SURVEYS OF MARBLED MURRELETS DURING THE BREEDING SEASON ON THE CENTRAL COAST OF BRITISH COLUMBIA, 1991.

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R. Burns
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SURVEYS OF MARBLED MURRELETS DURING THE BREEDING SEASON ON THE CENTRAL COAST OF BRITISH COLUMBIA.

L. Prestash[1], R. Burns[1], and G.W. Kaiser[2]

ABSTRACT

We conducted surveys for Marbled Murrelets (*Brachyramphus marmoratus*) in Queen Charlotte Sound, Milbanke Sound, Mathieson Channel, Kynoch Inlet and Mussel Inlet during May and June 1991. There were far fewer birds in Queen Charlotte and Milbanke Sounds than in 1990. A new form of stationary count in the channels and inlets revealed unexpectedly large movements of murrelets near dawn and dusk indicating much larger populations than observed during more typical moving boat surveys. Morning movements of murrelets characterized early May but evening movements typified observations later in the month when more of the birds remained in the inlet during daylight hours. Activity and behaviour typical of breeding murrelets implied that some birds may be nesting on the walls of the inlets, but no nests were found. Birds with brood patches were captured over the water with the help of a specially designed system of floating mist nets.

RESUME

Nous avons effectué, en mai et juin 1991, des relevés de l'Alque marbrée (*Brachyramphus marmoratus*) dans le détroit Queen Charlotte, le détroit Milbanke, le chenal Mathieson, l'inlet Kynoch et l'inlet Mussel. Dans les détroits Milbanke et Queen Charlotte, il y avait beaucoup moins d'oiseaux qu'en 1990. Une nouvelle technique de dénombrement stationnaire
dans les chenaux et les inlets a mis en évidence des mouvements d'Alques étonnamment à l'aube et au crépuscule, révélant la présence d'effectifs beaucoup plus élevés qu'on n'en observait pendant les relevés classiques à bord de bateaux en mouvement. Les Alques se déplacaient plutôt le matin au début de mai, et plutôt le soir plus tard dans le mois, époque où davantage d'oiseaux restaient dans l'inlet pendant la journée. On a constaté une activité et un comportement typiques de la saison de nidification, ce qui laissait penser que certains individus nichaient sur les parois des inlets, quoiqu'on n'y ait pas trouvé de nid. On a capturé sur l'eau au moyen d'un système spécialement conçu de filets japonais flottants, des oiseaux présentant sur le ventre la plaque de peau nue révélatrice de l'incubation.

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SURVEYS OF MARBLED MURRELETS DURING THE BREEDING SEASON ON THE CENTRAL COAST OF BRITISH COLUMBIA.

INTRODUCTION

Little is known about the breeding biology of Marbled Murrelets (*Brachyramphus marmoratus*) in British Columbia (Sealy 1974, 1975; Campbell *et al.* 1990). In part, this is due to the difficulty in locating and assessing nest sites. Only two actual nests have been found in British Columbia (I. Manley unpub.). It has also been difficult to catch these birds and this has limited the use of modern techniques such as radio telemetry.

This project was designed to determine the distribution and abundance of Marbled Murrelets in selected inlets on the central mainland coast of British Columbia, and to evaluate nesting habitat in that area. The study was conducted mainly in Mussel and Kynoch Inlets because in June 1989 we located over 200 Marbled Murrelets there. We returned in May and June the following year to conduct more detailed surveys of murrelets in both inlets and to do a preliminary at-sea survey along the central mainland coast (Kaiser *et al.* 1991). Mussel and Kynoch inlets were also of interest because of the absence of large, old-growth trees that are the typical nesting habitat of murrelets farther south (Marshall 1988).

This report presents results of additional studies of Marbled Murrelets undertaken on the central coast in the late spring and early summer of 1991. Our objectives were: to provide more complete and intensive at-sea counts for the central mainland coast of British Columbia, to develop a method of capturing murrelets on the water (see Appendix 6), and to identify potential nesting populations and habitat.

STUDY AREA.

Our study included five survey areas on the central coast of British Columbia between 51° 50' and 52° 57' North, and 127° 49' and 128° 45' West (Figs. 1 & 2). These areas covered two Ecoregions (as described by Demarchi and Harcombe in Campbell *et al.* 1990): the Continental Shelf and the Coastal Gap. Surveys in the Continental shelf Ecoregion included only the Hecate Depression Ecosection. Surveys in the Coastal Gap Ecoregion included two Ecosections: the Hecate Lowlands and the Kitimat Ranges. Two survey areas contained open ocean habitats and three contained the more protected habitats of fiords and channels:

(a) **Queen Charlotte Sound** - Currie Islet to Cape Mark.

This area is fully exposed to the Pacific Ocean and is approximately 530 km^2. The most prominent land features are the Goose Group in the south and the McMullen and Bardswell Groups in the north (Fig. 2). All islands are low lying with a forest fringe along the outer edges and boggy interiors (Guiguet 1953).

Near shore waters have many rocks, reefs, and small islands and contain diverse fish populations. Pacific herring (*Clupea harengus*) are particularly abundant (Pers. obs.). The shallow coastal shelf drops off to deeper water within 6 km of the shore.

(b) Milbanke Sound - south portion.

This area of approximately 400 km^2 is open water but is exposed only to the effects of wind and waves from Queen Charlotte Sound (Fig. 2). Milbanke Sound is deep (up to 345 m) and contains two small banks: the Emmaline Bank and an area of shallows around Susan Rock. The islands surrounding the sound are flat and featureless with rocky jagged shorelines.

(c) Mathieson Channel.

This channel is 65 km long with an average width of 3 km (Fig. 3). Most of the channel is deep (up to 610 m) with steep sides. The southern entrance is bounded by Rankin Point and Cross Point, and the northern boundary is the northern portion of Mathieson Narrows. The western side of the channel consists of a series of islands and passages. The eastern side is the Don Peninsula, part of the mainland. The narrows at the north and south ends and the entrance to the passages are relatively shallow.

Some logging occurs on the east side of the channel and consists mainly of small clearcuts by "hand loggers". Logging activity ceases at the boundary of Fiordland Recreation Area. Rescue Bay appears to be the only small craft anchorage in the area that is secure from strong winds in all directions.

(d) Kynoch Inlet.

This inlet, which penetrates the Kitimat Ranges, is 18.5 km long and approximately 1 km wide (Fig. 4). Most of the inlet is over 360 m deep although there is a shallow area of 125 m east of Kynoch Point. Large sections of the shoreline are composed of high cliffs, some of which are over 1200 m. Desbrisay Bay is located on the north shore of Kynoch Inlet and its entrance is marked by sheer, high cliffs. Culpepper Lagoon opens into the head of the inlet but no large fresh water systems empty into the inlet. There are no small craft anchorages in Kynoch Inlet that are safe from inflow winds that can reach 45 km/h.

(e) Mussel Inlet.

This inlet is 11 km long and averages 1.7 km in width (Fig. 5). It has an average depth of 280 m. There are three prominent bays along the inlet. Two major fresh water systems enter Mussel Inlet at its head: Mussel River and Poison Cove Creek. The rivers are 20 km and 17 km long respectively and flow through narrow, steep-sided valleys. Both valleys end abruptly in glaciers, snow, and rock. In both valleys the trees appear stunted and damaged by wind. Many have dead tops. The predominant trees in the valley bottoms are Western Hemlock (*Tsuga heterophylla*). The average tree height on the forest cover maps (British Columbia Ministry of Forests) is 28 m.

The mountains on either side of Mussel Inlet are part of the Kitimat Ranges. On the north shore they rise abruptly to an elevation of 1150 m and on the south shore they rise more slowly to 1213 m. The lower slopes are characterized by forests of Western Hemlock and the upper slopes by Mountain Hemlock (*Tsuga mertensiana*). The summits are covered by moist alpine tundra (Campbell *et al.* 1990). The sub-alpine zone begins at 600 m and the alpine at 760 m.

David Bay provides a secure small craft anchorage with a source of fresh water. There is an area suitable for a tent camp about 500 m east of David Bay on the south shore of the main arm of Mussel Inlet.

METHODS.

Survey Design.

(a) **Queen Charlotte Sound** - Currie Islet to Cape Mark and (b) **Milbanke Sound** - south portion.

The boat used in this project was the *Pacific Provider*, a 13 m commercial salmon troller. It is equipped with stabilizers which make it a steady platform for viewing birds. Observations were made from inside the wheelhouse approximately 2 m above the water surface.

We surveyed Queen Charlotte Sound and the southern portion of Milbanke Sound (Fig. 2) three times at approximately two week intervals between 30 April and 2 June, 1991. Our survey path followed an arbitrary route that ensured both simple navigation and good coverage of underwater features within the survey area.

The route followed the LORAN-C navigation lines on Canadian Hydrographic Service Chart #3744. We used both the 5990-X-13000 and the 5990-Z-41000 LORAN-C chains marked on the chart. To get complete LORAN-C coverage of this portion of the study area we transferred the LORAN-C lines to a larger scale chart (#3728) and extrapolated the lines shoreward where necessary. Theoretically the survey path can be replicated to an accuracy of 18.5 m on the 13000 chain (signal station) and to 30 m on the 41000 chain. This is the limit of resolution on the chart.

We used a Furuno model 850 depth sounder with a paper recorder to look for fish and underwater features. Upon reaching each intersection of the LORAN-C lines on our chart, we marked the sounder paper and recorded time and position. This model of sounder is equipped with a powerful transducer (1320 watts) which transmits a reduced beam of 17°, giving a detailed picture of the ocean bottom. Small concentrations of fish or euphausiids have distinct signatures on the recording and we correlated type and density of schools to murrelet activity whenever possible.

We collected surface water samples in a 4 l bucket every half hour while the boat was under way. Sea surface salinity (SSS) was measured with an American Optical refractometer to 0.5 ppm and sea surface temperature (SST) was measured with a thermometer to 0.5°C. These parameters were compared to bird distribution and densities.

Birds were counted by two observers, each of whom watched an area from straight ahead of the boat to 90° on either side. We recorded all birds within 300 m on each side whether the birds were flying or on the water. Both observers used 7 X 50 binoculars. In addition a 25 X spotting scope (Alderscope) was used to confirm difficult sightings. Throughout our stay in the study area, we recorded social interactions and other behaviour of the murrelets. Field notes, tables, and appendices in this report use the four letter acronyms

of Campbell and Harcombe (1985) for convenience (Appendix 7). These were constructed from the first two letters of the birds names (*e.g.* MAMU for Marbled Murrelet) or initials of compound names (*e.g.* RTLO for Red-throated Loon).

Surveys were done when weather and sea conditions were optimal for viewing. All times were recorded in Pacific Daylight Saving Time and each survey began at 06:00 hours and ended at approximately 16:00 hours. The boat speed was about 13 km/h. As we reached each intersection of the LORAN-C lines on the chart, the time of day was recorded. Observations of murrelets were recorded directly onto data sheets and that information was transferred onto photocopies of our survey chart (Figs. 6-11) at the end of the day.

(c) Mathieson Channel, (d) Kynoch Inlet, and (e) Mussel Inlet.

We surveyed Mathieson Channel, and Mussel and Kynoch inlets frequently from 2 May through 11 June. We used two survey methods in these inland waters:

(1) Moving boat surveys.

These were done at 13 km/h and were conducted 230 m to 460 m off the shoreline, or by cruising along the middle of the waterway. We conducted both morning and afternoon surveys. Because LORAN-C signals are unreliable in these water we determined our position by radar from landmarks noted on charts #3734 and #3962. As in the open water, we collected information regarding underwater features and fish from the sounder and took sea surface salinity and sea surface temperature readings at half hour intervals.

All birds sighted in ten minute intervals were recorded on data sheets. As noted above, two observers, using binoculars and a spotting scope, counted all birds on either side of the boat to a distance of 300 m.

2) Stationary boat counts.

This method took advantage of the daily mass exodus of murrelets from Mussel and Kynoch inlets as described below. We conducted these counts at various places in the inlets and in Mathieson Channel by positioning the boat in the centre of the inlet or channel and remaining there with the engine off. Each of the two observers focused their binoculars on a prominent feature on opposite shorelines and counted all murrelets flying across their set field of vision. Birds sitting on the water were counted only if seen landing. The observer seeing the least number of birds also did all the recording on a data sheet. We allotted four to five hours for morning counts of this type and we positioned the vessel before dawn. We allotted four hours for evening counts and had the boat in position three hours before dark.

We conducted three overnight counts during which we drifted with the engine off. On these counts we recorded only the times and numbers of visual or auditory detections of murrelets.

RESULTS.

Survey Design.

(a) Queen Charlotte Sound - Currie Islet to Cape Mark and **(b) Milbanke Sound** - south portion.

Our first survey confirmed that extrapolating LORAN-C lines close to shore enabled us to navigate accurately in the study area. The depth sounding and LORAN-C numbers on our vessel's equipment corresponded exactly with the LORAN-C numbers and depths shown on our modified chart (#3728). We were able to replicate the survey path very closely since the same underwater landforms appeared at exactly the same LORAN-C numbers on each pass.

(c) Mathieson Channel, (d) Kynoch Inlet, and (e) Mussel Inlet.

Although we were unable to conduct moving and stationary counts simultaneously, stationary count regularly gave higher numbers in each area than moving counts: Mathieson Channel (4 murrelets on 3 May moving count compared to 1265 on 4 May stationary count), Kynoch Islet (94 on 9 May moving count compared to 175 on 12 May stationary count), and Mussel Inlet (26 on 4 May moving count compared to 122 on 5 May stationary count).

Numbers and Distribution of Marbled Murrelets.

(a) Queen Charlotte Sound - Currie Islet to Cape Mark.

We did three surveys - one on each of 30 April, 13 May, and 1 June (Figs. 6-8; Tables 1a-c) There were few Marbled Murrelets in this area during any of the surveys. Only four Marbled Murrelets were seen on 30 April during 10 hours of surveys, and 18 on each of 13 May and 1 June during similar time periods. On 13 May, the Marbled Murrelets were scattered between 4.6 km and 13.0 km offshore. On 1 June, 12 were northwest of Golby Passage in an area of shallows. On these surveys we detected no concentrations of fish on the sounder paper.

Although murrelets, in the open water, were most abundant in more saline areas, there was no significant ($p > 0.05$) correlation between sea surface salinity (SSS) and sea surface temperature (SST) and the abundance or density of Marbled Murrelets.

(b) Milbanke Sound - south portion.

We surveyed Milbanke Sound three times - 2 and 22 May and 2 June (Figs. 9-11; Tables 2a-c). Murrelets were most abundant on 2 May (103) and least abundant on 2 June (39).

In the western section of Milbanke Sound, murrelets sitting on the water concentrated along the east shores of the islets and islands east of McInnes Island and on the southeastern shore of Price Island. In the eastern section of Milbanke Sound they concentrated to a lesser extent along the western shore of Athlone Island. As well, there were concentrations of murrelets along the centre of Milbanke Sound.

On 2 May, we counted 46 murrelets in the western section of Milbanke Sound and 14 in the eastern section. Most of these birds were sitting on the water. One pair in the latter group performed a courtship display. Forty three murrelets were found throughout the centre of the sound along a line running northeast to southwest. On 22 May, we saw 19 murrelets in the western section and six in the eastern section, most of which were sitting on the water. Seventy five murrelets were in the centre of the sound. On 2 June, of the 39 murrelets seen, the majority (27) were along the southeast shore of Price Island. Most of these birds were sitting on the water. We saw only one murrelet in the centre of the sound.

The majority of murrelets seen in the centre of Milbanke Sound were flying southwesterly directly from Mathieson Channel, through the Sound, to an unknown destination. All birds flew "purposefully" in a straight line until lost to view. On 2 May, 28 of the 43 murrelets in the centre were flying to the southwest, and on 22 May, 71 of 75 birds flew in that direction. The only birds flying southwest were Marbled Murrelets. Sooty Shearwaters (*Pufinus griseus*) seen outside the southern boundary of Milbanke Sound ranged in various directions, while gulls, eagles, cormorants, loons, and other alcids and fish-eating birds were almost always flying from one side of the sound to the other.

On 2 May, the depth sounder detected fish at 11 to 75 m beneath the murrelets near McInnes Island. On 22 May , we saw 6 Marbled Murrelets over large schools of herring along the southeast shore of Price Island.

Beyond Milbanke Sound - Seaforth Channel.

On 15 May, the *Pacific Provider* left the study area and entered Seaforth Channel (Fig. 2) en route to Bella Bella. As the boat rounded Cape Swaine at 06:00 hrs we noted about 20 Marbled Murrelets sitting on the water. The boat continued running up Seaforth Channel and by 06:15 hrs we realized that many pairs of murrelets were flying out of Seaforth Channel and into Milbanke Sound. All birds were flying along the south side of the channel - none were seen in the centre or along the north side. Between 06:15 hrs and 07:20 hrs we saw 13 singles, 77 pairs, 9 groups of three, and 31 murrelets in groups of 4 or more for a total of 225. When the boat reached Idol Point the flow of birds ceased suddenly. Those murrelets may have been coming from Spiller Channel, a long inlet that runs parallel to Mathieson Channel and opens into Seaforth Channel.

(c) Mathieson Channel.

Parts of Mathieson Channel (Fig. 3) were surveyed on 2, 3, 4, 9, 10, 11, 12, 17, 22, 23, 30 May, and 4 June (Table 3a). Some surveys were conducted while moving either up or down the channel and others were stationary counts, usually done at Hird Point.

During moving counts in the first three weeks in May we often saw groups of Marbled Murrelets on the water near areas of tidal activity such as Perceval and Mathieson Narrows, and at the entrance to Moss and Oscar Passages. Scattered pairs occurred along the entire length of the channel but before 23 May, those numbers were small, never exceeding 29 pairs. We found no correlation between SSS, SST, and Marbled Murrelet distribution.

During stationary morning counts in mid-channel at Hird Point we counted high numbers of birds flying down Mathieson channel (1265 on 4 May). Most birds flew by the boat between 05:30 hrs and 08:00 hrs, peaking near 06:20 hrs (Fig. 16). All murrelets were flying less than 2 m above the water. They approached us from as far up-channel as we could see and flew "purposefully" down the channel until lost to sight. Very few (< 10) of the birds called.

We used stationary counts at other sites in Mathieson Channel to locate the source of the birds flying past Hird Point (Table 3b). No birds were seen coming from Griffin Passage or from any of the heavily wooded valleys leading from the Don Peninsula (Fig.3) At a station 2 km south of Kynoch Point, we saw murrelets flying out of Kynoch Inlet but none came through Mathieson Narrows.

The flying birds were sensitive to the presence of the boat. Even when we had counts of over one thousand birds, few came close to the vessel. Most birds flew along either shoreline. If the boat drifted close to one shore the birds diverted to the opposite shore. When we moved the boat back to mid-channel, the birds resumed flying along both shores.

Although the vast majority of murrelets flew down the channel, we occasionally saw birds (usually pairs) land on the water. Sometimes those birds would rejoin the others flying out but on other occasions they remained behind. As we ran up or down Mathieson Channel during other times of the day we found the occasional single bird or pair of murrelets still sitting on the water.

On 11 May, at 08:10 hrs during a stationary count, two pairs of Marbled Murrelets flew down the channel along the east shore. One pair suddenly turned up-channel and abruptly gained altitude to between 150 and 180 m, then flew across to the west shore. As they neared land they went into a steep glide to the water. This was the first time we had seen the murrelets flying other than close to the water surface.

On 23 May, at 07:00 hrs during a moving count one pair of murrelets was observed copulating in the middle of the channel below McPherson Creek.

Depth soundings were recorded for some of the moving counts in Mathieson Channel. Usually the record indicated few fish or euphausiids under the surface. However, the sounder paper showed high concentrations of euphausiids in the water (Fig. 14) on 23 May. During a moving count in mid-channel, we saw 294 murrelets were on the water over a distance of 17 km.

(d) Kynoch Inlet.

We did four surveys in Kynoch Inlet (Fig. 4), one each on 3, 9, and 23 May, and 11 June (Table 4). The survey on 3 May included a count in Culpepper Lagoon at the head of Kynoch Inlet. The majority of Marbled Murrelets were in the lower part of the inlet between Desbrisay Bay and the mouth of the inlet.

Between 10:00 and 11:30 hrs, on 3 May, we ran a survey from Kynoch Point to the head of the inlet along the south shore. We saw only 7 murrelets all of which were evenly distributed along the inlet - 4 sitting on the water below Desbrisay Bay and 3 above. We surveyed Culpepper Lagoon in mid-afternoon without seeing any birds. Off Kynoch Point, the depth sounder recorded large swarms of unidentified euphausiids (Fig. 15).

The route on 9 May started at Garvey Point and ran along the north shore of the inlet, inside Desbrisay Bay, on to the head of the inlet, and then back along the opposite shore to Kynoch Point. The survey began at 07:10 hrs and ended at 11:20 hrs. We then re-surveyed the first three segments of the survey between Garvey Point and "Old Lady" Falls in order to compare these numbers with that morning's count. There were 25 murrelets there at mid-day compared to 36 murrelets in the morning. The birds in the area re-surveyed were not included in the day's total of 94. We found 82% of the murrelets in Desbrisay Bay and towards the mouth of the inlet. Most of those were present in the early morning on the north shore. All murrelets but one were sitting on the water. A few dove when the boat drew near but most remained loafing. Only one pair was in winter plumage, some had partially moulted to summer plumage and the rest were in full summer plumage.

On 23 May, the survey began at 08:30 hrs and ended at 10:00 hrs. The route started at Kynoch Point and ran along the south shore to the head of the inlet. We saw 31 murrelets, 71% of which were between Kynoch Point and Desbrisay Bay. Again most murrelets were sitting on the water.

On 11 June, we counted the largest number of Marbled Murrelets - 201. The route was the same as on 9 May. The count started at 09:45 hrs and ended at 13:40 hrs. Most murrelets were sitting on the water and 82% occurred between the head of Desbrisay Bay and the mouth of the inlet. One hundred murrelets were present inside Desbrisay Bay itself. One Marbled Murrelet near the head of Kynoch was still in full winter plumage. It appeared paired with a bird in full summer plumage and the two remained together after being disturbed by the boat.

(e) Mussel Inlet.

i) Boat surveys

We counted murrelets in Mussel Inlet (Fig. 5) between 4 May and 14 June on 18 days. The counts included 15 morning, 9 evening, and 3 overnight counts (Table 5).

On 5 May we positioned the boat for a stationary count at the mouth of Mussel Inlet, in mid-channel east of Crosson Point. For 4 hours, all of the murrelets appeared to be coming from Mussel Inlet and flew west down Sheep Passage. Some birds approached Mathieson Narrows, but turned and continued down Sheep Passage until lost to sight. On 6 May, we positioned the boat farther up Mussel Inlet, in mid-channel south of Carse Point. During the 4 hour count we drifted slowly down the inlet until we were halfway between McAlpin Lake and Crosson Point. All of the 163 Marbled Murrelets leaving the inlet during the count flew from up inlet, except for one bird that flew out of Oatswish Bay. We saw no birds coming from the heavily wooded valley which contains McAlpin Lake.

On 7 May, we positioned the boat about 30 m from the cliffs at the head of Mussel Inlet. This location offered a clear view of the mouths of Poison Cove and the Mussel River valley. Murrelets leaving either place would pass within 0.5 km of the boat. We started our count at 05:00 and stayed in position until 06:30 without seeing one murrelet fly out of either place. At that point we moved the boat down the inlet. On the two previous counts, birds had begun flying out of Mussel Inlet by 06:00. At a new position, 3 km west, we still could not see birds flying past from the head of the inlet, but we could see murrelets flying away from us, out of the inlet. There was no apparent source for those birds.

Finally, at 07:10 we saw one bird enter Mussel Inlet in a very steep, fast, glide from high up. Just before reaching the water it made a sharp turn and landed. We stayed in this area and continued counting until 09:30. Although we saw other birds leave the inlet, we only saw the one arrive.

On 8 May, we returned to the position 3 km from the head of the inlet. Only 29 birds were seen during that morning's count. At 06:20, we saw a single bird gliding steeply into the inlet. Upon landing it began calling repeatedly. At the same time, we heard repeated calls that sounded as though they came from a single location on the slopes of the north shore of Mussel Inlet.

The first evening counts occurred on 5,6, and 7 May. On 5 May, we did a stationary count off Carse Point from 19:00 to 21:40 and saw one pair sitting on the water. On 6 May, we again did a stationary count at Carse Point from 19:35 to 21:45. Our only sighting was of 6 murrelets sitting in David Bay. An overnight count between David Bay and Poison Cove from 19:45 on 7 May to 04:00 on 8 May produced no visual or auditory detections of Marbled Murrelets.

On 19 May, during a morning count on one of the few sunny days, we detected some movement high up the north shore slopes about 3 km from the head of the inlet. With binoculars, we saw some birds descending from high elevations (about 1000 m). Size, colour, and a "wobbly" diving glide suggested that they were murrelets but we could not positively identify them. As they descended further we lost them against the backdrop of the dark trees. Within the same survey unit (10 min.), we saw Marbled Murrelets appear on the water close to the north shore where none had been seen earlier. Later, we detected more movements on the same slopes and a group of 22 Marbled Murrelets materialized on the water close to the north shore.

On 20 and 21 May, we attempted to observe the arrival of murrelets more closely. Before daylight, one observer (LP) watched from the mouth of "Gravel Creek" directly below the north shore slopes. The other observer (RB) kept the boat in mid-channel and carried out a stationary count. No birds were seen coming from off the slope by either observer. On 20 May, the land observer saw only 4 murrelets on the water compared to the mid-channel count of 45. On 21 May, the land observer counted 40 murrelets compared to 86 in mid-channel.

From 27 May through 30 May, we continued trying to locate the source of the birds arriving in the morning. We saw no birds flying in from the west, (the mouth of Mussel Inlet) nor were they arriving from the east (the head of Mussel Inlet). Occasionally we glimpsed murrelets entering the inlet on steep glide paths from the direction of the north shore always about 3 km from the head of the inlet.

Often birds suddenly appeared on the water "out of nowhere" 3 to 4 km from the head of the inlet. In one instance on 28 May, between 06:00 and 06:30, 456 murrelets appeared around the boat with no hint as to where they came from or how they got there. From that time on, many of our morning counts became estimates since it was impossible to keep track of which birds had been counted and which ones were new arrivals. After they were on the water, many made short, low level flights or swam toward the head of the inlet. Many birds were actively diving.

During May, the daily activity of the murrelets changed (Fig. 17). At first (5-8 May) most of the murrelets left the inlet in the morning. We had stopped evening counts on 7 May when virtually no birds were seen on any of those counts. By mid-May (18-21) modest numbers (< 126) remained in the inlet in the mornings. By the end of May, many birds used the inlet all day and we saw a departure of large numbers (520) when we resumed our evening count on 26 May (Table 5). We heard additional birds departing but we were unable to continue counting in the failing light and could see no birds on the water with the spotlight. We continued counting nocturnal departures until our last survey on 14 June, but from 5 June, we noticed that many birds remained on the water of the inlet at night.

When more birds began to stay in the inlet at night (5 June), they also shifted their centre of evening concentration from the large bay east of David Bay, to areas closer to the

north shore. Between 23:00 and 24:00 on 14 June, we searched parts of the inlet with the boat's searchlight and found that the main concentration had moved west of Barrie Point.

As increasing numbers of murrelets remained in the inlet, we noticed increases in feeding activity and calling. Group size shifted from pairs to loose flocks of 3 to 12. On the afternoon of 11 June, we tallied the different group sizes. Of 393 murrelets, 81.9% were in groups of 3 or more, compared to an average of only 17.2% before 27 May (Fig. 18).

Concurrent with the behavioral changes at the end of May, we noticed many light coloured murrelets in the inlet. Those birds were paler than any we had seen so far. One of those light birds was closely observed through the spotting scope. It had very little brown marbling on its throat, breast, belly, or flanks, giving it a whitish appearance. Thin, light brown barring on the chest area was particularly noticeable when the bird "stood up" on the water to flap its wings. A faint, white, partial throat collar was easily seen. Its head, neck back, and wing feathers were a light brown.

The pale birds were seen only as members of groups of 3 or more and usually accounted for about 25% of each group. Some groups lined up in single file as they sat or swam on the water, while others were more randomly organized.

During daylight, between 11 and 14 June, our activity in the boats flushed groups of murrelets off the water. Most of these birds flew up the faces of the hills that line the inlet and disappeared from sight.

Murrelets occasionally performed displays and exhibited other special behaviour. On 7 May, we watched a pair of loafing Marbled Murrelets in David Bay for 37 minutes. For the whole period one bird was in a resting position with its head and neck retracted. The other bird was actively looking around with its head and neck extended. It continually turned its head from side to side as if on watch. On 8 May, we saw 3 birds swimming and diving together in a compact group. Two or 3 times one of the 3 assumed a posture with its head and neck outstretched parallel to the water and approached one of the other birds while in that position. On 27 May, 3 Marbled Murrelets flew about 2/3 m above the water directly toward the boat. At the last moment, amid much calling, they rose within a few seconds to an altitude of about 500 m. Two of the birds were silhouetted against the sky as they levelled out and flew in a zigzag path down the inlet. They were lost to view against the backdrop of the darkening mountains. On 29 May, one pair of murrelets was copulating near the mouth of "Gravel Creek".

ii) Capturing Murrelets

On the evening of 24 May, we set our mist nets (Appendix 6) at 19:00 when most murrelets were on the water up inlet from the net. At 21:40 the first birds began flying out of the inlet and by 22:15 we had captured three murrelets. We did not make a second attempt until 5 June when additional help (G.K. and his field assistants) arrived with the telemetry equipment. Two birds were caught on that date but the weather on subsequent evenings was too wet and windy for safe netting although brief attempts were made.

Birds were banded, weighed, and measured (Table 6). The recommended 3B stainless steel bands were clearly too large but size 3 proved a good fit. We had not handled murrelets before and found a brood patch on only one of the first 3 birds. It was completely bare of feathers and 3 cm wide. The flesh was taut and reddish purple but indented in the middle as though recently impressed by an egg. There was probably a brood patch on at least one of the other two birds. Both of the birds captured on 5 June had brood patches.

In an attempt to find some easily described sexual differentiation, we examined the cloaca on four of the birds. On the bird with no brood patch, it was purplish grey, loose and markedly raised. On the birds with brood patches, the cloaca of the bird captured 24 May was tight, not protuberant, and pinkish and of the two birds captured on 5 June, one had a protuberant, grey, and firm cloaca and the other's was flush with the body, loose and pink.

iii) Helicopter Surveys

On 12 and 13 June, we used a helicopter to explore the walls of Mussel and Kynoch Inlets and the Mussel River and Poison Cove Creek valleys. Habitat in the valley bottoms and along the valley sides was photographed and evaluated as murrelet nesting habitat. The largest trees that we saw occurred in a narrow band along the valley floors. Those trees had sparse branches and were much smaller in height and diameter than "classic" old growth trees. The trees along the valley sides can best be described as "scrubby". Many trees in the valley bottom had mossy pads on the branches but there were few of the large branches overhanging those mossy pads that are typical of forest nest sites (K. Nelson unpub.). Although the helicopter often flew at tree top level no evidence of tree nests was seen, nor were any murrelets flushed from the trees.

Also on the first day, teams of two landed on each of four ridges with southeast faces above Mussel Inlet, and searched for egg shells, feces, feathers, dropped fish, runways or any other indications of use by murrelets. The searches were unsuccessful and lasted for 1 to 3 hours until rain and fog began to reduce visibility.

The ridges were near the tree line, about 800 m above the inlet, where we had frequently seen Mountain Goats (*Oreamnos americanus*). The area was free of snow except in crevices and depressions. Rock outcrops were bordered by dense shrubs from 0.5 to a little more than 2 m high. Most of the ground cover was moss and lichen. We saw no

Steller's Jays (*Cyanocitta stelleri*), Northwestern Crows (*Corvus caurinus*), or Common Ravens (*C. corax*) in the area.

Four observers spent the night of 12-13 June at 840 m, on one of the westernmost ridges of the inlet's north side. It was above this ridge that we had earlier detected morning activity. Unfortunately, fog, rain, and creek noises made any kind of observations impractical. The observers attempted to listen for calls between 19:00 and 23:00 and again between 03:00 and 08:35 without success. Poor visibility made retrieval by the helicopter risky. The project was ended on 15 June and we departed the study area.

DISCUSSION

A) Survey methods

The stationary counts at dawn or dusk generally resulted in more sightings of murrelets than the running counts. For example, during 3 of the stationary counts in Mathieson Channel, we counted more than 1100 murrelets (Table 3b) but the largest comparable running count (17 May) scored only 162 (Table 3a). The stationary counts depended on the daily mass movements in which many birds flew past in one direction. It was only a matter of selecting a narrow passage through which the birds were funnelled (Fig. 16).

The mass movements of birds within a short time span imply that time of day is an essential factor in survey results. Counts outside those periods tally only the remnants of the local population and may seriously underestimate it. Because the birds flew past until lost to view, our stationary counts avoided some of the structural biases associated with running counts. There was no problem with roll-up (birds being flushed forward to be counted again) or birds diving out of sight. On running counts it is always difficult to judge the birds distance from the boat in relation to theoretical boundaries of the transects. Wave height, glare from the sun, and other physical factors that limit the distance at which sitting birds can be seen, have little effect on the visibility of flying birds and the quiet stationary boat had little effect on the birds' behaviour. On the quiet boat, it was also possible to detect distant calls.

Stationary counts may also be useful in reducing the effort needed to locate likely nesting habitats. First, a series of counts along an inlet can help identify the source of the birds. Our counts at several points along Mathieson Channel, Mussel Inlet, and Kynoch Inlet suggest that Kynoch Inlet is the source of birds passing Hird Point in Mathieson Channel and that birds from Mussel Inlet do not. Second, mass movements indicate the scale of the minimum population in relatively large geographic areas and may be a useful tool in locating and evaluating the importance of breeding concentrations and general foraging areas over the whole coast of British Columbia and southern Alaska. Because the passing birds come from areas with no clear geographic boundaries, stationary counts cannot be used to calculate density.

The biggest technical drawback to stationary counts at dawn or dusk is the effect on visibilty of poor light either at the start or at the end. This seems to affect counts at dusk more than those at dawn since few birds were flying past at first light. There is also some extra risk of travelling to or from the count site in the dark. It is possible to compensate for the effect of darkness in a rough way by extrapolating the total number of birds from the frequency curve (Fig. 16).

B) Numbers and distribution of murrelets

i) Queen Charlotte Sound - Currie Islet to Cape Mark

The 1991 observations of murrelets on the open coast contrasted strongly with those of 1990. During our passage in 1990 (Kaiser *et al.* 1991) we saw 100 murrelets at the Goose Island anchorage and counted 149 between Golby Passage and Cape Mark. There were also large numbers of other fish-eating birds in the area including 130 Bald Eagles (*Haliaeetus leucocephalus*) feeding on a fish ball. In 1991, there were few Marbled Murrelets or other fish-eating birds. We were unable to detect schools of fish with the depth sounder and their absence may be the direct cause of the low counts of birds.

ii) Milbanke Sound - south portion

During our surveys, more than half of the murrelets in this area were using the perimeter of Milbanke Sound to feed and loaf. The cluster of small islands and islets around the sides of the sound create many loafing and feeding spots in the type of sheltered waters which murrelets appear to prefer (Campbell *et al.* 1990). We detected schools of fish on the depth sounder and saw the murrelets diving. In contrast, there were few murrelets in the exposed central parts of the sound and we detected no schools of fish or euphausiids on the depth sounder.

Murrelets did pass over the centre of the sound (Figs 9, 10). On 22 May, we counted 71 following a corridor from Mathieson and Seaforth Channels to some unknown destination to the southwest (Fig. 10). They were the only species following that path. Other fish-eating birds crossed the murrelets' path, usually to mixed groups feeding in the distance. The murrelets did not seem to be attracted to the mixed foraging groups. We never found concentrations of murrelets in Milbanke Sound that would correlate with the hundreds flying out of Mathieson Channel.

iii) Mathieson Channel

Mathieson Channel contains the flight corridor for murrelets leaving Kynoch Inlet to feeding areas beyond Milbanke Sound. In May, more than 1100 murrelets passed through daily but occasionally pairs of murrelets stopped to loaf or to feed, especially when schools of fish or euphausiids were present. The bulk of the birds were only detected during the mass movements at dawn but running counts were needed to determine how many remained in the inlets. The presence of lone pairs and single birds in such channels may indicate likely areas in which to conduct formal stationary counts at dawn.

Fluctuations in the number of murrelets tallied in Mathieson Channel reflect changes in the type, time, and location of the counts and/or changes in the number of birds. Stationary counts at daybreak in May, near Hird Point, resulted in very high numbers of records. Running counts conducted along the channel, later in the day, gave much smaller

numbers with the exception of counts on 4 June in which only 90 were seen flying by at dawn but large numbers remained in the channel and inlets all day. This exception may reflect changes in prey distribution or behavioral changes linked to the progress of the breeding season.

A boat is an essential tool for the stationary counts in an area like this. Even though Mathieson Channel is narrow, land based observers would be trying to count birds against a broken background at 1.7 km. Observers in a boat are working at half that range and can achieve greater precision.

iv) Kynoch Inlet

We did no stationary counts of murrelets in Kynoch Inlet, either at dawn or dusk and cannot make an estimate of its minimum population. However, it appeared that the entire Mathieson Channel movement originated there and did not include birds from Mussel Inlet. Even though these two neighbouring inlets may have discrete populations, we noticed some synchrony in behavioral changes. When murrelets began staying in Mussel Inlet during the day, birds from Kynoch Inlet began staying in Mathieson Channel between Kynoch and Hird points. Whether these changes were due to changes in prey abundance (Fig. 14), a new phase in the reproductive cycle such as the hatching of eggs, or some other factor, is uncertain.

It is 65 km from Kynoch Inlet to the southern entrance of Mathieson Channel and a further 20 km to southern Milbanke Sound. Breeding murrelets using that route would make a round trip of 170 km in addition to the flight over land to the nest. This exceeds the suggested maxima of 112 km
(Rodway 1990) and 150 km (Marshall 1988) and implies that murrelets might need to nest close to the inlets for energetic reasons. Inland from our study area, extensive ice fields and glaciated slopes suggest that it is the forested shores and valleys or rocky slopes of the inlets which are likely to offer nesting habitat.

We believe that at the beginning of May, 6.5 times more murrelets leave Kynoch Inlet (Table 3b) than Mussel Inlet (Table 5). This is out of proportion to the physical differences between the two inlets. Kynoch is only 40% longer and about the same width. It does have many more steep rocky slopes and sheer cliff faces that rise to 1200 m. Perhaps murrelets can find nest sites on the rocky slopes (Simons 1980) or in crevices (Johnston and Carter 1985).

v) Mussel Inlet

In the breeding season, Mussel Inlet appears to be an important centre for Marbled Murrelets. Although we found no nests, we believe there were many other indications of nearby breeding: intensive calling between members of pairs, birds with brood patches, and changes in daily activity patterns consistent with the progress from incubation to the care of

nestlings. From 3 June, we occasionally saw adults holding fish, an activity associated with the feeding of young (Carter 1984). In 1990, a murrelet chick with an egg tooth was seen near the head of the inlet (Kaiser *et al.* 1991).

During the third week of May, we noticed a shift from pairs to groups of 4 or more on the water and a noticeable increase in calling activity. There was a concurrent increase in abundance from 202 (6 May) to 551 (24 May) with about 25% of the increase consisting of distinctly paler birds. If eggs were hatching at the same time, the remainder of the increase could be due to the release of both members of pairs from incubation duties. Sealy (1975) noted that sub adults began gathering in flocks of 4 to 11 during the nestling period. He also noted an increase in calling but stated that there was no apparent difference in plumage. Light coloured birds are also abundant in other concentrations of murrelets (Kaiser *et al.* 1991) but further study is required to see if they have any special significance.

Calling activity is an easily observed individual behaviour and counts of calls are used to determine the use of forest habitats (Paton *et al.* 1990). In Mussel Inlet, most calling occurred on or over the water during daylight. They were not heard during overnight counts, at the tent camp on the south shore, or by the party delivered by helicopter to the western ridge of the north shore. We heard calls from land only once when single calls were repeated from the steep north shore slopes. We never heard birds as they returned to the inlet and wonder if their silence reflects the proximity of nests (Simons 1980, Johnston and Carter 1985, Singer *et al.* 1991).

An important goal of this project was to identify potential nesting habitat for further study. We feel that the murrelet activity continues to suggest that the north shore of Mussel Inlet deserves the most attention. When murrelets arrived in the inlet, they consistently appeared at the foot of the north shore hills, 3 to 4 km from the head of the inlet. They appeared to be arriving from above and definitely not from the east or west. This is an area of steep rocky outcrops and narrow ravines choked with brush and detritus and its exploration requires more careful planning than we were able to devote in 1991.

CONCLUSION

Marbled Murrelets could be nesting on the north shore of Mussel Inlet on the ground or in cavities as described by Simons (1980) and Johnston and Carter (1985), or they could be using trees at lower elevations. We suggest examining this area in more detail in 1992 and using radio telemetry as an aid in the difficult search for nests. The Mussel Inlet murrelets occupy a place near the centre of the species' range but appear to be using nesting habitat that has not been previously studied.

Although large numbers of murrelets appear to come from Kynoch Inlet and the potential for nesting habitats is similar to Mussel Inlet, we believe that Kynoch Inlet would be a much more difficult area in which to work. It is much larger and does not offer suitable anchorages.

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TABLES

Table 1a. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Islet and Cape Mark on 30 April 1991.

TABLE 1a. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Islet and Cape Mark on 30 April 1991.

Coordinates (LORAN-C)		Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Depth of feed	Species Observed MAMU	RHAU	COMU	CAAU	ANMU	Unid. alcid	Large gull***	MEGU	BOGU	SOSH	PALO	BLKI	Total
13420	41380	700	9.0	30.0				3				11				2		
13400	41380	720	9.0	30.0			5		5			10			16	1		
13380	41380	745	9.0	30.0	20-30	2	3	1	1			12		2	2	7	1	
13380	41400	825	9.0	30.0	40-50							13				5		
13360	41400	845	9.0	30.0	40-60			1				5						
13340	41400	905	9.0	30.0	20-30			1				17				1		
13320	41400	925	9.0	30.0	20-30		2	2	2			6				2		
13320	41420	955	9.3	30.0					4			5						
13340	41420	1015	9.0	30.0								5						
13360	41420	1037	9.0	30.0			4					3				6		
13360	41440	1105	9.0	31.0			5	6				4				70		
13340	41440	1123	9.0	31.0			3					4				1		
13320	41440	1140	9.0	31.0		2	2					2						
13300	41440	1158	9.5	31.0								7				1		
13300	41460	1228	9.0	32.0								3						
13320	41450	1245	9.0	32.0								1				3		
13331	41460	1306	9.0	32.0			16					11				55		
13349	41455	1330	9.0	31.0			4	12				9				27		
13360	41455	1340	9.0	31.0				1								19		
13369	41454	1450																
13330	41460	1430	9.0	31.0			2					1						
13330	41480	1506	9.5	31.0			4		2			4				1		
13300	41480	1540	9.5	31.0			2											
13280	41480	1556																
TOTAL		9.0h				4	52	27	14	0	0	133	0	2	18	201	1	452
COMPOSITION (%)						0.9	11.5	6.0	3.1	0.0	0.0	29.4	0.0	0.4	4.0	44.5	0.2	100.0

* SST - sea surface temperature
** SSS - sea surface salinity
*** Most large unidentified gulls were likely Glaucous-winged Gulls.

Table 1b. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Islet and Cape Mark on 13 May 1991.

TABLE 1b. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Islet and Cape Mark on 13 May 1991.

Coordinates (LORAN-C)		Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Depth of feed	Species Observed MAMU	RHAU	COMU	CAAU	ANMU	PIGU	Unid. alcid	Large gull***	MEGU	BOGU	SOSH	PALO	Total
13420	41380	650	9.0	33.0			1	2		3			1		1	8	2	
13411	41380	700	9.0	33.0	40-50			2				6				3		
13404	41380	710	9.0	33.0	30-45			1							1	2		
13400	41380	715	9.5	31.0	30-45	3	7	4	1			1	1			109	2	
13380	41380	731	9.0	30.0	30-45		25	5			1	1	57		4	167	4	
13380	41400	806	9.0	30.0	30-45	2	5	2					8			150	1	
13360	41400	824	9.5	30.0	30-45		1						1			53		
13340	41400	840	9.5	31.0	30-50		1						9			12		
13320	41400	858	9.5	31.0	30-50	4	3	3					9			25		
13320	41420	920	9.5	31.0	20-30		2	2								13		
13340	41420	947	9.8	30.0	20-30	3	8	2					12	1	6	10	6	
13360	41420	1015	10.0	30.0	10-20		9						8			3	24	
13360	41440	1040	10.0	30.0	20-40		3	2					4		7	3		
13340	41440	1058	10.0	31.0			4			1						4		
13320	41440	1117	10.0	31.0	20-25	2		3					1			7		
13300	41440	1132	10.0	31.0	10-20	4		1					1			18		
13300	41460	1202	10.0	31.0	10-20			1					6			3		
13320	41460	1221	10.0	31.0	20-30			7					3		3	5	11	
13330	41460	1230	10.0	31.0	20-30		3						1				1	
13345	41455	1245	10.0	31.0	20-30		4	2					2				13	
13360	41455	1257	10.0	31.0	20-30		1	4									5	
13370	41455	1306	10.0	31.0	20-30													
13330	41460	1417	10.0	31.0				23					12			2	18	
13330	41480	1445	10.0	31.0									3					
13320	41485	1455	10.5	32.0	15-30								1					
13309	41482	1505	10.5	32.0	15-30								1				2	
13300	41480	1515	10.0	32.0			1	3					30			1	1	
13280	41480	1540																
TOTAL		8.6h				18	78	69	1	4	1	8	171	1	22	598	90	1061
COMPOSITION (%)						1.7	7.4	6.5	0.1	0.4	0.1	0.8	16.1	0.1	2.1	56.4	8.5	100.0

* SST - sea surface temperature
** SSS - sea surface salinity
*** Most unidentified large gulls were mostly likely Glaucous-winged Gulls.

Table 1c. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Island and Cape Mark on 1 June 1991.

TABLE 1c. Surveys of fish-eating birds in Queen Charlotte Sound between Currie Island and Cape Mark on 1 June 1991.

Coordinates (LORAN-C)		Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Species Observed MAMU	RHAU	COMU	CAAU	ANMU	Unid. alcid	Large gull***	MEGU	BOGU	SOSH	PALO	Total
13420	41380	645	11.0	33.0		6	3				1			4		
13400	41380	702	10.3	31.0		13	1				4			3		
13380	41380	812	10.0	32.0		18	8	1			8			14		
13380	41400	840	10.0	31.0		36	3	1		2	3			21	3	
13360	41400	900	10.0	30.0		9								4		
13340	41400	917	10.3	30.0		6		1						2		
13320	41400	935	10.8	30.0		9			1		2			4		
13320	41420	1006	10.3	30.0										2		
13340	41420	1024	10.3	30.0		9								2		
13360	41420	1042	10.3	30.0	2	12	1	2		8	15					
13360	41440	1110	10.3	30.0	2	15	1	2			9				4	
13340	41440	1128	11.5	31.0		5		1						2	1	
13320	41440	1145	11.0	31.0		1	3				1					
13300	41440	1204	11.0	31.0		2	4				1				1	
13300	41460	1232	11.0	31.0	2	18	4	6			2			5	1	
13320	41460	1300	12.0	30.0	6	15		12		2	8			23	6	
13345	41455	1312	11.0	30.0	4	6	6			4	5				1	
13360	41455	1327	11.0	30.0		3				1	4				1	
13370	41455	1335														
13330	41460	1416	12.0	31.0	2	13	5				1				6	
13330	41480	1443	12.0	31.0												
13320	41485	1455	11.8	31.0		1				2						
13300	41480	1516	12.0	31.0		9	5	3			1				2	
13280	41479	1530														
TOTAL		9.8h			18	206	44	29	1	19	65	0	0	86	26	298
COMPOSITION (%)					6.0	69.1	14.8	9.7	0.3	6.4	21.8	0.0	0.0	28.9	8.7	100.0

* SST - sea surface temperature
** SSS - sea surface salinity
*** Large gulls were mostly Glaucous-winged Gull.

Table 2a. Surveys of fish-eating birds in Milbanke Sound - South Portion on 2 May 1991.

TABLE 2a. Surveys of fish-eating birds in Milbanke Sound-South Portion on 2 May 1991.

Coordinates (LORAN-C)		Time (PDS)	Species Observed MAMU	RHAU	COMU	CAAU	GWGU*	MEGU	BOGU	SOSH	PALO	Total
13280	41500	615	2	10			12				13	
13280	41480			4			1					
13260	41480			2	1		2		13	12	1	
13240	41480	712	2	4	4		5			41	2	
13220	41480	737		2			19		21			
13200	41480	753	10	7		2	70				17	
13200	41500	826	8	2			1					
13220	41500	843		6		2	3				15	
13240	41500	903	12	2							5	
13260	41500	920					2					
13280	41500	937	14	5	2		3					
13280	41520	1010	4				5					
13260	41520	1027	10				11				2	
13240	41520	1043	2				2					
13220	41520	1100	22				1				1	
13207	41520	1110	6				32	1			14	
13195	41540	1140					6				1	
13220	41540	1204	8				15				8	
13240	41540	1220	3				3					
13260	41540	1235										
13280	41540	1255					1					
13275	41540	1345	18						1			
13279	41560	1405	12				1					
TOTAL		8.6h	133	44	7	4	195	1	35	53	79	551
COMPOSITION (%)			24.1	8.0	1.3	0.7	35.4	0.2	6.4	9.6	14.3	100.0

* GWGU includes other large gulls that were not identified.

Table 2b. Surveys of fish-eating birds in Milbanke Sound 22 May 1991.

Table 2B. Surveys of fish-eating birds in Milbanke Sound on 22 May 1991.

Coordinates (LORAN-C)		Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Depth of feed	Species Observed MAMU	RHAU	COMU	CAAU	ANMU	Unid. alcid	Large gull***	MEGU	BOGU	SOSH	PALO	BLKI	Total
13280	41500	545	10.0	32.0			5		2			13		3		13		
13280	41480	615	10.5	30.0		6	8				2	2		1	1	1		
13260	41480	635	9.5	30.0		9						1		1	3			
13240	41480	655	9.5	30.0		25	3					7		2	3			
13220	41480	713	9.8	30.0		3						2						
13200	41480	730	9.8	30.0		6	6					4		5		1		
13200	41500	758	9.8	30.0		4	23					14		18		11		
13220	41500	817	9.8	30.0		4						3		1		3	1	
13240	41500	835	10.0	30.0		9						6		3		2		
13260	41500	851	10.3	30.0		14						7		2				
13280	41500	910	10.3	30.0		6	2					31				2	2	
13280	41520	937	10.3	30.0		3						1				8		
13260	41520	955	10.3	30.0								13				6		
13240	41520	1013	10.3	30.0								4				1		
13220	41520	1030	10.3	30.0		1						31				10		
13206	41520	1043	10.0	30.0	15-30	6	1	1				112				68		
13196	41540	1115	10.0	31.0								9				4		
13220	41540	1135	10.0	30.0		2										10		
13240	41540	1152	10.0	30.0								6		1		7	1	
13260	41540	1210	9.8	30.0								1		3		1		
13280	41540	1227	9.8	30.0								5		1		5		
13290	41540																	
13275	41540	1250	10.3	30.0		14						2						
13280	41560	1310	10.3	30.0		6												
TOTAL		7.5h				118	48	1	2	0	2	274	0	41	7	153	4	650
COMPOSITION (%)						18.2	7.4	0.2	0.3	0.0	0.3	42.2	0.0	6.3	1.1	23.5	0.6	100.0

* SST - sea surface temperature
** SSS - sea surface salinity
*** Unidentified large gulls were most likely Glaucous-winged Gulls

Table 2c. Surveys of fish-eating birds in Milbanke Sound - South Portion on 2 June 1991.

TABLE 2c. Surveys of fish-eating birds in Milbanke Sound-South Portion on 2 June 1991.

Coordinates (LORAN-C)		Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Species Observed MAMU	RHAU	COMU	CAAU	ANMU	Unid. alcid	Large gull***	MEGU	BOGU	SOSH	PALO	Total
13280	41500	605	11.0	33.0	2	8	2				8			1	4	
13280	41480	613	10.5	32.0		7	2				1				1	
13260	41480	630	10.5	32.0		1					1			1		
13240	41480	646	10.5	31.0		21	2		1							
13220	41480	707	10.5	31.0	2					1						
13200	41480	727	9.3	31.0	7	21	1	2			68			15	6	
13200	41500	758	9.5	30.0											4	
13220	41500	815	10.0	30.0		1		1		3				1	4	
13240	41500	833	10.0	30.0	1						5			1		
13260	41500	849	10.8	30.0		3					3				2	
13280	41500	908	10.8	30.0			1				3			7		
13280	41520	935	12.0	28.0										5		
13260	41520	953	11.0	31.0		1	1									
13240	41520	1012	11.0	31.0							1					
13220	41520	1030	11.0	31.0											1	
13206	41520	1040	10.0	32.0	23	1	3				3				10	
13196	41540	1113	10.0	32.0	4	1	3		1	1						
13220	41540	1133	11.0	32.0			3									
13240	41540	1150	11.5	29.0							2					
13260	41540	1207	12.0	28.0							5					
13280	41540	1225														
TOTAL		6.3h			39	65	18	3	2	5	100	0	0	31	32	295
COMPOSITION (%)					13.2	22.0	6.1	1.0	0.7	1.7	33.9	0.0	0.0	10.5	10.8	100.0

* SST - sea surface temperature
** SSS - sea surface salinity
*** Unidentified large Gulls were most likely Glaucous-winged Gull.

Table 3a. Running counts of fish-eating birds in Mathieson Channel, 1991.

TABLE 3a. Moving boat surveys of fish-eating birds in Mathieson Channel, 1991.

Date	Landmark	Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Species Observed MAMU	Large gull***	MEGU	BOGU	COLO	PALO	COME	RTLO	RNGR	WEGR	PIGU
02 May	PERCIVAL NARROWS	1415	9.8	30.0	22	2	2								
	AGNES POINT	1425	9.8	30.0											
	HYDE POINT	1435	11.5	30.0	5			1							
		1445	11.5	30.0											
		1450	11.5	30.0											
	TOM BAY	1505	11.5	30.0			2								
	SYMONDS POINT	1515	11.8	30.0		2									
		1525	11.8	30.0			6		2						
	DE FRIETAS ISLETS	1535	11.8	30.0											
		1545	12.0	30.0		16	3		1	5					
	CARMICHAEL POINT	1555	12.0	30.0		1			2		2				
	SALMON BAY	1600	12.3	30.0											
	URSUS POINT	1615	12.3	30.0											
03 May	HIRD POINT	730	10.5	26.0			2		3			1			
		740	10.5	26.0					2						
		750	10.5	26.0			2		1						
		800	10.5	26.0			10		1						
		810	10.5	26.0											
		820	10.5	26.0			2		6						
	MCPHERSON CREEK	830	10.0	26.0		1	7								
		840	10.0	26.0	2										
		850	10.0	26.0		1	2								
		900	10.5	26.0											
		930	10.5	26.0	2	2	5		1		1		2		
		940	10.5	26.0			2								
		950	10.5	26.0			755		1						
	KYNOCH POINT	1000													
04 May	POOLEY POINT	1130	10.5	28.0								1			
		1140	10.5	28.0											
		1150	10.5	28.0	2							2			
		1200	8.0	30.0					1			1			
		1210	8.0	30.0											
	OPP GARVEY POINT	1220	8.0	30.0											
		1230	9.0	30.0											
		1240	9.0	30.0			1								
		1250	9.0	30.0											
	CHARLES HEAD	1000	9.0	30.0			29		5						
	COUNSEL POINT	1010	9.0	30.0		3		2				1			
		1020	9.0	30.0											
		1030	8.0	31.0			2								
		1040	8.0	31.0	2	6	1						1		
		1050	8.0	31.0				2	1						
	JAMES BAY	1100	8.3	30.0	1		1								
		1110	8.3	30.0			9								
		1120	8.3	30.0					3			1			
09 May	MATHIESON NARROWS	620	8.0	18.0	5	3	2		1						
		630	9.0	23.0	12	15	56					1			
		640	9.0	23.0	11	10	28	2	3						
		650	9.0	23.0	5		5					2			
		700	9.8	25.0		2	1			1					
	GARVEY POINT	710			13	8	38	1							
	KYNOCH POINT	1330	10.3	25.0	25	1	6					1			
		1340	10.3	25.0									3		
		1350	10.3	25.0	3	10	9								
		1400	10.0	26.0	2	42	14		7						
	OPP POOLEY POINT	1410	10.0	26.0		7	2								
		1450	10.0	26.0	8	2	4		2						
	MCPHERSON CREEK	1500	10.8	25.0		1	2		1						
		1510	10.8	25.0	2	1	7			3					
		1520	10.8	25.0	1	1	15		1						1
		1530	12.0	28.0		4				7					
		1540	12.0	28.0		1			2	16		1			
		1550	12.0	28.0		5				1		2			
		1600	11.5	28.0			3								
		1610	11.5	28.0			1		1				2		
		1620	11.5	28.0		4									
	MIALL ISLAND	1630													

* SST - sea surface temperature
** SSS - sea surface salinity
*** Adult large gulls were mostly California and Glaucous-winged Gulls.

TABLE 3a (Cont'd). Running counts of fish-eating birds in Mathieson Channel, 1991.

Date	Landmark	Time	SST (C)	SSS** (ppm)	MAMU	Large gull***	MEGU	BOGU	COLO	PALO	COME	RTLO	RNGR	WEGR	PIGU
17 May	PERCIVAL NARROWS	730	10.0	30.0	2										
	ALEC ISLAND	740	10.0	30.0	26	4					2				
	STAPLETON POINT	750	10.0	30.0	7	6									
	GUARD POINT	800	9.5	31.0	9	8	1								
		810	9.5	31.0	7										
		820	9.5	31.0	6	3									
		830	10.0	31.0	2	1									
	JERMAINE POINT	840	10.0	31.0	42										
		850	10.0	31.0	37										
		900	10.0	29.0									2		
		910	10.0	29.0	1	8									
	OSCAR PASS	920	10.0	29.0	4	5									
	MIALL POINT	930	10.0	29.0	2								1		
	SPANIEL POINT	940	10.0	29.0							1				
	JACKSON NARROWS	950	10.0	29.0											
		1000	11.0	28.0	1										
		1010	11.0	28.0			1								
	S GRIFFIN PASS	1020	11.0	28.0	6	6				5					
	CHARLES HEAD	1030	10.3	26.0	5	1	1				1				
		1040	10.3	26.0											
		1050	10.3	26.0		3	1								
		1100	11.5	25.0	2	2		4							
		1110	11.5	25.0		4									
		1120	11.5	25.0		5	3								
	OPP MCPHERSON CREEK	1130	11.8	25.0	1								1		
	JAMES BAY	1140	11.8	25.0	2					2					
		1150	11.8	25.0						1					
		1200	11.0	25.0											
22 May	PERCIVAL NARROWS	1310	9.8	31.0	6										
		1330			22		1								
		1340													
	HYDE POINT	1353			35										
		1400			3										
		1410													
		1420			10										
		1430	12.0	30.0	4										
		1440			2										
	DE FRIETAS ISLETS	1450			1										
		1500	13.0	30.0			1								
	SALMON BAY	1510													
	URSUS POINT	1520											2		
		1530	12.5	29.0											
		1540											1		
	SPANIEL POINT	1550													
23 May	Counsel Point	650			32	1									
		705			26										
		710			48										
		720			18										
		730			36										
		740			46										
		750			12										
		800			7	2									
		810													
		820			6										26
	Kynoch Point														

* SST - sea surface temperature
** SSS - sea surface salinity
*** Adult large gulls were mostly California and Glaucous-winged Gulls.

Table 3b. Stationary Counts of Marbled Murrelets in Mathieson Channel, 1991.

TABLE 3b. Stationary counts of Marbled Murrelets in Mathieson Channel, 1991.

Morning	04 May	10 May	11 May	23 May	04 June
Departing	1265	1219	1110	354	81
Arriving			5		
On the water		11	9	64	9
TOTAL	1265	1230	1124	418	90
% Departing	100.0	99.1	98.8	84.7	90.0

Table 4. Surveys of Kynoch Inlet from a moving boat in May 1991.

TABLE 4. Surveys of Kynoch Inlet from a moving boat in May 1991.

Date	Landmark	Physical Data Time (PDS)	SST* (C)	SSS** (ppm)	Species Observed MAMU	GWGU ***	MEGU	BOGU	COLO	PALO	COME	RTLO	RNGR	PIGU	TOTAL
03MAY91	KYNOCH POINT	1000	11.0	26.0			2								
	along south shore	1010	11.0	26.0		2	5								
		1020	11.0	26.0	2	1	8		1						
		1030	10.0	25.0		5	1		5						
	OPP DESBRISAY BAY	1040	10.0	25.0	2	1	4		2			1	1		
		1050	10.0	25.0		1	3					2			
		1100	8.5	25.0	1		1					2			
		1110	8.5	25.0										3	
		1120	8.5	25.0			2		1					2	
	HEAD OF KYNOCH	1130	8.0	20.0											
TOTAL 03 MAY		1.5h			5	10	24	0	9	0	0	5	1	5	59
COMPOSITION (%)					8.5	16.9	40.7	0.0	15.3	0.0	0.0	8.5	1.7	8.5	100.0
09MAY91	MOUTH OF KYNOCH	740	10.0	22.0	15	13	8		1						
	OLD LADY FALLS	750	10.0	22.0	8	7	19								
	along north shore	800	10.0	22.0	5	7									
		810	10.0	22.0	9	6									
	DESBRISAY BAY	820	10.0	22.0	10	2	7								
		830	9.0	11.0											
		840	9.0	11.0	2			6	2		3				
		850	9.0	11.0	5						1				
		900	8.5	13.0	1						1				
	KYNOCH INLET	910	8.5	13.0	2		1								
		920	8.5	11.0	3	2	1				2				
		930	8.5	11.0	10										
		940	8.5	11.0		10	16	6	1		12				
	HEAD OF KYNOCH	950	8.0	4.0		11					4			4	
	HEAD OF KYNOCH	1000	8.0	4.0											
	along south shore	1010	8.0	4.0	1		1								
		1020	8.0	4.0	3	1					2				
		1030	8.5	12.0	3	1	1				6	2			
		1040	8.5	12.0	1										
		1050	8.5	12.0	1										
		1100	9.5	15.0	2	1	1								
		1110	9.5	15.0		11		1							
	KYNOCH POINT	1120													
TOTAL 09 MAY		3.7h			81	72	55	13	4	0	31	2	0	4	262
COMPOSITION (%)					30.9	27.5	21.0	5.0	1.5	0.0	11.8	0.8	0.0	1.5	100.0
23 May	KYNOCH POINT	830			1	1	2								
		840			7										
		850				3									
		900			3	1	1								
	DESBRISAY BAY	910			3	6									
		920			6	1									
		930			2										
	HEAD OF INLET	940			9	1					8			5	
TOTAL 23 MAY		1.1h			31	13	3	0	0	0	8	0	0	5	60
COMPOSITION (%)					51.7	21.7	5.0	0.0	0.0	0.0	13.3	0.0	0.0	8.3	100.0
11JUN91	GARVEY POINT	945	9.0	16.0	1		3								
	OLD LADY FALLS	955	9.0	16.0	6		1								
	along north shore	1005	9.0	16.0	8		1								
		1015	9.8	15.0	3										
		1025	9.8	15.0	20		1								
	DESBRISAY BAY	1035	9.8	15.0	27						2				
		1045	9.8	15.0	47						18				
		1055	9.8	15.0	15										
		1105	9.8	15.0	5		3								
	KYNOCH INLET	1115	9.8	15.0	5		1								
		1125	9.5	16.0	8										
		1200	9.5	16.0	8		2		2						
		1210	9.5	16.0											
		1220	9.3	15.0	5										
	HEAD OF KYNOCH	1230	9.3	15.0	5										
	along south shore	1240	9.3	15.0	4		1								
	OPP DESBRISAY BAY	1250	9.3	15.0	20										
		1300	9.3	15.0	3										
		1310	9.3	15.0	3		1								
		1320	11.0	18.0	4										
		1330	11.0	18.0	4										
	KYNOCH POINT	1338													
TOTAL 11 JUNE		4.0h			201	0	14	0	2	0	20	0	0	0	237
COMPOSITION (%)					84.8	0.0	5.9	0.0	0.8	0.0	8.4	0.0	0.0	0.0	100.0

Table 5. Stationary counts of Marbled Murrelets in Mussel Inlet, 1991.

TABLE 5. Stationary counts of Marbled Murrelets in Mussel Inlet, 1991.

Morning Counts	May										June							
	05	06	07	08	18	19	20	21	24	26	27	28	29	30	04	05	11	14
Departing	97	163	34	21	23	0	31	9										
Arriving	6	9	2	1	5	3	1	0										
On the water	19	30	19	7	35	45	17	117			100	535	264	142	80	300	543	
TOTAL	122	202	55	29	63	48	49	126	*	*	100	535	264	142	80	300	543	*
%DEPART	79.5	80.7	61.8	72.4	36.5	0.0	63.3	7.1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Evening Counts	May										June							
	05	06	07	08	18	19	20	21	24	26	27	28	29	30	04	05	11	14
Departing	0	0	0						49	520	337	213	66					160
Arriving	2	6	0							4								51
On the water	0	0	0						151	27	4	36	2					
TOTAL	2	6	0	*	*	*	*	*	200	551	341	249	68	*	*	*	*	211
%DEPART	0	0	0						24.5	94.4	98.8	85.5	97.1					75.8

FIGURES

FIGURE 1. Marbled Murrelet study area on the coast of British Columbia.

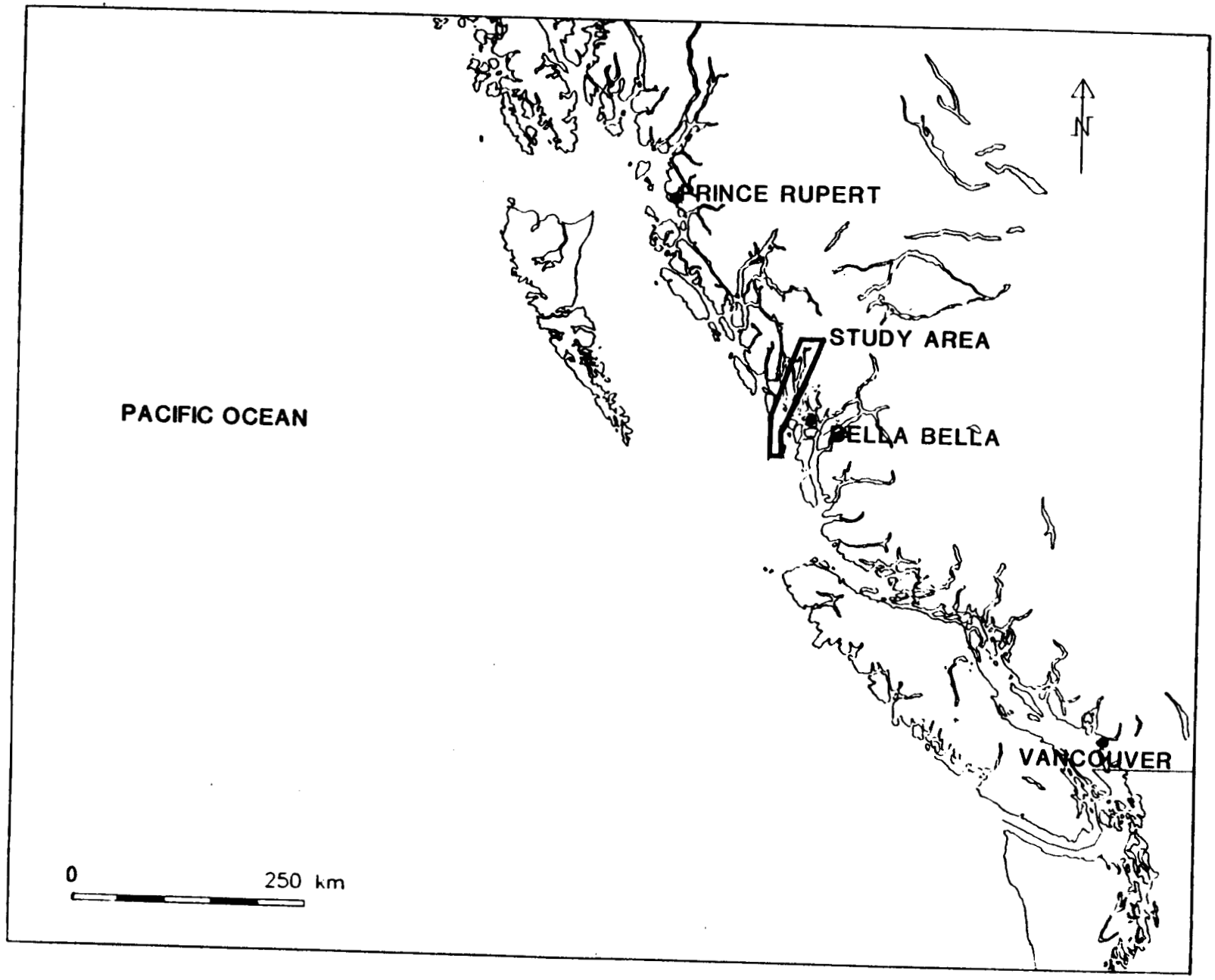

PRINCE RUPERT
STUDY AREA
PACIFIC OCEAN
BELLA BELLA
VANCOUVER
N
0
250 km

FIGURE 2. Marbled Murrelet study area and major place names used in the text.

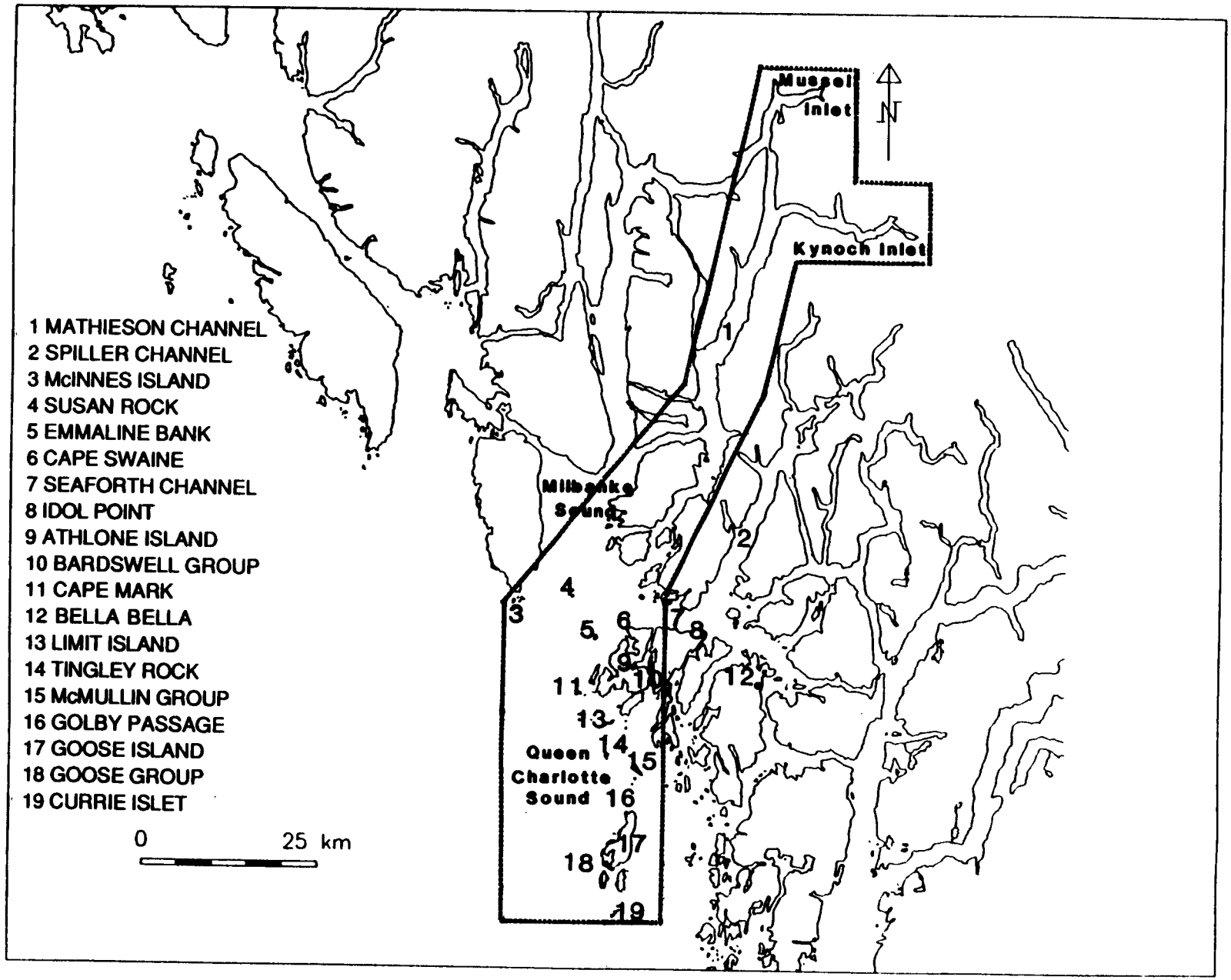

1 MATHIESON CHANNEL
2 SPILLER CHANNEL
3 McINNES ISLAND
4 SUSAN ROCK
5 EMMALINE BANK
6 CAPE SWAINE
7 SEAFORTH CHANNEL
8 IDOL POINT
9 ATHLONE ISLAND
10 BARDSWELL GROUP
11 CAPE MARK
12 BELLA BELLA
13 LIMIT ISLAND
14 TINGLEY ROCK
15 McMULLIN GROUP
16 GOLBY PASSAGE
17 GOOSE ISLAND
18 GOOSE GROUP
19 CURRIE ISLET
0
25 km
Mussel Inlet
Kynoch Inlet
Milbanke Sound
Queen Charlotte Sound
N

FIGURE 3. Sites of stationary counts and other activities in the central study area.

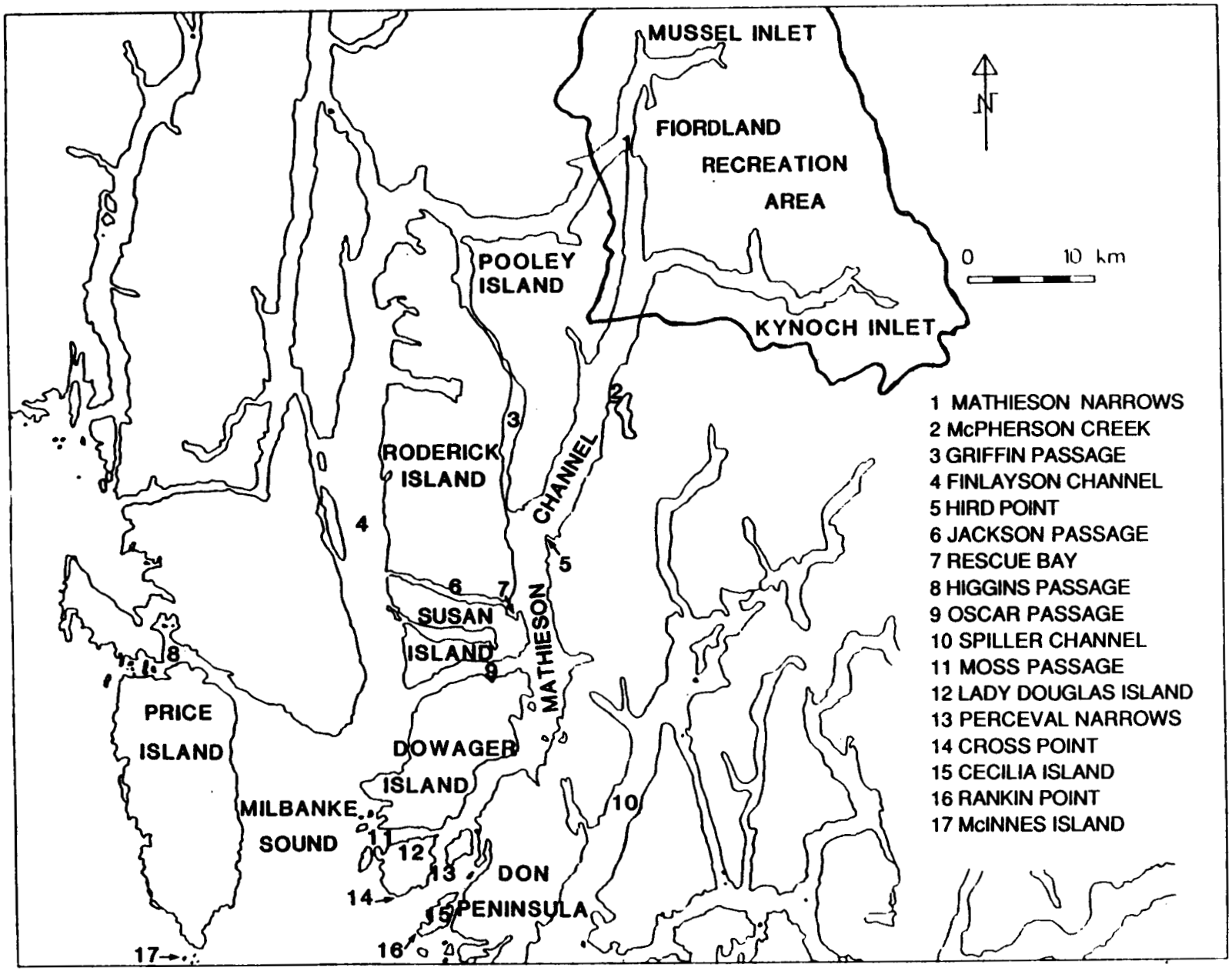

MUSSEL INLET
FIORDLAND
RECREATION
AREA
N
0
10 km
POOLEY
ISLAND
KYNOCH INLET
RODERICK
ISLAND
CHANNEL
MATHIESON
SUSAN
ISLAND
PRICE
ISLAND
DOWAGER
ISLAND
MILBANKE
SOUND
DON
PENINSULA
1 MATHIESON NARROWS
2 McPHERSON CREEK
3 GRIFFIN PASSAGE
4 FINLAYSON CHANNEL
5 HIRD POINT
6 JACKSON PASSAGE
7 RESCUE BAY
8 HIGGINS PASSAGE
9 OSCAR PASSAGE
10 SPILLER CHANNEL
11 MOSS PASSAGE
12 LADY DOUGLAS ISLAND
13 PERCEVAL NARROWS
14 CROSS POINT
15 CECILIA ISLAND
16 RANKIN POINT
17 McINNES ISLAND

FIGURE 4. Place names used in surveys and other activities in Mussel and Kynoch Inlets.

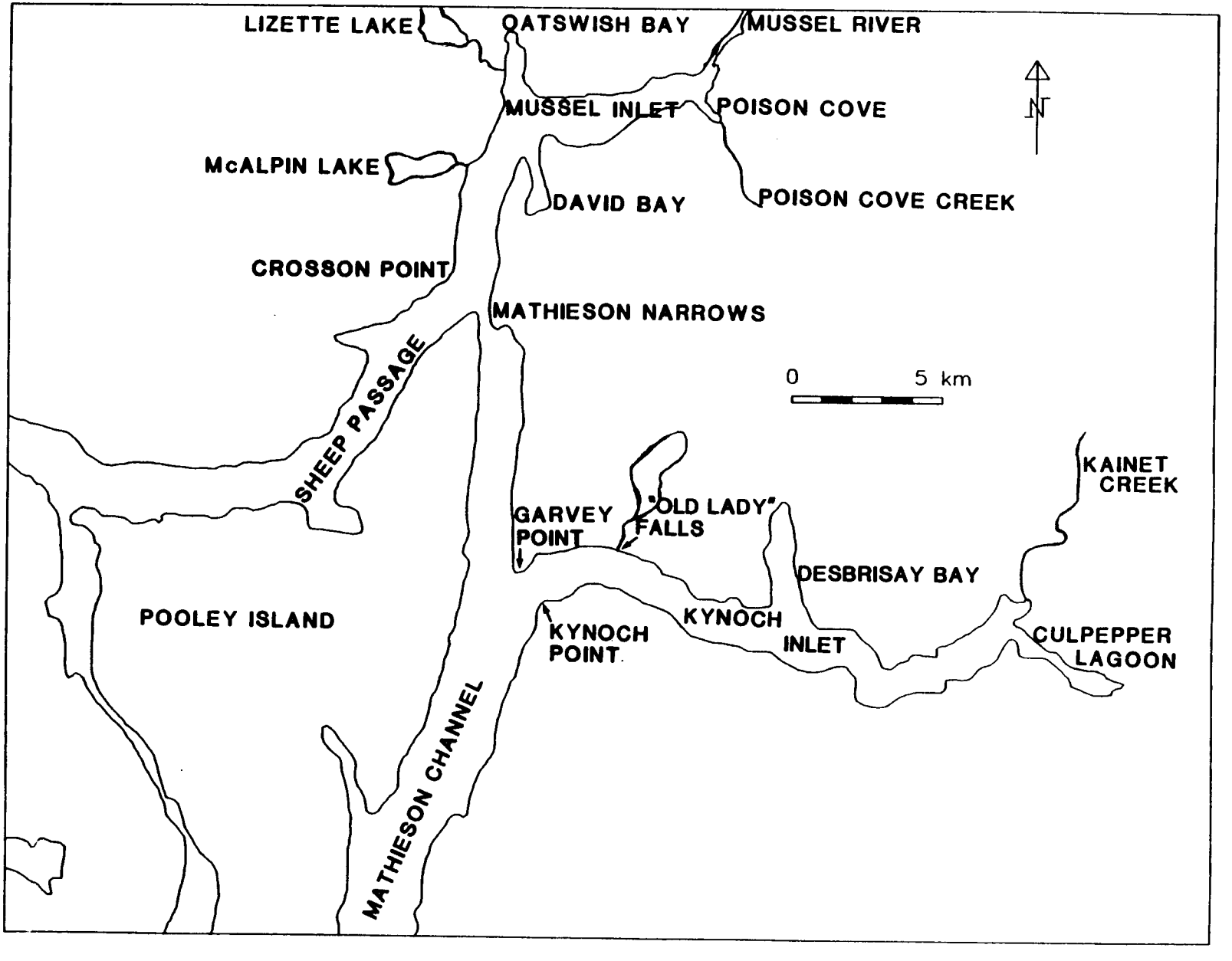

LIZETTE LAKE
OATSWISH BAY
MUSSEL RIVER
MUSSEL INLET
POISON COVE
N
McALPIN LAKE
DAVID BAY
POISON COVE CREEK
CROSSON POINT
MATHIESON NARROWS
0
5 km
SHEEP PASSAGE
KAINET CREEK
GARVEY POINT
"OLD LADY" FALLS
DESBRISAY BAY
POOLEY ISLAND
KYNOCH POINT
KYNOCH INLET
CULPEPPER LAGOON
MATHIESON CHANNEL

FIGURE 5. Sites of stationary counts and other activities in Mussel Inlet.

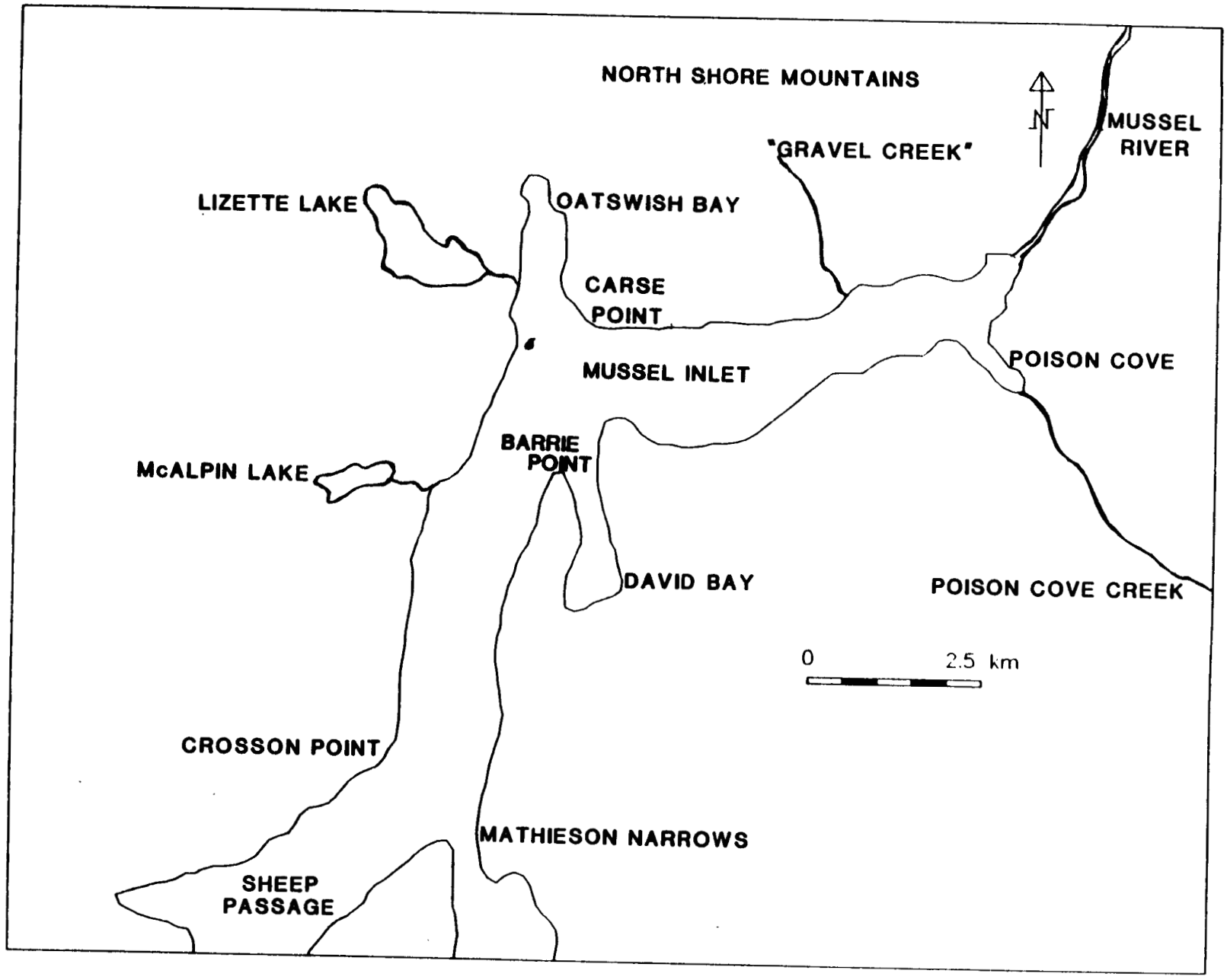

NORTH SHORE MOUNTAINS
N
MUSSEL RIVER
"GRAVEL CREEK"
LIZETTE LAKE
OATSWISH BAY
CARSE POINT
MUSSEL INLET
POISON COVE
BARRIE POINT
McALPIN LAKE
DAVID BAY
POISON COVE CREEK
0
2.5 km
CROSSON POINT
MATHIESON NARROWS
SHEEP PASSAGE

FIGURE 6. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys between Currie Islet and Cape Mark, 30 April 1991.

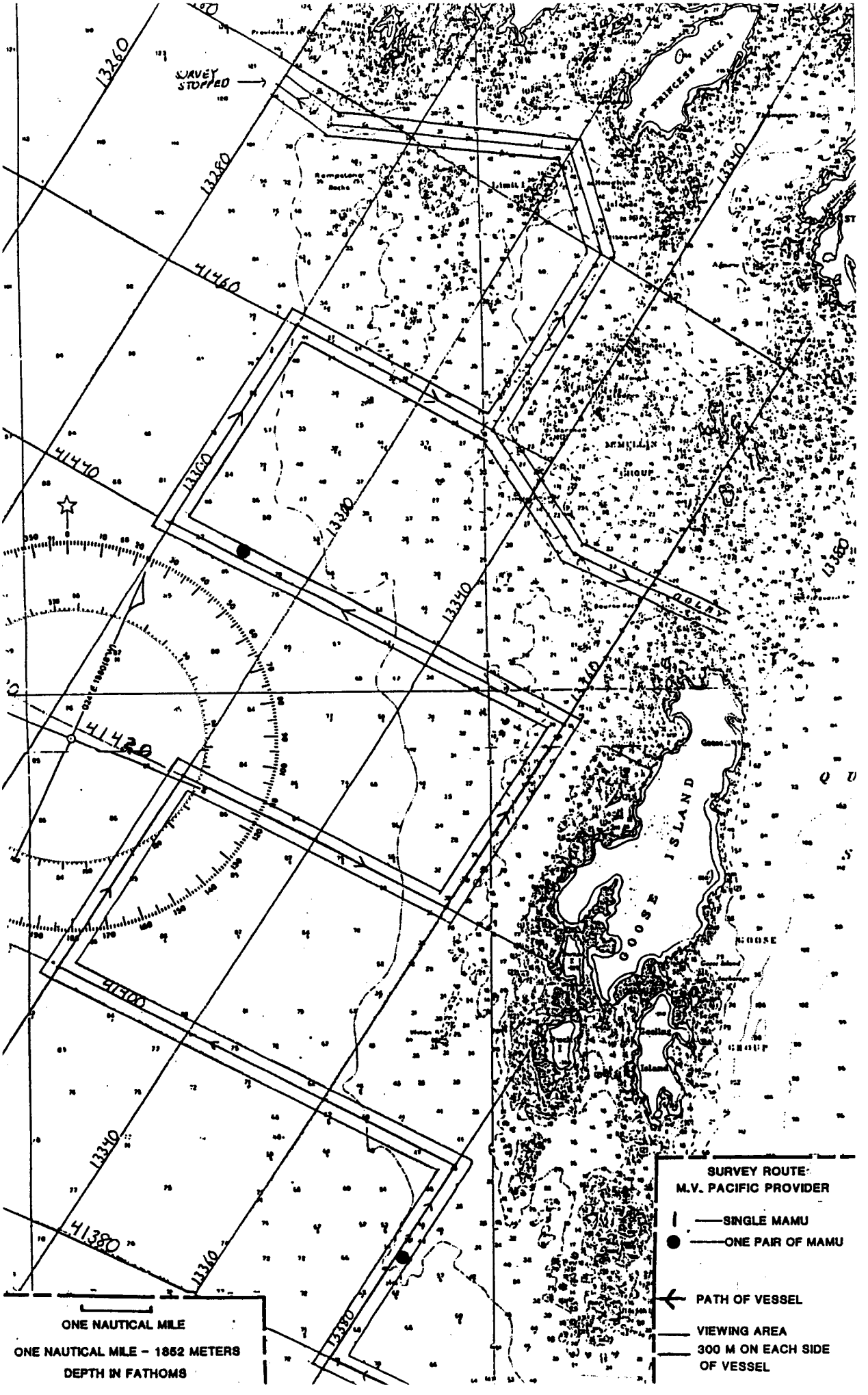

SURVEY STOPPED
13360
13340
41460
41440
41420
41400
41380
GOOSE ISLAND
GOOSE
ONE NAUTICAL MILE
ONE NAUTICAL MILE – 1852 METERS
DEPTH IN FATHOMS
SURVEY ROUTE
M.V. PACIFIC PROVIDER
SINGLE MAMU
ONE PAIR OF MAMU
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE
OF VESSEL

FIGURE 7. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys between Currie Islet and Cape Mark, 13 May 1991.

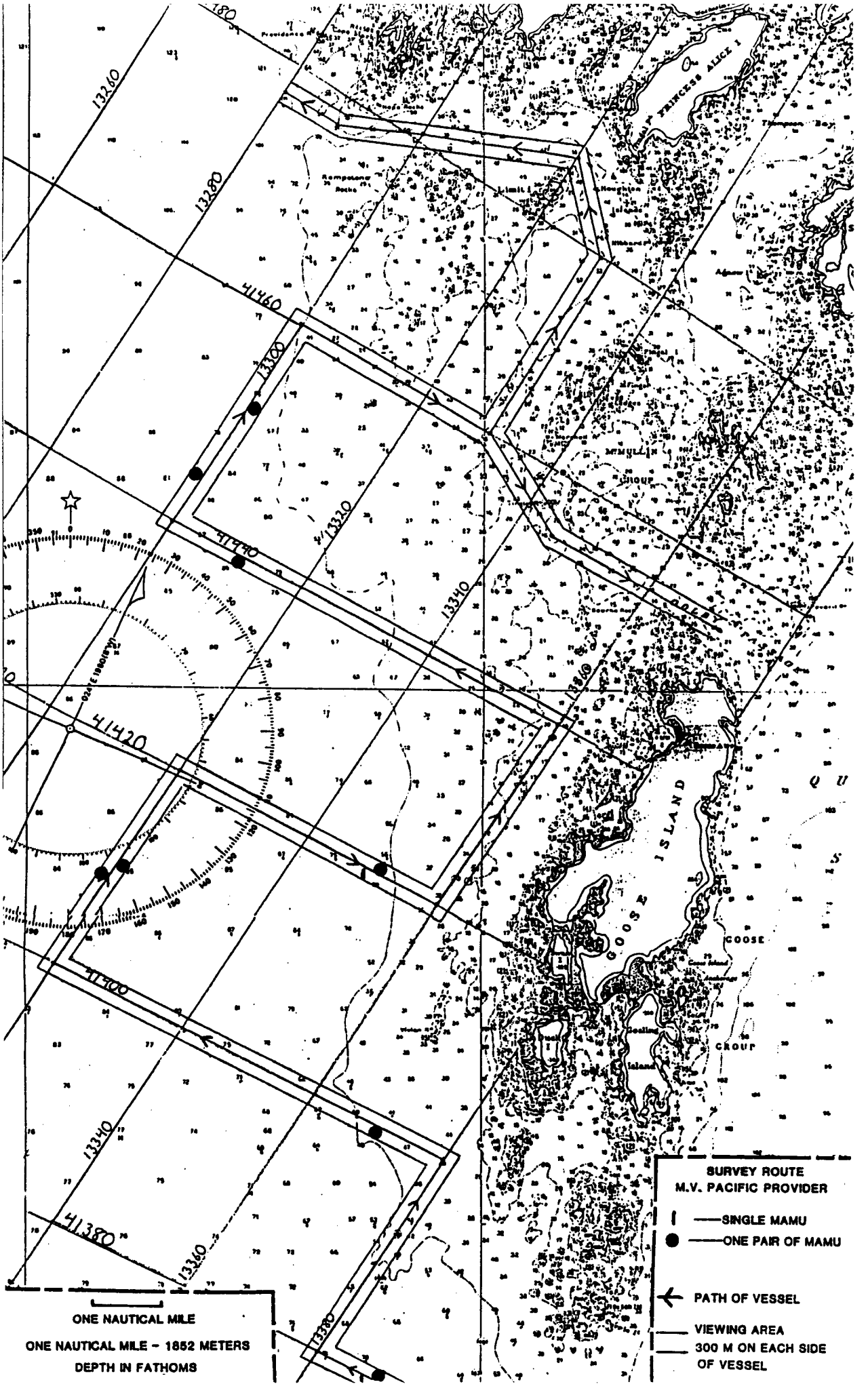

180
13260
13280
41460
13300
13320
41440
13340
13360
41420
41400
13340
41380
13360
13380
PRINCESS ALICE I
GOOSE ISLAND
GOOSE
GROUP
SURVEY ROUTE
M.V. PACIFIC PROVIDER
SINGLE MAMU
ONE PAIR OF MAMU
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE
OF VESSEL
ONE NAUTICAL MILE
ONE NAUTICAL MILE = 1852 METERS
DEPTH IN FATHOMS

FIGURE 8. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys between Currie Islet and Cape Mark, 1 June 1991.

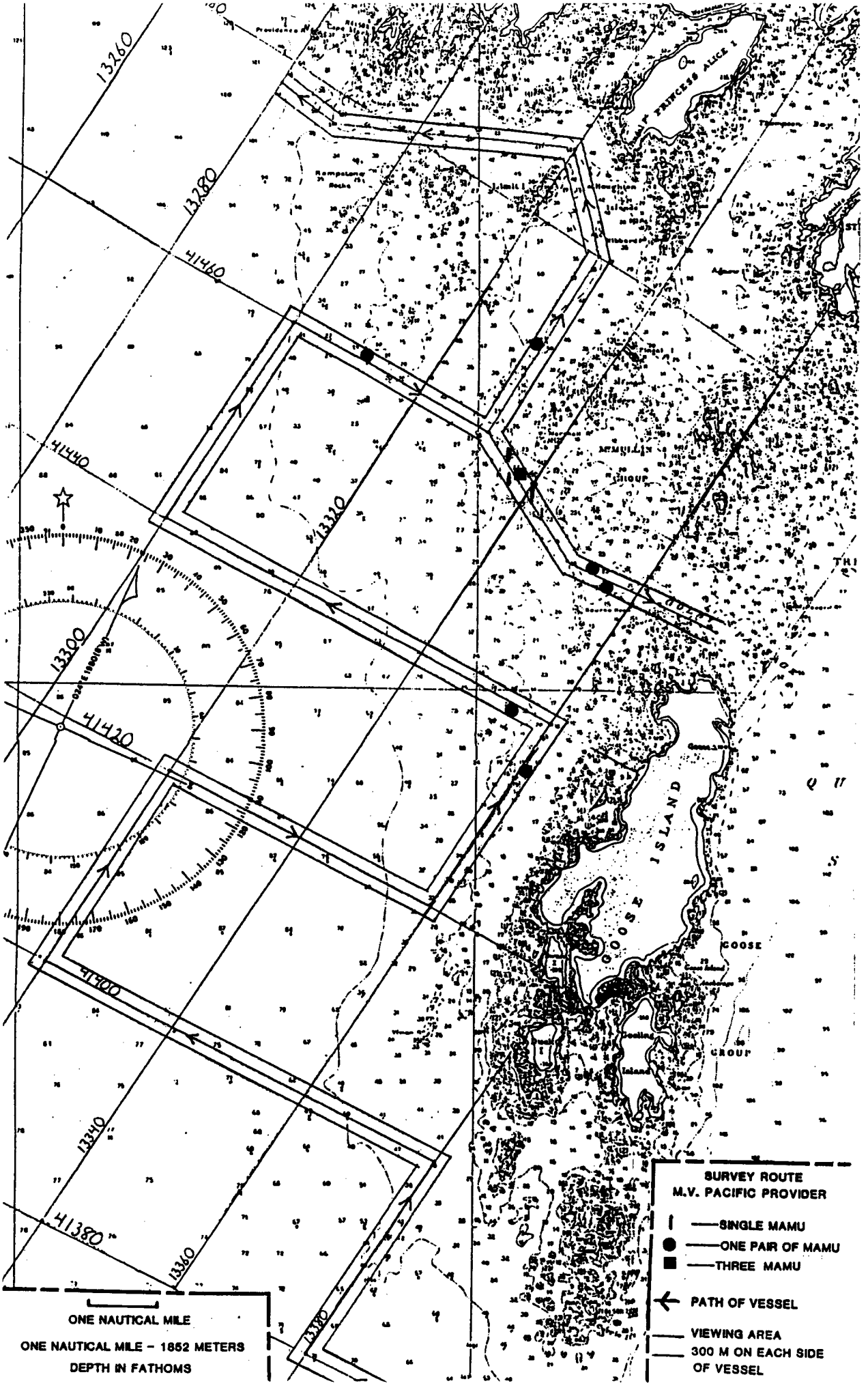

13260
13280
41460
41440
13320
13300
41420
41400
13340
41380
13360
13380
ISLAND
COOSE
GROUP
ONE NAUTICAL MILE
ONE NAUTICAL MILE – 1852 METERS
DEPTH IN FATHOMS
SURVEY ROUTE
M.V. PACIFIC PROVIDER
SINGLE MAMU
ONE PAIR OF MAMU
THREE MAMU
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE
OF VESSEL

FIGURE 9. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys in Milbanke Sound, 2 May 1991.

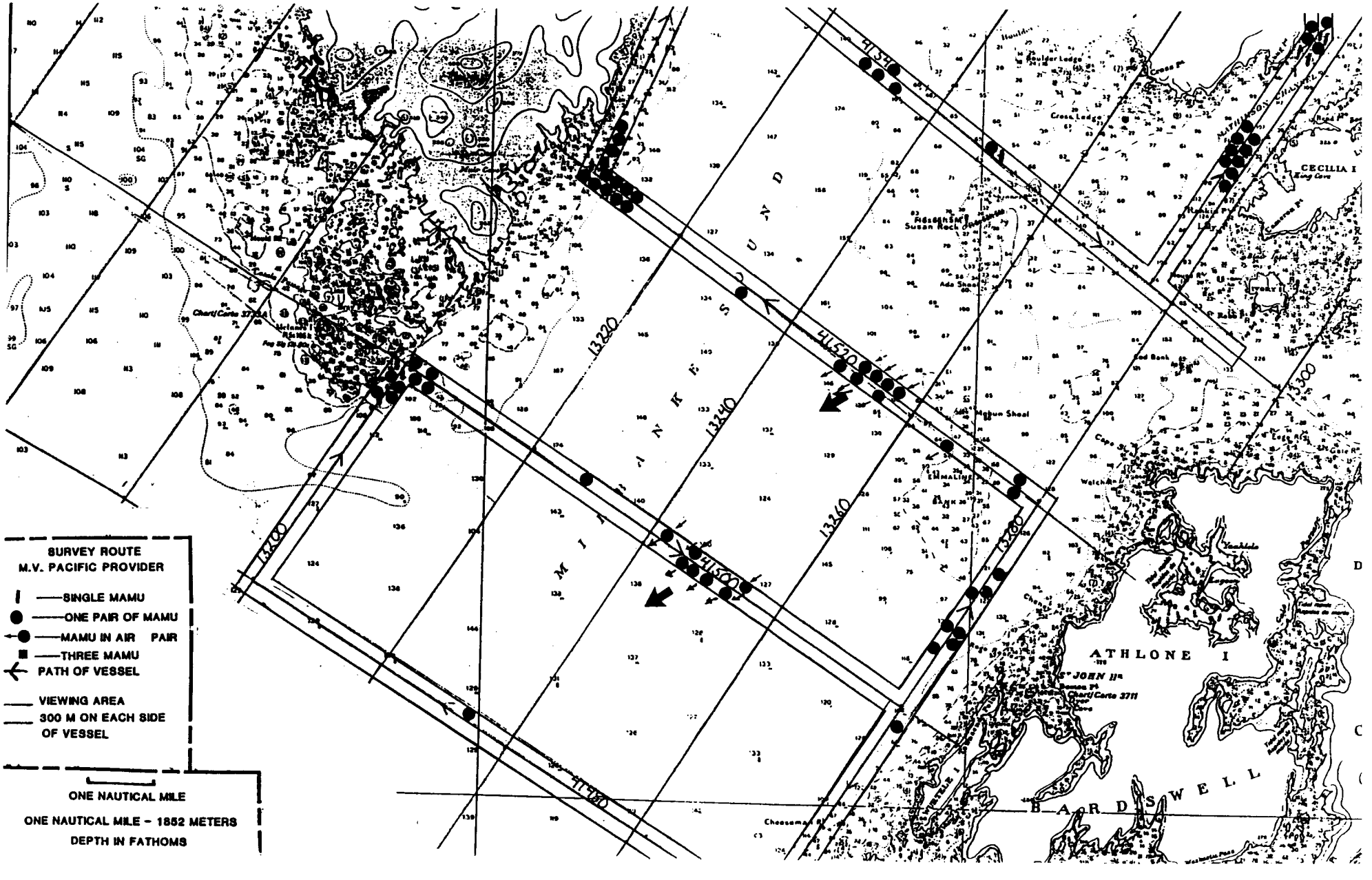

SURVEY ROUTE
M.V. PACIFIC PROVIDER
SINGLE MAMU
ONE PAIR OF MAMU
MAMU IN AIR PAIR
THREE MAMU
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE OF VESSEL
ONE NAUTICAL MILE
ONE NAUTICAL MILE = 1852 METERS
DEPTH IN FATHOMS
13220
13240
13260
13280
13300
13320
41340
41520
41500
41480
41460
ATHLONE I
BARDSWELL

FIGURE 10. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys in Milbanke Sound, 22 May 1991.

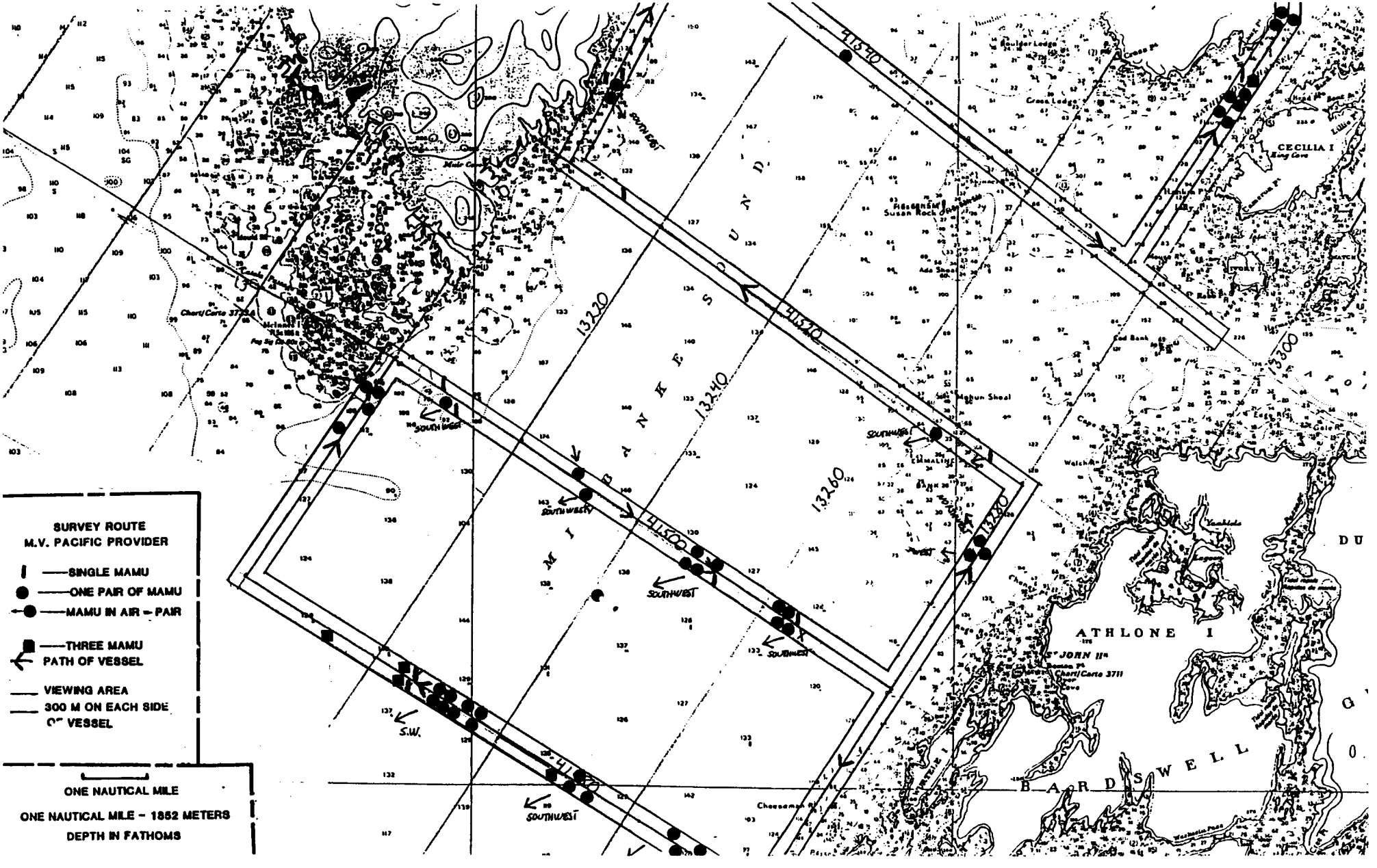

SURVEY ROUTE
M.V. PACIFIC PROVIDER
—SINGLE MAMU
—ONE PAIR OF MAMU
—MAMU IN AIR – PAIR
—THREE MAMU
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE
OF VESSEL
ONE NAUTICAL MILE
ONE NAUTICAL MILE = 1852 METERS
DEPTH IN FATHOMS
MINNESUNDA
13220
13240
13260
13280
13300
41520
41500
41480
SOUTHWEST
S.W.
SOUTHEAST
CECILIA I
ATHLONE I
BARDSWELL

FIGURE 11. LORAN-C notations and locations of Marbled Murrelet observations on a copy of the nautical chart followed for murrelet surveys in Milbanke Sound, 2 June 1991.

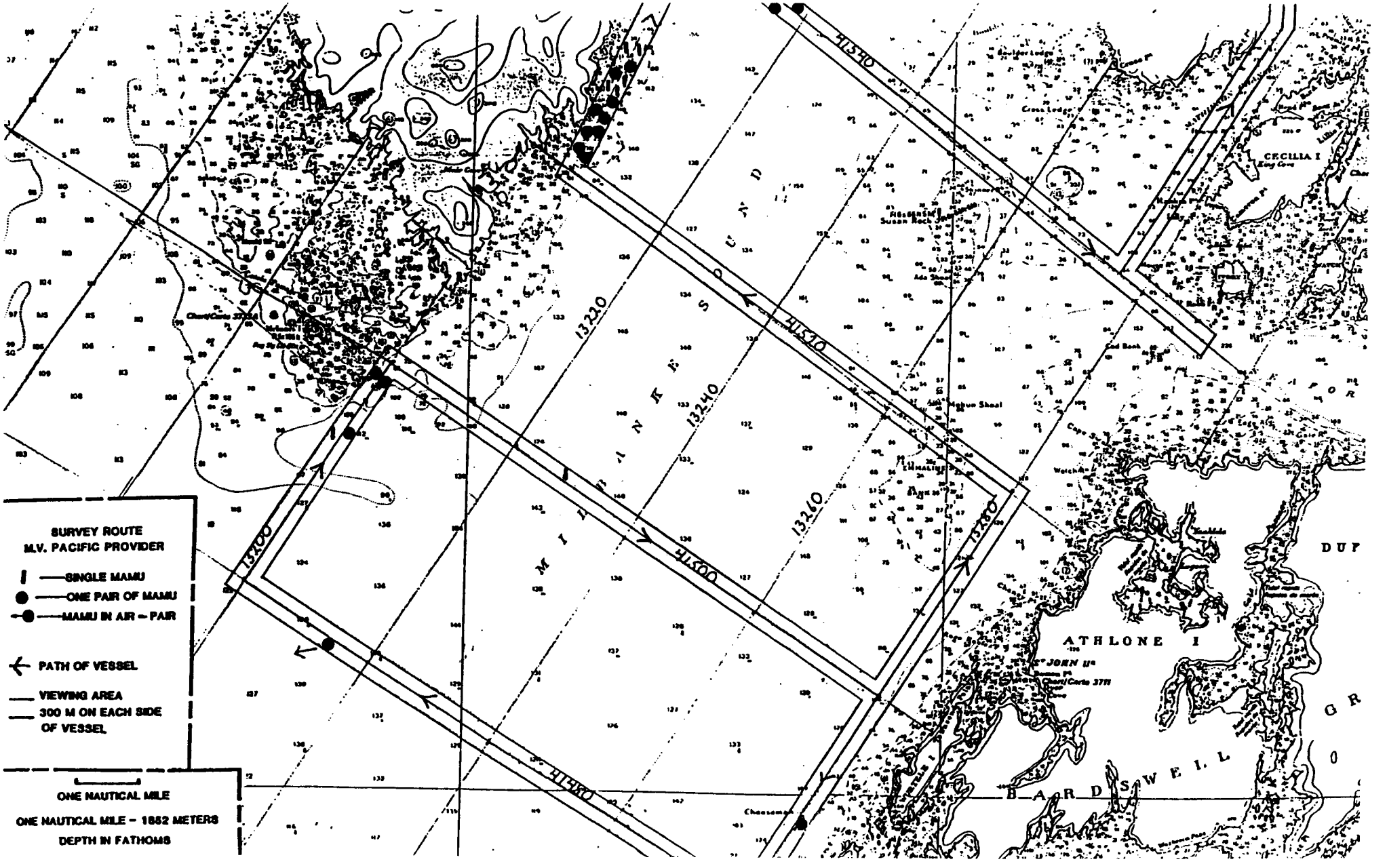

SURVEY ROUTE
M.V. PACIFIC PROVIDER
—SINGLE MAMU
—ONE PAIR OF MAMU
—MAMU IN AIR – PAIR
PATH OF VESSEL
VIEWING AREA
300 M ON EACH SIDE
OF VESSEL
ONE NAUTICAL MILE
ONE NAUTICAL MILE – 1852 METERS
DEPTH IN FATHOMS
13220
13240
13260
13280
13300
41540
41520
41500
41480
MIDDLE GROUND
CECILIA I
ATHLONE I
BARDSWELL

FIGURE 12. Annotated depth sounder trace from Milbanke Sound indicating schools of fish over bottom features, 22 May 1991.

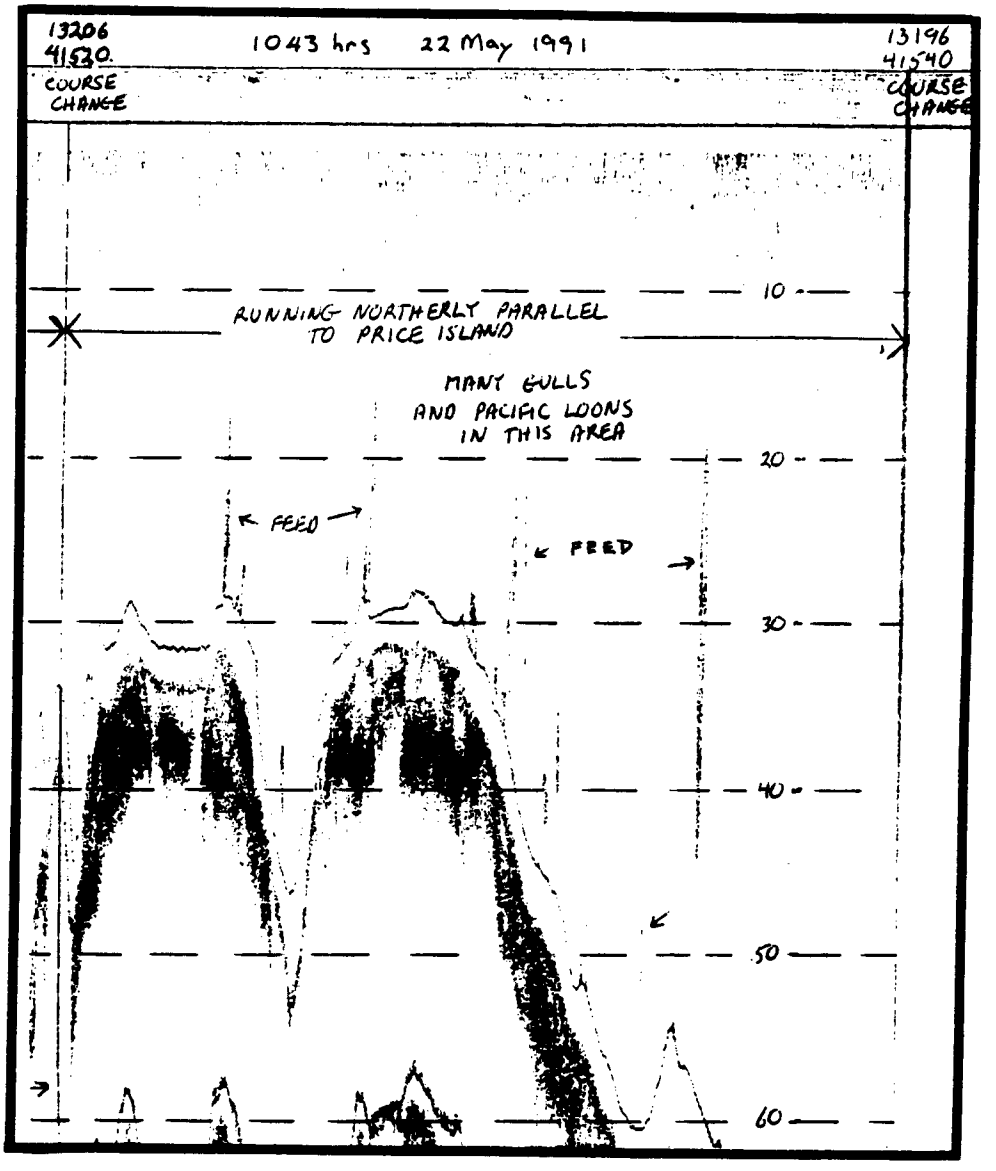

13206
41530
1043 hrs 22 May 1991
13196
41540
COURSE CHANGE
COURSE CHANGE
10
RUNNING NORTHERLY PARALLEL TO PRICE ISLAND
MANY GULLS AND PACIFIC LOONS IN THIS AREA
20
FEED
FEED
30
40
50
60

FIGURE 13. Annotated depth sounder trace from Milbanke Sound indicating concentration of Red-necked Phalaropes over bottom features, 22 May 1991.

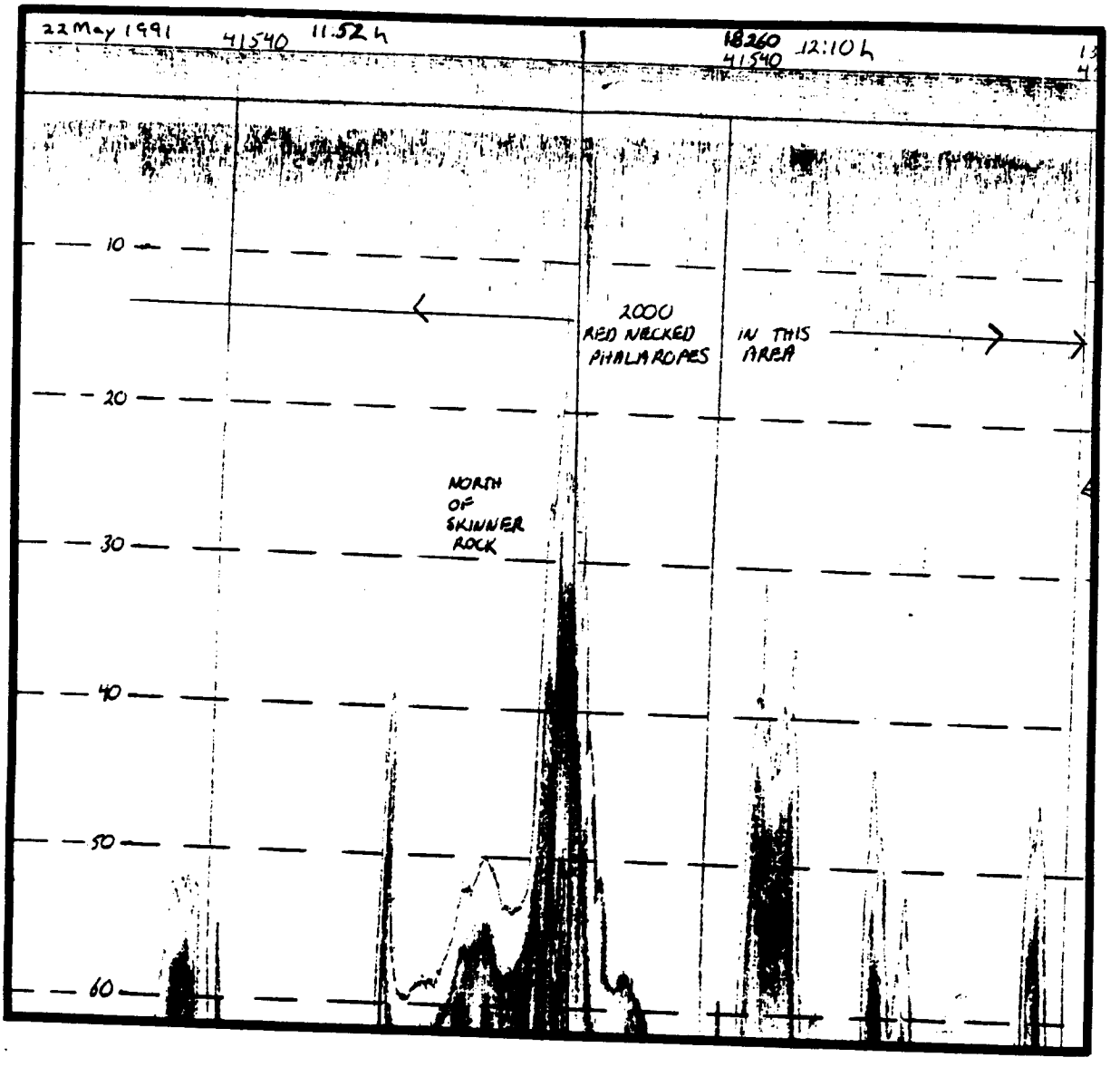

22 May 1991 41540 11.52 h
18260 12:10 h
41540
10
20
30
40
50
60
2000
RED NECKED
PHALAROPES
IN THIS
AREA
NORTH
OF
SKINNER
ROCK

FIGURE 14. Annotated depth sounder trace from Mathieson Channel showing signals believed to be shrimp, 23 May 1991.

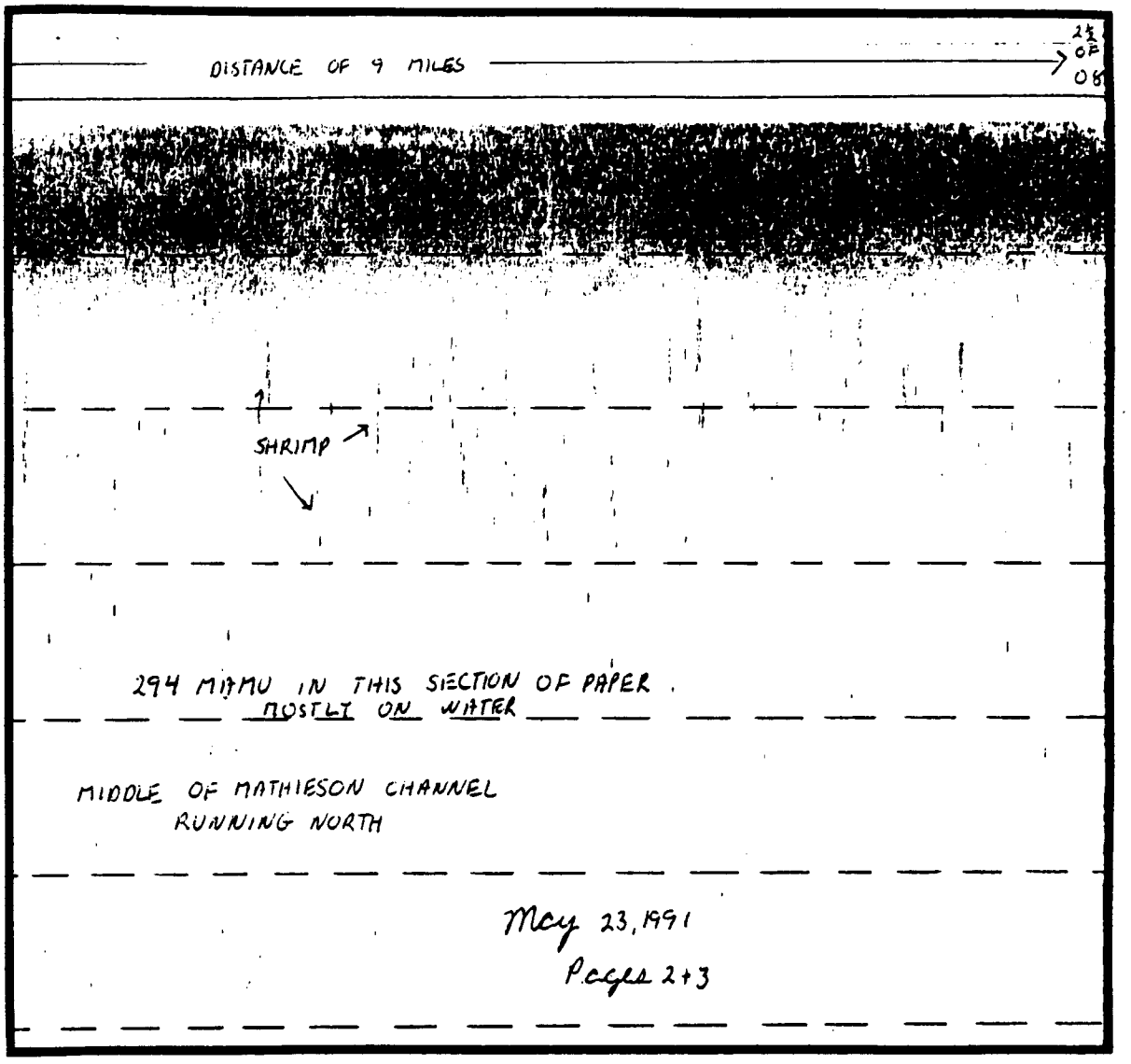

DISTANCE OF 9 MILES
2½ OF 06
SHRIMP
294 MIMU IN THIS SECTION OF PAPER.
MOSTLY ON WATER
MIDDLE OF MATHIESON CHANNEL
RUNNING NORTH
May 23, 1991
Pages 2+3

FIGURE 15. Annotated depth sounder trace from Kynoch Inlet showing large schools of fish beneath a flock of Mew Gulls, 3 May 1991.

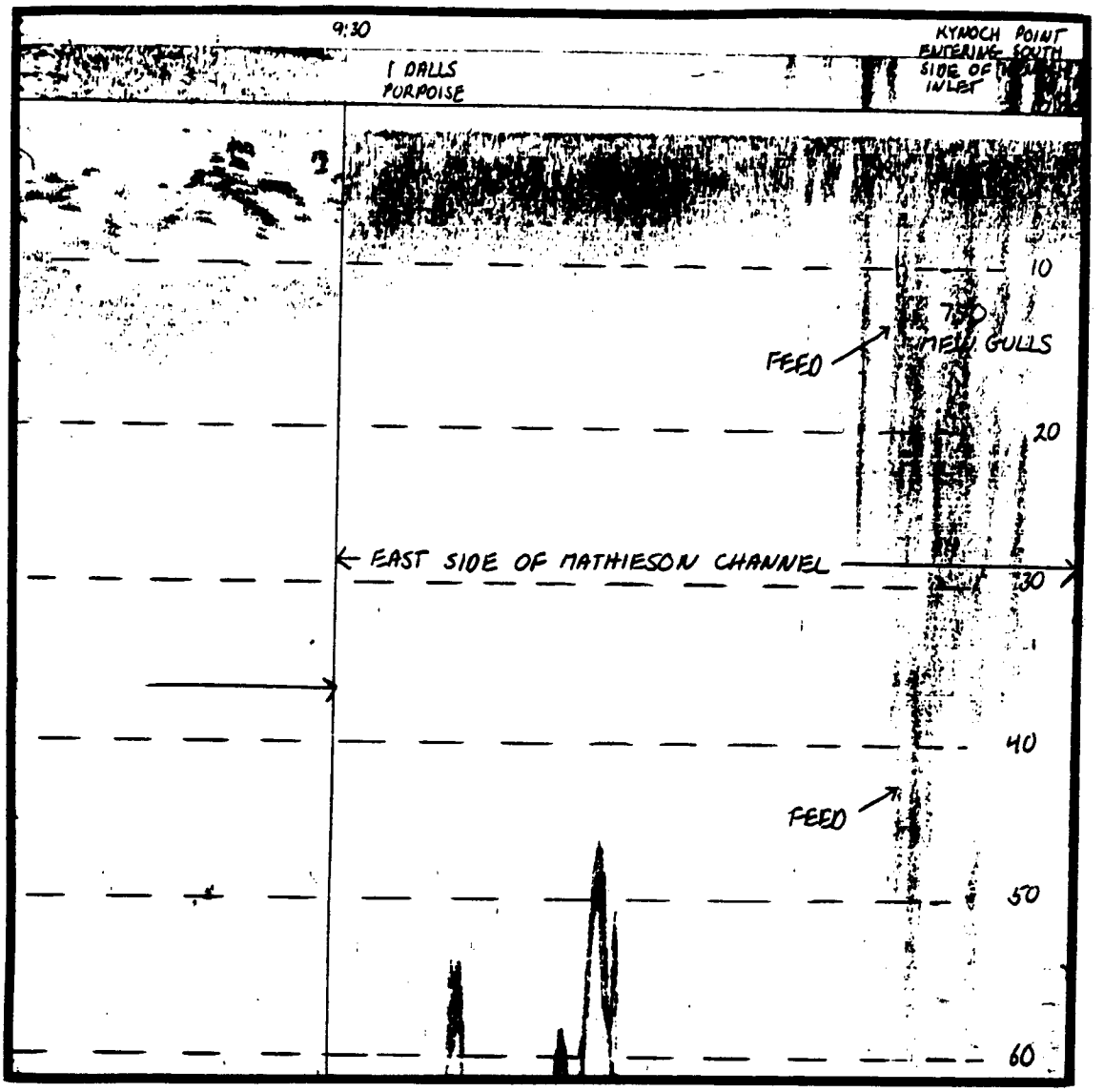
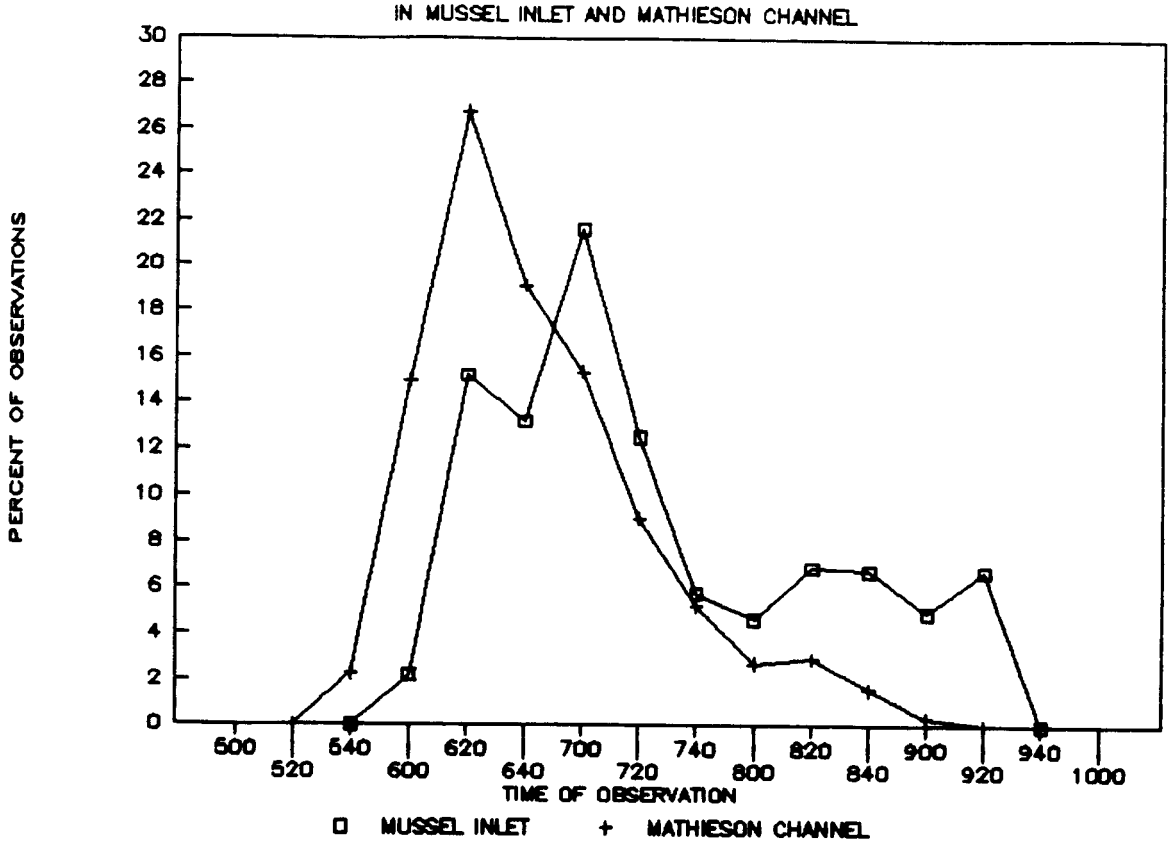

9:30
KYNOCH POINT
ENTERING SOUTH
SIDE OF
INLET
DALLS
PORPOISE
10
7:50
FEED
GULLS
20
EAST SIDE OF MATHIESON CHANNEL
30
40
FEED
50
60

FIGURE 16. Peak periods of movements by Marbled Murrelets as inferred from changes in the frequency of observation during stationary counts in Mussel Inlet and Mathieson Channel, May 1991.

MORNING COUNTS OF MARBLED MURRELETS

IN MUSSEL INLET AND MATHIESON CHANNEL



EVENING COUNTS OF MURRELETS

IN MUSSEL INLET

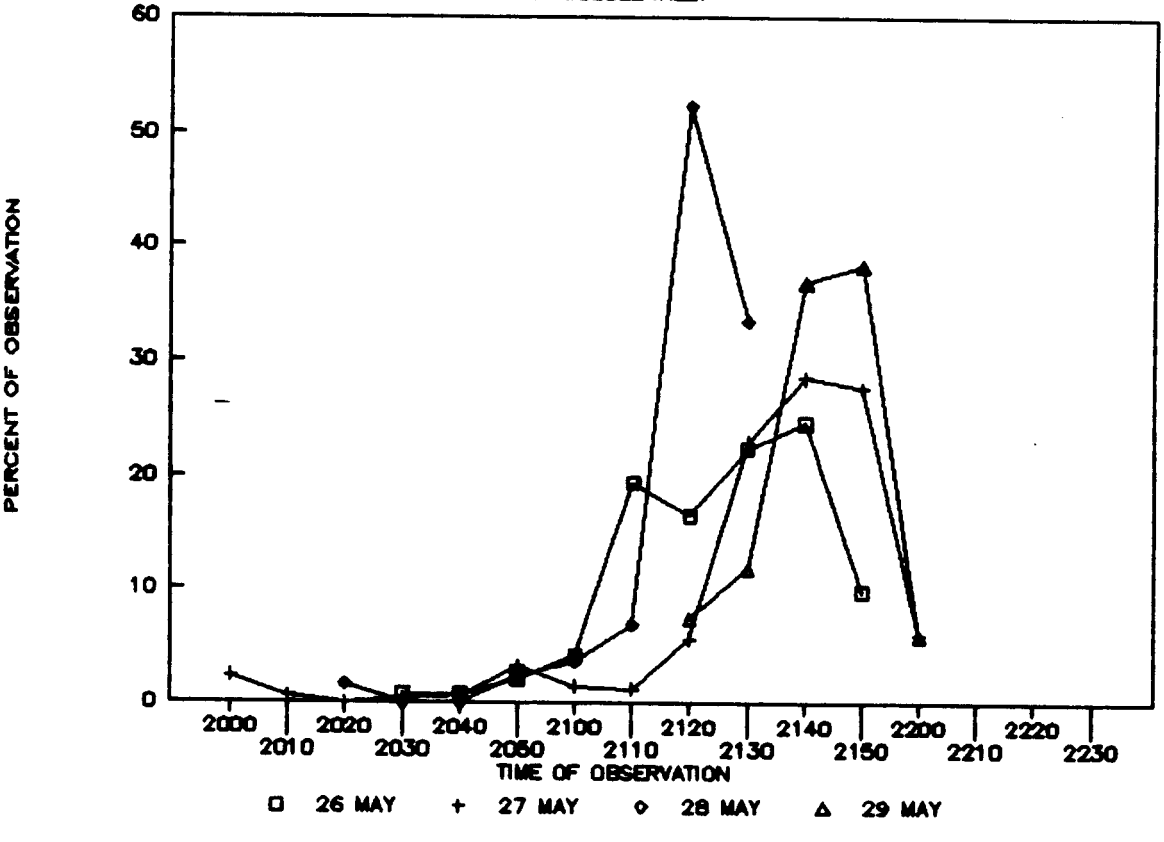


FIGURE 17. The shift from morning departures to evening departures from Mussel Inlet by Marbled Murrelets during May and June, 1991.

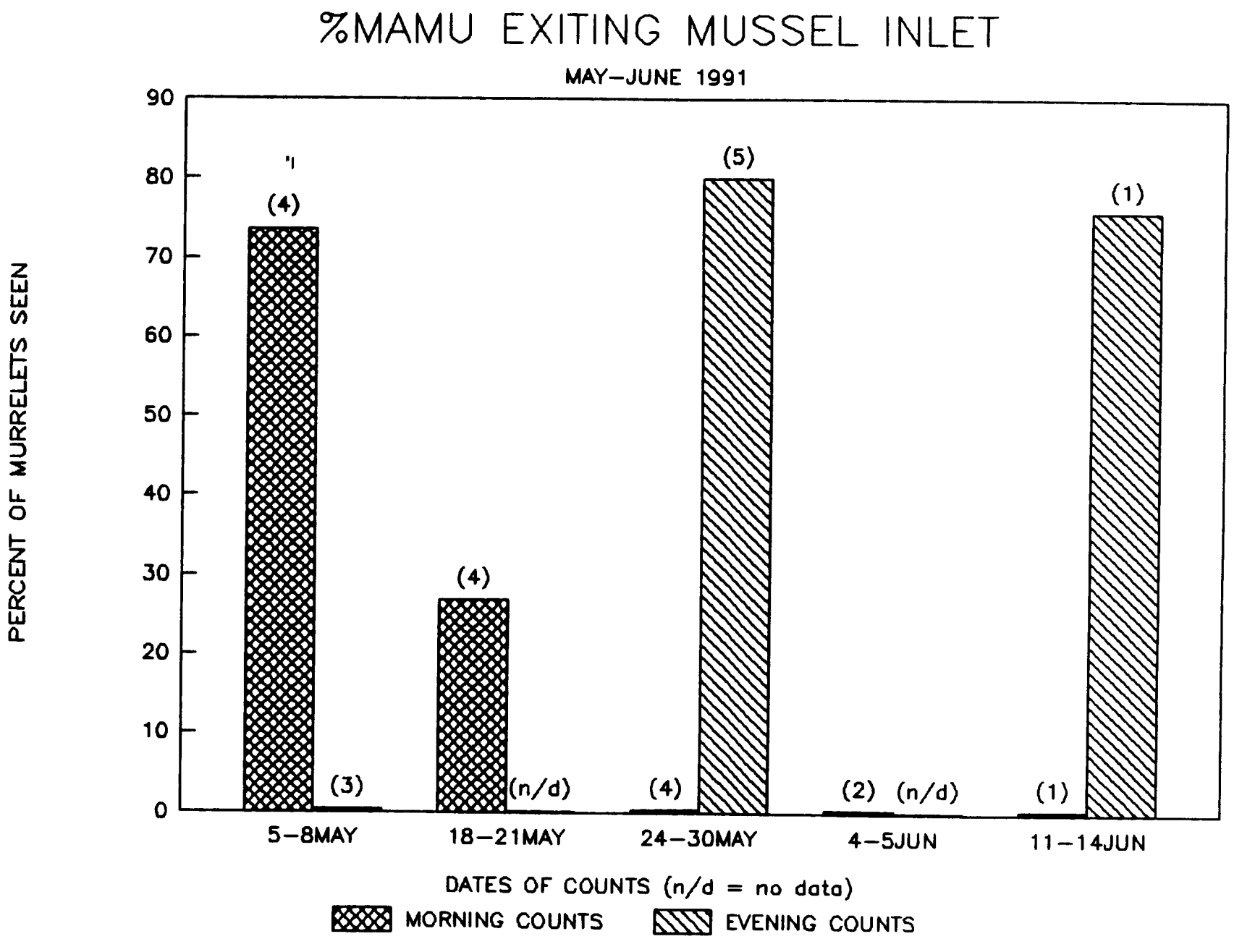
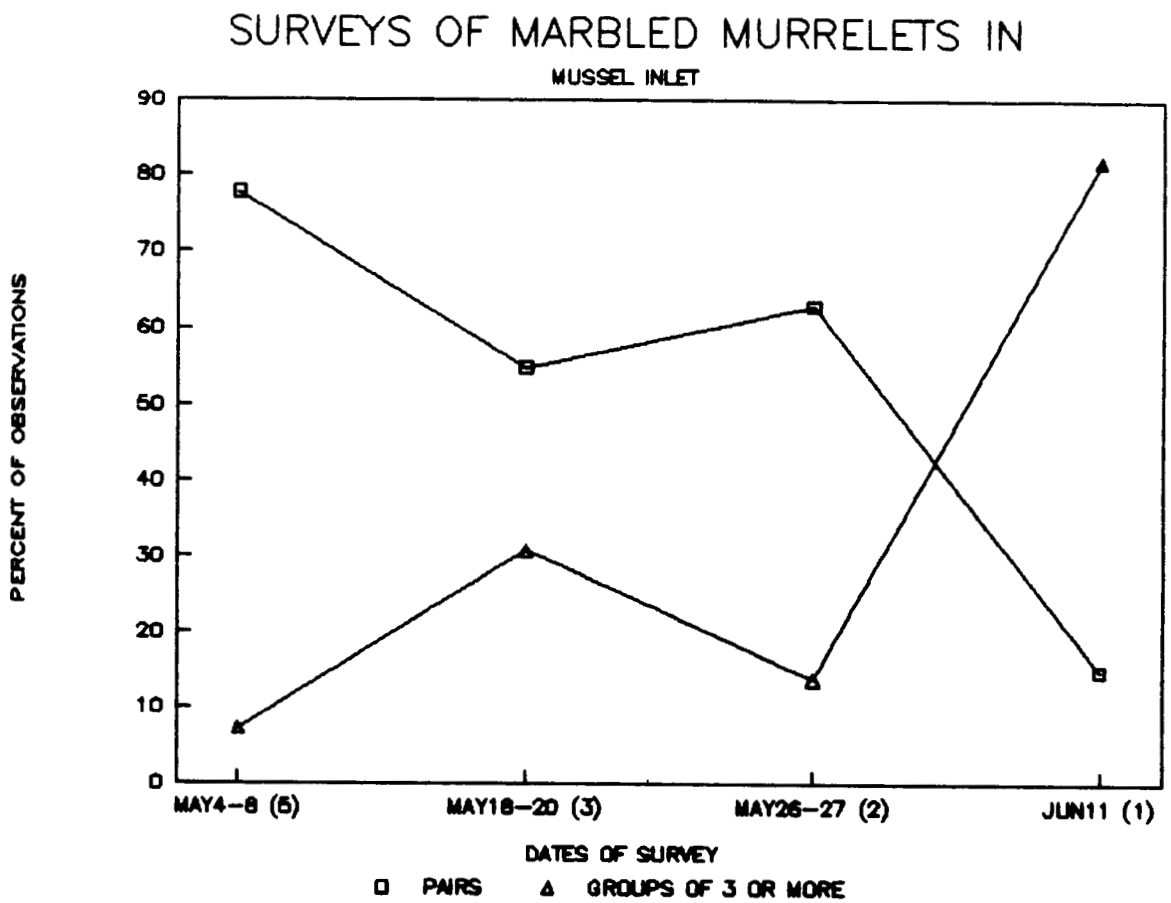

%MAMU EXITING MUSSEL INLET
MAY–JUNE 1991
PERCENT OF MURRELETS SEEN
90
80
70
60
50
40
30
20
10
0
(4)
(3)
(4)
(n/d)
(4)
(5)
(2)
(n/d)
(1)
(1)
5–8MAY
18–21MAY
24–30MAY
4–5JUN
11–14JUN
DATES OF COUNTS (n/d = no data)
MORNING COUNTS
EVENING COUNTS

FIGURE 18. Changes in group size among Marbled Murrelets in Mussel Inlet during the early breeding season, 1991.


SURVEYS OF MARBLED MURRELETS IN
MUSSEL INLET
PERCENT OF OBSERVATIONS
90
80
70
60
50
40
30
20
10
0
MAY4–8 (5)
MAY18–20 (3)
MAY26–27 (2)
JUN11 (1)
DATES OF SURVEY
□ PAIRS
△ GROUPS OF 3 OR MORE

APPENDIX 1. Other waterbirds seen in Queen Charlotte Sound and Milbanke Sound, May-June 1991.

APPENDIX 1. Other birds seen in Queen Charlotte Sound and Milbanke Sound, April - June 1991.

Species Code	Queen Charlotte Sound Currie Islet to Cape Mark			Milbanke Sound south portion		
	30 Apr	13 May	1 June	2 May	22 May	2 June
NOFU	0	0	1	0	0	0
FTSP	1	23	8	0	9	0
PECO	8	0	0	0	0	0
COLO	2	1	0	11	7	2
RTLO	2	0	1	1	3	3
RNGR	0	0	0	1	0	0
WEGR	0	0	0	0	2	0
CAGO	2	0	9	0	0	0
BRAN	9	0	0	12	0	0
HADU	0	0	0	6	0	4
WWSC	10	6	0	31	56	5
SUSC	180	6	0	60	61	2
COME	0	0	0	2	1	0
RBME	0	0	0	0	8	0
WHIM	5	0	0	0	0	0
DUNL	0	0	0	20	0	0
RNPL	* 100	0	12	0	2000	1
WEGU	4	2	0	1	1	0
CAGU	0	0	0	17	0	0
HEGU	0	1	0	0	0	0
BAEA	2	49	25	6	11	5
CORA	4	0	0	0	0	0
NWCR	2	0	0	0	0	0

* unidentified phalaropes

APPENDIX 2. Other waterbirds seen in Mathieson Channel, May 1991.

Appendix 2. Other waterbirds seen in Mathieson Channel, May 1991

Species Code	Date of Survey May 03	04	09	10	11	12	17	23
FTSP	0	0	0	0	0	0	1	0
CAGO	0	0	0	2	1	0	0	0
HADU	12	4	0	2	0	2	10	0
WWSC	0	0	0	2	0	0	0	0
SUSC	633	6	0	22	4	0	30	5
BAGO	3	0	0	0	5	5	7	0
BUFF	0	0	0	0	3	0	0	0
RBME	0	0	9	0	3	0	0	0
MALL	0	0	0	0	20	0	0	0
GWTE	0	0	0	0	1	0	0	0
AMWI	0	0	0	0	0	0	3	0
Scaup	0	4	0	0	4	0	0	0
GRYE	0	0	0	2	0	0	0	0
DUNL	0	0	0	0	0	0	40	0
CAGU	0	1	1	0	0	0	2	0
HEGU	0	0	2	0	0	0	0	0
BAEA	0	5	25	2	2	3	12	3
NWCR	0	20	3	3	12	4	13	0

APPENDIX 3. Other waterbirds seen in Kynoch Inlet, May-June, 1991.

Appendix 3: Other waterbirds seen in Kynoch Inlet, May - June 1991.

Species Code	Date of Survey 03 May	09 May	23 May	11 June
CAGO	0	8	0	0
HADU	0	24	0	0
SUSC	33	456	70	10
OLDS	0	1	0	0
BAGO	0	104	0	10
BUFF	0	2	0	0
MALL	0	10	0	4
GWTE	0	2	0	0
Scaup	0	0	0	1
CAGU	0	4	0	0
HEGU	0	1	0	0
BAEA	2	3	0	3
NWCR	4	17	5	1

APPENDIX 4. Observations of waterbirds in Mussel Inlet, May-June 1991.

APPENDIX 4. Observations of waterbirds in Mussel Inlet, May - June 1991.

Date	Time	Species Code CAGO	GWFG	MALL	GWTE	NOSL	scaup	BAGO	BUFF	HADU	SUSC
04 May	am			6	5			16		14	17
05 May	am							8		4	4
	pm					4					2
06 May	am							1		4	14
	pm									4	
07 May	am							11		21	
	pm	6								2	
08 May	am									2	9
09 May	am									2	
18 May	am	1							13		9
19 May	am									1	
20 May	am									3	3
21 May	am									2	33
24 May	am			11							
25 May	am		4				8			7	
	pm									7	
26 May	am									2	
	pm						11				
27 May	am	1								2	
	pm									6	
28 May	am									31	31
	pm						3			13	3
29 May	am						18				
	pm									4	17
05 Jun	am									4	4
14 Jun	pm										6

Note. On 30 May, we also saw a Fork-tailed Storm-Petrel and a Pomarine Jaeger.

OBSERVATIONS OF MARINE MAMMALS

Queen Charlotte Sound - Currie Islet to Cape Mark

Harbour Porpoise: 30 April-1.

Milbanke Sound - south portion

Dall's Porpoise: 2 May-7, 22 May-7, 2 June-1.
Pacific White-sided Dolphin: 22 May-10.

Mathieson Channel

Steller's Sealion: 2 May-3.
Harbour Seal: 3 May-50, 4 May-89, 9 May-4, 17 May-5, 23 May-3.
Dall's Porpoise: 3 May-9, 4 May-6, 9 May-28, 10 May-11, 11 May-7, 12 May-4, 17 May-6, 23 May-9.
Pacific White-sided Dolphin: 12 May-30.

Kynoch Inlet

Harbour Seal: 9 May-21.

Mussel Inlet

River Otter: 6 May-3, 7 May-1, 24 May-12.
Harbour Seal: 5 May-1, 6 May-3, 7 May-2, 8 May-1, 18 May-1, 19 May-1, 21 May-2.
Dall's Porpoise: 5 May-2, 8 May-2 adults and 3 young, 26 May-2 adults and 1 young, 27 May-1, 30 May-1.

TERRESTRIAL MAMMALS

Kynoch Inlet

Black Bear: 9 May-1 adult and 1 cub.

Mussel Inlet

Gray Wolf: 7 May-1.
Mountain Goat: 8 May-7, 19 May-7, 21 May-4, 24 May-1, 28 May-4.
Grizzly Bear: 24 May-1, 5 June-1.
Black Bear: frequently seen.
Hoary Marmot: 5 June-1.

APPENDIX 6: CAPTURING MARBLED MURRELETS IN MIST NETS.

CAPTURING MARBLED MURRELETS IN MIST NETS.

METHOD.

We used the *Pacific Provider*, a 13 m troller to transport the equipment and act as a platform for heavier work such as setting and retrieving anchors. We used an inflatable skiff while erecting the poles, setting the net, and retrieving birds.

We set the net in a part of Mussel Inlet which was 275 m deep, 1.7 km wide, and subject to strong outflow winds. We had designed the support system to be set in deep water, compensate for tidal fluctuations of more than 6 m, and withstand the unfavourable weather conditions common along the coast. It was constructed from commercial fishing gear and all visible parts were painted flat black:

1. POLES AND NETS

Equipment

(a) 2 6 m bamboo poles with a minimum diameter of 1.3 cm, of the type commonly used by halibut fishermen;
(b) 2 4.5 kg lead end weights which bolt to the end of the bamboo poles;
(c) 2 chains 2 m long (7.5 mm links);
(d) 2 jaw and eye stabilizer swivels (7.5 mm link);
(e) 12 cylindrical styrofoam floats (15 x 30 cm);
(f) 12 nylon rings (2.5 cm dia.);
(g) 1 7.5 mm rope 25 m long;
(h) 1 nylon mist net (2.8 x 18 m, 6 cm mesh);
(i) 1 painted board for wrapping the net.
(j) 2 nylon pulleys (10 cm dia.)
(k) 30 m twine

Assembly

We assembled the poles for the nets before departing to the field. Six of the styrofoam floats (e) were bolted to each pole (a) so that the last was about 0.3 m from the thick end (Fig. 1). Six of the nylon rings (f) were attached to each pole so that the net would be fully spread when set. An end weight (b) was bolted to each pole and we attached one end of a chain (c) to the bolt. A swivel (d) and then a pulley (j) were attached to the other end of the chain.

2. ANCHORING

Equipment

(l) 2 16 kg halibut kedge anchors each with an added 18 kg lead ball;
(m) 2 11 kg lead balls as counterbalance weights;
(n) 2 7.5 mm polypropylene ropes, spliced, for smooth passage through pulleys, in 360 m lengths. Polypropylene rope floats and other types of rope become too heavy in great lengths;
(o) 2 large floats or boat bumpers;

Assembly

The anchors and lines were assembled in the field (Fig. 1).

Deployment

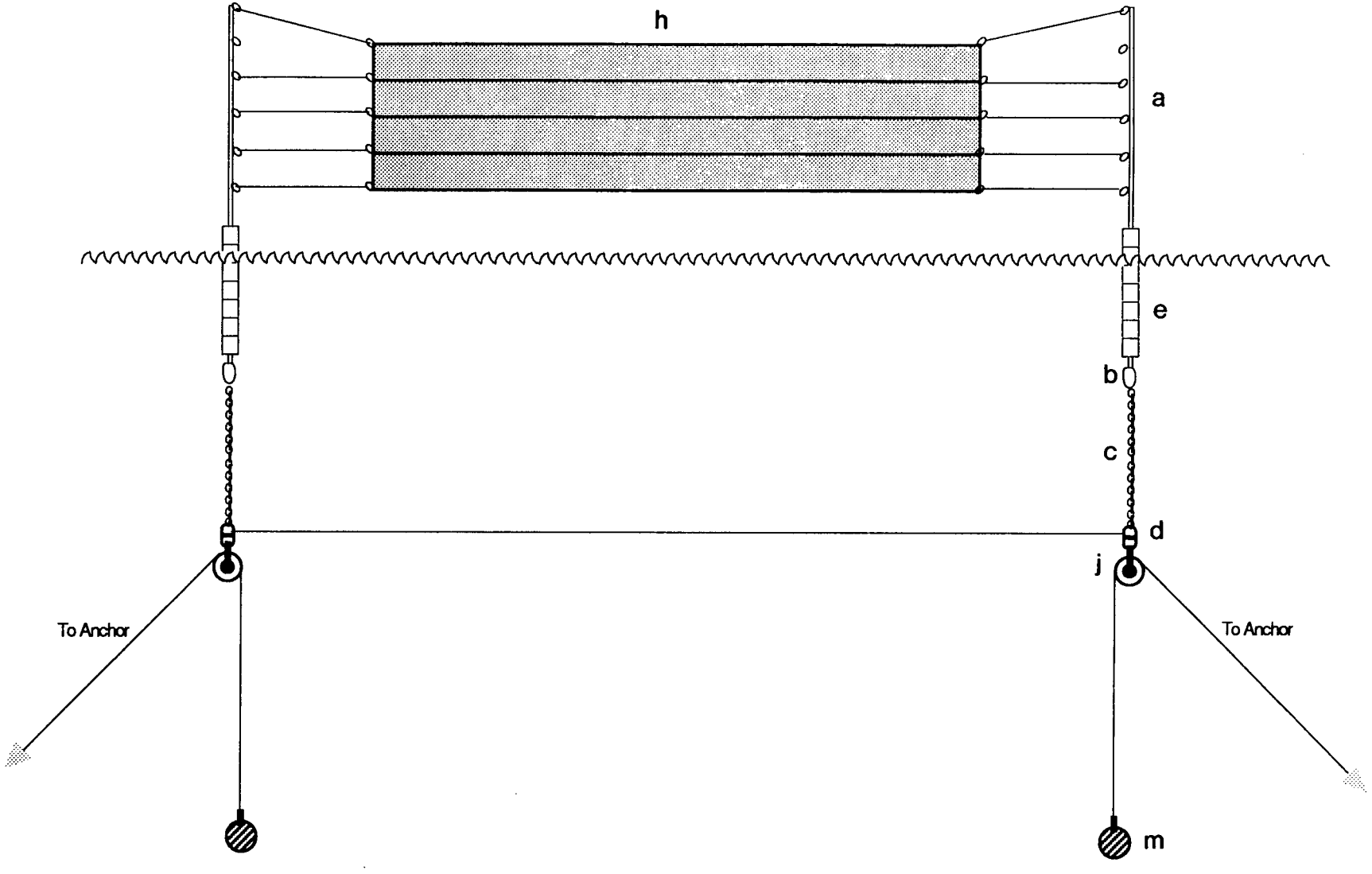
We selected a prominent shoreline feature and set the net along a bearing from it that would cross the murrelets flight path at right angles. First we set a weighted anchor (l) on one of the long lines (n) and secured the excess line to a float (o). The second weighted anchor was set 125 m along the bearing from the first but we carried the excess line to within 40 m of the float from the first anchor, attached a float, and cut off the excess line. We then ran the first line to within 40 m of a spot directly above the second anchor and cut off the excess line. This complex process allowed a good angle to the anchors from the set nets and left sufficient line for the attachment of counter weights (m).

To attach the first pole (a) we released the float (o), ran the anchor line through the pulley on the end of the pole assembly and reattached the float. We repeated the process with the second pole. At this point both poles floated flat on the surface but more than 40 m apart. To correct the distance, we tied an end of the 25 m line (g) to each of the stabilizer swivels (d).

The poles stood upright when we replaced the floats with the counter weights (m) at the end of the anchor lines. The counter weights must be released carefully to ensure that none of the lines are tangled and the ropes run freely through the pulleys. When the system was at rest, only the top two floats on the poles were visible. Changing the sequence of the deployment process would make it difficult to set the distance between the poles.

The mist net was attached to the poles by tying twine from the nylon rings on the poles to the shelf string loops on the net.

FIGURE a. Components of anchoring and flotation system for mist nets used in Mussel Inlet, 1991.



MIST NET SYSTEM USED TO CATCH MARBLED MURRELETS OVER WATER

Figure a. Components indicated by letters are described in Appendix 1.

TABLE 1. Measurements of Marbled Murrelets caught in Mussel Inlet, 1991.

TABLE a. Measurements of Marbled Murrelets caught in Mussel Inlet, 1991

DATE	BAND NUMBER	HEAD LENGTH (mm)	CULMEN LENGTH (mm)	WING LENGTH (mm)	TARSUS LENGTH (mm)	WEIGHT (gm)	BROOD PATCH LENGTH (mm)
24 May	1103 40856	65.2	-	127	-	226	30
24 May	1103 40500	65.1	-	135	-	238	0
05 June	1313 50434	62.3	16.0	128	18.5	219	60
05 June	1313 50435	61.3	16.0	124	14.8	229	60

APPENDIX 7. Acronyms of bird names used in text.

Appendix 7: Acronyms for species of birds used in figures and appendices.

AMWI	American Wigeon
ANMU	Ancient Murrelet
BAEA	Bald Eagle
BAGO	Barrow's Goldeneye
BEKI	Belted Kingfisher
BLKI	BLack-legged Kittiwake
BOGU	Bonaparte's Gull
BRAN	Brant
BUFF	Bufflehead
CAAU	Cassin's Auklet
CAGO	Canada Goose
CAGU	California Gull
COLO	Common Loon
COME	Common Merganser
COMU	Common Murre
CORA	Common Raven
DUNL	Dunlin
FTSP	Fork-tailed Storm-Petrel
GRYE	Greater Yellowlegs
GWFG	Greater White-fronted Goose
GWTE	Green-winged Teal
HADU	Harlequin Duck
HEGU	Herring Gull
MALL	Mallard
MAMU	Marbled Murrelet
MEGU	Mew Gull
NOFU	Northern Fulmar
NOSL	Northern Shoveler
NWCR	Northwestern Crow
OLDS	Oldsquaw
PALO	Pacific Loon
PECO	Pelagic Cormorant
PIGU	Pigeon Guillemot
RBME	Red-breasted Merganser
RHAU	Rhinoceros Auklet
RNGR	Red-necked Grebe
RNPL	Red-necked Phalarope
RTLO	Red-throated Loon
SOSH	Sooty Shearwater
SUSC	Surf Scoter
WEGR	Western Grebe
WEGU	Western Gull
WHIM	Whimbrel
WWSC	White-winged Scoter