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Harbor Porpoise (*Phocoena phocoena*)
Distribution, Abundance, Survey Methodology and Preliminary Notes on Habitat Use and Threats

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Abstract

Aircraft and shipboard surveys and land-based observations were simultaneously made on the harbor porpoise. Concurrent observations made by land observers, a 36' power vessel, and a high wing aircraft, over a well-defined body of water (Head Harbor Passage, N.B., Canada), allowed a comparison of each method. Analysis of the data for four days of varying conditions reveal that land station observations saw 61 to 82 percent, the aircraft saw 14 percent, and the survey vessel saw 52 percent of all porpoise in the area. Small craft surveys in the region during the summer of 1980 reconfirm that local harbor porpoise abundance peaks in August. Analysis of previously collected data on porpoise cow/calf distribution indicates a preference for protected nearshore waters and particularly near the entrances of Passamaquoddy Bay. Aerial survey data reveal that harbor porpoise occur across the entire Bay of Fundy at times, and that the distribution pattern shifts rapidly. The western portion of the lower Bay of Fundy is consistently inhabited by porpoise from June through October. Population estimates from the aerial data show a peak in abundance of 3456 animals on August 30 in the western half of the Bay of Fundy. Interviews with Passamaquoddy tribal members indicate a subsistence take of up to 50 animals per year. Historical records show that hunting of porpoise by native peoples may be a tradition extending back at least one thousand years.

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INTRODUCTION

In 1978, Prescott and Fiorelli initiated a review of the status of harbor porpoise (Phocoena phocoena) in U. S. waters of the western north Atlantic. Their study identified substantial information gaps in our knowledge about this species, and raised serious questions about the health of North American population (Prescott and Fiorelli, 1980).

Significantly, no population estimate exists for P. phocoena in the western north Atlantic. Gaskin's (1977) estimate of 4,000 in the Bay of Fundy region is admittedly crude, and includes only a portion of the known range. Prescott and Fiorelli (1980) used winter stranding records from a single year to postulate a minimum mid-Atlantic regional population of 726 to 1,525 (between Long Island Sound and Cape Hatteras), but acknowledge that no information on stock or population discreteness exists for U. S. coastal waters.

Harbor porpoise are among the shortest lived of all cetaceans, reaching a maximum age of 13 years in the western north Atlantic (Gaskin and Blair, 1977). Sexual maturity is reached between four and six years, giving each animal, optimistically, only 5 to 7 years of potential reproductive capability (Van Utrecht, 1978; Gaskin and Blair, 1977). Fisher and Harrison (1970) suggest that females have resting years between pregnancies, but observations by Gaskin and Blair (1977) and Watson (1976) indicate yearly calving intervals.

There are several factors which may be seen as threats to the continued health and stability of the harbor porpoise population. Agricultural and silvacultural pesticide use continues, and chlorinated hydrocarbon residues are commonly concentrated in animals at high trophic levels. Tissue samples from harbor porpoise in the Bay of Fundy showed higher concentrations of dieldrin and the DDT group than any other mammal, including humans (Gaskin, Holdrinet, and Frank, 1971). Although pesticide levels appeared to decline between 1969 and 1973 in P. phocoena of the Fundy region (Gaskin, Holdrinet, and Frank, 1976; Gaskin et al., 1979) (possibly because of a decline in pesticide use in the New Brunswick forests since 1967), the presence of other contaminants such as mercury and PCBs in porpoise tissues (Gaskin, Ishida, and Frank, 1972) is cause for continued concern, since

a reduction in porpoise abundance in the Baltic Sea has been attributed to pollution and overfishing (Anderson, 1972; Brownell, 1977; van Utrecht, 1979). Helle, Olsson, and Jensen (1976) linked high pesticide levels in seals with pathological changes in the uterine tract, resulting in reproductive failure. While these findings are not applicable to cetaceans, and to date there have been no conclusive findings on the effects of any environmental contaminants on harbor porpoise, they serve as a warning for animals occupying a similar ecological niche.

Another potential danger to the harbor porpoise population are the recent changes in fishery technique and effort. P. phocoena are susceptible to incidental capture in gill nets, probably because they are unable to detect them (Perrin and Hunter, 1972). There has been an increase in gill-net fishing over the past five years, and this fishery technique is expanding offshore to areas that were once exclusively the domain of deep- and mid-water trawlers. Incidental catches of harbor porpoise are generally not reported, so there is little information available on the level of take (Prescott and Fiorelli, 1980). However, the very high levels of take (1200/yr) in the Greenland gill net fishery (Kapel, 1975, 1977) lead us to believe that fishery-caused mortality of harbor porpoise in U. S. waters may be substantially higher than the scarcity of reports indicates.

Additionally, harbor porpoise are subjected to some subsistence take, and are in direct competition for several commercially valuable species of fish. The cumulative effect of these phenomena as well as natural predation and parasitism on the population is unknown.

Lack of essential information to make informed management recommendations about this species resulted, in 1980, in the award by the National Marine Fisheries Service of a contract to the New England Aquarium and University of Guelph to initiate a long-term study of P. phocoena along the east coast of the U. S. The objective of this study is to determine relative abundance, whether the population is increasing or decreasing, winter distribution, habitat requirements, social organization, stock divisions, if any, and migrations. This many-faceted program was started in May of 1980, and the initial results are reported here.

First-year objectives included the determination of a consistent and efficient survey technique for harbor porpoise, the initiation of studies on porpoise habitat use and requirements, and an assessment of subsistence take by native people of northern Maine. The University of Guelph collected many field sightings during the summer, but was also responsible for a re-analysis of harbor porpoise data collected over the past ten years. Dr. Gaskin's primary work has been to identify habitat requirements for P. phocoena and, to a lesser extent, examine environmental contaminants, and reanalyze his early population data in light of current methodology.

The New England Aquarium research tasks were directed toward developing survey methodology. A comparative survey experiment utilizing aircraft, shipboard, and land-based observation platforms was conducted to determine a consistently effective survey method. In addition, Aquarium research staff collected P. phocoena sightings during the course of large whale surveys, during boat trips, and opportunistically from land during the entire summer. These data will be incorporated into the harbor porpoise research data base for future analysis. An investigation of the subsistence take of harbor porpoise in the Passamaquoddy Bay region was completed by Pátricia Fiorelli under contract to the University of Maine, and is included here. Several native people involved with hunting were interviewed. Past and present methods, extent, and significance of the harbor porpoise hunt were investigated. Archeological and anthropological literature has established a porpoise hunting tradition nearly one thousand years old in the Indian tribes of the region.

This report is presented in three sections: survey methodology, habitat use, and subsistence take. Because this study is a long-term project, some of the first year effort is reported as work in progress. Original data is stored at the New England Aquarium and the University of Guelph.

SURVEY METHODOLOGY EXPERIMENT

Methods

Between August 4 and 12, 1980, 30 to 34 persons from College of the Atlantic, the University of Guelph, and the New England Aquarium took part in an experiment

sponsored and directed by the New England Aquarium to test harbor porpoise (P. phocoena) survey methodology. The experiment was designed in consultation with Dr. James Gilbert, University of Maine, Orono, Me., to compare aircraft, shipboard, and land-based survey platforms providing, quite literally, a ground truth comparison.

The experiment took place in Head Harbor Passage, a narrow channel running NE-SW, bounded by Campobello Island (N.B.) on the east, and a series of small islands and ledges on the west (see Fig. 1a). Head Harbor Passage was chosen for three reasons: (1) the northwestern coast of Campobello Island provides easy accessability to readily available land observation stations; (2) the passage is only 800 to 1,000 meters wide, with many easily identifiable landmarks, allowing accurate orientation and navigation in a clearly defined area; and (3) harbor porpoise are known to frequent the passage with some regularity.

The experiment was planned for early August, since good weather and high counts of harbor porpoise were expected, based on information provided by Dr. David Gaskin from data collected during the past ten years. Though the weather was much worse than expected, eight complete survey transects were completed in five days of good weather. The survey vessel was the College of the Atlantic's R/V Beluga, a 36' power vessel, and the survey aircraft a U. S. Fish and Wildlife Service amphibious Cessna 185.

Four transects were laid out at 200-meter intervals over a five kilometer stretch of Head Harbor Passage (Fig. 1a). The transects were surveyed by both the aircraft and the survey boat. Because of the differences in survey speed, the experiment was designed so that the aircraft would cover all four transects for every one the boat completed. For example, while the R/V Beluga was enroute along Transect #3, the aircraft would survey Transects 1, 2, 3, and 4 in order, then break off until the boat had started survey Transect #4, at which point the aircraft would survey all four transects again.

Six land stations were set up on the coast of Campobello Island at approximately 500-meter intervals. These stations were supplemented by one to three additional stationary observation points set up at 500-meter intervals on or near Spruce Island (across the passage) by Dr. Gaskin's personnel. Two observers were posted

NOTE: No page 5; missing Figure 1a.

at each station, to record locations and movements of all harbor porpoise within a 100°-m. arc of them on a field form designed specifically for this experiment (Appendix A-1). All land stations were oriented to true northwest, so overlapping sightings would later be easy to identify by triangulation. Sighting distances were estimated by the observers, based on a series of distance calibration trials done by radar the first day with the R/V Beluga and a wooden life-size harbor porpoise model. Additionally, during every trial, the 200-m. interval transects made by the R/V Beluga served as automatic distance calibrations for each station. In the analysis of the data, only observations from the four-kilometer survey area in view of the six land stations on Campobello Island have been considered, since the consistency of position and orientation of the supplementary boat stations across Head Harbor Passage was tide dependent and variable.

Vessel transects were run with two observers and a recorder stationed on the bow of the R/V Beluga (approx. height of eye above water = 2.5 meters). Each observer was responsible for 95° of horizon, from a point directly abeam of the survey vessel to a point 5° off the bow, overlapping viewing fields by 10° at the bow to insure complete coverage. Sightings were recorded on forms designed for vessel observations (Appendix A-2). Observers were changed after each transect to reduce the effects of fatigue. Navigation was accomplished by the use of radar and triangulation with landmarks. Vessel speed was held at 9 kts ± 2 kts, variability caused by the strong currents in Head Harbor Passage.

Aircraft transects were flown at an altitude of 750 ft. at 90-100 knots. Two experienced aerial observers and a recorder participated in each flight. Navigation was done by triangulation on a variety of landmarks, including large orange markers at each land station, and sighting locations were pinpointed with the same method. Sightings were recorded on a sighting form designed for these flights (Appendix A-3). Visual survey techniques were the same as those employed in standard aerial surveys, but with an important difference. Because observers were looking specifically for harbor porpoise, and because the survey area was delineated by land masses, observers restricted their search scans to within 600 meters of the transect line. On two days of the experiment, observers noted the angular distance from the transect line by inclinometer, categorizing sightings by 90° to 40° (< 200 meters from the aircraft) or 40° to 20° (between 200 and 630 meters from the aircraft).

Species identification problems were not a factor during the experiment, since: (1) all aerial and shipboard observers were experienced in P. phocoena observations from their respective platforms; (2) land-based observers reported no other cetacean species in the vicinity during the entire week; and (3) P. phocoena is sometimes difficult to spot, but once sighted, has clear and unique field marks that make it easy to identify. Summary of the porpoise survey experiment is shown in Table I.

TABLE I

Summary of Experiment on Survey Methodology
for Harbor Porpoise
August 1980

	Completed Vessel Transects	Completed Aircraft Transects	Operating # of Land Stations
August 4	4	12	7
August 5	5	14	9
August 7	8	32	8
August 8	8	36	7
August 11	8	40	8
	33	134	

Results

Triangulation of land station sightings resulted in accurate plots of porpoise movements through the area for every set of 4 transects. Aircraft and shipboard sightings were then plotted using the same methods over the same time periods. The number of sightings made by aircraft and shipboard platforms were then compared independently against the number of sightings made by ground stations to test sightability from each platform. A "sighting" represents one or more porpoise. Analysis of observations by all platforms on all days show that "sighting" group size ranges from 1.94 to 2.38 porpoise per group. The results of the experiment are summarized in Tables II, III, and IV.

TABLE II

Numbers of Groups of Harbor Porpoise
Observed by Ground Observers and from the Air
in Head Harbor Passage, New Brunswick

	Observed from Aircraft									
Observed from Ground	August 5		August 7		August 8		August 11		Total	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Yes	2	19	0	7	4	23	8	37	14	86
No	0	--	0	--	1	--	2	--	3	--
	*P = 0.10		P = .00		P = .15		P = .18		P = .14	
	**G = 1.00		G = 1.00		G = .80		G = .80		G = .82	

* P = calculated probability of sighting from aircraft.

** G = calculated probability of sighting from ground.

TABLE III

Numbers of Groups of Harbor Porpoise
Observed by Ground Observers and from Shipboard
in Head Harbor Passage, New Brunswick

	Observed from Shipboard									
Observed from Ground	August 5		August 7		August 8		August 11		Total	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Yes	7	3	1	0	1	5	2	2	11	10
No	2	--	1	--	0	--	4	--	7	--
	*S = .70		S = 1.00		S = 0.20		S = 0.50		S = .52	
	**G = .78		G = 0.50		G = 1.00		G = 0.33		G = .61	

* S = calculated probability of sighting from shipboard.

** G = calculated probability of sighting from the ground.

TABLE IV

Mean Number of Harbor Porpoise per Group,
as Observed from the Ground, Boat, and Aircraft

Platform	August 5	August 7	August 8	August 11	All Days
Ground	3.81	1.72	2.19	2.03	2.39
Boat	2.46	1.75	1.33	1.44	1.98
Aircraft	4.00	2.00	1.66	1.47	1.94

Discussion

Analysis of the data shows that vessel transects provide more consistent coverage for P. phocoena than aircraft. Vessels may not be as efficient as aircraft in terms of the amount of area covered, but in low density porpoise regions, aircraft tend to miss porpoise because of their relative size, high survey speed, and limited effective survey width. Aircraft effectiveness appears to rise in high density porpoise areas, and may be a useful technique in known high density porpoise habitat. However, the results suggest that shipboard surveys are the superior method in estimating harbor porpoise distribution and abundance. In analysis of survey data, these results may be applied as correction factors to aircraft and shipboard observations to provide more accurate estimates of porpoise abundance. If aircraft see 14% of all P. phocoena, multiplying resultant estimates by 7.14 will approximate 100% of the population. Similarly, shipboard estimates can be multiplied by 1.61 to approximate 100% of the population.

Further work on survey methodology should examine the effect of eye height, ship speed, and meteorological conditions upon survey results. The estimation by observers of distances from sighted porpoise to survey vessel needs clear definition for open-ocean surveys. Nevertheless, if survey methods similar to those described here are adhered to during the course of a survey, the results reported here are applicable,and useful in estimating porpoise abundance more accurately.

HABITAT USE

Methods

Observations on Phocoena have been seasonally made by the Cetacean Research Group of the University of Guelph since 1969 in the western north Atlantic. Weather and other conditions have prevented data collection on a year-round basis. Occasionally, CRG has been able to work during the period April-December, but the period May-September has been the more usual period each year, with maximum effort expended in July and August. In 1980, observations began on May 16 and concluded on September 16.

The geographical area of investigation is the western Bay of Fundy (Fig. 1b). Only limited data are available for the offshore areas around the Wolves and Grand Manan. The bulk of the data are from the inner Quoddy region, especially

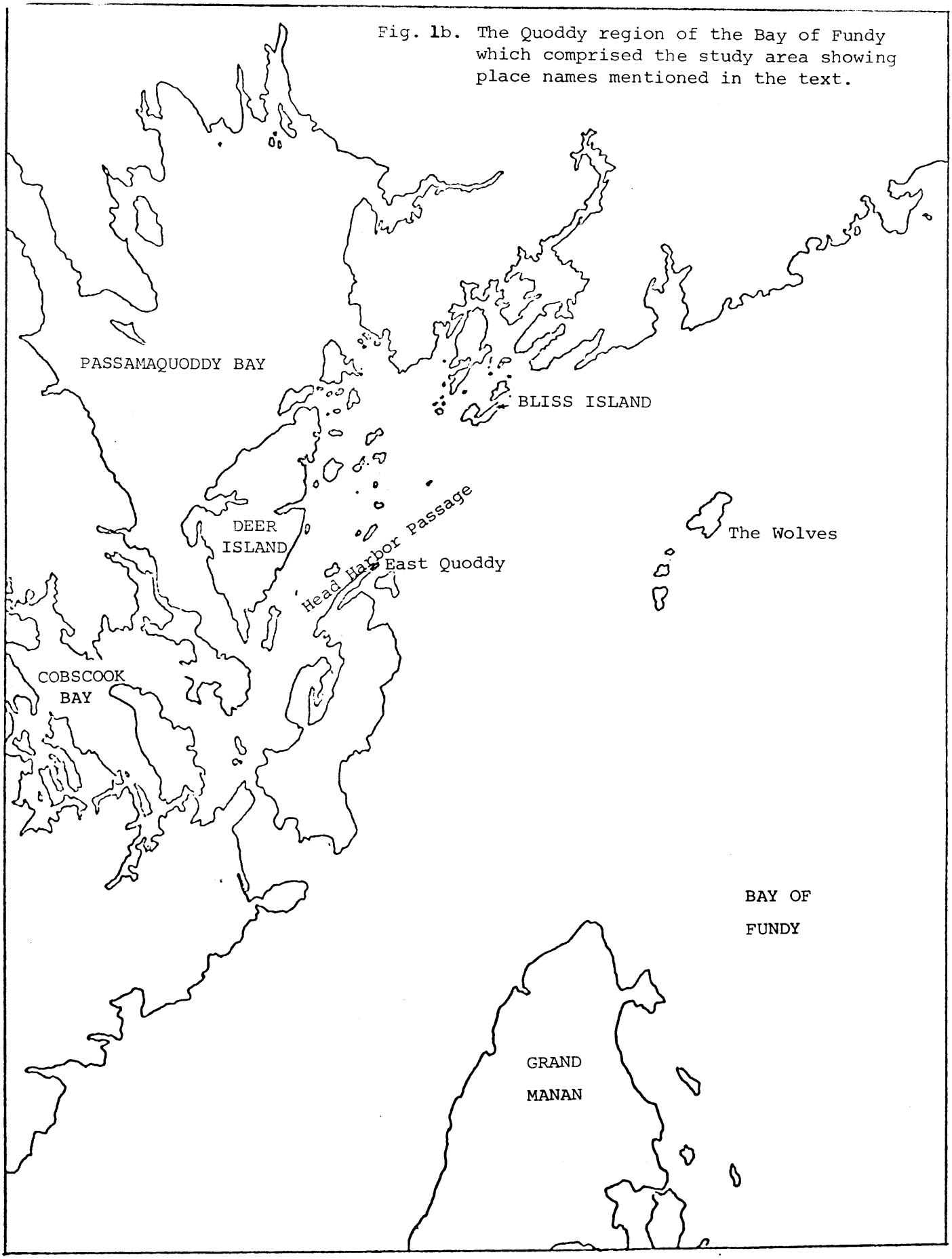


Fig. 1b. The Quoddy region of the Bay of Fundy which comprised the study area showing place names mentioned in the text.

within the area from East Quoddy to Bliss Island and inshore to Deer Island and the passages to Passamaquoddy Bay. Less emphasis was placed on Passamaquoddy Bay itself.

The harbor porpoise is a particularly difficult animal to study since it is small and unobtrusive. Unlike many oceanic delphinids, it is wary of motorized vessels, rarely leaps clear of the surface and usually occurs in small groups of two to five individuals. There are many problems therefore associated with census of this species which CRG is continuing to define and solve. Weather conditions under which observations are made are most important. These have been categorized according to sea state, visibility and lighting conditions. Although the data contained here are not corrected for spotting conditions, they were usually obtained when the sea state was less than Beaufort force 3 and lighting and visibility were rated as good (Gaskin, 1977).

Examination of the data for bias introduced by different observers, the number of observers on watch, or by using different vessels is not yet complete. However, inexperienced observers were trained and supervised by experienced personnel. During the 1980 field season, 12 observers and three boats were utilized.

Although many observations included in this report were obtained during the course of other work (e.g. plankton tows, oceanographic experiments), the major surveys were conducted using a strip census approach. Due to the topographical nature of the inner Quoddy region (about 40 islands and major ledges) it is virtually impossible to run line transects. However, the cruises were designed to survey as much area as possible and the vessels were run at a slow, constant speed (4-5 knots). No special equipment or techniques were used to measure the right angle distance of observed porpoises from the transect line because of the near impossibility of taking accurate bearings from a small boat on objects only fleetingly visible. The distance was estimated by eye and recorded in four categories: $<$100m, 100m, 250m and 500m.

Results and Discussion

1. Census Data

The number of hours of observation and the uncorrected number of Phocoena seen in the inner Quoddy region in 1980 are shown in Table V. These data, converted to uncorrected sighting per unit effort values, are presented graphically in Fig. 2.

As in previous years, the number of harbor porpoise in the inner Quoddy region began to increase rapidly in July, reached a peak in August and decreased in September. The seasonal movements seem to be linked closely with those of the main food species, herring and mackerel (Smith and Gaskin, 1974). Although temperature is not a limiting factor, the first major influx of Phocoena occurs when water temperatures reach 8°C in mid-July. There is a large fluctuation in numbers from one locality to another. Previous studies using radio transmitters, fin tags and naturally scarred individuals have shown that harbor porpoise move 20-25 km away from the immediate Deer Island region at frequent intervals during the summer (Gaskin et al., 1975). When the equinoctial winds begin in September there is a dramatic decrease in the number of animals in the study area, especially females with young of the year. By late November few animals remain, but there is evidence of a small overwintering population of immature males.

2. Major Inshore Survey Cruises

The results of the inshore porpoise survey cruises are presented in Figs. 3-8. The cruise tracks were altered from cruise to cruise due to weather conditions and attempts to improve methodology. The amount of search time, the number of Phocoena seen, and the uncorrected sighting per unit effort values are given in Table VI. Although the S/UE value for the August 13 cruise was less than the values for the other two cruises, this may be due in part to the rough sea state encountered during part of this survey.

3. Cobscook Bay Surveys

Three survey cruises were made into Cobscook Bay. Once again the survey tracks were not consistent (Figs. 9-11), but this was due to inexperience

TABLE V

The Hours of Observation and Numbers of Harbor Porpoise Seen in the inner Quoddy Region by Weeks During the Summer of 1980

Week Ending	Hours on Watch	Number of *Phocoena* Seen
May 17	0.6	0
24	33.5	0
31	14.0	0
June 7	7.3	0
14	5.3	0
21	65.2	0
28	62.0	1
July 5	49.3	7
12	20.3	1
19	44.5	7
26	27.6	26
Aug. 2	23.0	81
9	52.9	162
16	44.9	129
23	13.6	56
30	52.5	81
Sept.6	17.8	1
13	35.9	35
20	4.7	3
TOTAL	574.9	590

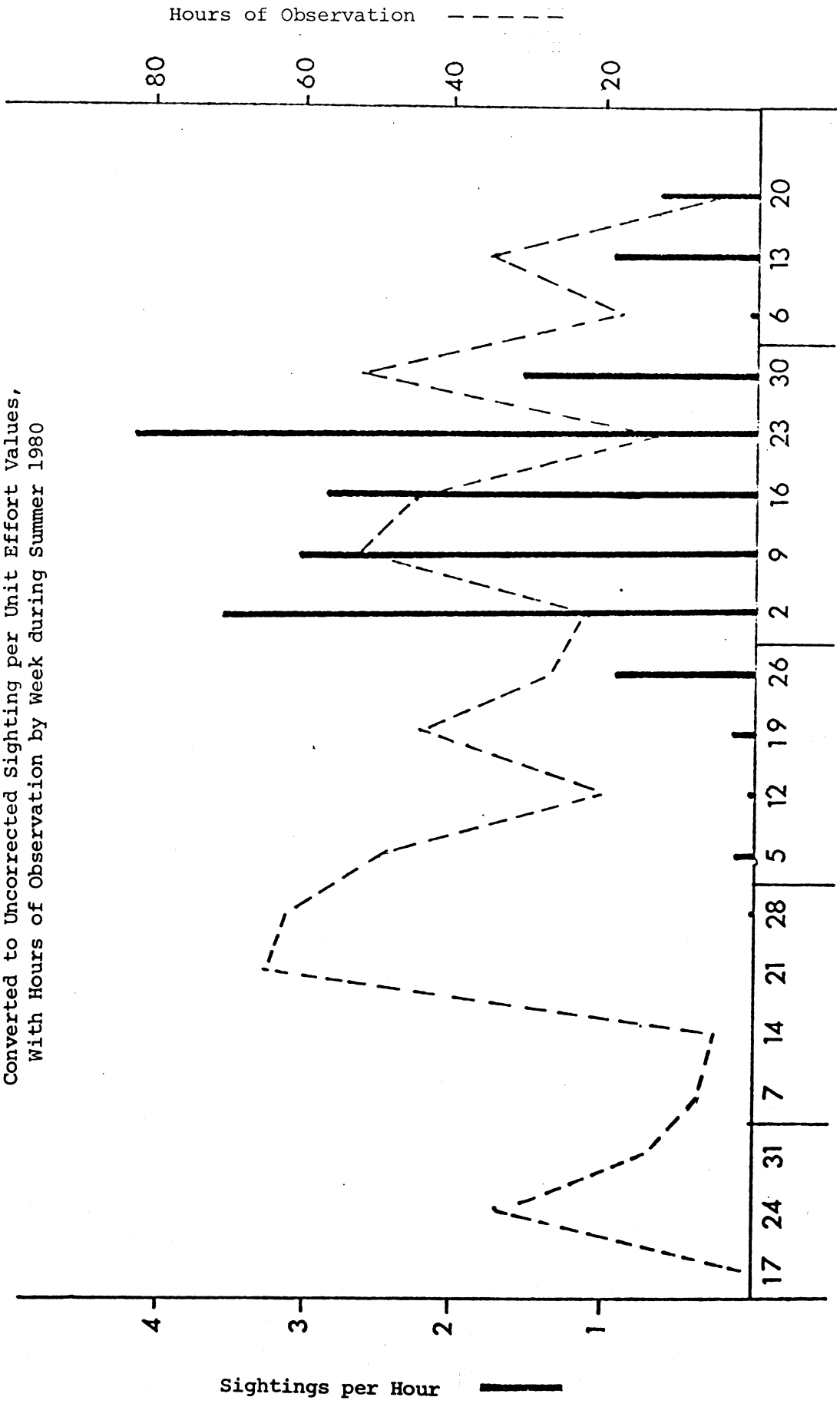


Fig. 2

Numbers of Harbor Porpoise Sighted in the inner Quoddy Region Converted to Uncorrected Sighting per Unit Effort Values, With Hours of Observation by Week during Summer 1980

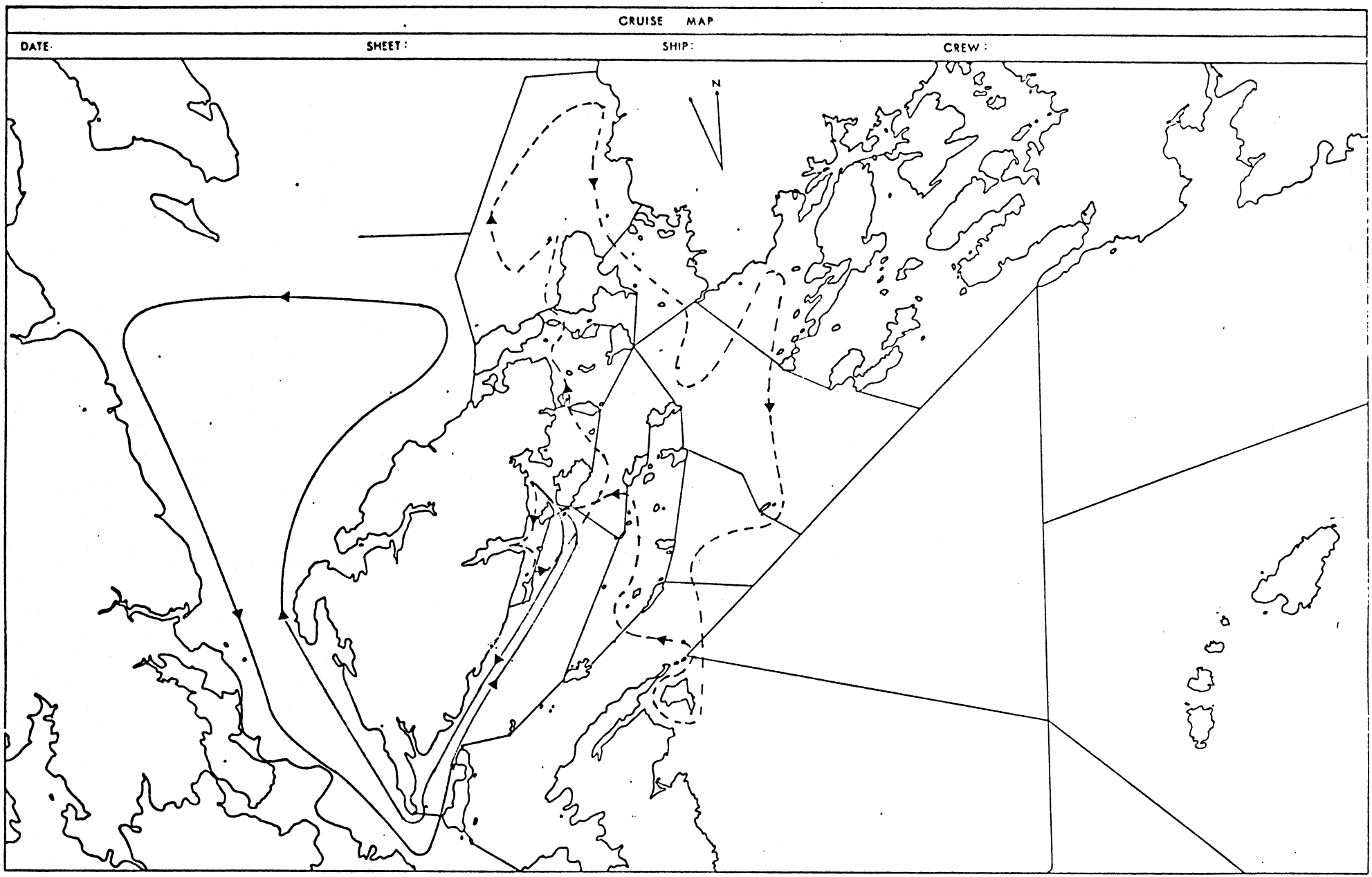


Fig. 3. Inshore Porpoise Survey : Cruise pattern, June 29/80

Boat #1 ——
Boat #2 – – –

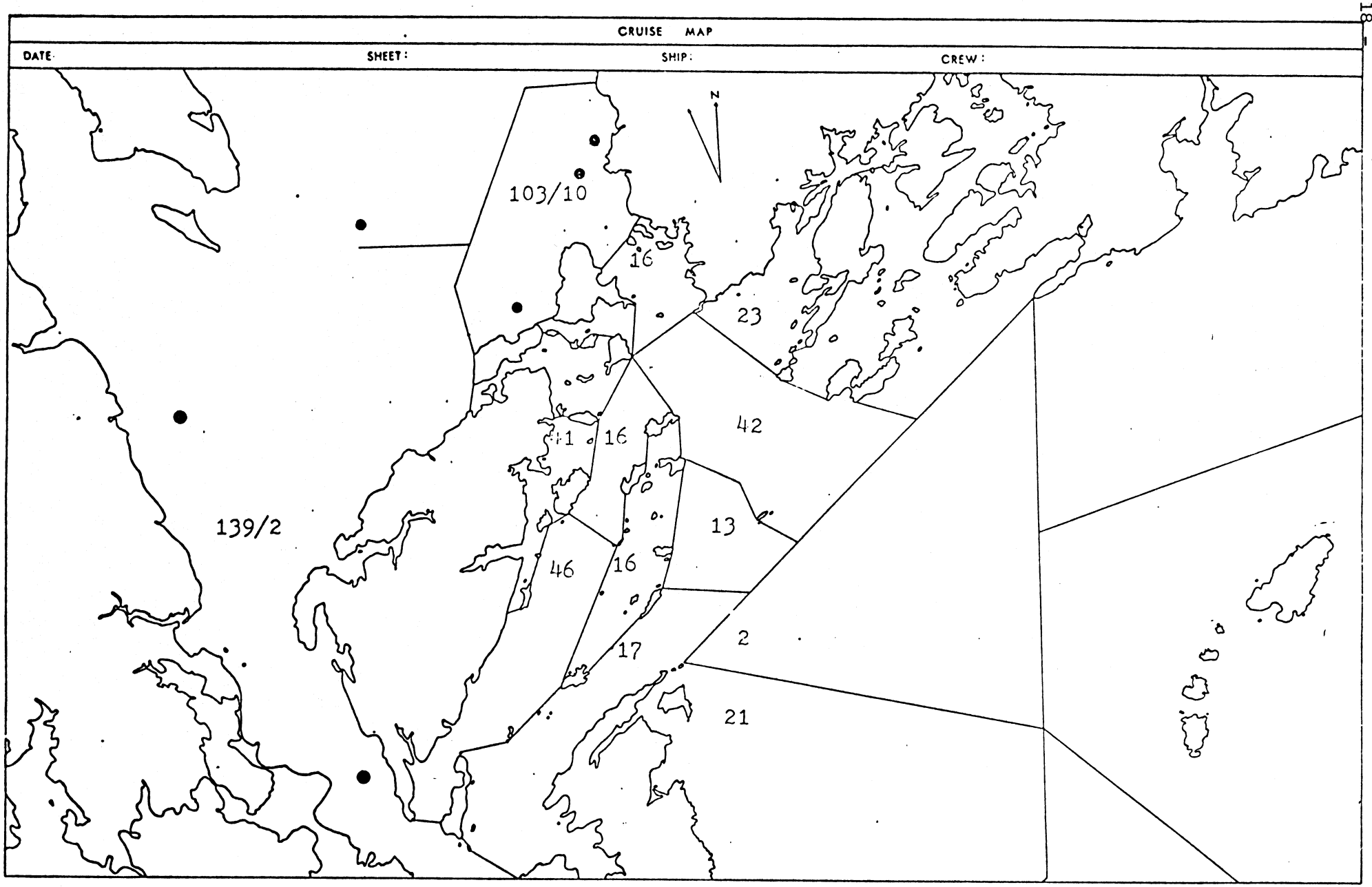


Fig.4. June 29/80 Survey
Time (min.) per area / no. animals sighted
Position of sightings - ●

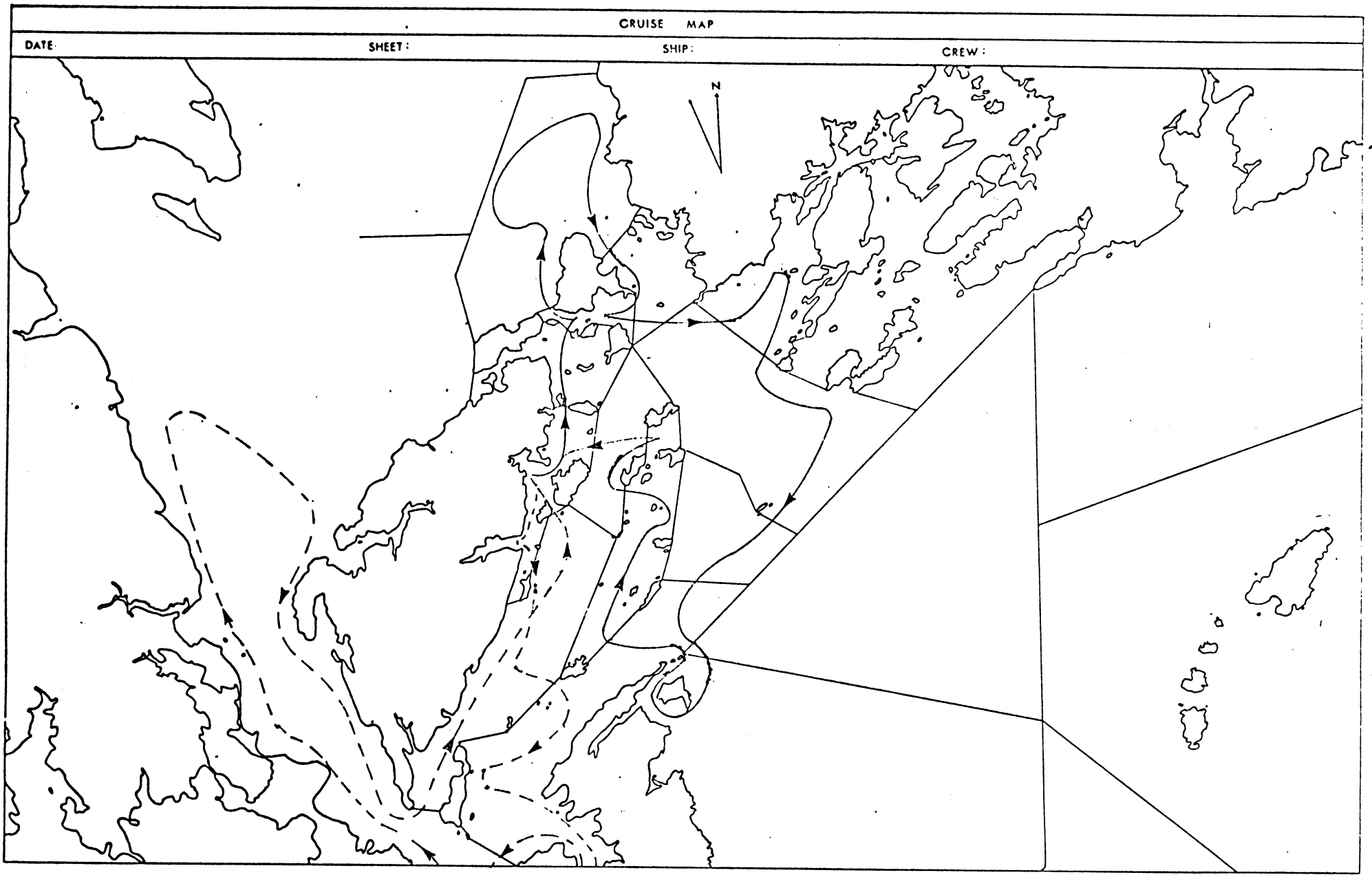


Fig. 5. Inshore Porpoise Survey : Cruise pattern, July 26/80

Boat #1 ——
Boat #2 – – –

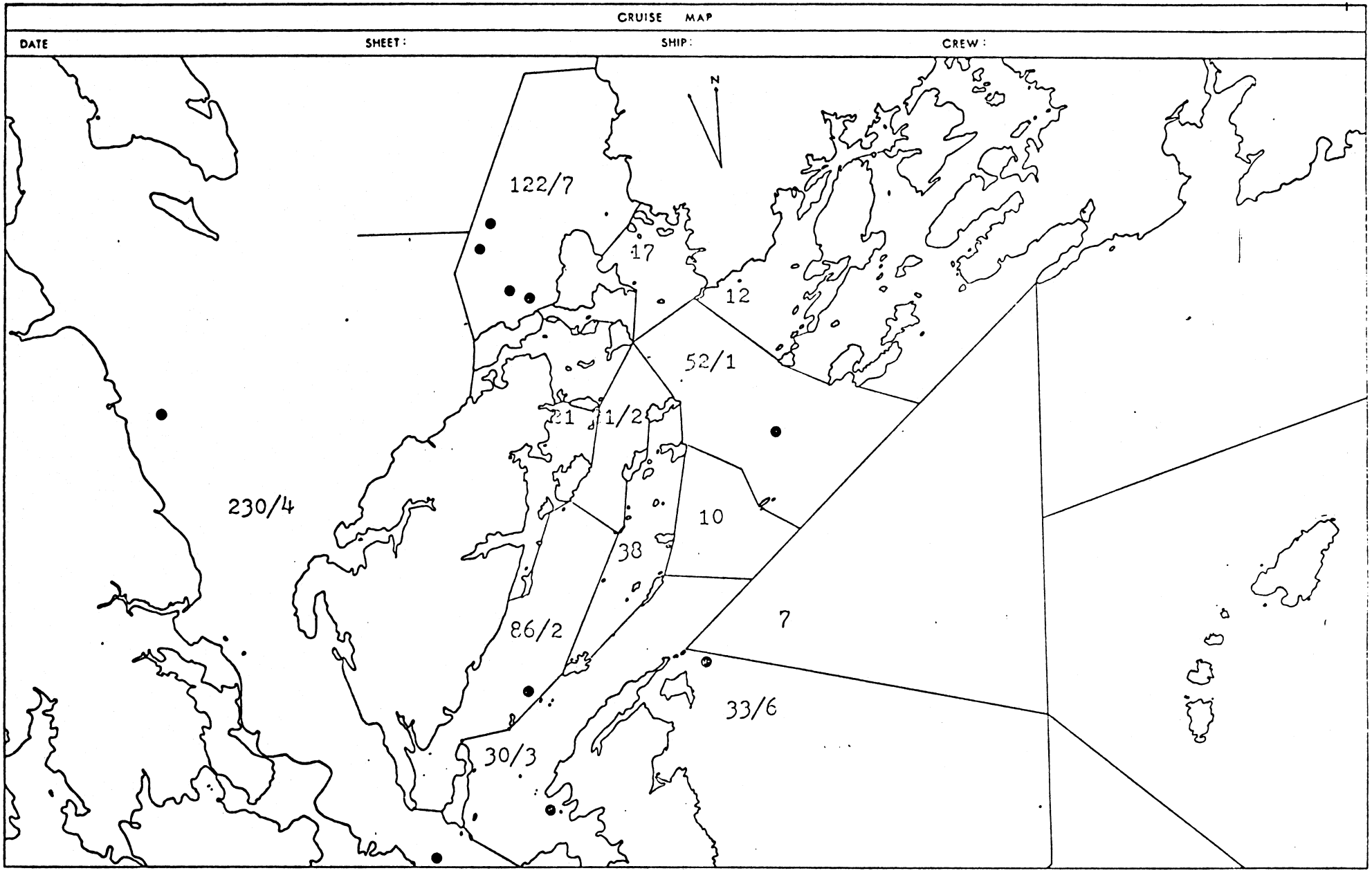


Fig. 6. July 26/80 Survey
Time (min.) per area / no. animals sighted
Position of sightings - ●

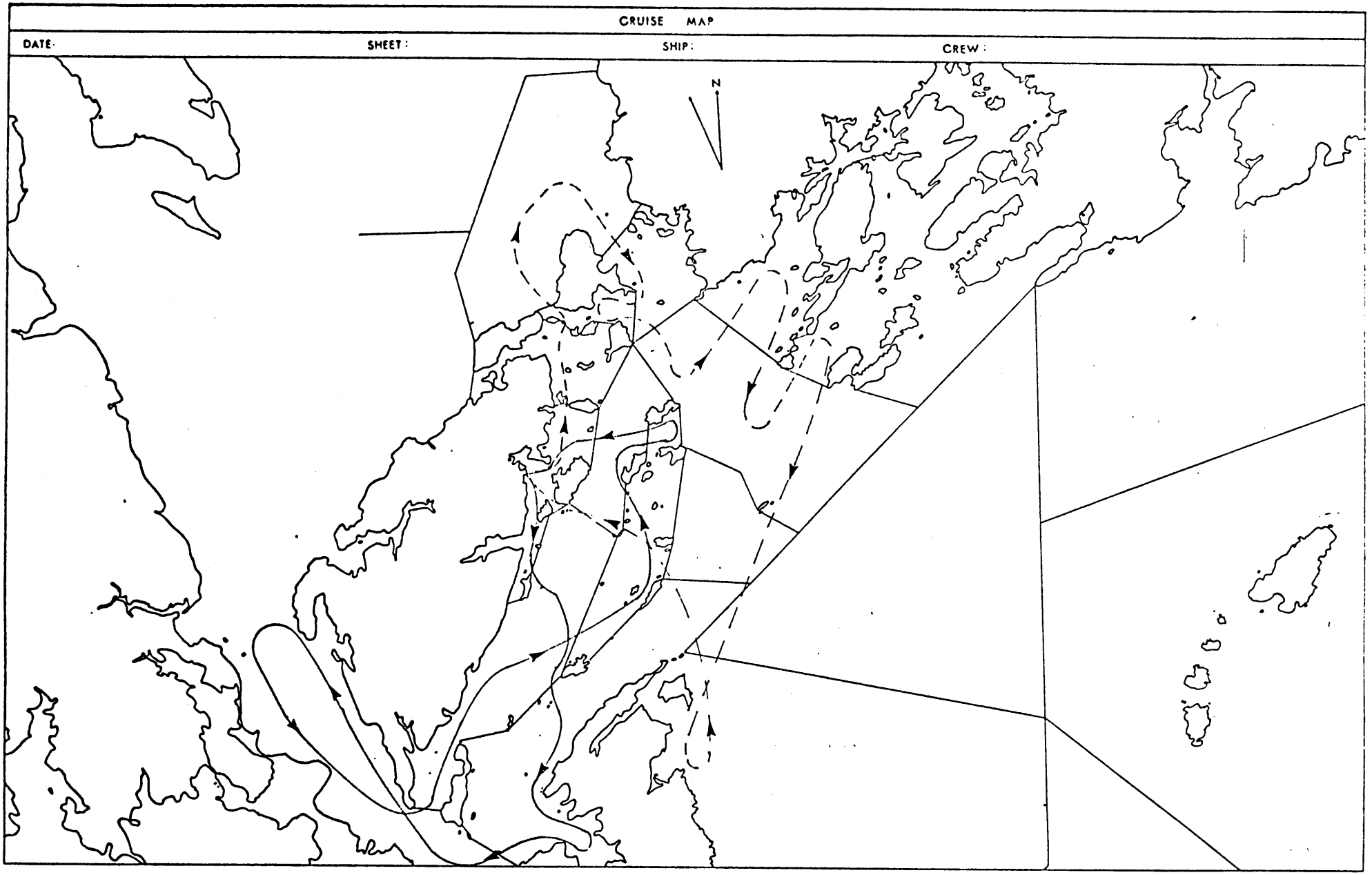


Fig. 7. Inshore Porpoise Survey : Cruise pattern, August 13/80

Boat #1 ———
Boat #2 – – –

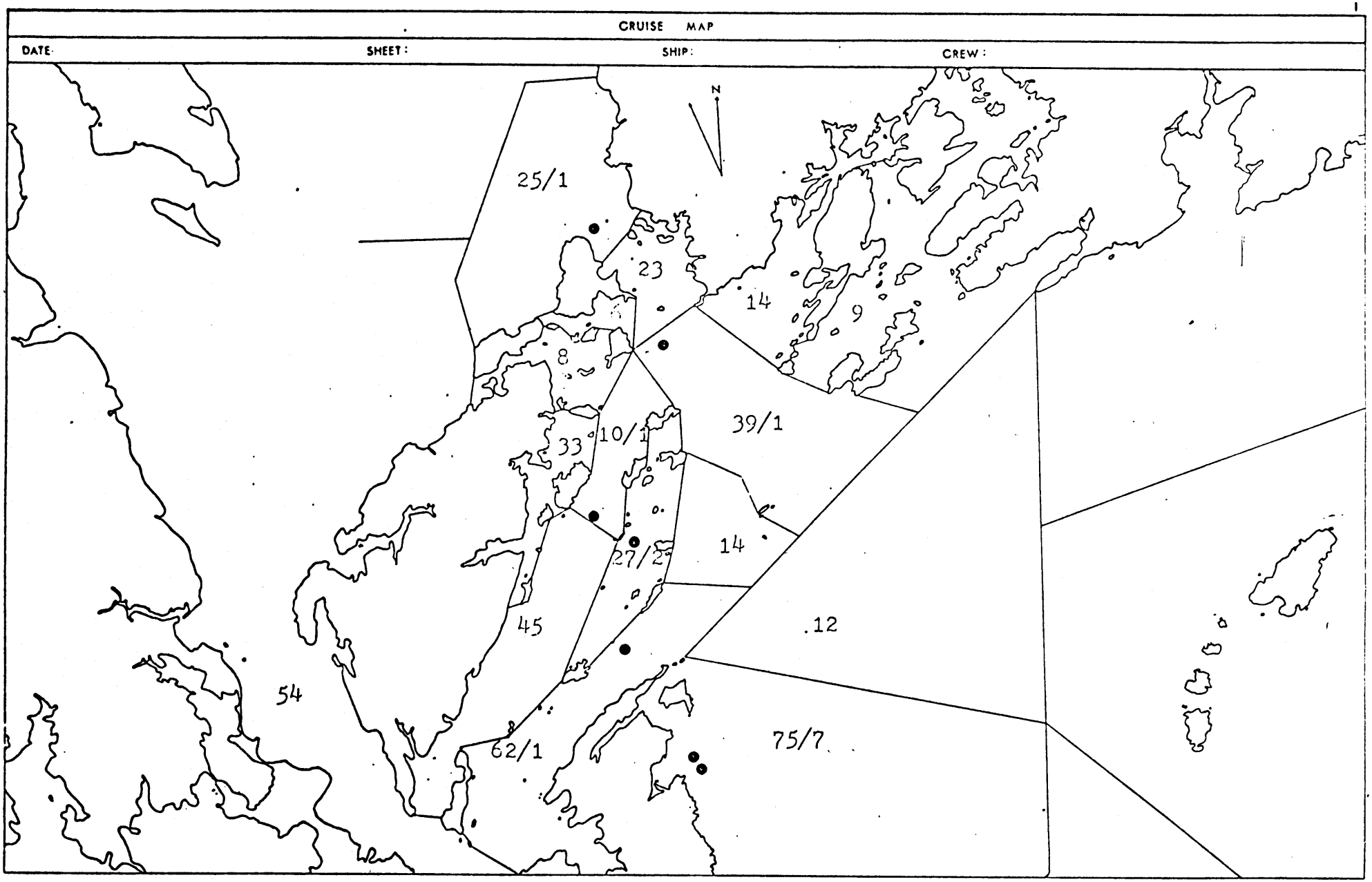


Fig. 8. August 13/80 Survey
Time (min.) per area / no. animals sighted
Postion of sightings ●

Fig. 9. SIGHTING MAP

DATE: July 5/80 SHEET: STN./SHIP: CREW:

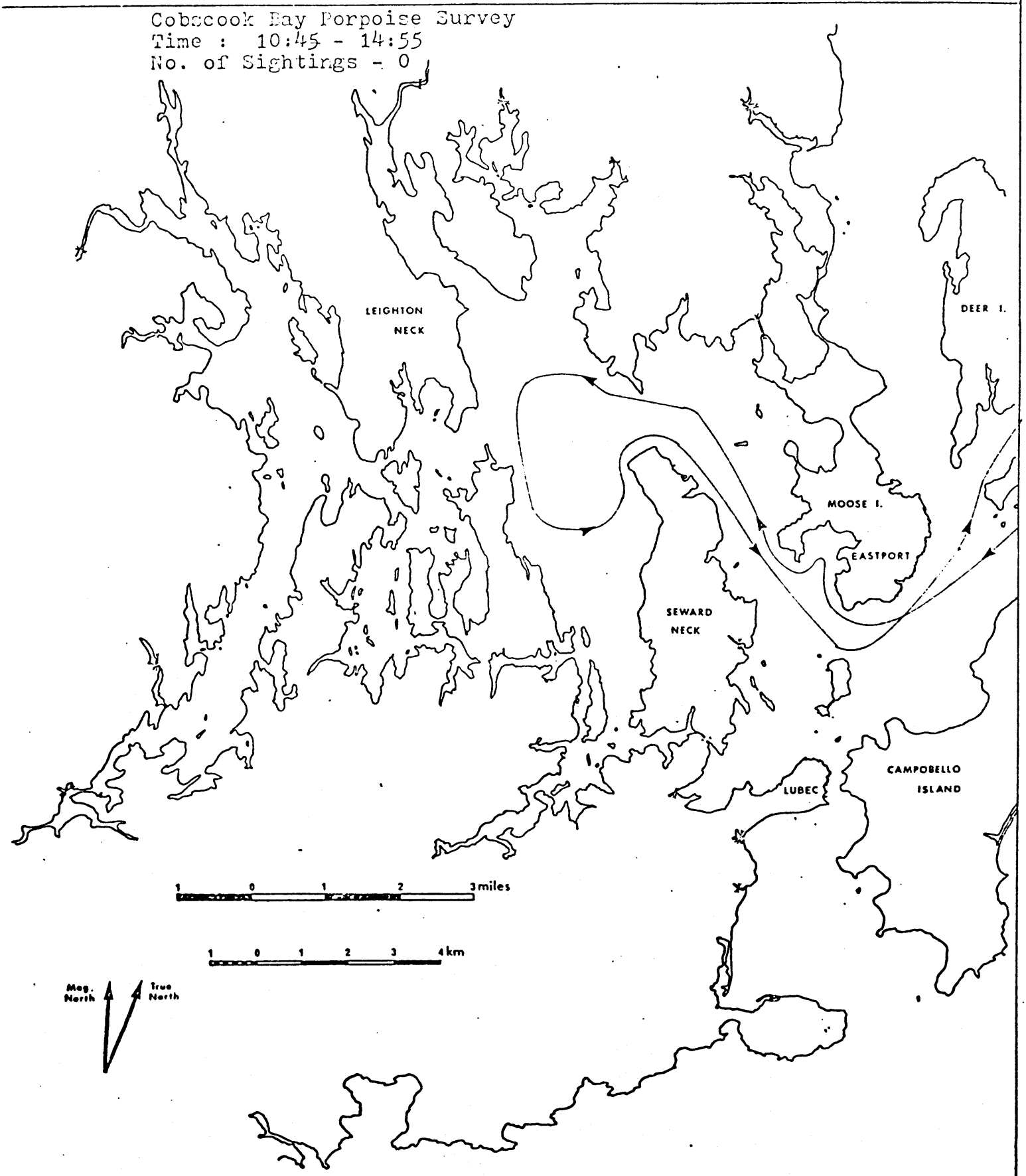


Fig. 10. SIGHTING MAP

DATE: July 31/80 SHEET: STN./SHIP: CREW:

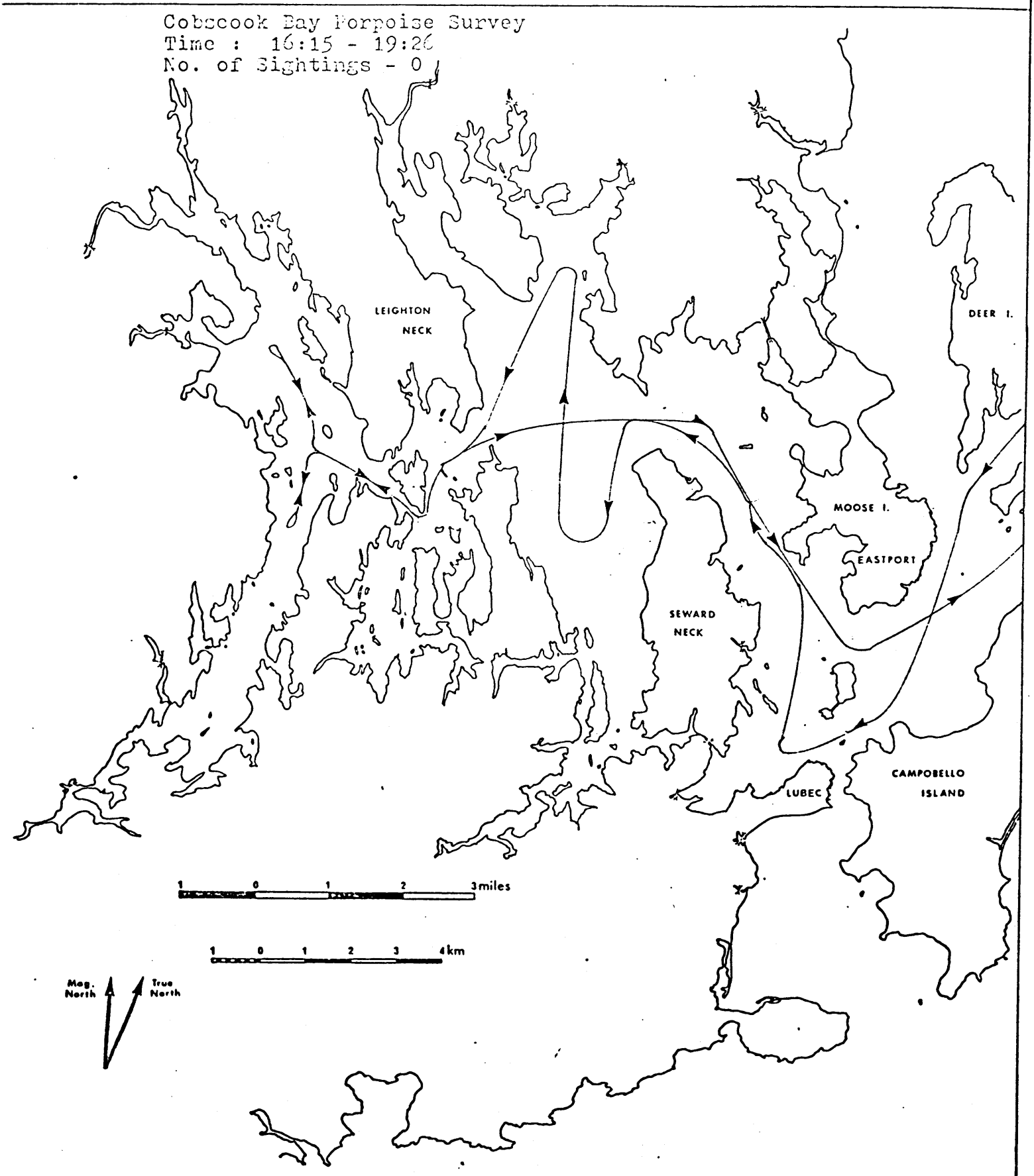
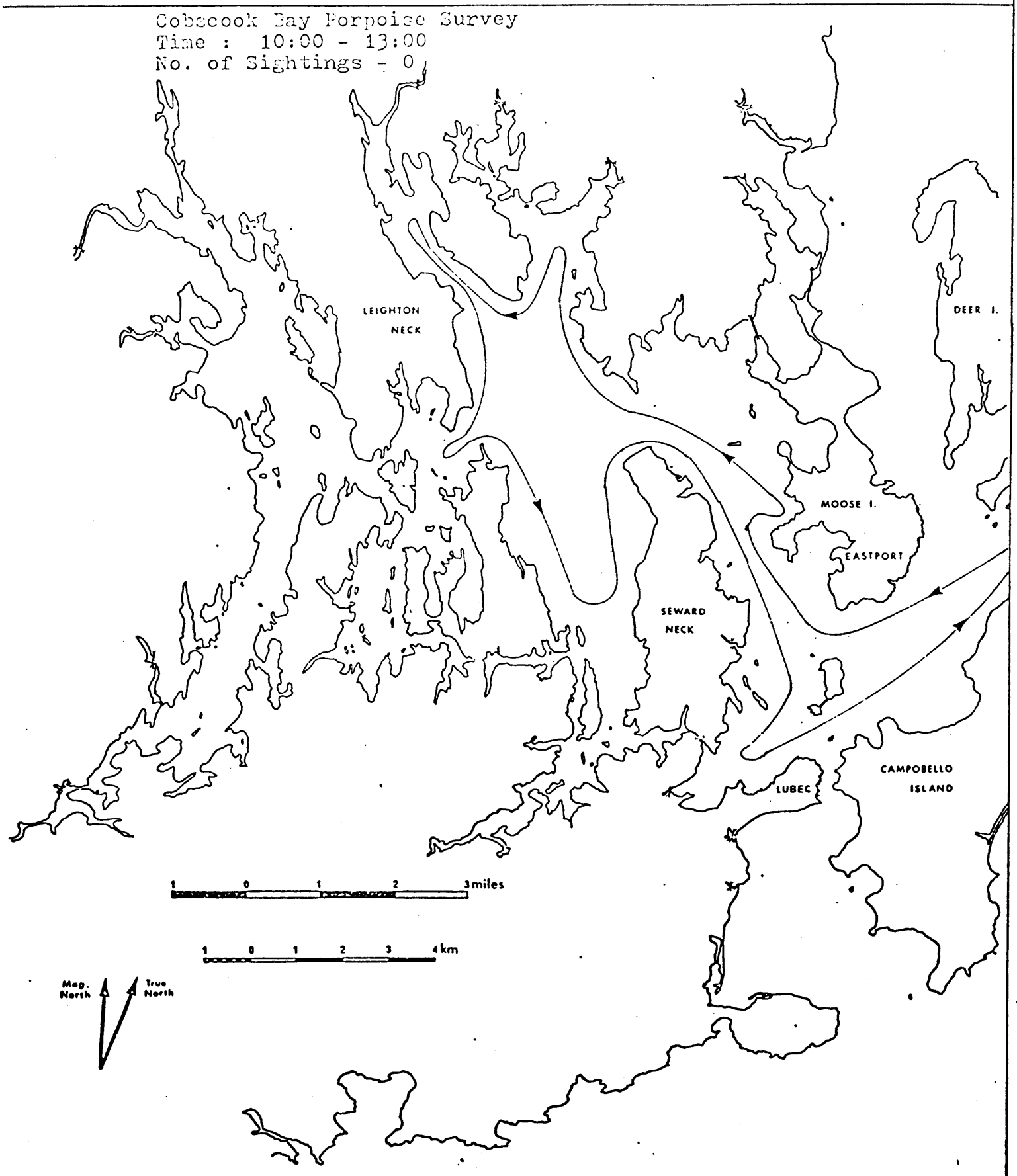


Fig. 11. SIGHTING MAP

DATE: August 25/80 SHEET: STN./SHIP: CREW:



in navigating treacherous waters. No harbor porpoise were seen during any of the cruises, and therefore support a conclusion that Cobscook Bay was not a particularly favorable habitat for Phocoena at times in 1980. This may have been a result of the retarded herring season in the inner Quoddy region.

4. Offshore Survey Cruises

Four offshore surveys were made in the vicinity of Grand Manan in July and August. The cruise tracks and sighting positions of harbor porpoise and baleen whales are shown in Appendix B. The majority of animals were seen between Deer Island and the Wolves and in the tide rips north of Grand Manan. The uncorrected sighting per unit effort values for harbor porpoise are given in Table VII. The values for July 27 and August 21 are higher than those recorded during the same time period in the inner Quoddy region (Table V). There is some evidence to suggest that large numbers of herring remained offshore in 1980 and this may have influenced the shoreward movement of harbor porpoise.

5. Observations from the Grand Manan Ferry

Observers from CRG made a total of nine round trips on the Grand Manan ferry during the summer of 1980. The sighting positions of harbor porpoise and baleen whales along the cruise track are shown in Appendix C; the uncorrected sighting per unit effort values for harbor porpoise are given in Table VIII. The S/UE values followed the customary trend by reaching a maximum in August. They are, however, considerably higher than the values obtained in other parts of the study are in 1980. Several factors can be suggested to explain these differences. Observers on the ferry were on a stable platform some 7 m above the water surface, thus increasing the distance from the cruise track at which Phocoena might be sighted. False color infra-red imagery obtained during three overflights in August, 1980, showed an apparently permanent weed slick formed along a current boundary running parallel to the ferry route from the Wolves to Grand Manan. Studies by CRG in the inner Quoddy region have indicated that lower trophic level species reach high density levels under these weed slicks and the slicks then become preferential feeding zones for Phocoena. The ferry route crosses a shallow bank between the Wolves

TABLE VI

The Results of Three Survey Cruises for Harbor Porpoise
in the inner Quoddy Region in 1980
The Sighting per Unit Effort Values (per Hour) are Uncorrected

Date	Hours on Watch	Number of Phocoena Seen	S/UE
June 29	8.25	12	1.45
July 26	11.20	25	2.23
Aug. 13	10.8	13	1.20

TABLE VII

The Results of Four Offshore Survey Cruises for Harbor Porpoise
Made in the Vicinity of Grand Manan in 1980
The Sighting per Unit Effort Values (per Hour) are Uncorrected

Date	Hours on Watch	Number of Phocoena Seen	S/UE
July 14	11.9	6	0.50
July 27	6.2	42	6.77
Aug. 21	10.7	52	4.86
Aug. 25	7.5	13	1.73

TABLE VIII

The Observations Made from the Grand Manan Ferry in 1980
The Sighting per Unit Effort Values (per Hour) are Uncorrected

Date	Hours on Watch	Number of Phocoena seen	S/UE
June 24	3.5	0	0
26	3.85	0	0
July 5	3.72	10	2.69
19	3.77	31	8.22
26	3.82	10	2.62
Aug. 6	3.92	68	17.35
14	3.48	84	24.14
23	3.58	126	35.20
Sept.18	1.83	9	4.92
20	1.80	12	6.67
TOTAL	33.27	350	

and Grand Manan; large numbers of fish congregate here and it is a favorite fishing zone for both humans and harbor porpoise. Finally, as mentioned previously, the apparent abundance of herring offshore could have resulted in large numbers of Phocoena in this part of the study area. This region certainly warrants further study.

6. Toxicological Monitoring

CRG has monitored levels of organochlorines and mercury in harbor porpoise in the study area since 1969. Funds from the present contract were used to continue this work in 1980. Ten tissue samples were obtained from two animals and the levels of mercury determined (Table IX). Methods to analyze these samples for lead, cadmium and selenium are now being studied and results should be obtained by mid-1981. The levels of heavy metals in food species of harbor porpoise are also of interest. In 1980, CRG obtained tissue samples from 39 herring and seven pollock; these are presently being analyzed for the four metals mentioned above.

TABLE IX

Total Mercury (ppm) in Tissue Samples from Two Harbor Porpoise Collected in the inner Quoddy Region in August, 1980

Tissue	151 cm female	111 cm male
blubber	0.02	0.01
cerebellum	-	0.08
cerebrum	-	0.09
kidney	1.64	0.46
liver	13.86	0.83
muscle	0.52	0.14

Reanalysis of Data Bank Information

1. Energy Requirements of Phocoena

Energetic studies completed recently by Mr. W. Yasui produced a model energy budget for Phocoena (Yasui, 1980). Although many assumptions had to be made about essential parameters, it was possible to calculate energy intake estimates for male and female Phocoena of 49.8 and 59.4 $kcal.kg^{-1}.24h^{-1}$, respectively, and requirement estimates of 48.3 and 47.8 $kcal.kg^{-1}.24h^{-1}$. Sexually active females carry an additional energetic load, with a complete reproductive cycle costing approximately 320,000 kcal. These values compare favorably with those models published for other marine mammals. Aspects of this work are now being prepared for publication in the primary literature.

2. Density Estimates

Mr. D. Yurick is currently preparing computer compatible summaries of sighting data obtained by CRG from 1970-1979. These data comprise about 2,000 hours of observation and several thousand sightings of harbor porpoise (Yurick, 1977). Careful attention is being given to correcting the data with respect to the various factors mentioned previously. This time-consuming task should be completed early in 1981 and will result in quite accurate density estimates.

3. Habitat Utilization

The only social categories which can be determined with accuracy in the field are schools of female porpoises with young of the year. On average, 79 sightings of mother/calf pairs were made each year in the Quoddy region from 1970 to 1978. The uncorrected S/UE values for this social category, and for all other categories combined, are shown in Fig.12. CRG is in the process of analyzing these data and relating them to the various habitats found in the study area. Habitat characteristics are being defined by use of an oceanographic data base consisting of 2,500 temperature profiles, 50 current meter stations, surface drift marker experiments, and 300 false color infra-red aerial photographs. Work on this project should be completed also in early 1981.

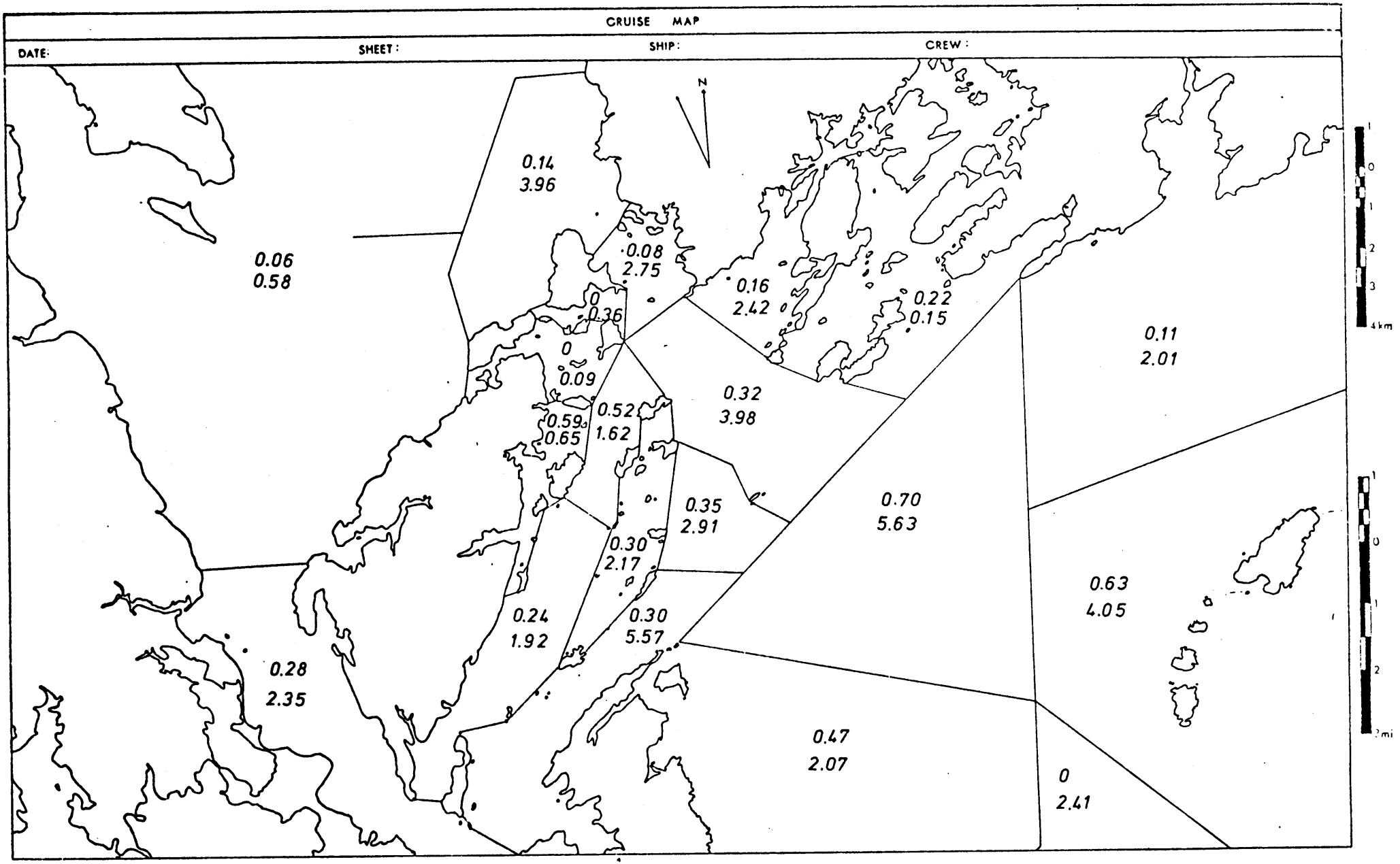


Fig. 12. Uncorrected S/UE values (per hour) for female harbor porpoise with young of the year (upper number) and all other harbor porpoise (lower number) averaged over the period 1970-1978.

Harbor Porpoise
Phocoena phocoena

A total of 265 harbor porpoise were seen during the course of eleven survey days. Of these nine were calves accompanied by cows, representing a population birth rate of 3.4% for all aerial observations.

The patterns of distribution shown here (Fig. 18) are based upon aerial, shipboard and land based observations. Porpoise distribution appeared to shift rapidly during the summer, but the causes behind the shifts remain unknown. There was no discernible pattern to distribution of cow/calf pairs observed from the air, but this is probably due to the limited number seen. Gaskin's reanalysis of ten years of observations show an apparent preference by cow/calf pairs for protected waters (Fig. 21).

The aerial survey data showed that the limit of sightability for harbor porpoise is approximately .35 nautical miles from the trackline at an altitude of 750 feet (Fig. 17). Analysis of the survey data was completed with a strip census method, taking into account the reduced effective strip width.

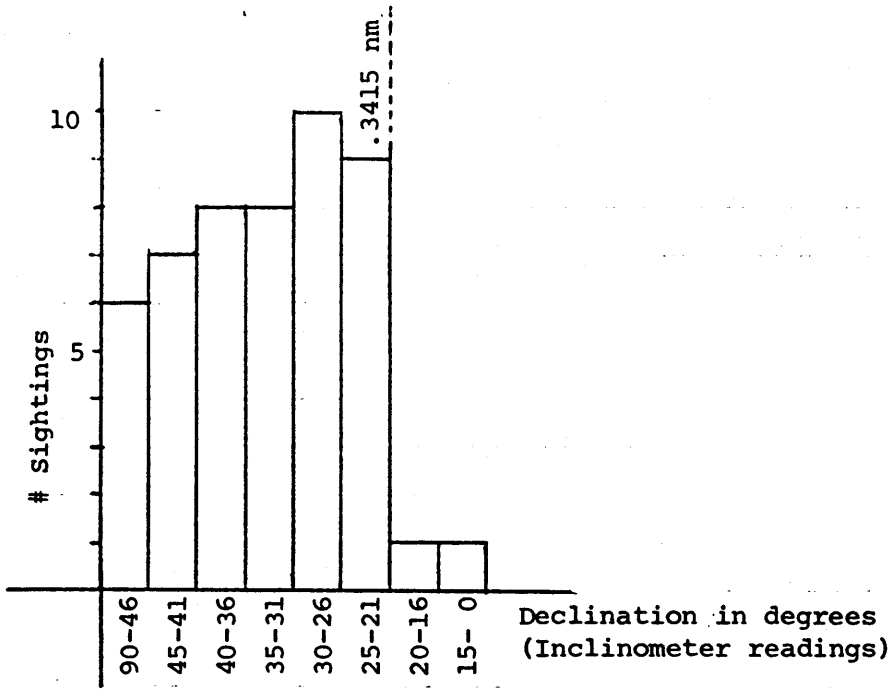


Fig. 17

Sighting Histogram for Harbor Porpoise (P. phocoena)
from Aerial Survey Data Taken at 750'

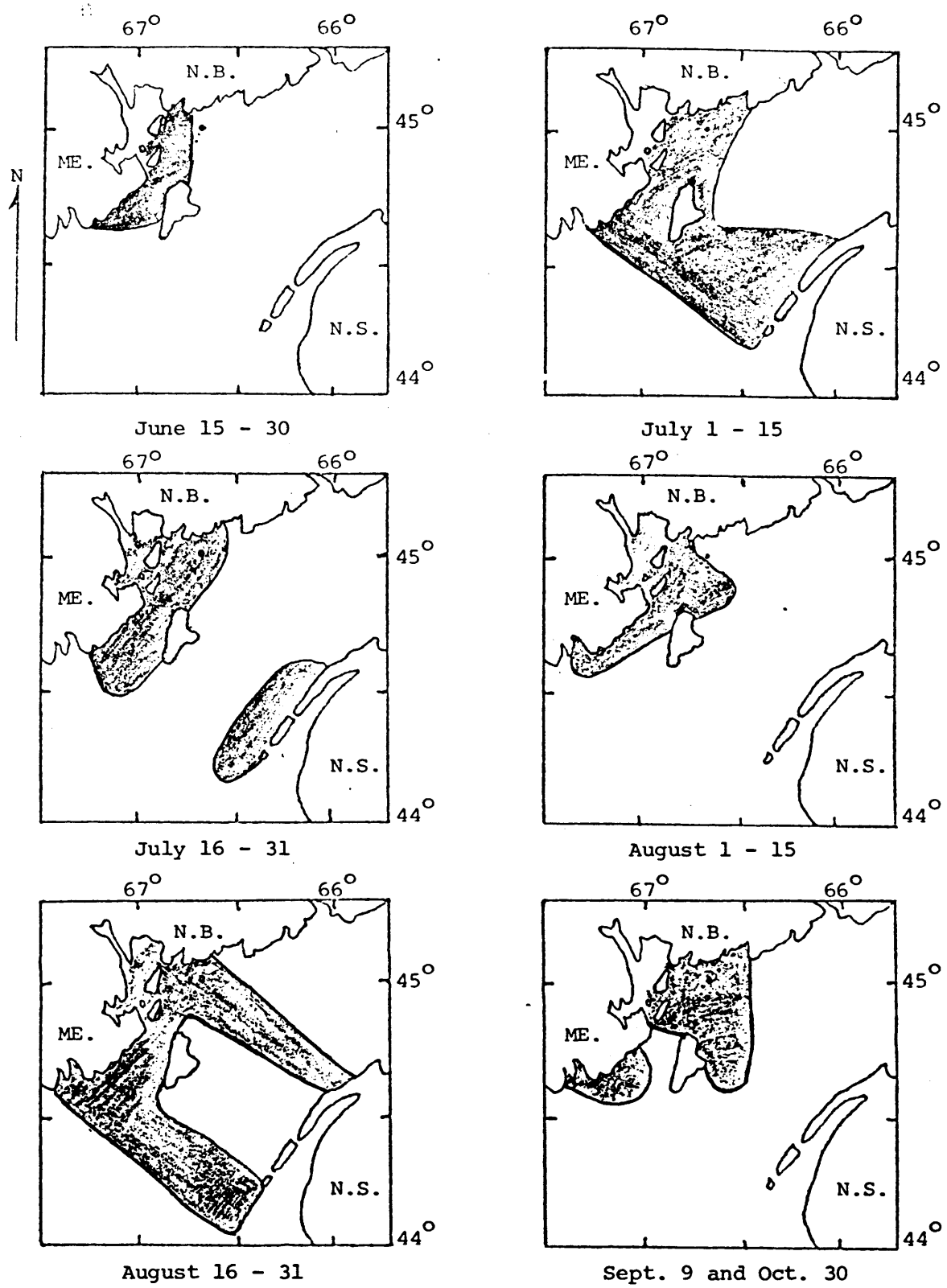


Fig. 14

Distribution of Harbor Porpoise, P. phocoena, in the Lower Bay of Fundy During the Summer and Fall of 1980

Results of the harbor porpoise survey experiment show that density estimates obtained in this fashion probably represent 14 percent of the actual density. Abundance estimates have been corrected to the 100 percent level and are given in Table VII below. The estimates show a gradual increase in abundance right up until our last random survey. Porpoise were still in the area on October 30.

TABLE VII

Harbor Porpoise (P. phocoena)
Bay of Fundy - 1980

Date	Survey & Day	Trackline Mileage	n	Uncorrected Density (D) (per sq.mi.)	Corrected Population (P) Estimates by Area (A) * A'B'C'	ABC
6/17	I - 1	259.2	1	.0056		64
6/18	- 2	240.5	4	.0244	139	
7/9	II - 1	259.4	15	.0847		967
7/10	- 2	240.6	12	.0730	417	
8/1	III - 1	254.5	38	.2186		2497
8/11	IV - 1	239.3	2	High sea state precludes analysis		
8/14	- 2	125.4	14	.1635	933	
8/29	V - 1	231.3	36	.2279		2603
8/30	- 2	99.2	41	.6051	3456	

$$D = \frac{n}{2L(.3415)}$$

$$P = D(A)(7.14)$$

where

$(A) = A'B'C' = 800nm^2$

or $(A) = ABC = 1600nm^2$

* These estimates are corrected (x 7.14) from the experimental results showing aircraft sighting efficiency is 14%.

SUBSISTENCE TAKE

Methods

Reports that harbor porpoise (P. phocoena) are hunted and taken for human consumption in the Passamaquoddy Bay, Bay of Fundy, and Gulf of St. Lawrence regions have persisted for a number of years (Prescott and Fiorelli, 1980). A seasonal take of unknown magnitude by the Passamaquoddy Indians of Perry, Maine, prompted a review of historical, archeological information, and current practices. A series of interviews were conducted during August, 1980, under contract to the University of Maine at Orono. Nine members of the tribe were interviewed, including members of the tribal council and porpoise hunters.

Overview

The hunting of marine mammals by native peoples of northern Maine in historic times has been well documented (Gilpin, 1878; Ward, 1880; Michaelson, 1935; Leighton, 1947; Eckstorm, 1945; David, 1974; Erickson, 1978), though its aboriginal origins remain a matter of debate. Porpoise hunting reached a peak during the 19th century (Mitchell, 1975) at which time the animals were utilized primarily for oil rather than human consumption. The industry gradually died out with the introduction of petroleum. Men of the Passamaquoddy trible, however, continued to hunt on a limited seasonal basis (Speck, 1940). Meat was given away to other members of the tribe or traded for bear and moose meat among the Passamaquoddy tribesmen located farther inland (Newell Tomah, pers. comm.).

Hunting was accomplished by two men in a twenty-foot long birch bark canoe. The bow man was equipped with a shotgun (a ten-bore, long barrel muzzle loader) and a 12-foot lance or gaff. As the hunters approached the porpoise the bow man shot as the stern man paddled quickly in order to reach the animal before it sank. The porpoise was speared and held until it was dead, then lifted over the side of the boat by the man in the stern (Leighton, 1937). Hunting techniques have changed little since the 1800s. Porpoise hunters now use small boats with 25 horsepower motors. An individual may hunt alone using a 12-gauge shotgun.

Hunting persisted until the 1940s with catch estimates of 100+ during the summer season (Prescott and Fiorelli, 1980) and harbor porpoise meat was a common dietary item on the Passamaquoddy Indian reservation. Meat was often smoked. The pectoral fins were considered a delicacy and were often cooked on the shore immediately after the animal was captured (Wayne Newell, pers. comm.).

Harbor porpoise hunting, however, probably declined during the first half of the twentieth century. Many men were lost or disabled during World War I; many were unemployed and families were on welfare. Population levels on the reservation declined as people moved to the cities in search of work (Stevens, 1978). Concurrent with the rise in interest in civil rights issues in the early 1960s, a resurgence in native pride took place as tribal leaders became politically active, the Passamaquoddy land claims gathered momentum, native crafts and the hunting of traditional prey species was encouraged.

Interviews with non-native residents in the area, particularly those who have lived in the Passamaquoddy Bay/Bay of Fundy region over the last 50 years, indicate that the non-native population probably engaged very little in harbor porpoise hunting (Fred Cook, pers. comm.). Some people claim to have tasted porpoise meat, though the consensus was that these animals were obtained from weirs in which they had become entrapped (Lee Cox, pers. comm.). There are no present reports of any direct take other than the hunt described below.

Current Subsistence Take

The magnitude of porpoise hunting effort in recent years does not match that of earlier times. The Marine Mammal Protection Act of 1972 acts as a deterrent and the number of hunters within the tribe has diminished. Tribal sources maintain that four or five hunters are involved in a direct take today and that only one individual does so on a regular basis (Norman LaBerge, pers. comm.). Most hunters have learned the skill from older members of the tribe, usually relatives. The season begins in the spring (May) and continues through

the fall. Hunting is organized on a demand basis as tribal members make requests for meat when the need or desire arises. Apparently as many as fifty animals have been taken in a season. However, by the end of August in 1980 the total catch had amounted to only five animals. The largest animals are the most desirable as the yield of meat is greater. This may result in a hunting bias toward females, since Gaskin and Blair (1977) indicate that females attain a greater length at physical maturity than males. Calves are not hunted. When full-time hunting is undertaken, as many as six harbor porpoise may be taken in a single week by a skilled hunter, but this effort is related to the demand for porpoise meat within the tribe.

The loss rate appears to be variable. One hunter claimed almost complete accuracy during the 1979 season with a take of fifty ($\pm$) animals. Information from the same individual concerning the 1980 season (June - August) reveals that three harbor porpoise were struck and lost and five were taken. Hunters claim that the porpoise must be hit in the center of the rib cage and must be hauled on-board within 60 seconds in order to avoid losing it.

Passamaquoddy hunters believe that harbor porpoise occur in greater numbers in the Eastport/Deer Island area during the flood tide, just after it has turned. It is this factor that influences the time of day during which they hunt. Because of the legal ramifications of hunting marine mammals, hunters will often not return to U. S. waters with porpoise carcasses. Instead, animals are usually cleaned on the small Canadian islands in and around Head Harbour Passage.

Canadian authorities regularly patrolling the Head Harbour Passage area believe that harbor porpoise are not hunted in great numbers, contending that any large catch would come to their attention since the area is frequented by many boats. They have no information on how large the take may be and/or how many hunters exist (Corp. J. Clark, RCMP, pers. comm.).

Historical Subsistence Take of Marine Mammals

Evidence of aboriginal hunting of marine mammals by coastal Maine peoples is confusing because of substantial gaps in the historical record. Gilpin (1878) and Leighton (1937) claim that porpoise hunting was a recent development among the tribes of the northeast and one almost certainly acquired as a result of contact with Europeans. Modern Indians such as the Passamaquoddy claim that the hunting of marine mammals is a practice that has been handed down from generation to generation since ancient times (Wayne Newell, pers. comm.), and there is some evidence to support this idea (Rand, 1894; Eckstorm, 1932). Since written records are not available until the early 1600s, after at least 100 years of trade with Europeans, it is difficult to assess the situation during precontact times (Sanger, 1979). Early coastal archaeological sites that may have provided information have probably been destroyed, because coastal submergence in the Bay of Fundy and the eastern Gulf of Maine has occurred at the rate of one foot per 100 years over the past 4,000 years (Grant, 1970).

Little archaeological data exists to document the early in habitants of Maine during the Early and Middle Archaic Periods (11,000-5,000 B.P.), though it is known that the inhabitants lived in a tundra environment (Sanger, 1979). However, approximately 5,000 years ago a different culture emerged. Its origins remain unclear, but it appears that it was primarily a hunting and fishing culture with a preference for sites located on streams and small lakes (Snow, 1972). As coastal adaptations appeared, maritime hunting began to play a dominant role. Bourque (1979) reported substantial finds of animal bone at the Turner Farm site in Penobscot Bay indicating that swordfish (Xiphias gladius) and grey seal (Halichoerus grypus) were commonly hunted 4,500 years ago.

A variant of this culture is described by Tuck (1971) on the basis of hunting implements and osteological remains discovered at Point au Choix, Newfoundland. This culture extended northward to Quebec and southward to northern New England and included the Maritime Provinces, Newfoundland, and Labrador. It was

characterized by the exploitation of the woodland caribou (Rangifer caribou), marine mammals, sea birds, and fish. Burial sites dated between 3,200 and 4,000 B.P. indicated an elaborate bone industry producing such hunting artifacts as barbed and toggle harpoon heads (probably used for sealing), large whale bone lances up to 50 cm. long, foreshaft-like instruments also made of whale bone, and daggers made of split and carved walrus tusk. Tuck's excavations also yielded charms and amulets made from the claws and teeth of the martin, otter, and seal; and a carved stone effigy of a killer whale. The origins of this culture are unknown, though distinct similarities exist among sites as distant as Port au Choix and Waterville, Maine, particularly after 4,500 B.P. (Bourque, 1979). No traces of coastal marine mammal hunters occur in Passamaquoddy Bay during this period, possibly because rising sea levels have destroyed earlier sites (Sanger, 1971).

Around 3,000 B.P. subsistence patterns in Maine changed in a rather dramatic way. Sanger (1979) attributes this change to the appearance of a southern culture and Tuck (1978) maintains that this group of interior hunters moved to the coast and replaced the maritime peoples. It is from this period that the Algonkian speaking ancestors of the prèsent Micmac, Maliseet, and Passamaquoddy tribes are traced. Dependence on shellfish as a protein source made its appearance, probably as a result of climatological shifts, the development of aboriginal technology, and the disappearance of the woodland caribou (Snow, 1972) (Bourque (1979) indicates that this may have occurred earlier).

Shell midden sites dot the coast of Maine and indicate prehistoric man's preference for the common clam (Mya arenaria). Nevertheless, faunal remains excavated from these sites reveal that other species were relied upon as part of a subsistence pattern which began with the advent of the Ceramic Period, 2,000 B.P. (Tuck, 1978). The Minister's Island site in Passamaquoddy Bay dates from about 1,000 to 400 B.P. and contains beaver and deer bone fragments. Marine mammal remains include the harbor seal (Phoca vitulina), harp seal (P. greenlandica), grey seal (P. grypus), and hooded seal (Cystophora cristata) (Bonnichsen and Sanger, 1977). Further south, the Grindle site, located in the vicinity of Blue Hill Bay, has provided information about subsistence patterns in the

twelfth century A.D. Midden remains have preserved shells, and fragments of bone. Analysis has revealed five dominant species; beaver, moose, deer, bear, and harbor seal, in that order (Snow, 1972).

Little archaeological evidence exists to indicate a systematic exploitation of marine mammals other than the Phocidae during the Ceramic Period, though cetaceans were certainly available to prehistoric man. Eckstorm (1932) suggests that porpoise, as well as seal oil was used by Maine Indians and also claims that whales were forced to strand in shallow waters where they could be easily killed.

If early historic records are to be relied upon to describe aboriginal life style, it is important to recognize that settlement and subsistence patterns in the sixteenth century may already have been affected by exposure to European influences (Bourque, 1973). Lescarbot (1611), a contemporary of Champlain in the early 1600s, gives a detailed account of whale hunting. Indian inhabitants of the Gulf of St. Lawrence areas are described as approaching whales in canoes and dispatching the animal with harpoons driven into the blowholes. Father Peter Biard, a Jesuit priest working among the Indians of Maine in 1616, gives an extensive list of species exploited and includes the harbor seal. His information is confusing, however, in that he describes the pupping season of this species as January (Thwaites, 1959), indicating either grey or harp seal as the probable species. The Etchemins, who later gave rise to the Passamaquoddy tribe, are described by Eckstorm (1945) as "sea-faring, tide-dwelling Indians, expert canoemen, hunting principally the porpoise and the larger fishes." Rand (1894) supports the notion that marine mammal hunting has ancient origins by recording Micmac legends concerning whale hunting. His Micmac sources claimed that these stories had been handed down over many generations.

There is speculation that the now extinct gray whale in the western north Atlantic was at least partially reduced by aboriginal peoples (J. Mead, pers. comm.). Russell (1980) noted that stranded whales were butchered by local villages and were considered the property of the chief sachem in Massachusetts in the sixteenth century. Postcontact data in that area indicate that from Cape Cod eastward Indians hunted seals, porpoise and whales from dugout canoes. Seal and

porpoise oil was preserved in skins, jars, and gourds and buried for future use. It also was combined with deer's brain and used for softening hides (Russell, 1980). However, Salwen (1978) contends that in southern New England, porpoise and whales do not appear to have been systematically hunted in precontact times, though stranded individuals were frequently utilized.

By the nineteenth century it was a common sight to see Indians in Passamaquoddy Bay hunting porpoise by means of canoe and shotgun (Davis, 1974). Prescott and Fiorelli (1980) reviewed the commercial exploitation of the harbor porpoise during this period.

In conclusion, the tradition of hunting marine mammals by Maine's native peoples can be documented from the prehistoric period. Seals in particular have been exploited since precontact times. Documentation to support the notion of prehistoric whaling is difficult, though it may have been a common local practice. A subsistence take involving small cetaceans remains poorly documented. Small cetaceans were probably hunted by early inhabitants of the Maine-Maritimes area but a direct link has yet to be established between these people and the later Algonkians, the predecessors of today's Indian tribes in northern Maine.

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APPENDIX A-1

LAND STATION DATA

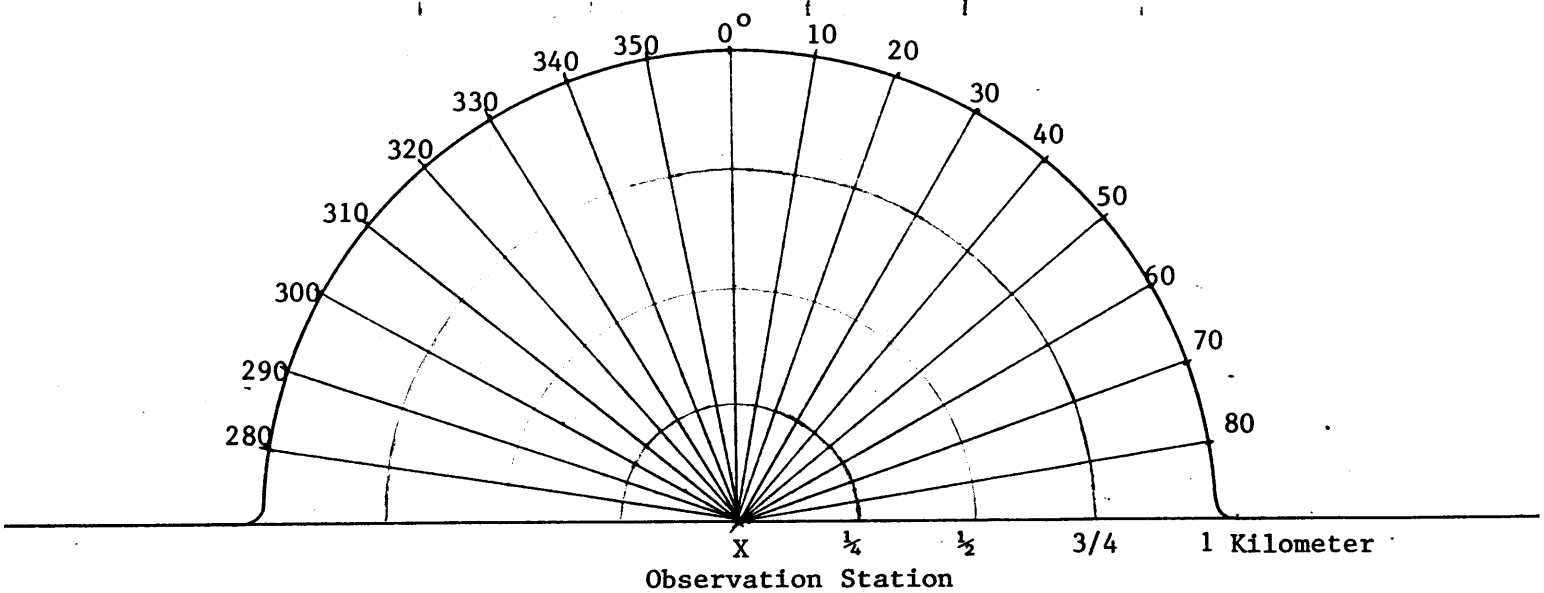
Date_____ Station #_____

Observers_____ Glare_____ Visibility_____

_____ Cloud cover_____ Sea State_____

_____ Wind_____

Time	Species	# Animals	Bearing	Range	Heading	Comments



VESSEL TRANSECT DATA

Date_____ Visibility _____ Glare _____

Vessel_____ Sea State _____ Wind_____

Vessel Speed_____ Cloud Cover_____

Transect # ____ Start_____ End _____

Transect description_____

Observers_____

Time	Species	#	1st Sighting bearing (°)	1st sighting range (m.)	animal heading	∟ distance	Comments

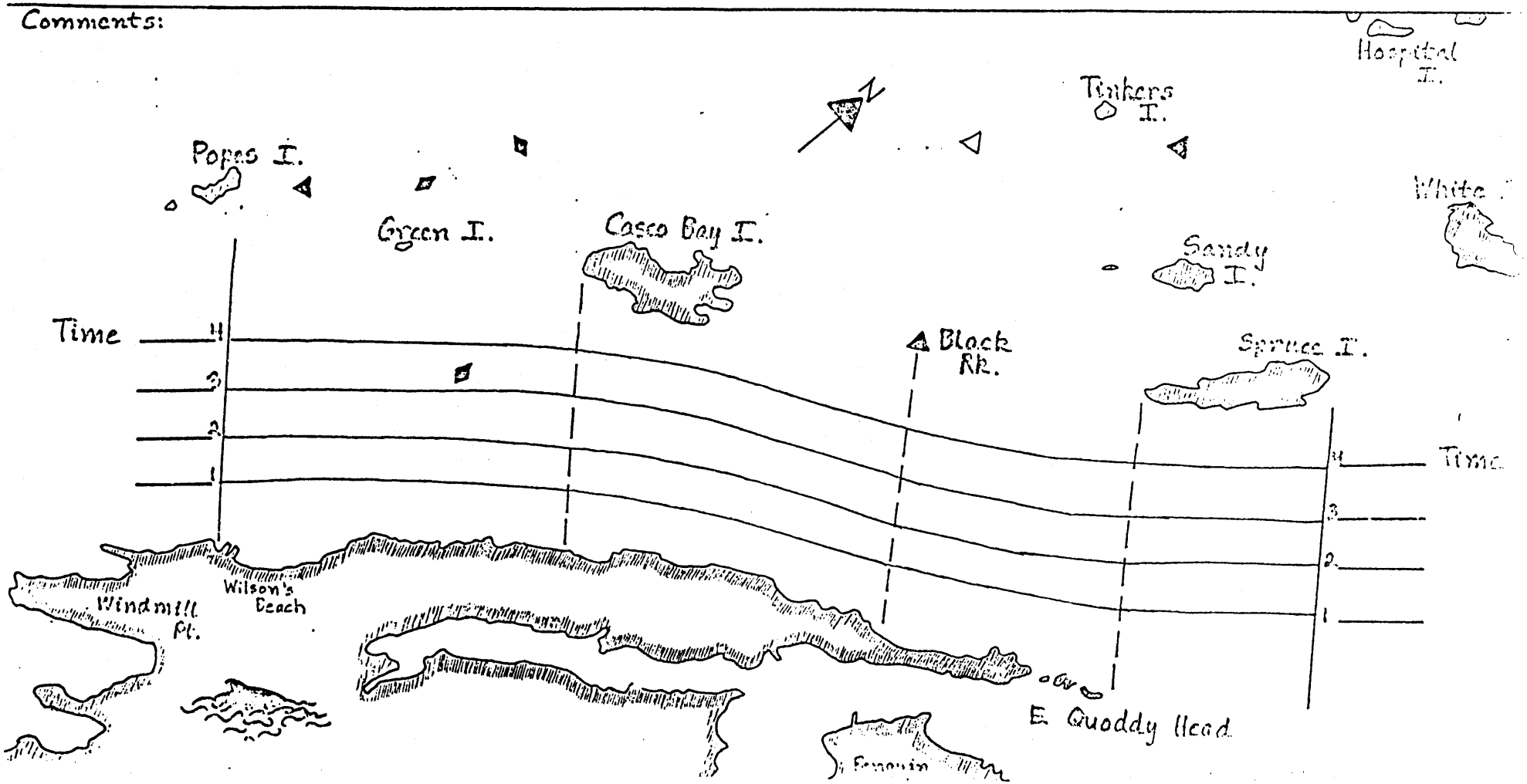
Date _____ AERIAL DATA - PHOCOENA PHOCOENA Height _____ Page _____

Observers: Speed _____ Visibility _____

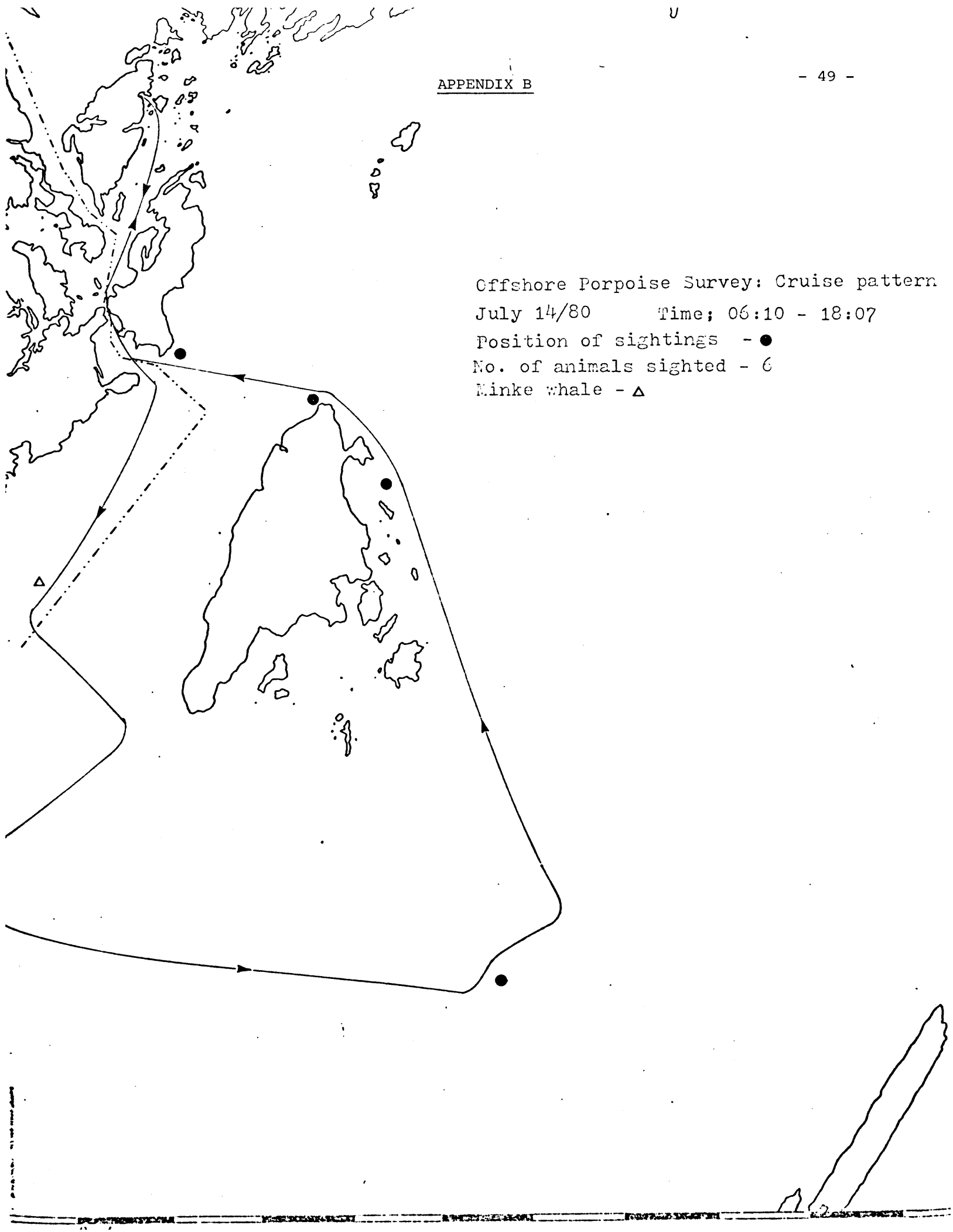
Trial # _____ Glare _____ Sea State _____

Transect # _____ Cloud Cover _____ Wind _____

Comments:

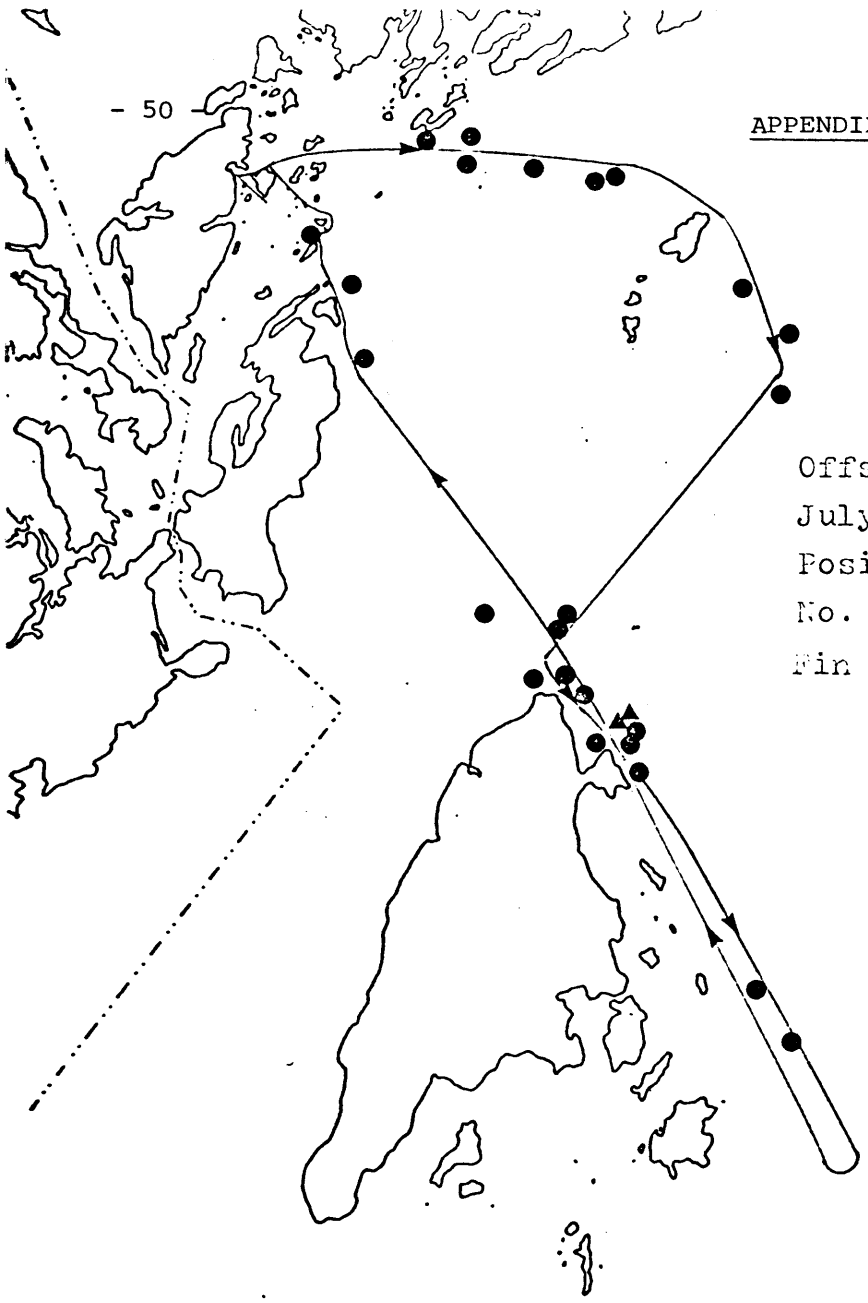


APPENDIX B

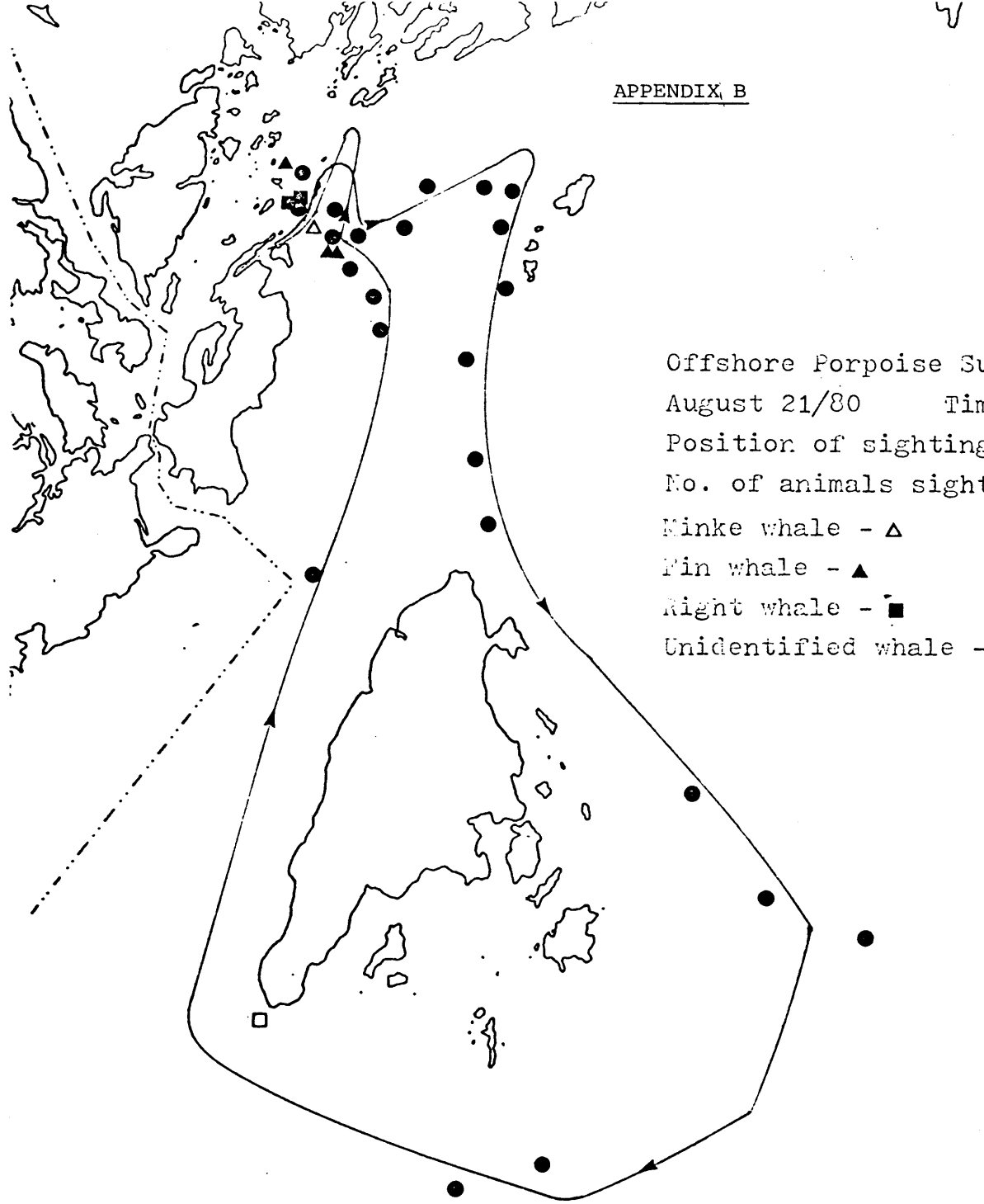


Offshore Porpoise Survey: Cruise pattern
July 14/80 Time; 06:10 - 18:07
Position of sightings - ●
No. of animals sighted - 6
Minke whale - △

APPENDIX B

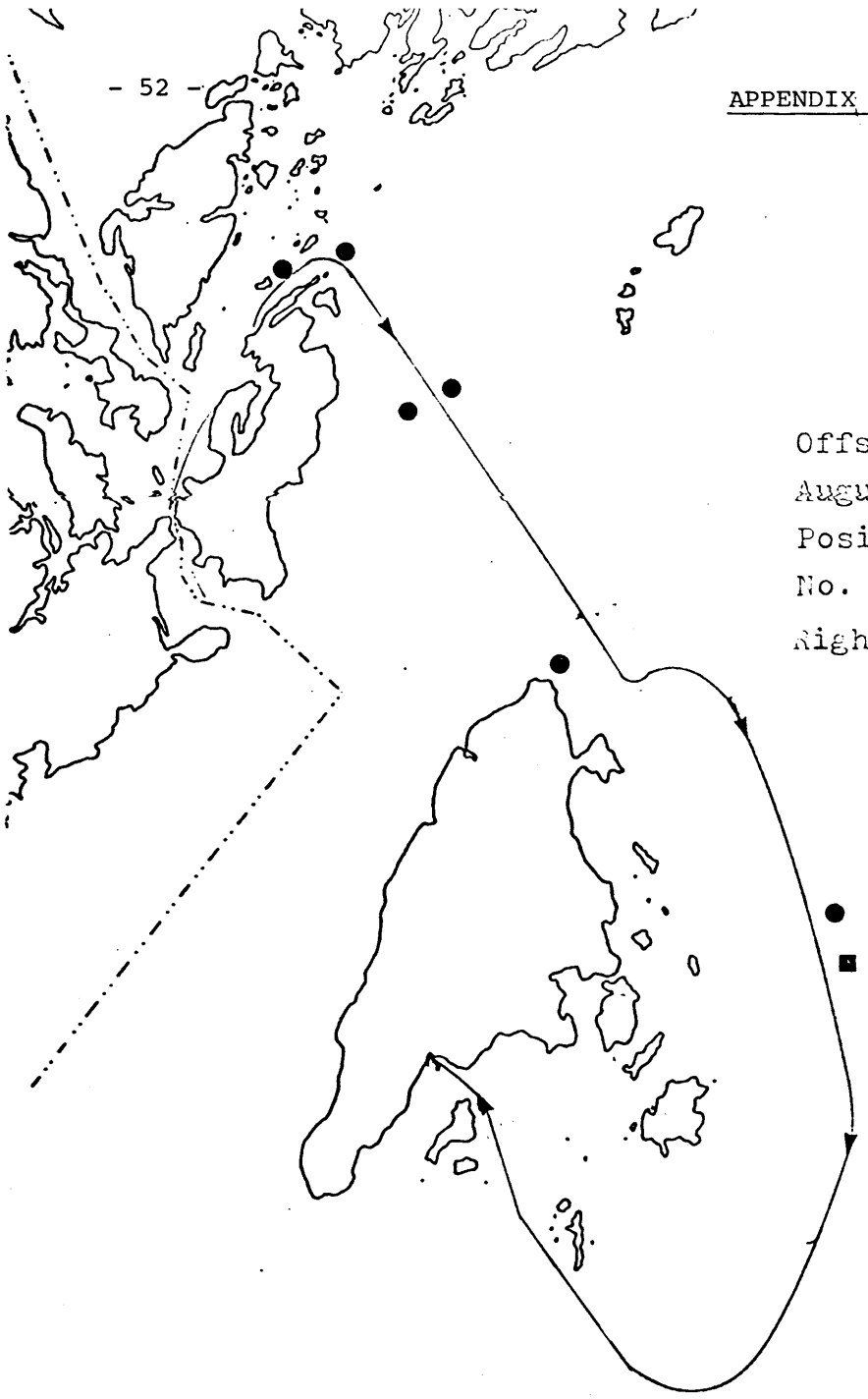


Offshore Porpoise Survey: Cruise pattern
July 27/80 Time: 13:22 - 19:35
Position of sightings - ●
No. of animals sighted - 42
Fin whale - ▲



Offshore Porpoise Survey: Cruise pattern
August 21/80 Time: 08:20 - 19:00
Position of sightings - ●
No. of animals sighted - 52
Minke whale - △
Fin whale - ▲
Right whale - ■
Unidentified whale - □

APPENDIX B



Offshore Porpoise Survey: Cruise pattern
August 25/80 Time: 09:02 - 14:30
Position of sightings - ●
No. of animals sighted - 13
Right whale - ■

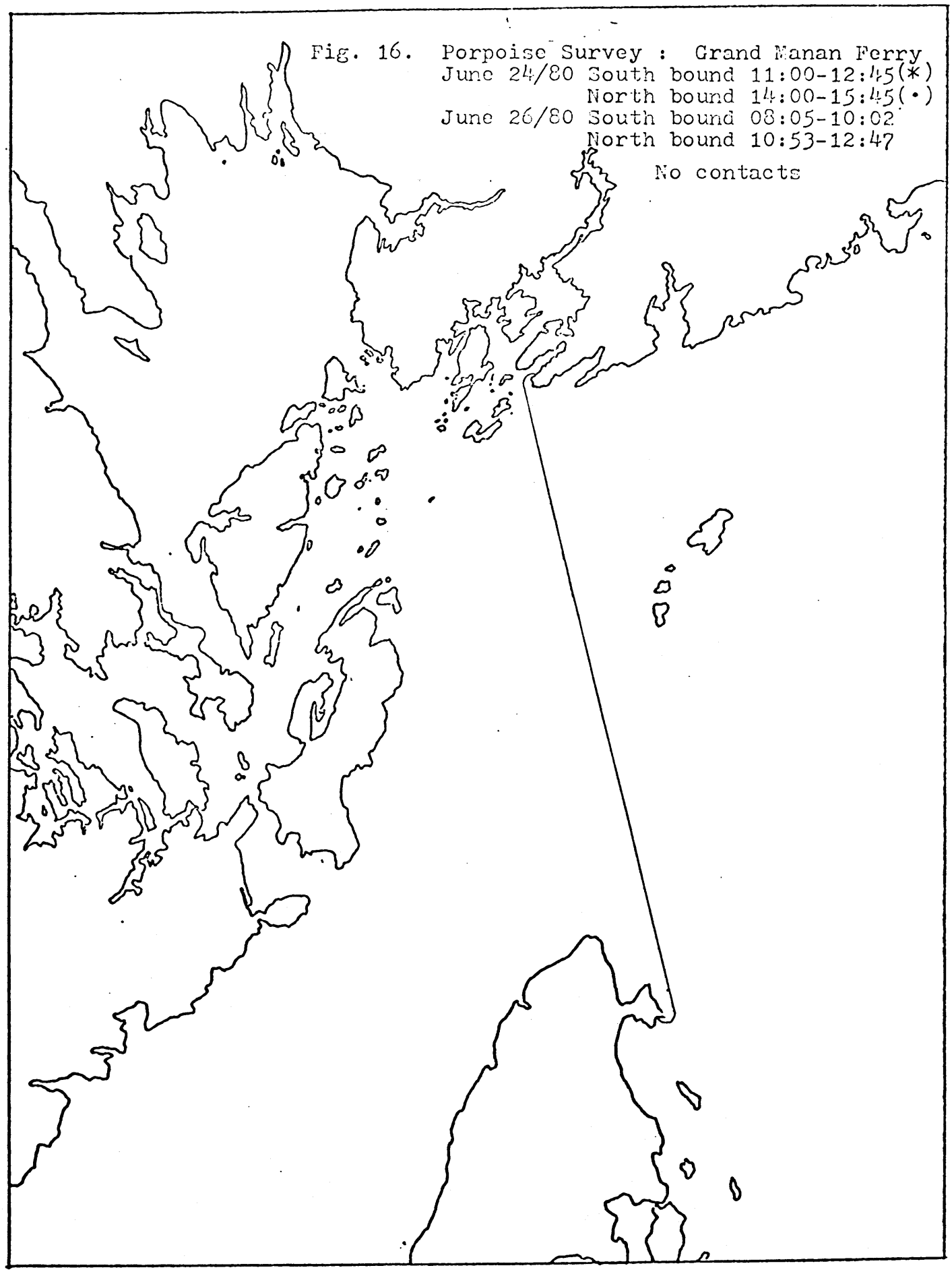
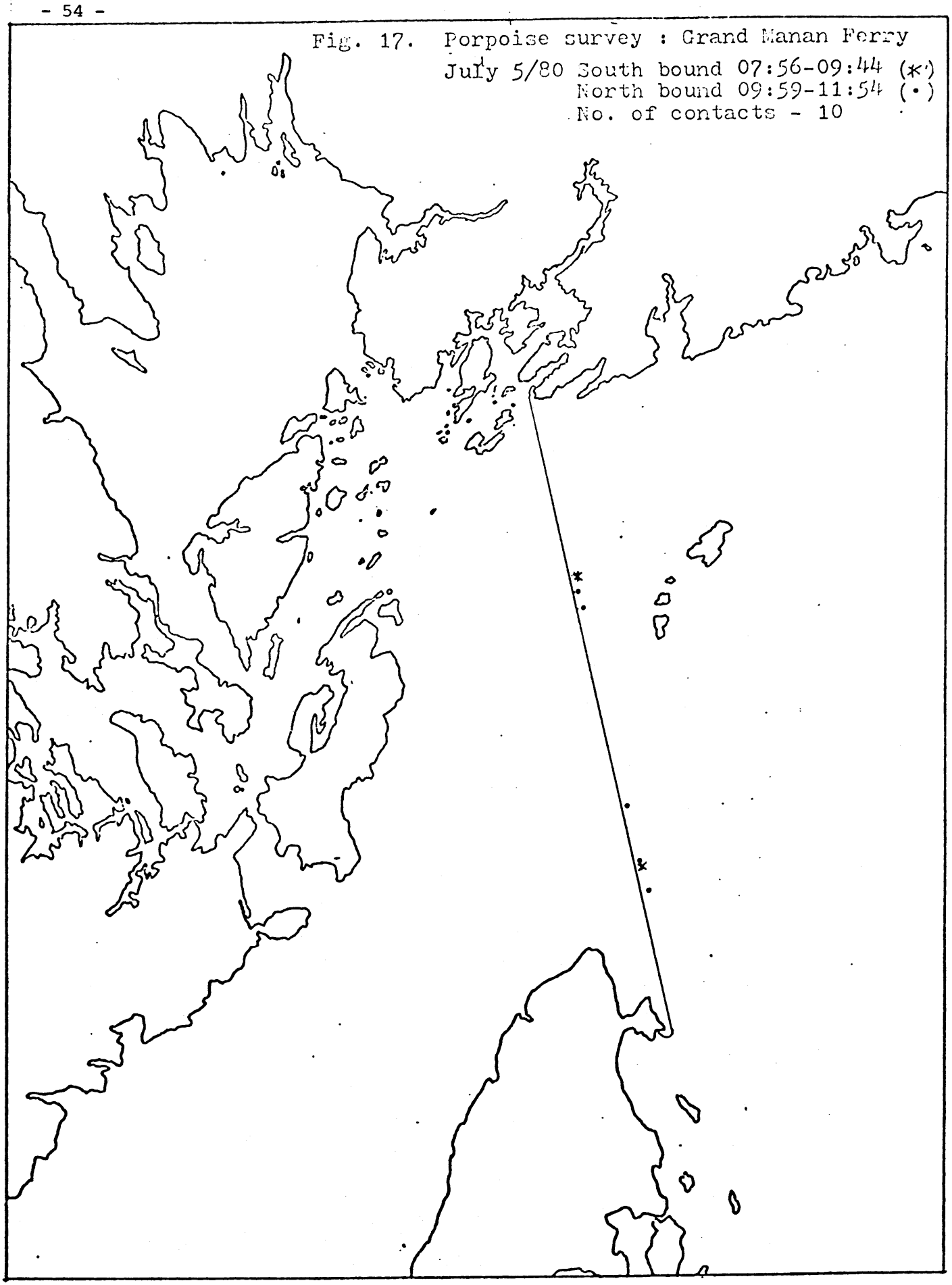


Fig. 16. Porpoise Survey : Grand Manan Ferry
June 24/80 South bound 11:00-12:45(*)
North bound 14:00-15:45(•)
June 26/80 South bound 08:05-10:02
North bound 10:53-12:47
No contacts

Fig. 17. Porpoise survey : Grand Manan Ferry
July 5/80 South bound 07:56-09:44 (*)
North bound 09:59-11:54 (•)
No. of contacts - 10



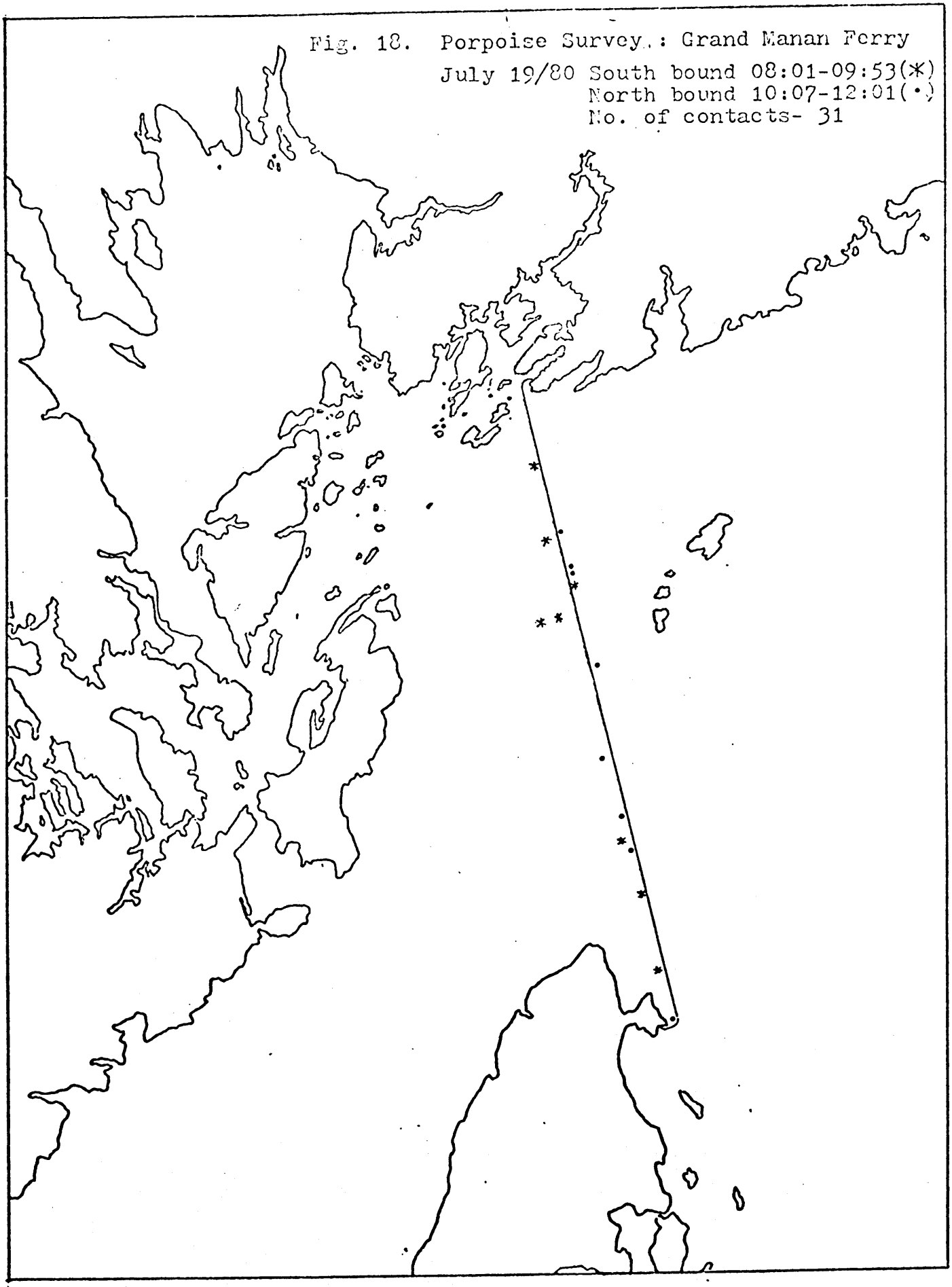


Fig. 18. Porpoise Survey.: Grand Manan Ferry
July 19/80 South bound 08:01-09:53(*)
North bound 10:07-12:01(•)
No. of contacts- 31

APPENDIX C

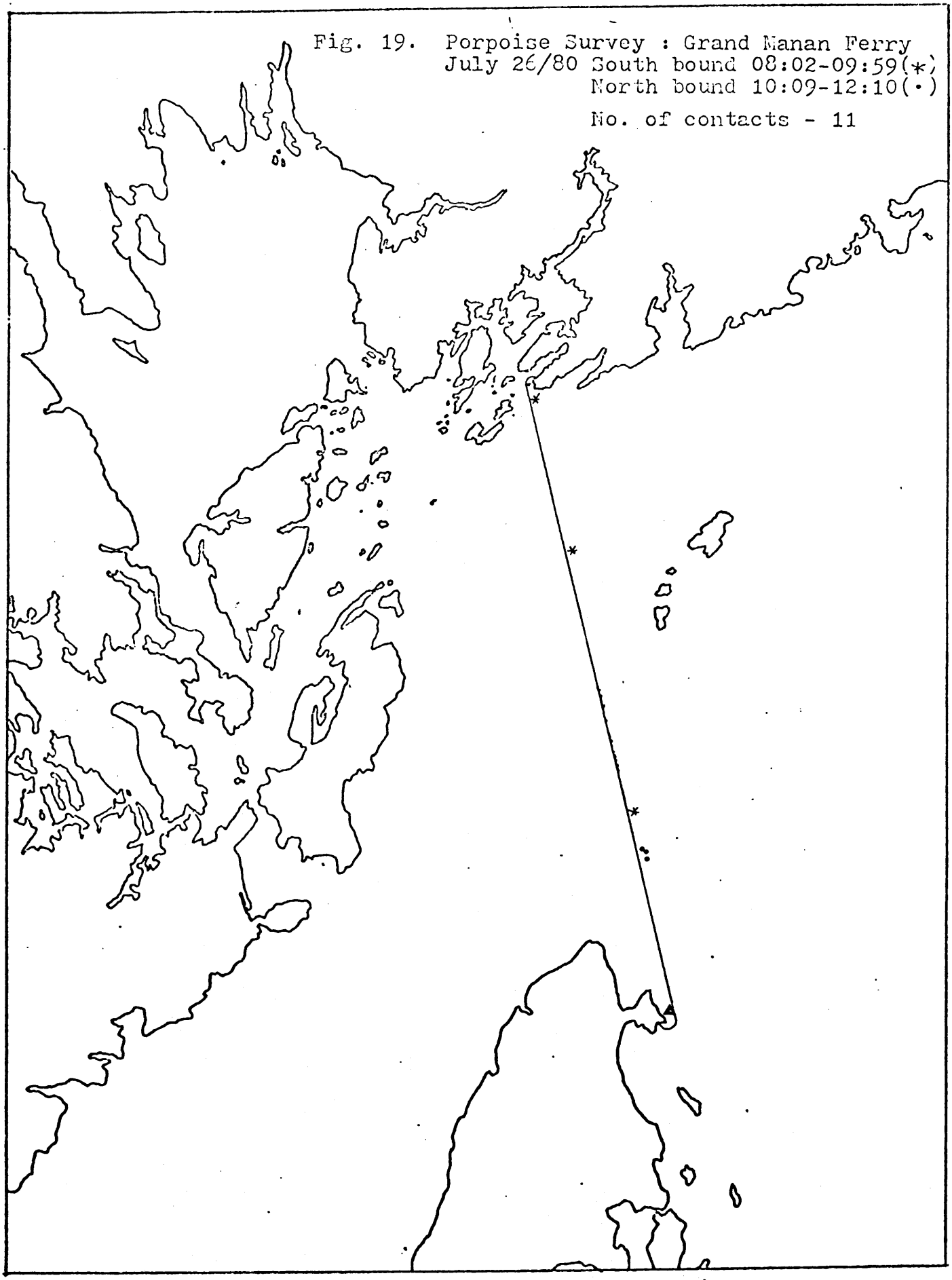


Fig. 19. Porpoise Survey : Grand Manan Ferry
July 26/80 South bound 08:02-09:59(*)
North bound 10:09-12:10(•)
No. of contacts - 11

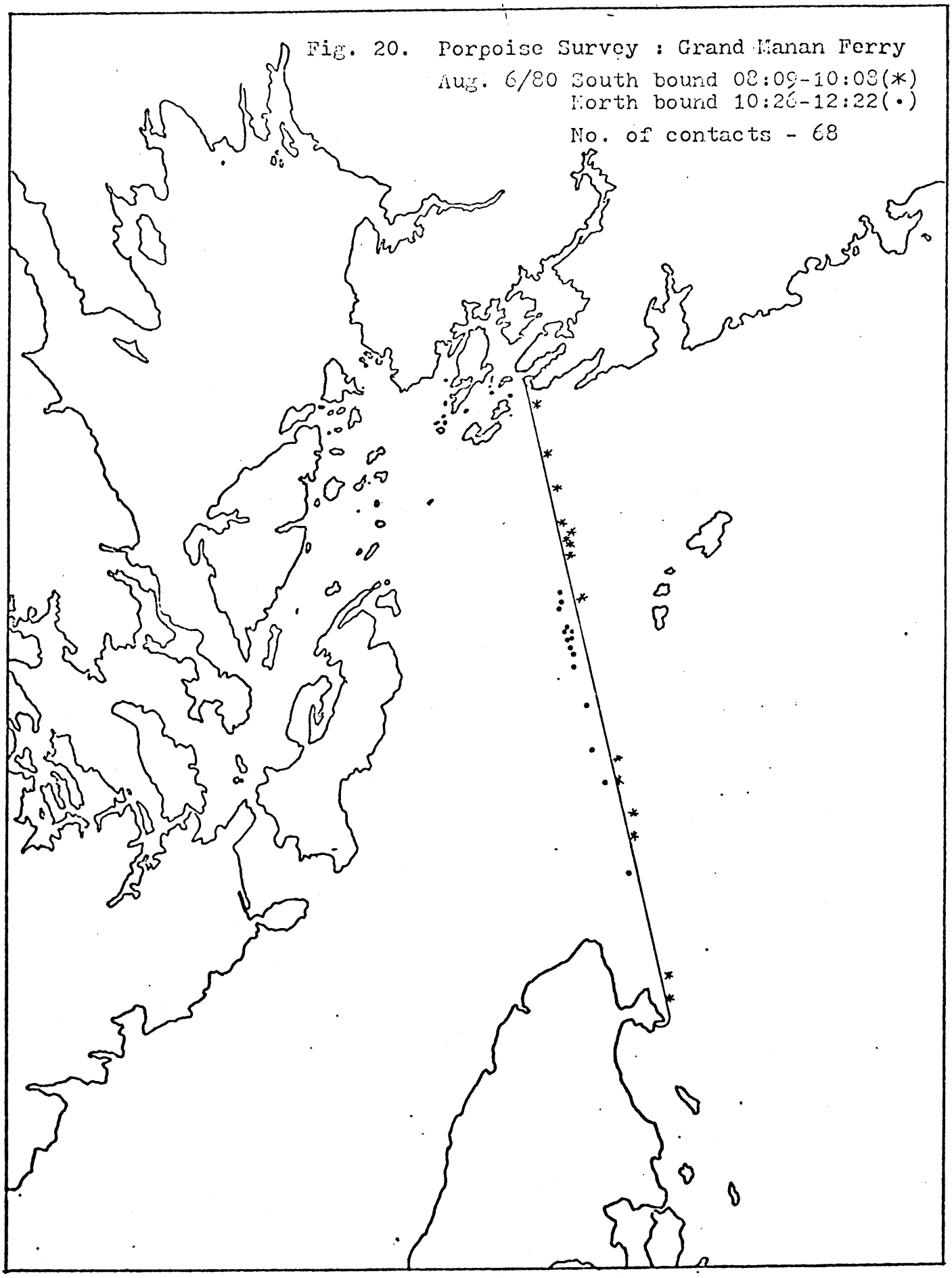


Fig. 20. Porpoise Survey : Grand Manan Ferry
Aug. 6/80 South bound 08:09-10:08(*)
North bound 10:26-12:22(•)
No. of contacts - 68

APPENDIX C

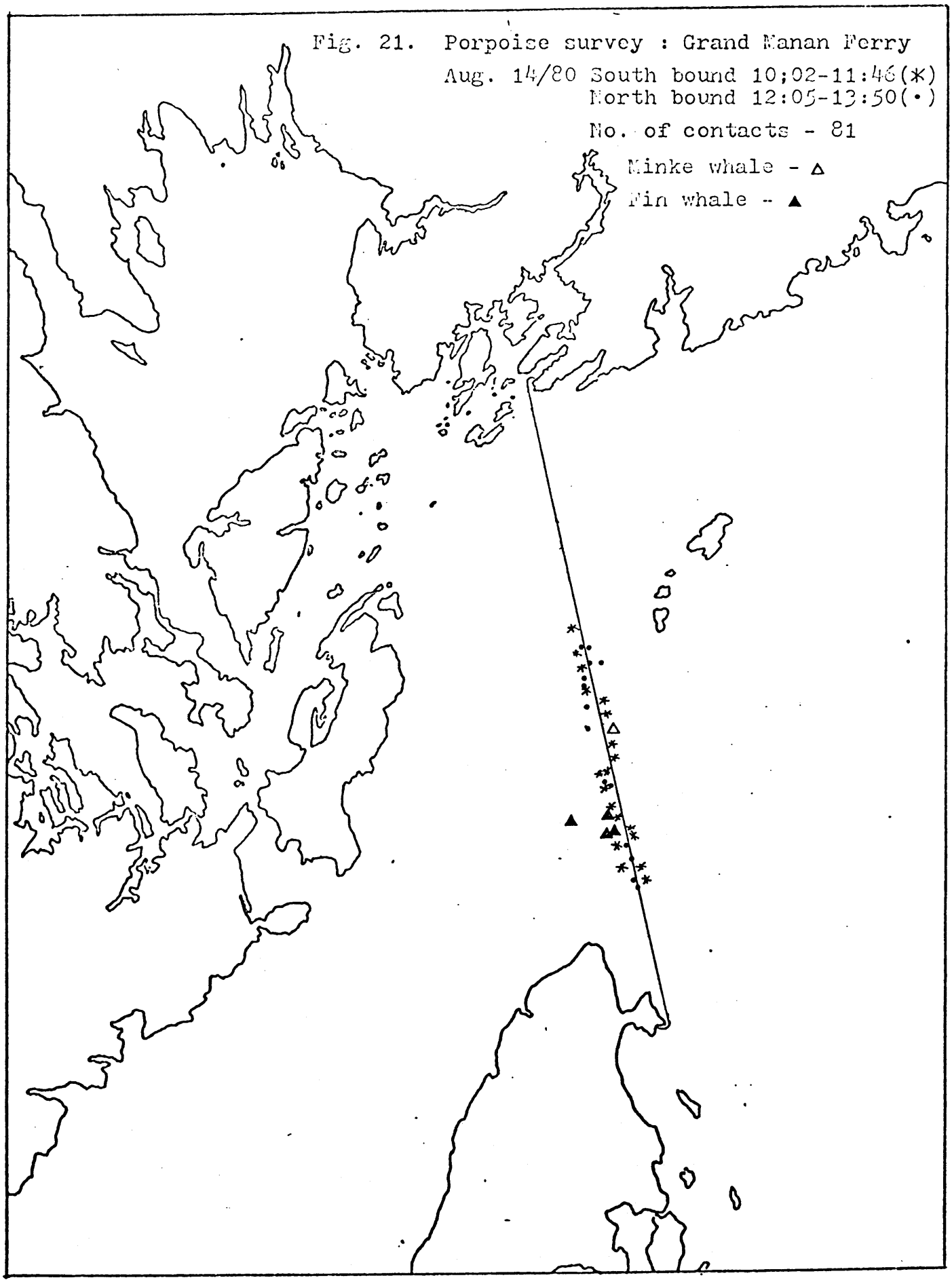


Fig. 21. Porpoise survey : Grand Manan Ferry
Aug. 14/80 South bound 10;02-11:46(*)
North bound 12:05-13:50(•)
No. of contacts - 81
Minke whale - △
Fin whale - ▲

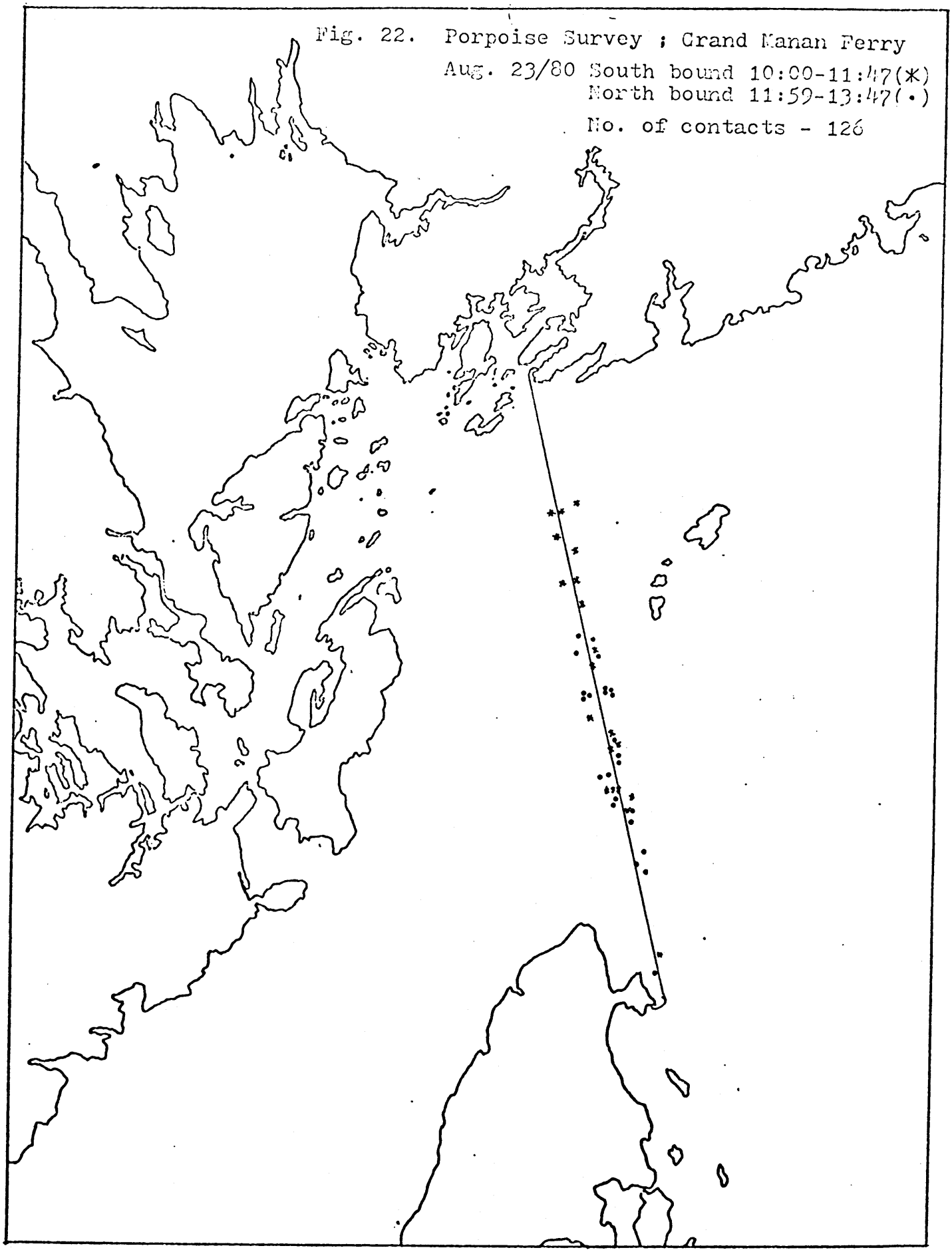


Fig. 22. Porpoise Survey ; Grand Manan Ferry
Aug. 23/80 South bound 10:00-11:47(*)
North bound 11:59-13:47(•)
No. of contacts - 126

APPENDIX C

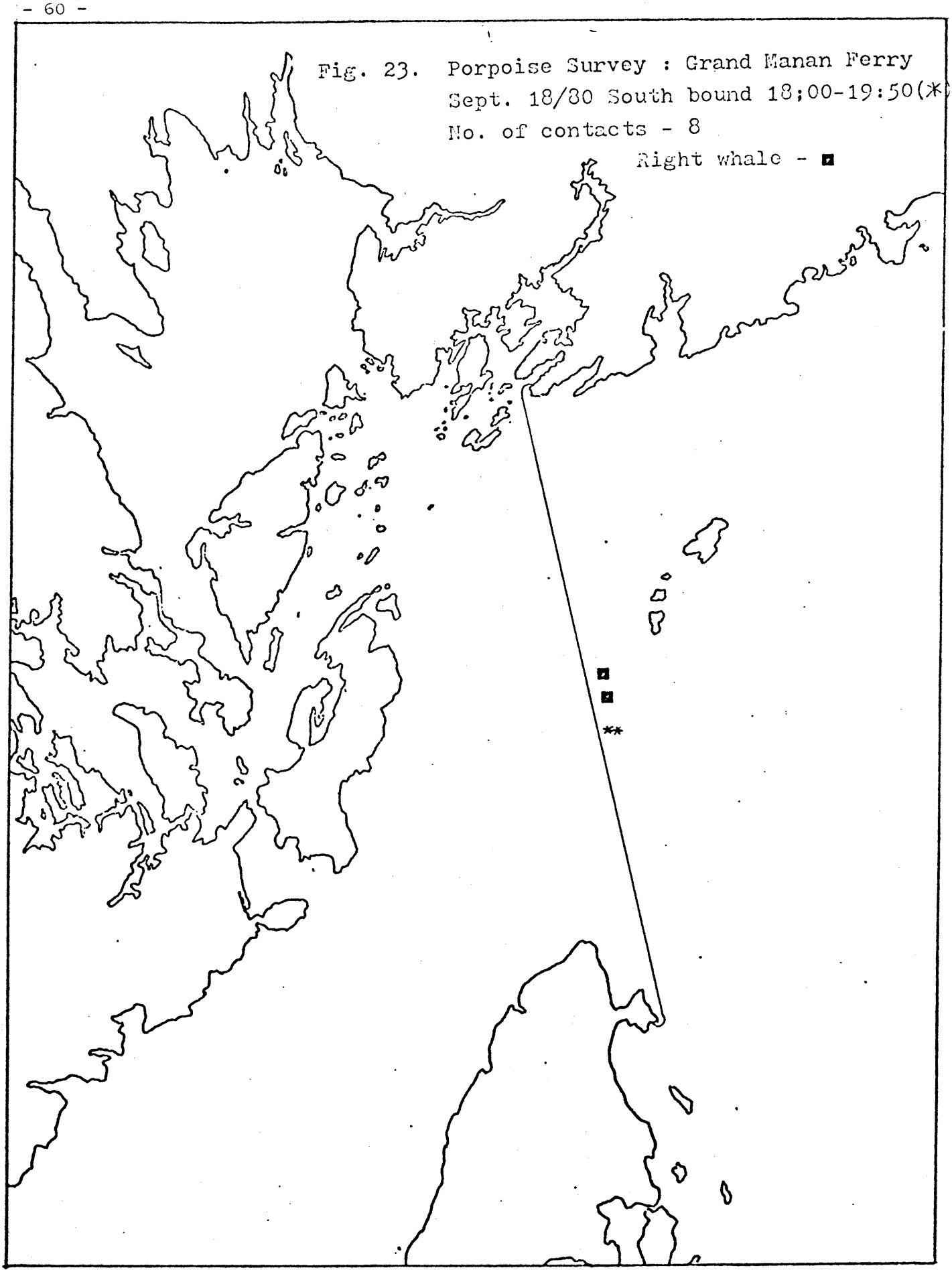


Fig. 23. Porpoise Survey : Grand Manan Ferry
Sept. 18/80 South bound 18;00-19:50(*)
No. of contacts - 8
Right whale - ■

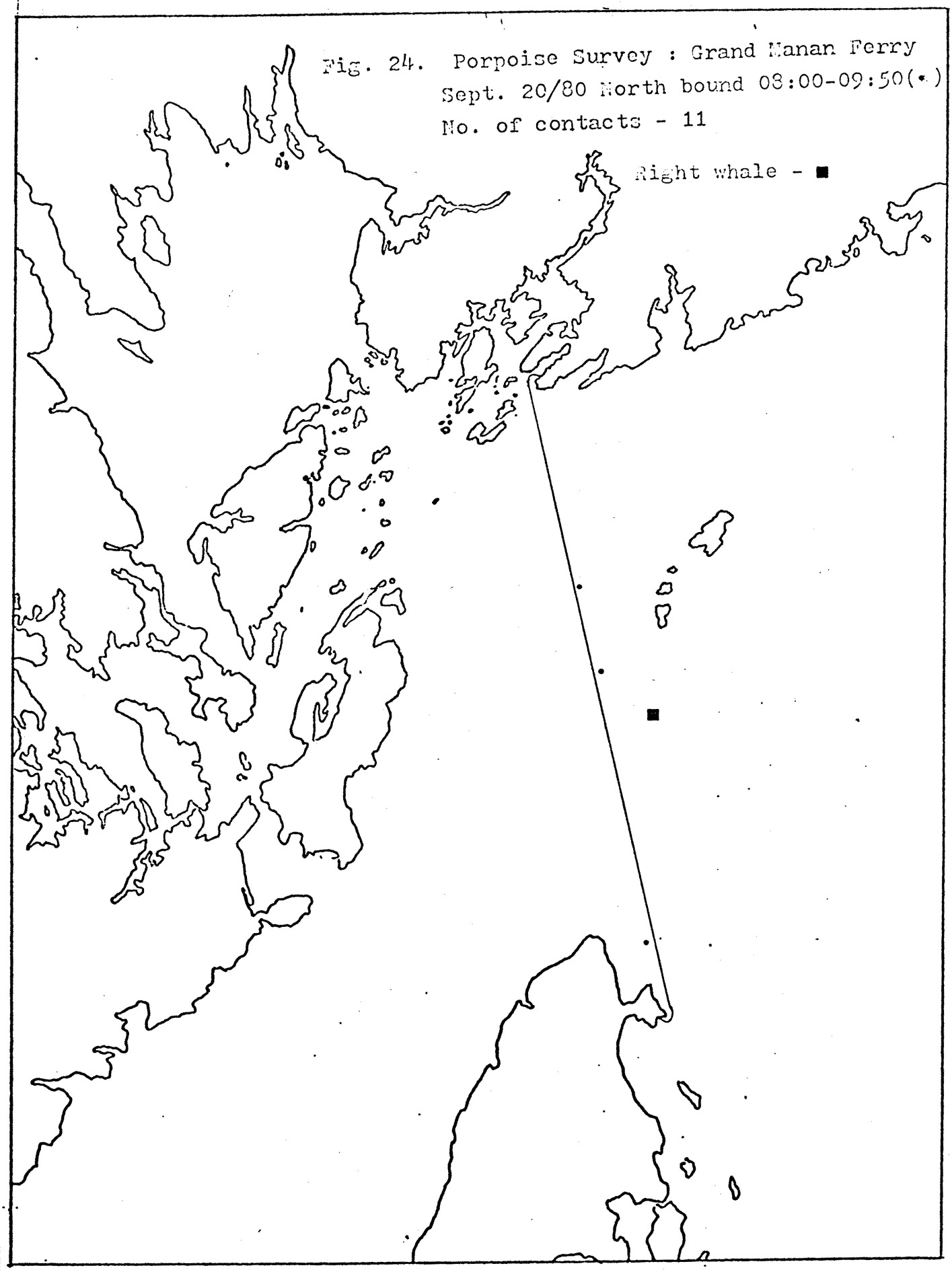


Fig. 24. Porpoise Survey : Grand Manan Ferry
Sept. 20/80 North bound 08:00-09:50(•)
No. of contacts - 11

Right whale - ■