fish and Wildlife Serv., Spec. Sci. Rep.-Fish. 451, 7p.

Winters, G.H. 1975. Estimates of tag extrusion and initial tagging mortality in an internal tagging experiment.

TABLE 1

A Summary of the Maine Department of Marine Resources'

Herring Tagging as of 20 April 1977

Tagging Date	Location	Avg. Length (Inches)	Age	Number	Returns Summer & Fall Within 3 miles or 2 weeks	Other	Winter Boothbay & Pemaquid	Winter South of Cape Ann	Total more than 3 mi. where tagged or out more than 2 weeks	Total
11 July	Matinicus	8.0	II	3000	0	44	3	0	47	47
12 July	Criehaven	7.9	II	1200	0	27	1	2	30	30
18 July	Isle au Haut	7.3	II	1800	382	9	3	1	13	395
4 Aug.	Bar Harbor	10.3 / 7.3	III / II	1100 / 1100	196	63	0	2	65	261
5 Aug.	Bar Harbor	9.9	III	1000	37	22	0	2	24	611
23 Aug.	Northeast Harbor	7.1	II	800	0	2	4	0	6	6
31 Aug.	Chebeague Island	8.2	II	2000	1	49	2	12	63	64
2 Sept.	Dyer's Island	6.8	II	1000	19	37	8	2	47	66
2 Sept.	Bois Bubert	10.2	III	2000	5	32	0	3	35	40
14 Sept.	Little Machias Bay		III,IV,V	2000	2	26	1	10	37	39
15 Sept.	Little Machias Bay	10.9	III,IV,V	3000	1	93	1	14	108	109
3 Oct.	Indiantown Island	8.4	II	1000	327	25	11	2	38	365
17 Nov.	Sawyer's Island	8.3	II	2000	0	0	22	6	28	28
8 Mar.	Sheepscot Bay	5.2	II	1000	-	-	1	0	1	1
	Total			24,000	970	429	57	56	542	1512
	% Return				4.0	1.8	.2	.2	2.2	6.3

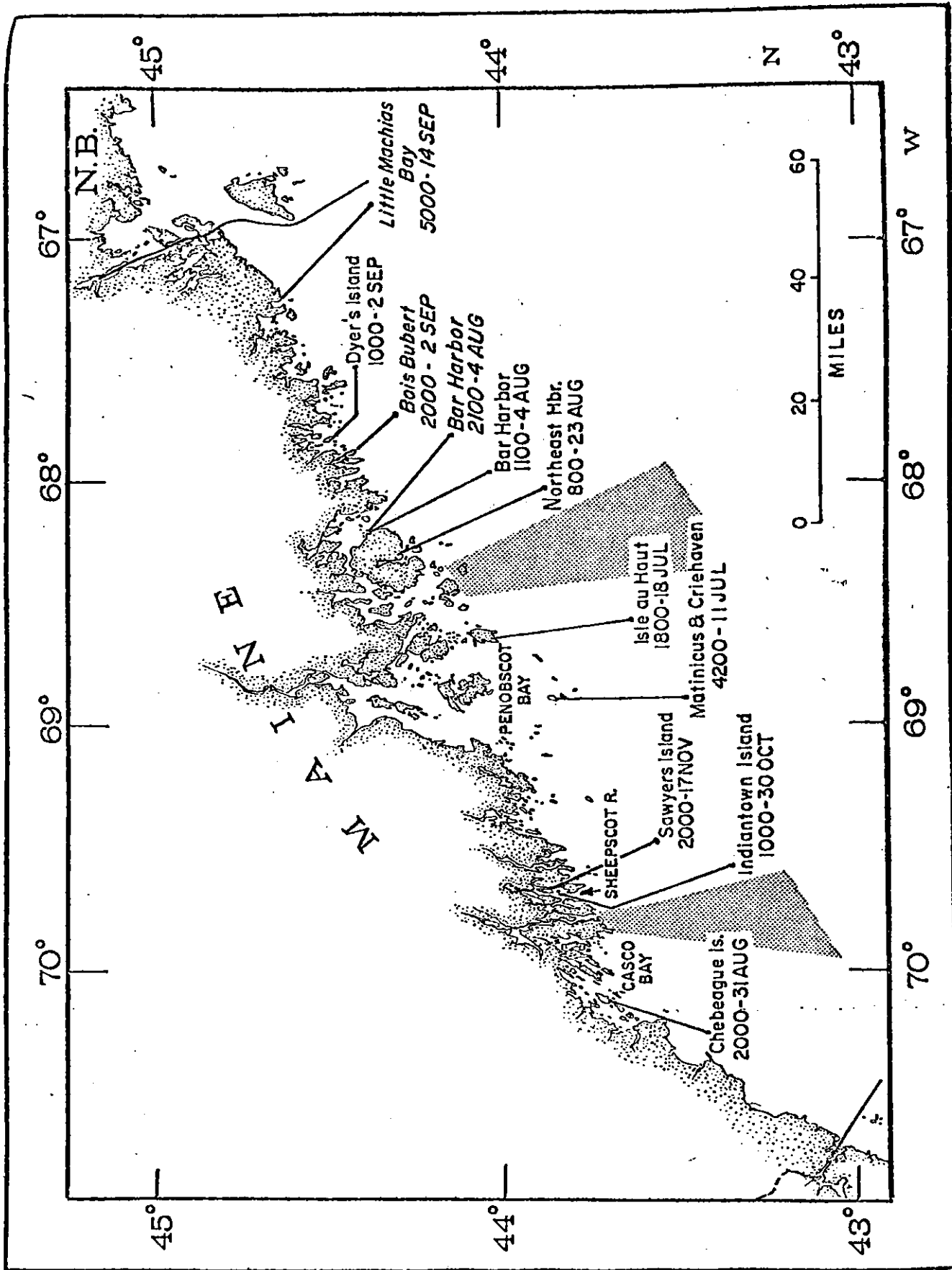Fig. 1

TOWING

TAGGING

A 9
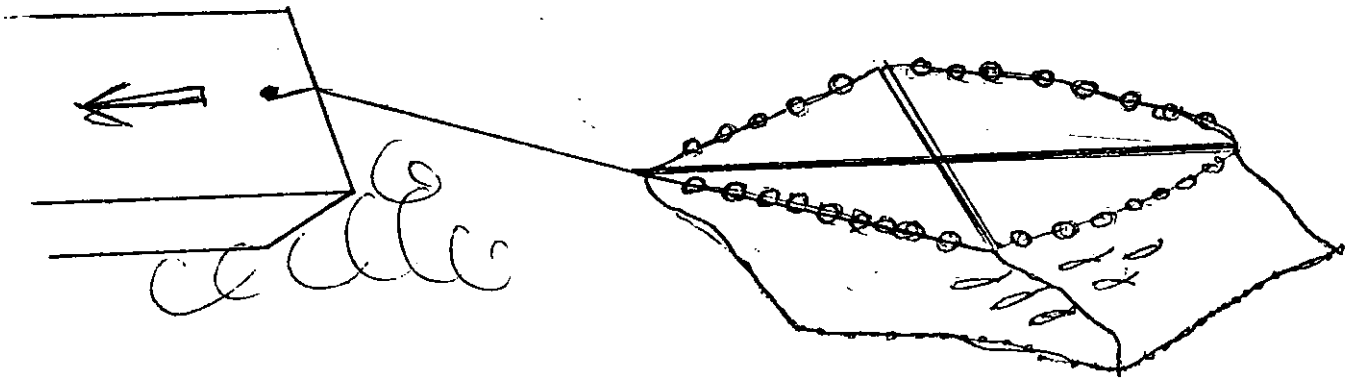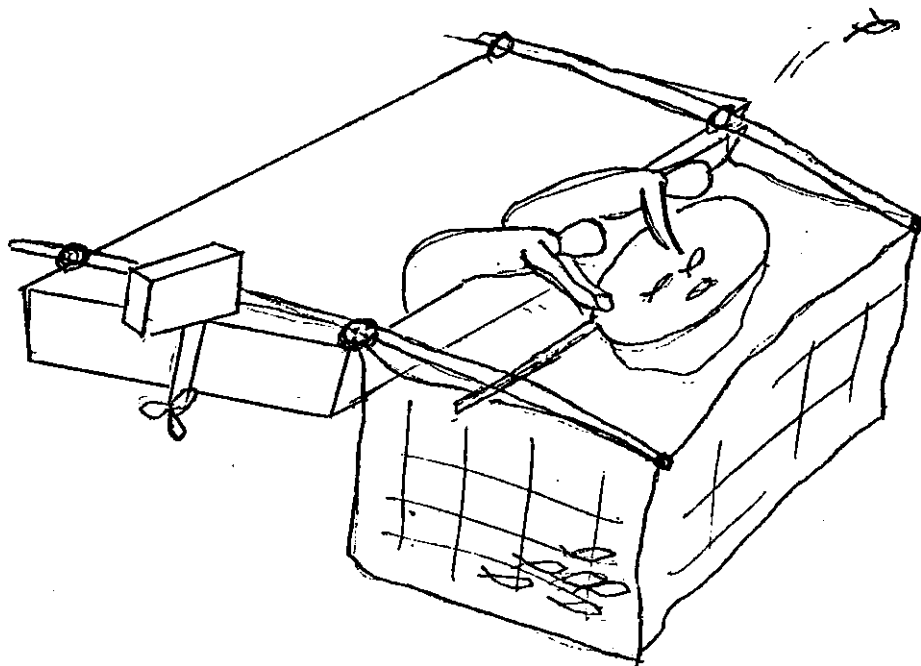
Fig. 2. Date, location, and number of herring tagged by the Department of Marine Resources in 1976. Most fish tagged at Bar Harbor, Bois Bubert, and Little Machias Bay (italicized in this figure) were three-year-olds. Almost all other fish were two-year-olds.

Fig. 3 through 16.   Location of tag returns as of 20 April 1977 for

herring that were recaptured more than 3 miles
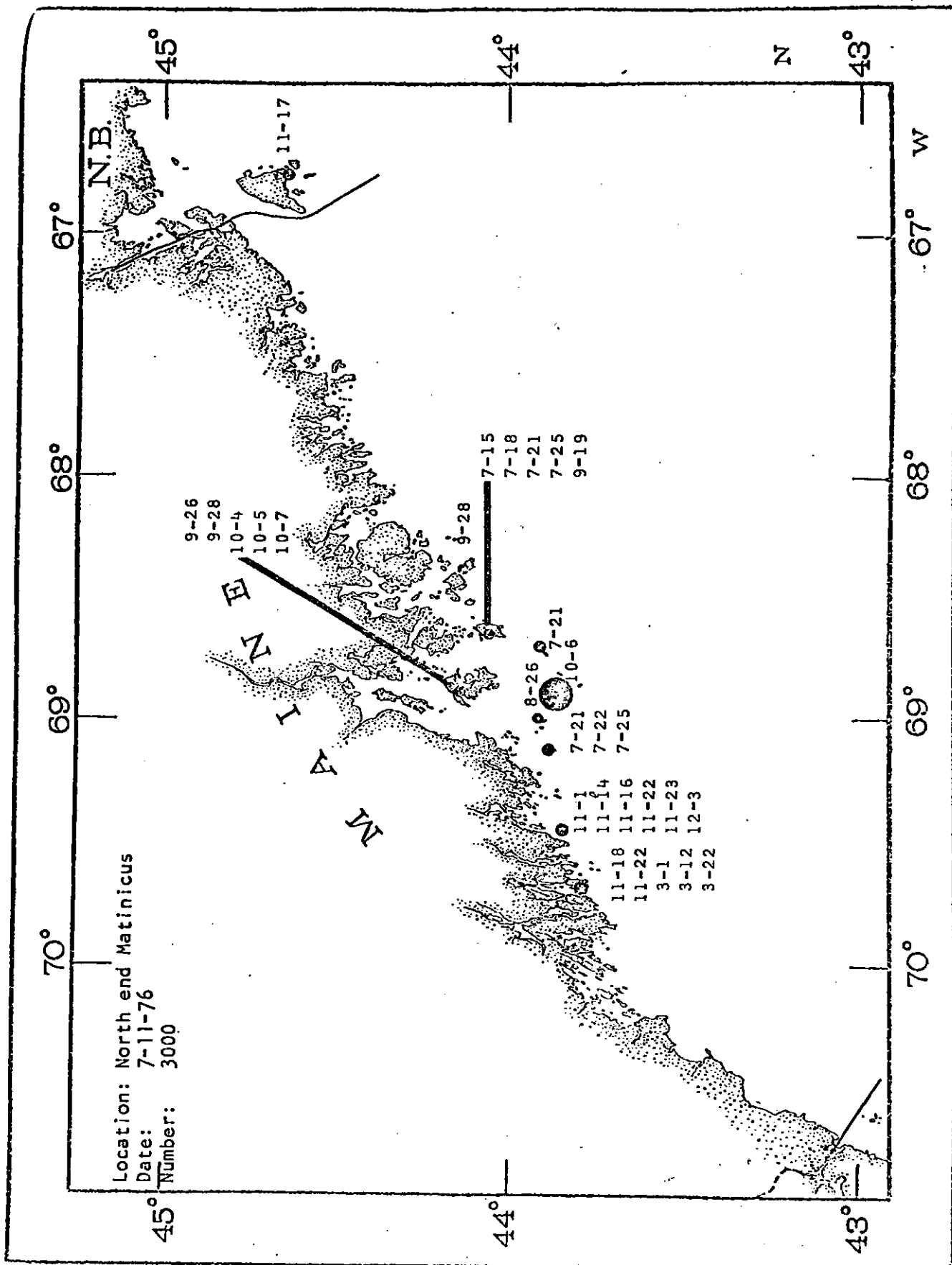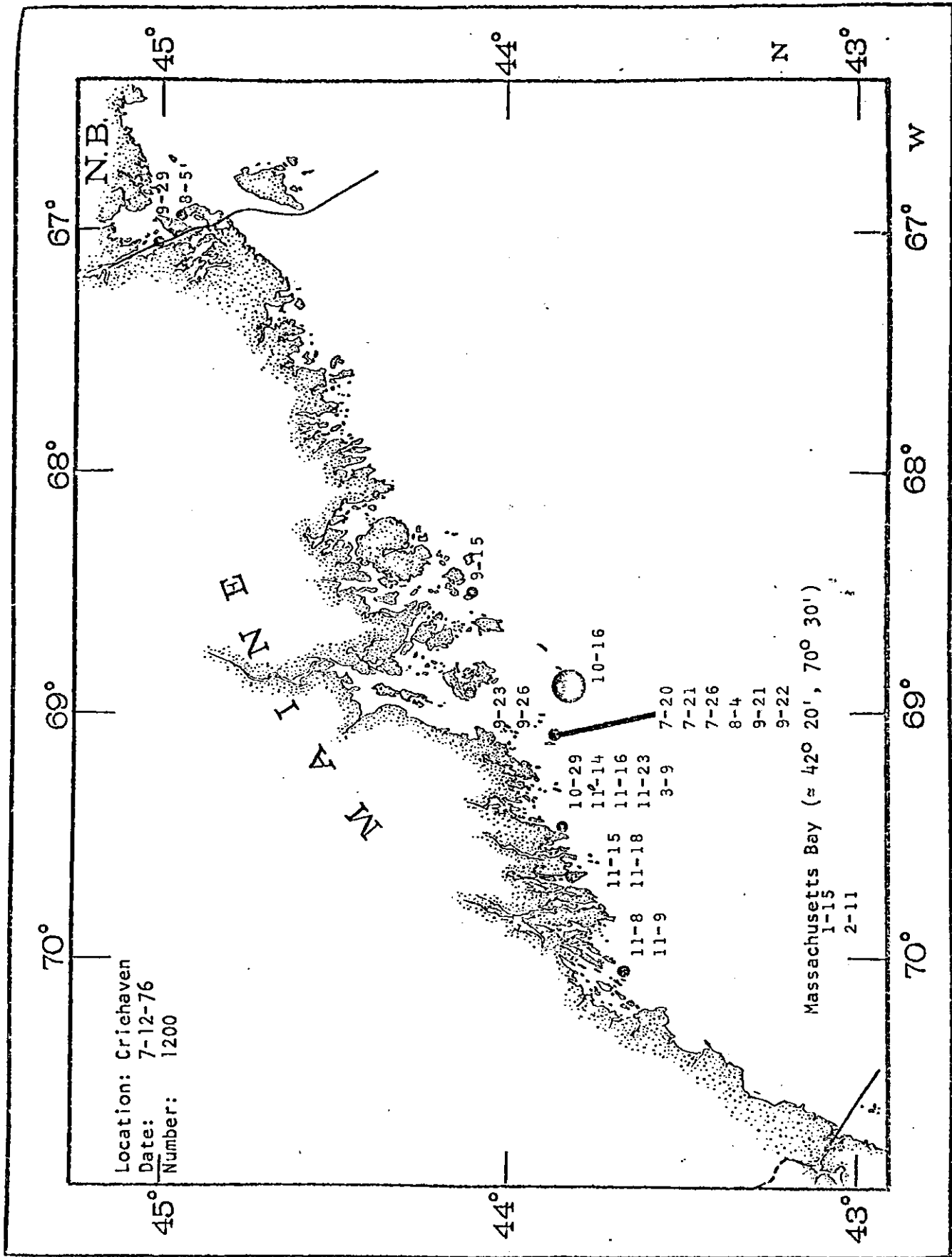
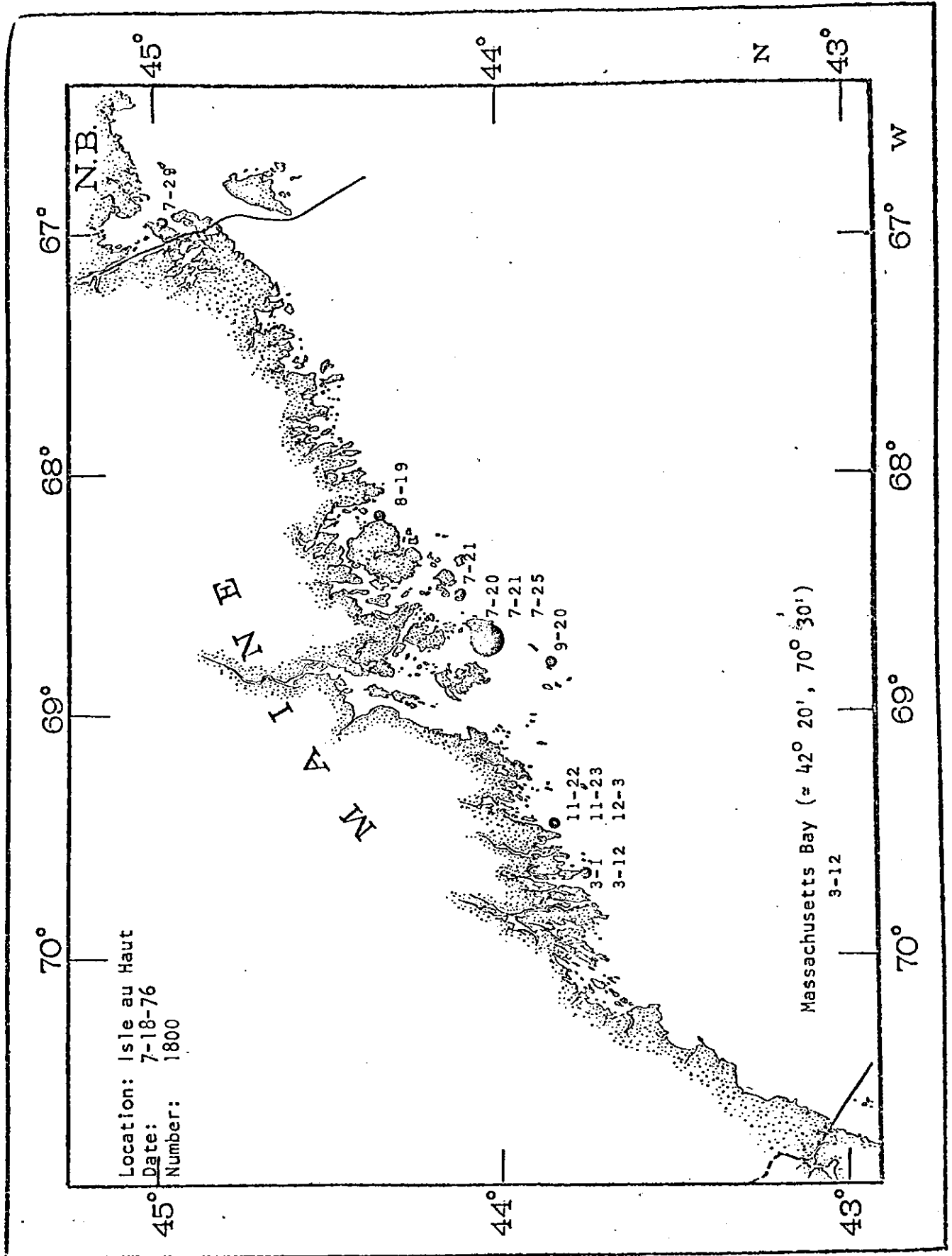from where tagged or were out more than two weeks.

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Location: S. of Bar Harbor Breakwater
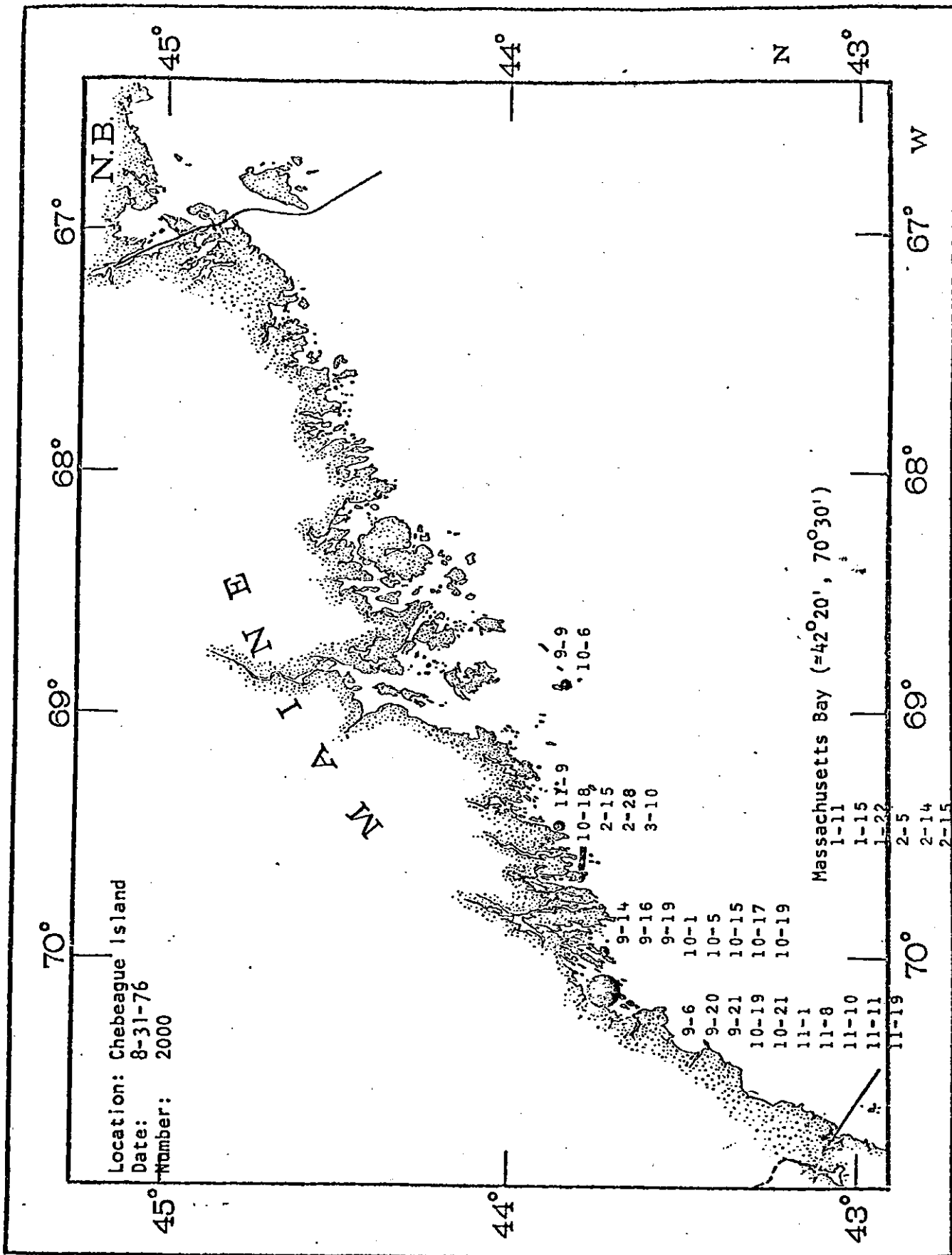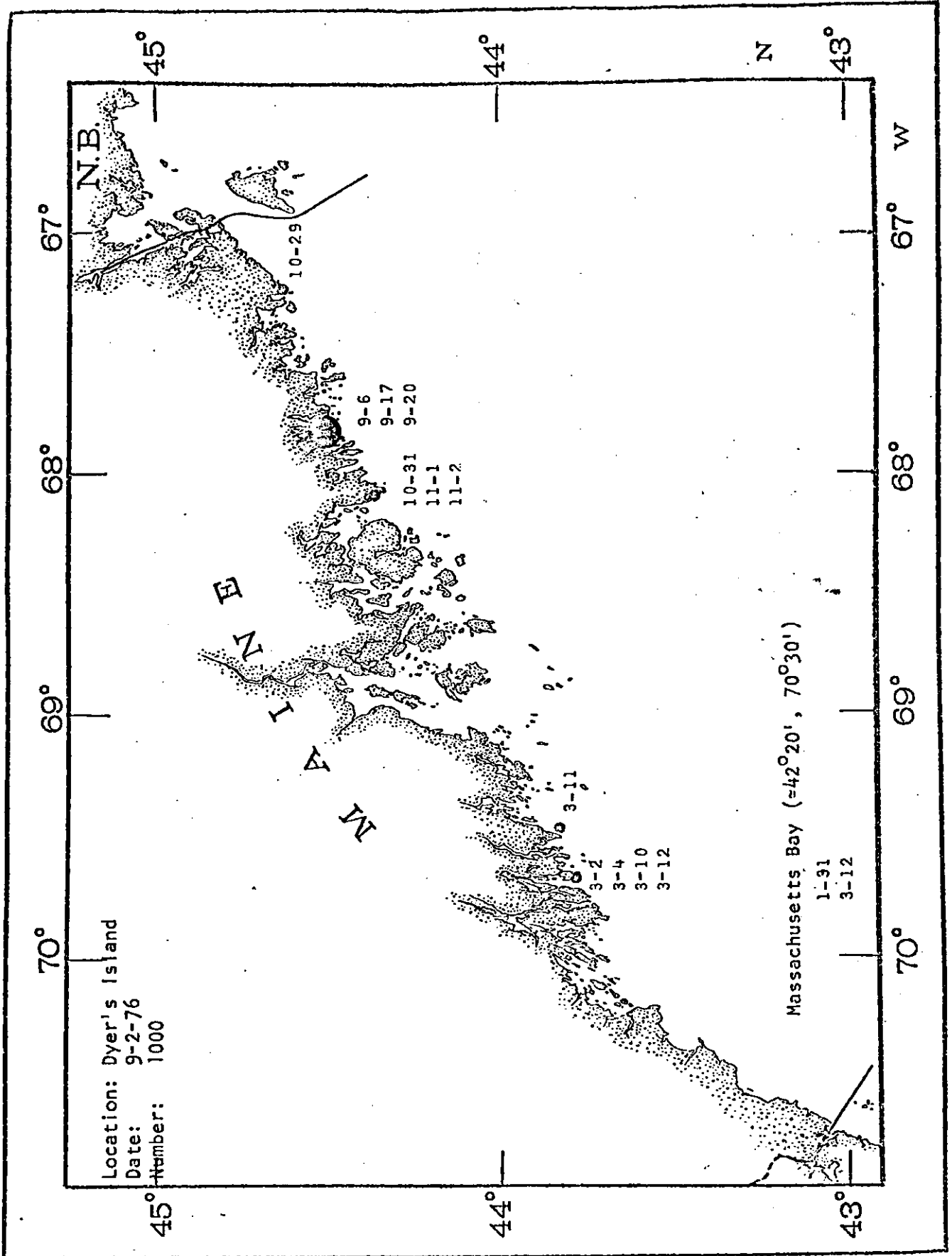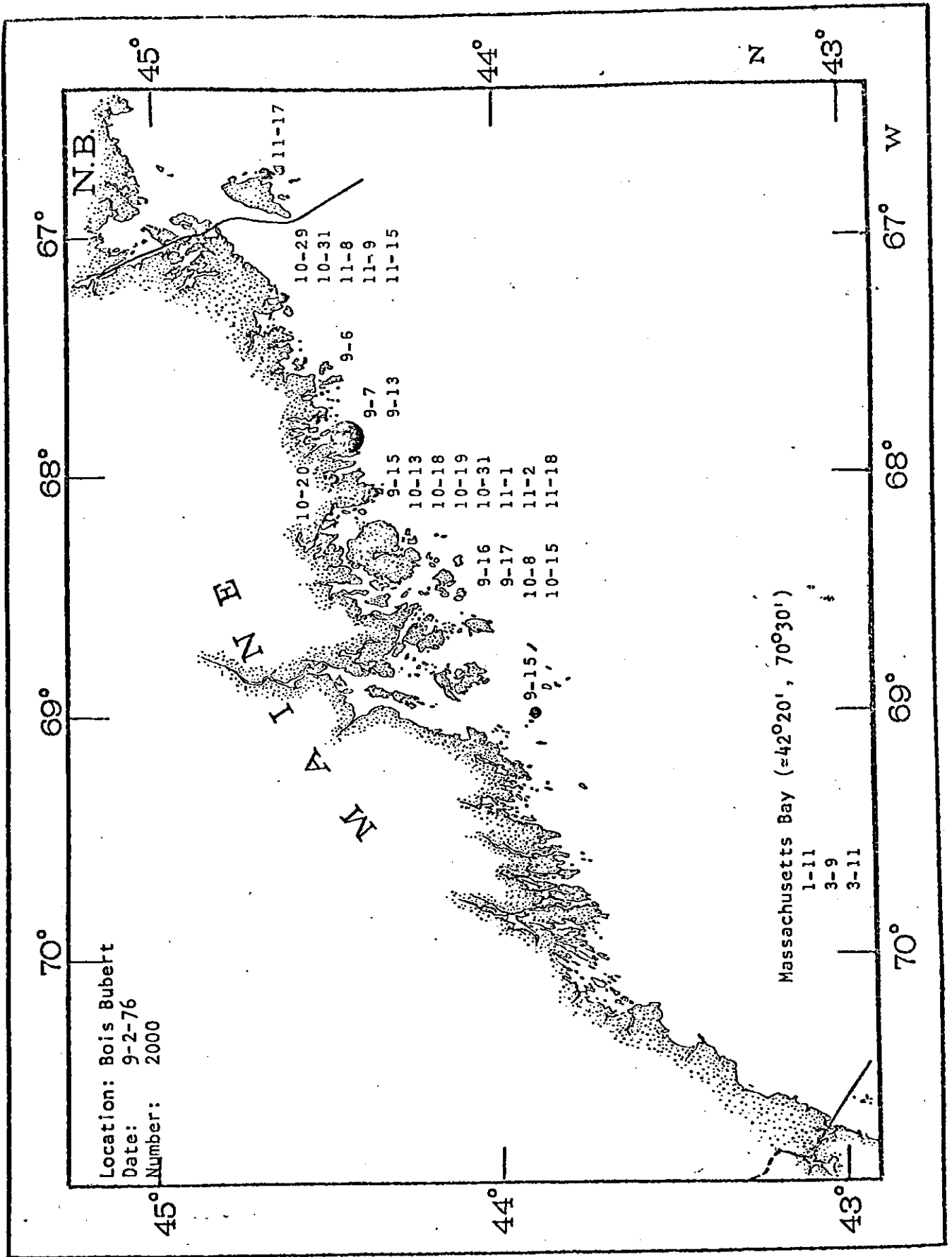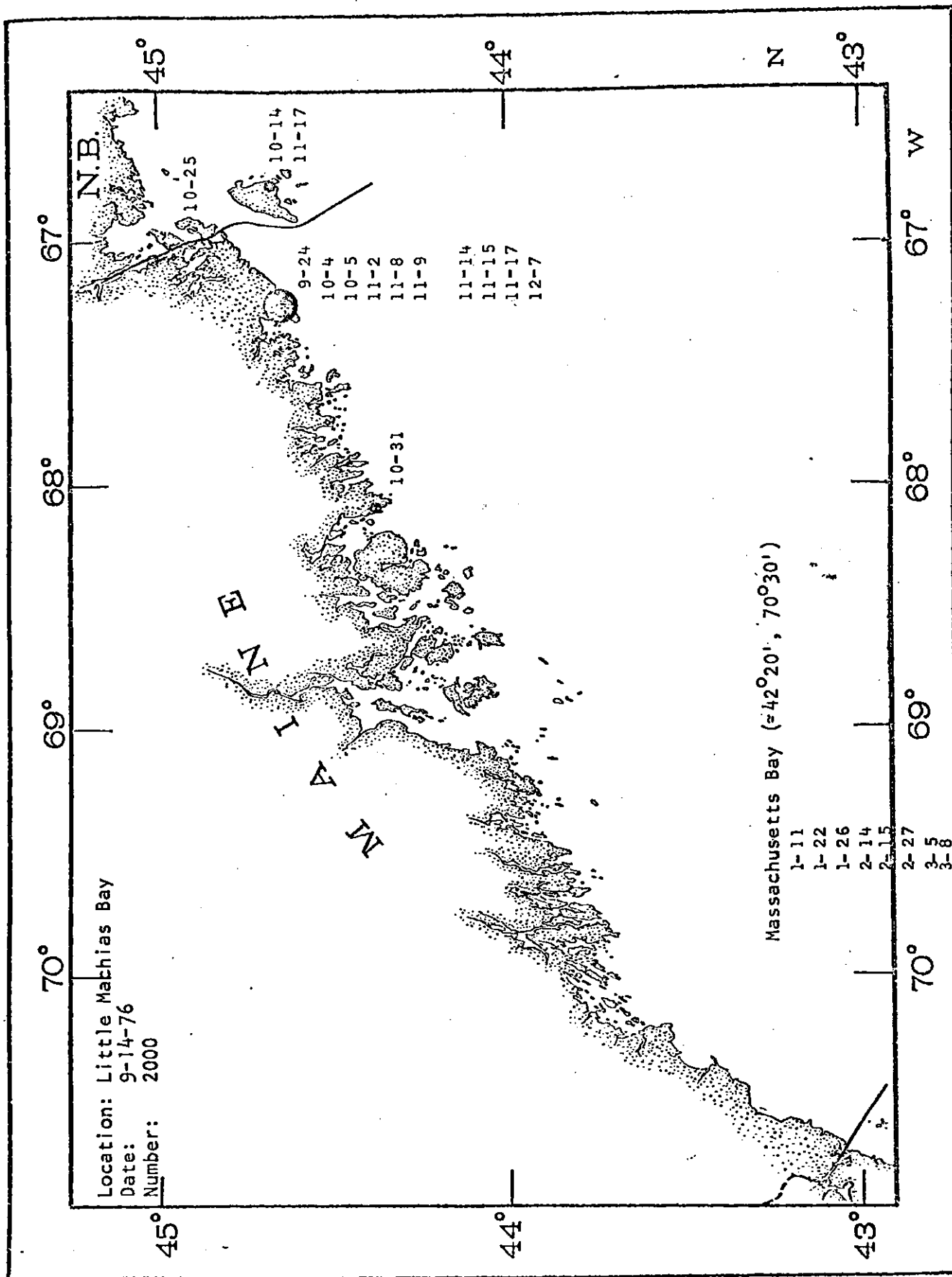Date: 8-5-76
Number: 959

Massachusetts Bay (≈42° 20', 71° 30')

B 2
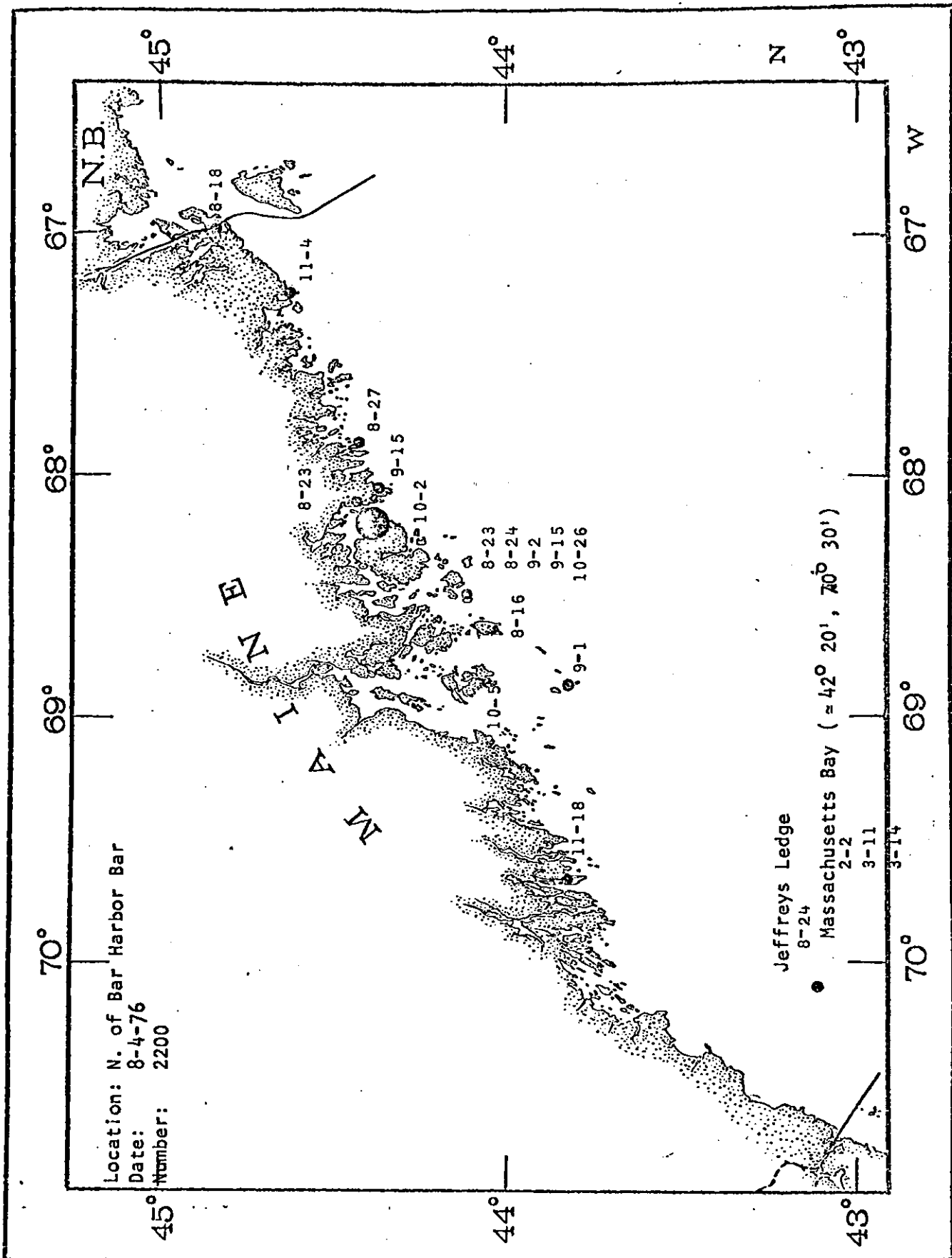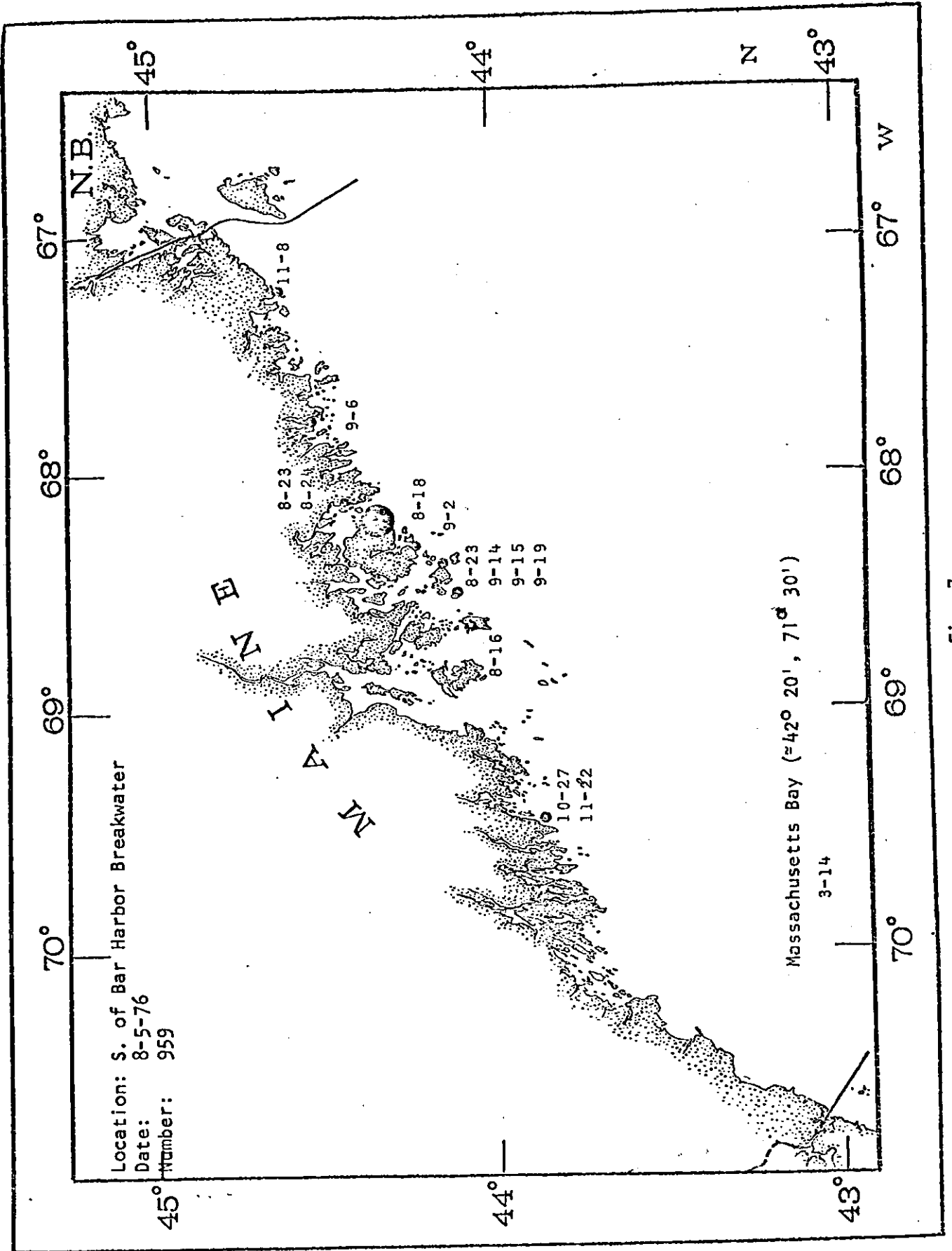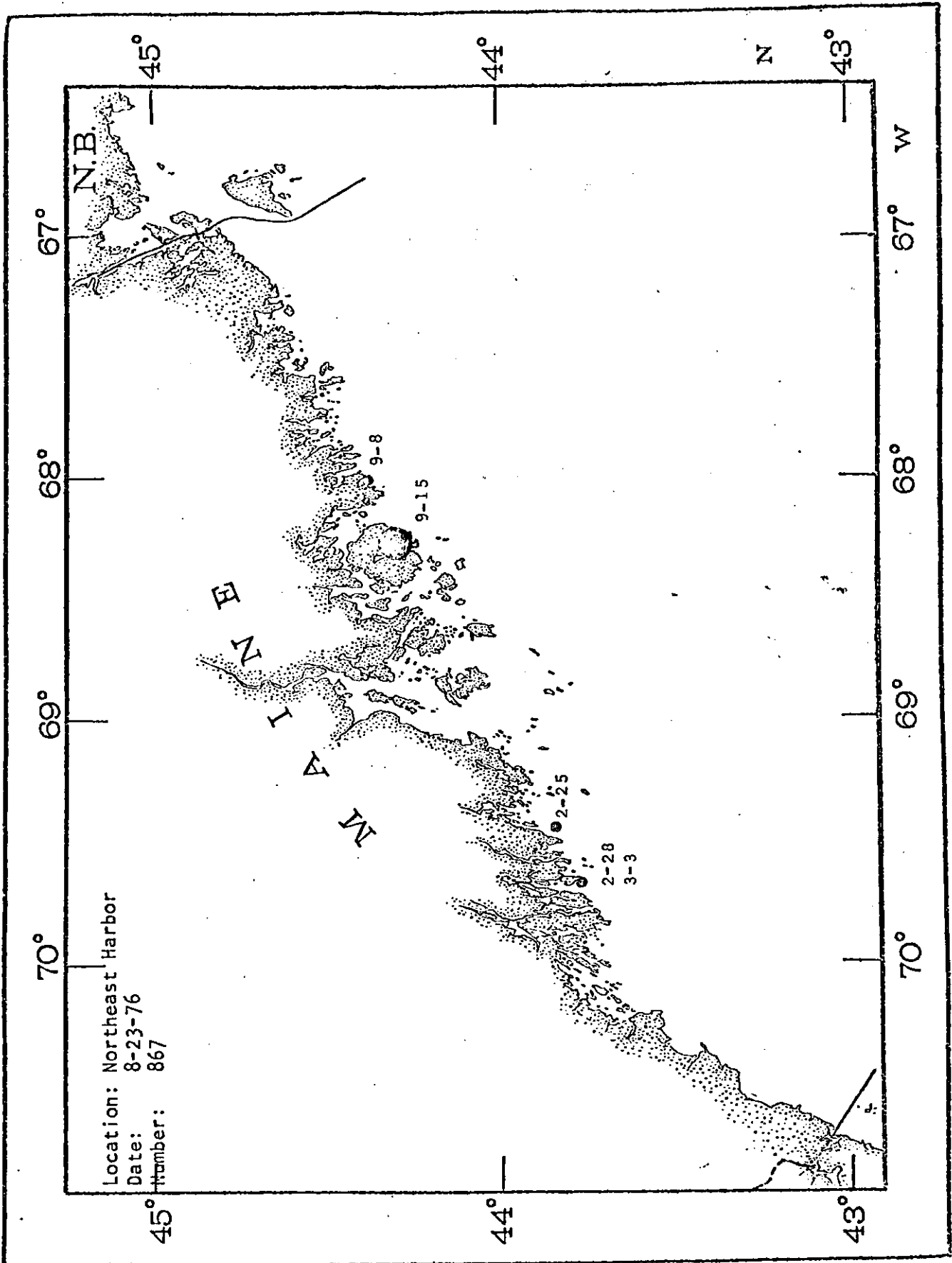
Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Location: Sawyer's Island
Date: 11-17-76
Number: 1900

Massachusetts Bay (≈42°20', 70°30')

N.B.

N

MAINE

2-2
2-15   2-16   2-25
2-27
2-28
3-1
3-2
3-3
3-9
3-10
3-12

2-10

3-11
3-12

Location: Sheepscot Bay
Date: 3-8-77
Number: 1000

N.B.

MAINE

3-31
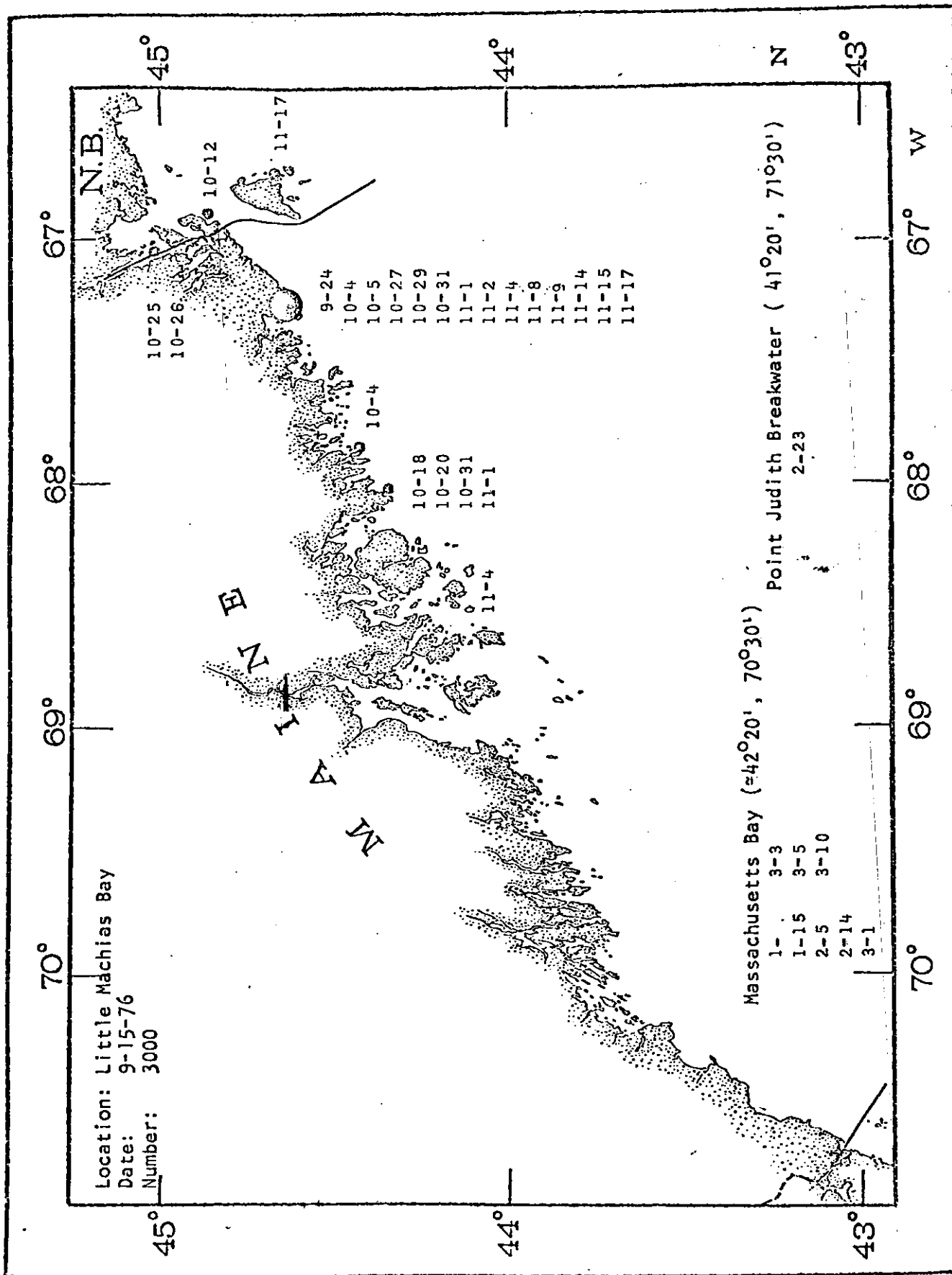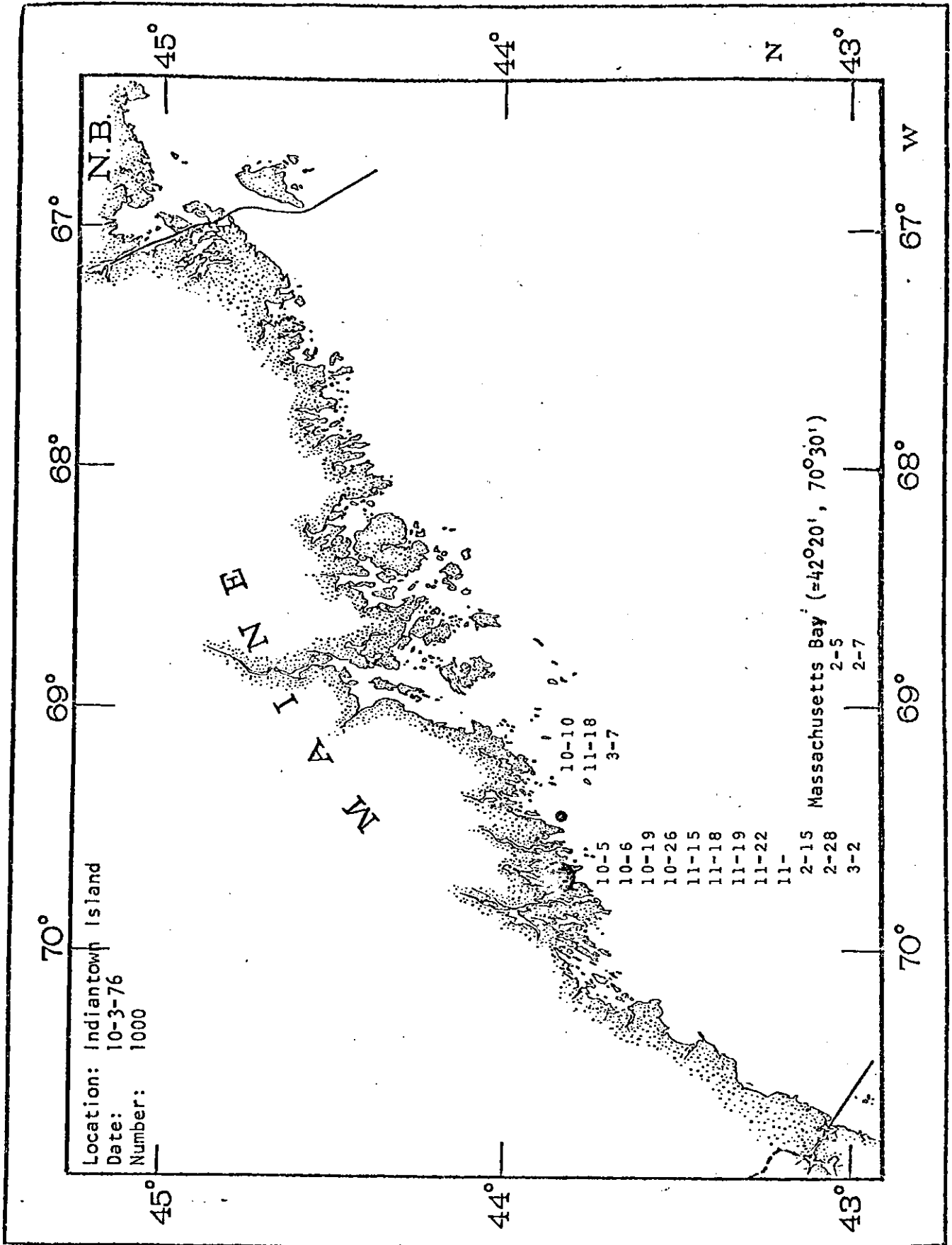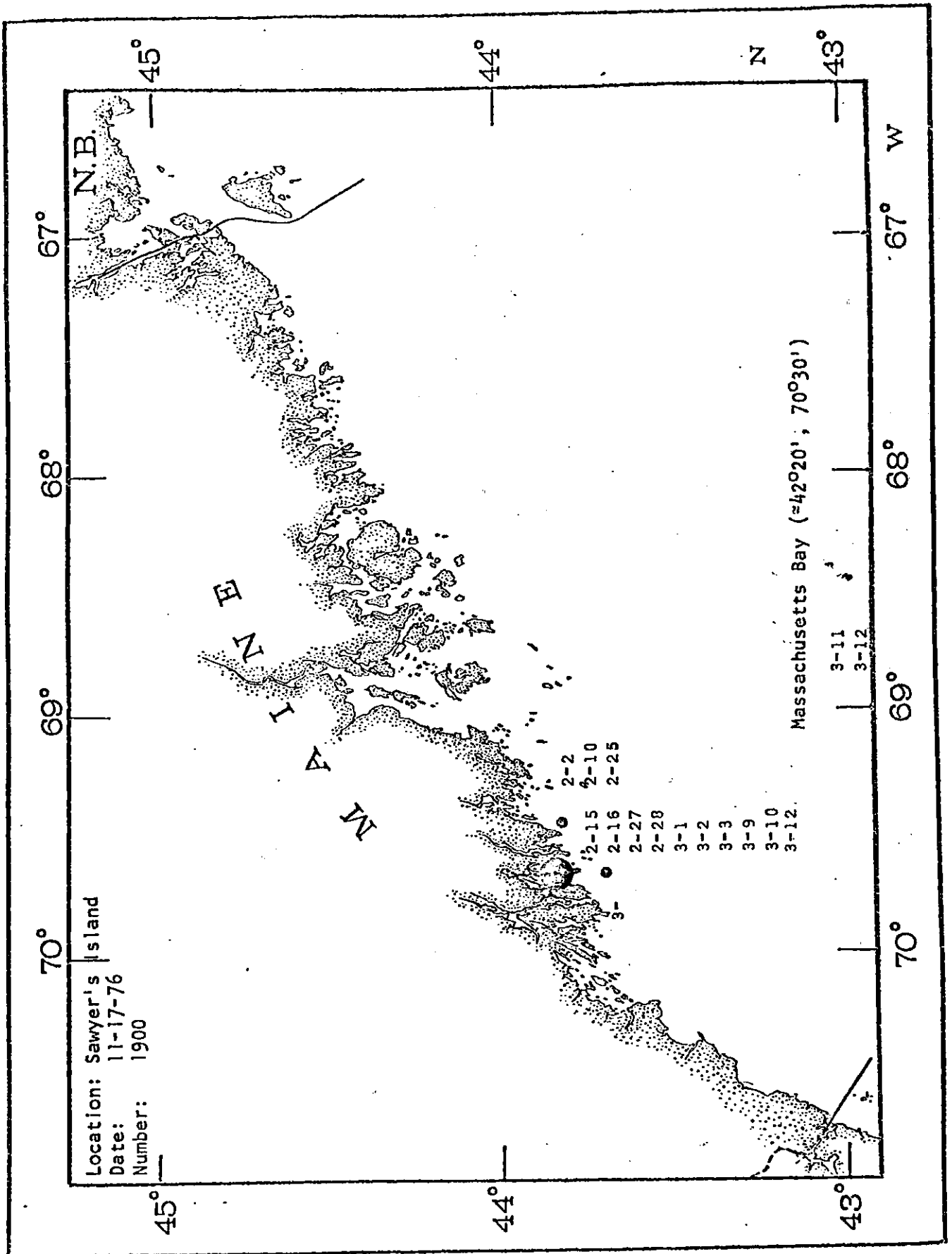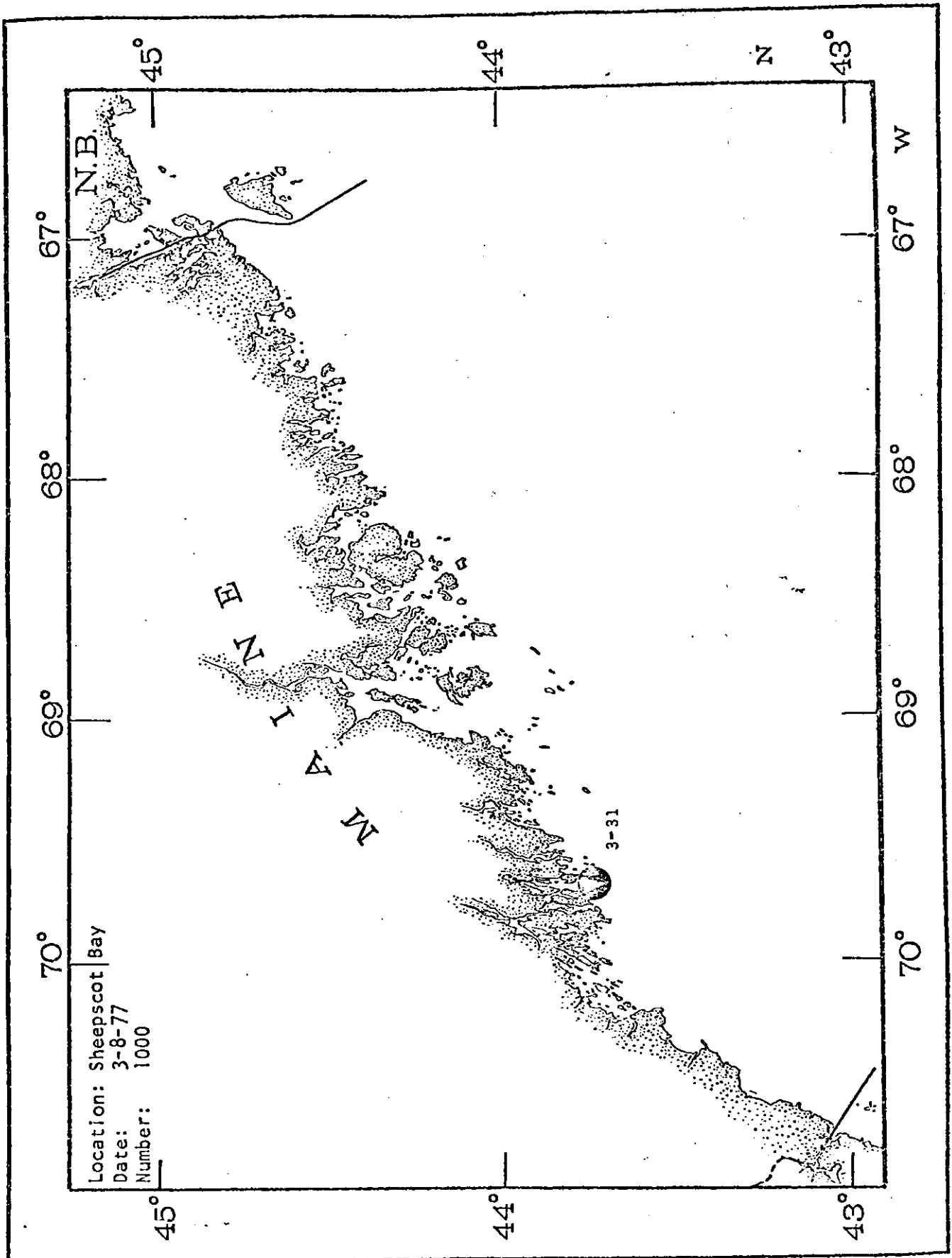
Fig. 16

APPENDIX I

MORTALITY OF HERRING IN AQUARIA AFTER TAGGING

There have been many techniques used to tag herring, but there is little information on tagging mortality. This information is important (1) to determine the effectiveness of different tagging and handling techniques, and (2) to estimate population parameters from recapture results.

To obtain an estimate of mortality of herring due to tagging, about 400 herring were put in an oval tank 3.55 m long, 1.85 m wide and .90 m deep and about 100 were put in a rectangular tank 1.75 m long, 1.20 m wide and .70 m deep. Once the herring started to school and mortalities dropped to one or two a day, 77 fish in the large tank and 30 fish in the small tank were tagged. using a Floy FD67 internal anchor tag with a 2.54 cm vinyl section and a 1.90 cm monofilament section. Floy "thin" needles were used. Fish were concentrated using the same large dip net used to concentrate fish in our tagging pockets. and were tagged using the same procedures used in the field. To get as random a sample as possible, all fish caught in the dip net were tagged. The only time fish were out of the water was during application of the tag, a period of about three seconds. The tanks were checked daily and dead fish were measured and checked for injury.

After 33 days, 93 of 107 tagged fish were alive (87%) and 187 of 196 untagged fish were alive (95%). There were five tagged fish unaccounted for at the end of the experiment. It is most likely that these fish were removed after death by maintenance personnel. If this were true, tagged fish had significantly lower survival than untagged fish (Table 1). If the fish were removed before death there was no significant difference in survival.

Most observed deaths (16 of 18) occurred in the first ten days of the experiment; all fish dying in this period had fin rot or a skin lesion.

Water temperatures dropped from 15°C to 9°C during the experiment.

DISCUSSION

These results demonstrate herring can be tagged with low mortality. Allowing for extra stresses related to field conditions, I estimate initial tagging mortality during our tagging operations was about 20%, but Winters (1975) got return rates varying by more than a factor of five from fish released from the same bar seine one or two days later. If some means could

be developed of predicting this variability in suvival, perhaps meaningful population estimates of herring could be made using tag returns.

From my own experience with herring I think scale loss is the most critical factor to survival after handling. Jensen (1955) related return rates with scale loss and there was a strong relationship.

If most initial mortality is due to scale loss, herring survival could be estimated by (1) observing the degree of scale loss during the tagging operation, and (2) knowing how scale loss affects survival through laboratory experiments. Scale loss during tagging operations could be determined by putting a respresentative sample of tagged fish in a tank of strong anesthetic soloution and then observing them once they stop moving.

A check on consistency of initial mortality estimates could be made by calculation of return rate variation as done by Winters (1975).

Table 1. Survival of tagged and untagged herring held from 10 October to 12 November 1976, assuming the 5 missing herring died before removal.

| | Large tank | | Small tank | | Total | |
	Tagged	Untagged	Tagged	Untagged	Tagged	Untagged
Mean length (mm)	254	245	204	207	237	
Standard deviation	2.32	2.69	3.66	3.03	11.01	
Number initially	77	155	30	41	107	196
Number dying	12	9	2	0	14	9
Number surviving	65	146	28	41	93	187
% surviving	84.4	94.2	93.3	100.0	86.9	95.4
z[1]	1.94		1.94		2.67	

[1]Null hypothesis (no significant difference (α = .05) in survival of tagged and untagged fish) rejected if $Z \geq 1.96$.