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A CAPTURE TECHNIQUE FOR MARBLED MURRELETS IN COASTAL INLETS

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Abstract.—Capturing Marbled Murrelets (*Brachyramphus marmoratus*) will facilitate demographic and telemetry studies needed to guide conservation and management programs. During the breeding season, an array of three mist nets floating on light rafts was used to catch 223 murrelets as they flew through narrow coastal channels. There was only one capture mortality. The mean capture times were 5 min before sunrise and 22 min after sunset. The mean capture rate was 2.5 birds/h (SE = 0.2) with a high of 8.8 birds/h on the evening of 25 Jun. 1994 in Theodosia Inlet, British Columbia.

UNA TÉCNICA DE CAPTURA PARA *BRACHYRAMPHUS MARMORATUS* EN ISLOTES COSTEROS

Sinopsis.—La captura de individuos de *Brachyramphus marmoratus* facilitará estudios demográficos y telemétricos necesarios para dirigir programas de conservación y manejo. Durante la época reproductiva, se utilizó un arreglo de tres redes aereas flotando en pequeñas balsas para capturar 223 individuos de *Brachyramphus marmoratus* cuando ellos volaban a través de

canales costaneros estrechos. Los tiempos de captura promedio fueron de 5 minutos antes amanecer y 22 minutos después del anochecer. La tasa de captura promedio fue de 2.5 aves/h (SE = 0.2) con un máximo de 8.8 aves/h en la tarde del 25 junio 1994 en el islote Theodosia, Columbia Británica.

Solitary and inaccessible forest nest sites have left Marbled Murrelets (*Brachyramphus marmoratus*) one of the most poorly understood alcids in North America (Campbell et al. 1990, Sealy 1975). Now that Marbled Murrelets have been declared a threatened species throughout their range (Carter and Erickson 1992, Marshall 1988, Rodway et al. 1992), we have an urgent need to understand their breeding habitat requirements and population characteristics. The ability to capture reliably large numbers of murrelets for marked populations is necessary if we are to estimate survival rates and other demographic characteristics or to locate nesting areas by radio telemetry. Unfortunately, murrelets are difficult to capture because they spend most of their life at sea and usually fly over land, too high for conventional netting techniques (see Keyes and Grue 1982, Meyers and Pardieck 1993, Paton et al. 1991).

We decided that they could be captured on the water. Waterfowl can be captured on ponds and lakes in gill nets (Ferguson 1980, Lensink 1957) or submerged mist nets (Breault and Cheng 1990). We tried several different floating and submerged nets near Theodosia Inlet (50°05′N, 124°40′W) in 1990 and 1991 but were unable to catch any murrelets (Kaiser et al. 1991). They were sparsely distributed and would not be herded towards the nets, and the nets were too cumbersome to be moved to the birds. We rejected a net gun after a trial at the same site. In the calm waters of the inlets, the murrelets dove to avoid the boat and dispersed when disturbed by persistent motor noise and occasional gunfire. Residents in the homes scattered around the inlet were also unlikely to tolerate this activity. Late in 1990, mist nets hung from floating poles seemed promising (Kaiser et al. 1991) and actually caught birds in May 1991 (Burns et al. 1994).

Here, we describe a practical capture method based on the murrelet's characteristic distribution and behavior. Like other alcids, Marbled Murrelets travel from site to site by flying close to the water surface; however, most other alcids forage on the open ocean. Along the coast of British Columbia, many Marbled Murrelets inhabit narrow coastal inlets where they can be intercepted when regularly travelled routes pass through natural funnels (Figs. 1 and 2).

Burns et al. (1994) caught 12 murrelets in mist nets hung on floating poles in 1991 and 1992. The floating poles were unwieldy, however, and required a 10-m fishing boat for transport and deployment (Burns et al. 1994). Our goal was to capture birds in sufficient quantity to support demographic and radio telemetry studies. We expected small teams to change netting sites frequently in 4–5 m inflatable boats and chose a design based on light, easily transportable rafts (Figs. 3 and 4).

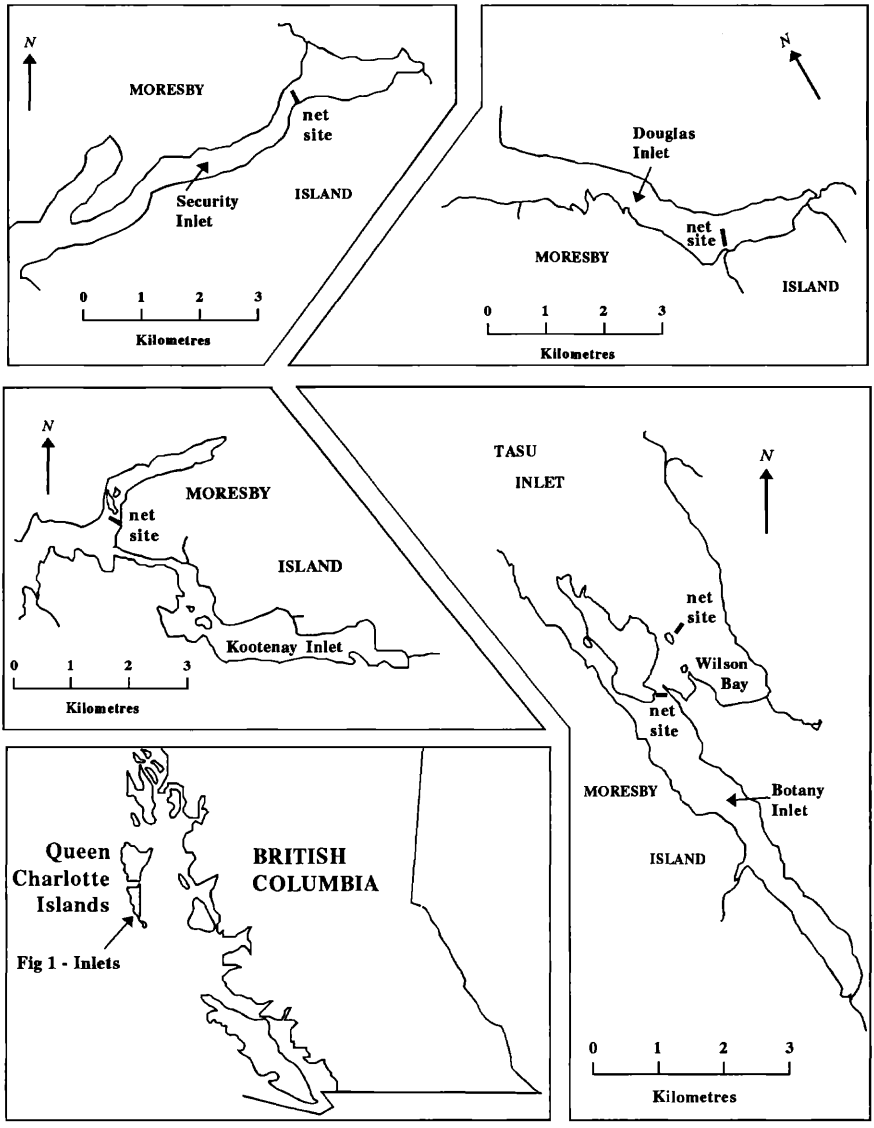

FIGURE 1. Locations of Marbled Murrelet mist-netting sites in the Queen Charlotte Islands, British Columbia.

METHODS

Equipment.—We used standard 2.1 × 18 m nylon mist nets of 6-cm 2-ply (110 denier) and 9-cm 4-ply mesh (210 denier) (Avinet, Inc., Dryden, New York) supported on aluminum tubing (15.8 mm × 3.7 m). For con-

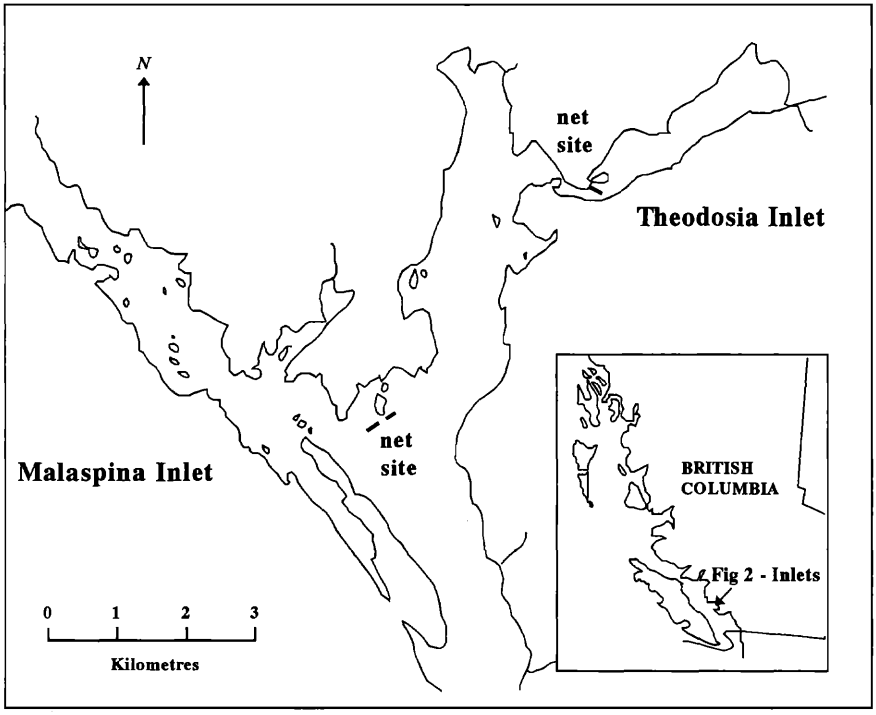

FIGURE 2. Locations of Marbled Murrelet mist-netting sites in Malaspina and Theodosia inlets, British Columbia.

venience, we cut the tubing in halves that could rejoined when supported by a 30 cm sleeve of 1.9-cm tubing. Comparable steel poles are too heavy for the rafts and quickly rust when used near salt water.

A machinist built the frame for the rafts from aluminum pipe (1.9 cm i.d. and 2.2 cm o.d.). Each frame had four 1.8-m legs set at right angles to a central hub (Fig. 3). For the hub, the machinist welded four sockets, bored to 2.3 cm i.d., about 10 cm from one end of a central 50-cm length of pipe. He inserted a pin through the long end to stop the net pole from passing completely through. Two bolts held each leg in place and prevented the arm from pivoting. We tied a cylindrical styrene float (13 × 35 cm) to the outer end of each leg. We suspended a 3-kg weight from the center of each hub to lower the center of gravity and provide stability in wind. The whole assembly was sprayed patchily with matte black, blue and green paint to disguise its shape.

Site selection.—We chose Theodosia Inlet (Fig. 2) because we had seen murrelets flying through the narrow neck and there were hundreds of murrelets in adjacent Lancelot and Malaspina inlets from May through July (Kaiser et al. 1991, Mahon et al. 1992). Like many inlets, it forms a

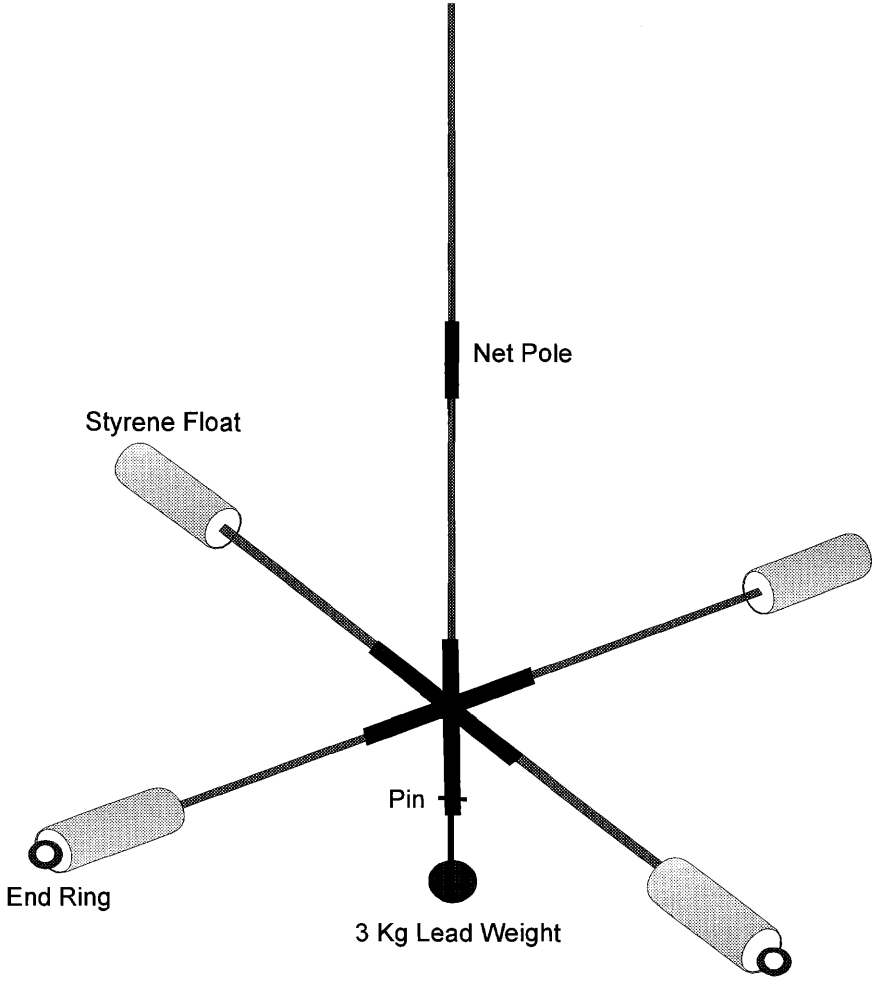

FIGURE 3. Construction of the raft and net pole for supporting mist nets in a floating array.

natural funnel between potential nesting areas in the nearby old growth forests and foraging areas. It offers a protected site to practice the deployment of the array.

Kootenay Inlet (52°51′N, 132°11′W) (Fig. 1) is similar in structure to Theodosia Inlet and was reported to hold several dozen murrelets (K. Moore, pers. comm.). It also had a small pristine watershed whose upland forest was proposed for harvest. We explored most of the other inlets close to Kootenay Inlet when we failed to catch birds at that site and caught birds in Security Inlet (53°03′N, 132°18′W) (Fig. 1).

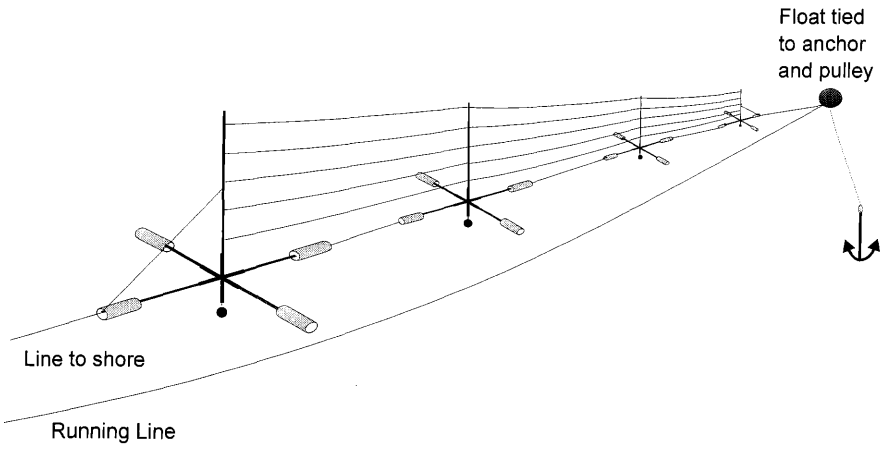

FIGURE 4. Layout of four rafts carrying three mist-nets as set up for capturing Marbled Murrelets.

Murrelet behavior in Theodosia Inlet guided the placement of nets. They regularly pursued Pacific sand lance (*Ammodytes hexapterus*) and other small fish in the inlet and at dawn and dusk flew low through its narrow (200 m) neck (Fig. 2). Our daily travel between sites in the Queen Charlotte Islands prevented observation of murrelet movements but we chose sites with a structure similar to Theodosia Inlet or in channels between islands (>0.1 and <1.0 km across). We set the nets against a forested background to reduce their visibility to approaching murrelets. None of the sites was exposed to ocean swell or strong winds but we expected the rafts to withstand strong tidal currents and moderate winds.

Deployment.—First we set an anchor (15 kg) with chain (2 m) firmly at one end of the desired net line and marked it with a red float to warn boat traffic. We had also posted a notice to mariners with the Coast Guard. We ran a 5-mm braided nylon running line from shore, through a pulley on the float, and back to shore (Fig. 4). On shore, we tied the first raft to one end of the running line and looped the first net onto the net pole. We pulled that raft into the inlet while we payed out the net. Subsequent rafts and nets followed. We spaced the rafts about 18 m apart with a line looped over the hubs. We secured a line from the near shore raft and the end of the running line to shore (Fig. 4). To maintain tension in the array, we adjusted the running line to accommodate changes in current and wind. We attached a 5-kg weight to the near shore leg to prevent it from lifting out of the water when the nets were under full tension. The most distal leg was held down by the weight of the anchored float at the pulley.

Once the rafts were in place, two people opened the nets by pulling themselves along the running line in a small boat. The bottom shelf was about 1 m above the water and the top line near the tip of the poles.

In the evenings we scheduled the opening of the nets for 2100 hours if wind and weather permitted and left them open until 30 min after the last capture (between 2230 and 2315 hours). For morning captures we set the nets at 0400 hours and left them open until daylight at 0630 hours. We measured the effective capture period from sunset to net closure at night or from 0400 to 0630 hours in the morning.

Retrieving birds.—Two people in an inflatable boat monitored the nets and retrieved birds. In action, one person pulled the boat into position along the line between the rafts. Once in place, the other person extracted the bird from the net. The inflatable boat was sufficiently stable for one person to stand and work in the upper shelves of the net. The flat bottom of the inflatable boat allowed it to slide over ropes, raft legs and floats. Between captures, we waited close to either the shore end or the anchor end of the pulley line. During full darkness, we listened for the wing-noise of birds and checked the nets every 10 min with a strong light. We used headlamps to work on birds in the nets.

RESULTS

We caught a bird in Malaspina Inlet (50°03′N, 124°47′W) (Fig. 2) on 27 Jun. 1991 but late night tug and barge traffic interrupted our efforts. After considering the characteristics of a good site, we moved to quieter Theodosia Inlet. Although we rarely saw more than 30 murrelets at a time in Theodosia Inlet, we captured 20 murrelets on five evenings between 2 and 23 Jul. 1991 and 15 more between 11 and 13 Jul. 1993.

In 1993, we caught murrelets at one site in the Queen Charlotte Islands but failed at four (Fig. 1). In Kootenay, Botany (52°45′N, 131°58′W) and Douglas (52°56′N, 132°12′W) inlets, murrelets were present in the day (168, 58 and 110, respectively) but we saw no murrelet movement across the line of the nets after dusk or before dawn. Wilson Bay (52°46′N, 131°57′W) held 144 murrelets on one count, but was a broad open bite and we were more dependent on chance, than geography for captures. Using more than one net array might have been successful.

We entered Security Inlet at 1800 hours on 25 May 1993. There were 34 murrelets present when we arrived. We captured three birds at sunset and six more at sunrise. All of the morning captures were flying towards an area of extensive old growth forest at the head of Security Inlet.

On 17 May 1994, we returned to Theodosia Inlet for a full season of netting. Although there were no murrelets on the water, we set out nets on 25 May and 6 June for practice and in case birds were moving after dusk. Our first capture occurred on 8 June. By 19 July, we had captured 176 murrelets including one recapture from 1993 and 2 from earlier in 1994. We were successful on 24 of 25 attempts in the evening until 19 July, catching between one and 11 birds/session (Fig. 5). After 19 July most murrelets moved to other areas. The unsuccessful session occurred on 5 July when high winds forced us to close the nets after 20 min. During successful evening attempts, we captured an average of 2.8 birds/h (SE = 0.4) for a total of 101 captures. We also netted at dawn and captured

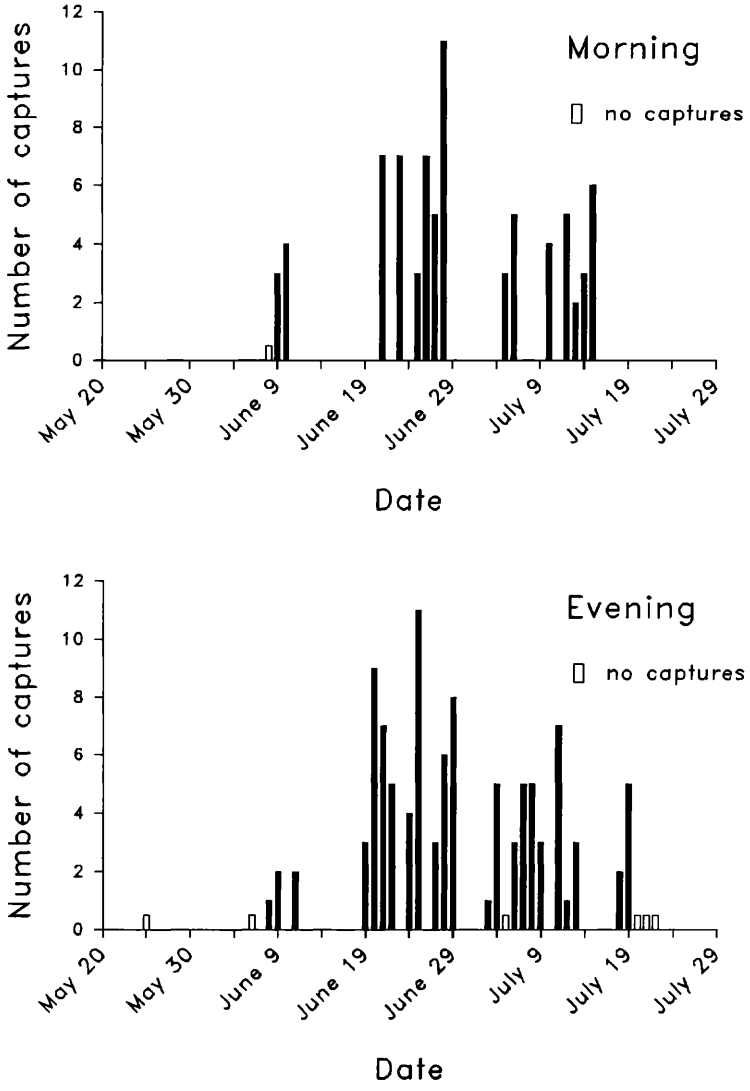

FIGURE 5. Number of Marbled Murrelets captured by date during morning and evening sessions in Theodosia Inlet, British Columbia in 1994.

birds on 15 of 16 attempts catching between two and 11 birds/session (Fig. 5). We caught 75 murrelets at an average of 3.0 birds/h (SE = 0.4).

During the capture period (8 June–19 July), we set the nets on 41 of the 84 possible mornings and evenings. Strong tidal currents in Theodosia Inlet, winds, rain and other work (surveys, telemetry, etc.) prevent-

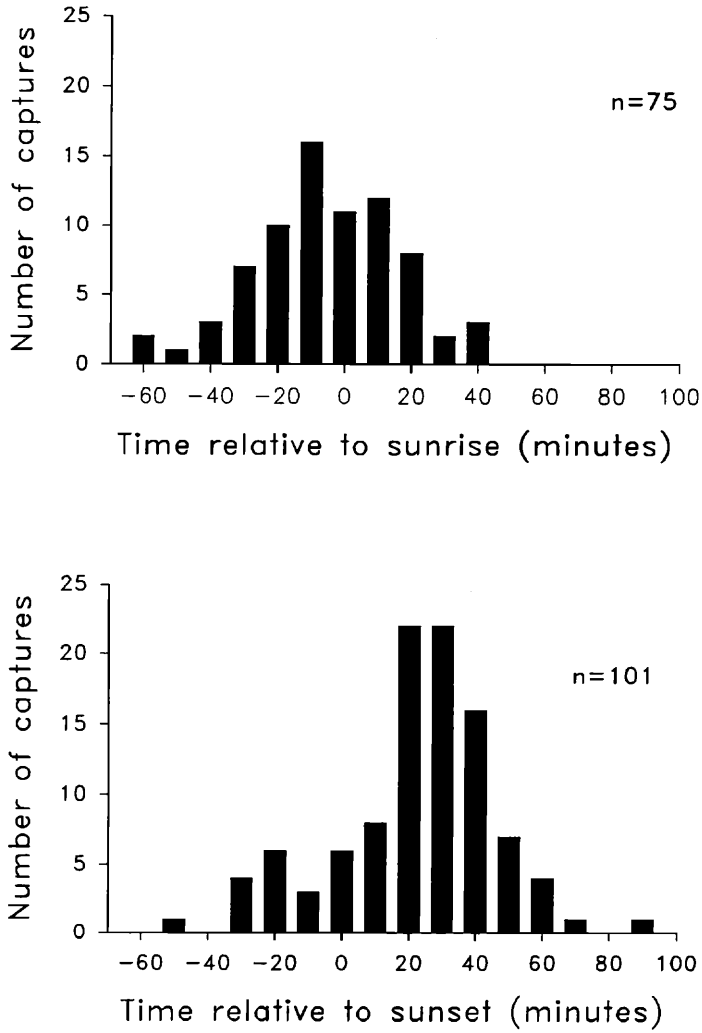

FIGURE 6. Number of Marbled Murrelet captures relative to sunrise and sunset in Theodosia Inlet, British Columbia in 1994.

ed us from netting at other times. We also set the nets on 20, 21 and 22 July to confirm that we had reached the end of the netting period.

In 1991 and 1993, at Theodosia Inlet, we captured 30 (86%) of the birds between 2120 and 2240 hours. During morning sets in 1994, we caught murrelets from 60 min before sunrise until 40 min after with the mean capture time at 5 min (SE = 3) before sunrise (Fig. 6). During evening sets in 1994, we caught murrelets from 60 min before sunset to 100 min after with the mean capture time at 22 min (SE = 2) after sunset

(Fig. 6). In early July, sunrise occurred at about 0515 hours and sunset at about 2130 hours. Most of the birds were flying out of the inlet when they hit the nets: 88% (57/65) in the mornings and 86% (68/79) in the evenings. Direction of movement was not recorded for 32 captures.

We made four unsuccessful attempts to catch murrelets during midday. On 12 July 1993, we opened the nets at 1600 hours; 25 murrelets flew over, four flew around and one flew under. Several murrelets swam under the nets. We captured eight birds after 2120 hours that night.

Birds hit near and far nets along the array. We caught most in the top two shelves of the outer two nets. The light poles cannot hold enough tension to prevent 200 g murrelets from becoming "double bagged," but only birds caught in the center of the lower shelves occasionally dragged the net into the water. Captured murrelets often became extremely tangled in the 210-denier 4-ply 9-cm mesh and we tried 2-ply 6-cm mesh of 110 denier. Some murrelets have enough momentum, at full speed, to fly through the 2-ply nets but there were no injuries or mortalities. During captures of three or four murrelets in one net, tension within the net stretched the wings and legs of the birds in awkward ways and those birds needed to be removed quickly to avoid injury. One bird apparently hit a shelf string in a 4-ply net and died from a broken neck. Another, among three concurrent captures, had minor damage to the skin of one leg and was immediately released. The remaining 221 captures occurred without serious injury.

With some experience, we were able to set the anchor and assemble the nets on rafts in 30 min, and another 15 min was required to open and adjust the nets. Closing and storage took about 20 min. We left the rafts assembled on shore at the capture site so that they could be easily deployed on the next evening.

DISCUSSION

Changes in Marbled Murrelet behavior and distribution during the breeding season affected our capture rate. We were unsuccessful in the Queen Charlotte Islands until 25 May 1993 and in Theodosia Inlet until 8 June 1994. Prior to those first captures, most of the murrelets flew above the trees or were not present at capture sites. At dawn and dusk, during the capture period, we often saw murrelets moving over the inlets at low levels although an unknown proportion continued to move at higher altitudes. During the peak period for captures, we heard no movement and caught no birds between midnight and first light. The lack of late night activity concurs with nocturnal radar surveys (A. E. Burger, pers. comm.) and diurnal activity studies (Carter and Sealy 1990, Eisenhawer and Reimchen 1990, Paton et al. 1988). Regular movements of murrelets in and out of Theodosia Inlet made capture predictable once initial success was achieved. In late July 1994, as the murrelet numbers decreased in adjacent inlets, nocturnal activity declined in Theodosia inlet and capture rate dropped rapidly.

Operation.—This system met our design objectives by being easily trans-

ported in small boats. It was inexpensive to construct and easy to handle with four people. Poles and rafts for three nets easily fit onto a 4-m inflatable boat with room for two passengers and equipment. The aluminum pipe and tubing, anchors, floats and line cost about $700 (US). Although three people can operate the system, captures of five or more birds at a time may put birds at risk. We feel it is safer and more efficient to use four persons. At least two of the crew need to be experienced net handlers and able to retrieve birds in the light while standing in a boat. Operational safety remains a concern. In spite of a Coast Guard notice to mariners, a boat ran through one array and we lost three anchors to passing log booms.

The welded sleeves with bolts to hold the legs in place seem to be a robust design. This type of construction is easy to assemble and the rafts have only two basic components, hubs and legs. By increasing the slack in lines, we were able to keep the net arrays vertical while they were retrieved in winds gusting to 35 km/h and tidal currents in excess of 2 m/s. The array adapted itself to changes in tide height, but occasionally tidal currents shifted the anchor by dragging on underwater ropes. There was no visible wear and tear on any of the raft components at the end of the season.

Capture sites.—Land form may be the most important factor affecting capture rate. Narrow sites (200–400 m) such as Theodosia and Security inlets restrict the flight paths of murrelets while making the nets difficult to see against a forest background. We never saw murrelets moving low through very narrow (<100 m) and high-walled (20 m) channels in Kootenay or Botany inlets. The birds in Kootenay Inlet flew high or dispersed seaward from the mouth of the inlet at dusk. Open sites, such as Wilson Bay and Douglas Inlet, do not concentrate flight paths and may be unreliable as capture sites even if several arrays are deployed. In spite of their numbers, murrelets may miss arrays by chance in such a large space.

The habitats in and around an inlet appeared to have a strong effect on the birds' behavior and distribution. Both Security Inlet and Theodosia Inlet have attractive foraging areas near shallow mud flats and estuarine marshes near their heads. In Douglas and Botany inlets and the north arm of Kootenay Inlet, the estuaries are small with little marsh development and the murrelets foraged nearer the mouths of the inlets. The south arm of Kootenay Inlet has a large estuarine marsh, but it was connected to the sea by a high-walled, narrow channel and the murrelets preferred to fly over the adjacent forest.

In remote or quiet areas, the murrelets may need time to acclimatize to the rafts and the net array. They seem more easily disturbed by boat traffic and noise, and wary of unfamiliar objects on the water. It is easy to approach within 10 m of some murrelets in Theodosia Inlet, which contains boat anchorages, logging camps, booming grounds and oyster farms. In the more isolated inlets of the Queen Charlotte Islands many murrelets moved off beyond 100 m or left the inlet completely. In Security

Inlet, which held a sport fishing camp and its fleet of small boats, we successfully captured murrelets on the evening of our arrival.

We are unsure of the significance of the low frequency of recaptures in Theodosia Inlet in 1994. Net-shyness is a possibility, but we are dealing with a population of unknown size and stability. Telemetry and observation of marked murrelets suggest that many banded birds remained in the area, however, earlier work (Kaiser et al. 1991) suggests an influx of new birds in July. The population may also be larger than previous surveys have indicated. Summer populations within 5 km of the net site reached 800 birds on 6 July 1990 (Kaiser et al. 1991). On 25 June 1994, at least 600 murrelets were scattered in a loose flock 20 km southeast of the netting site, in the Strait of Georgia. At that time many more murrelets were in Malaspina, Lancelot and Theodosia inlets: 222 on 21 June.

This netting system may be applicable to other species that fly low over wetlands, water bodies, and other habitats (e.g., mangrove swamps and sewage lagoons). The net array system has proved to be a cost-effective and reliable means of capturing Marbled Murrelets. Its continued use will provide data for the ecological insight necessary for this species' conservation.

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LITERATURE CITED

BREAULT, A. M., AND K. M. CHENG. 1990. Use of submerged mist nets to capture diving birds. J. Field Ornithol. 61:328–330.

BURNS, R. A., L. M. PRESTASH, AND K. J. KULETZ. 1994. Pilot study on the capture and radio tagging of murrelets in Prince William Sound, Alaska, July and August, 1993. Proj. 93051 B-Exxon Valdez Restoration Project Final Rep. U.S. Fish. Wildl. Anchorage, Alaska.

———, G. W. KAISER, AND L. M. PRESTASH. 1994. Using mist nets to capture marbled murrelets over the water. Northwestern Naturalist Symposium Proceedings, Biology of Marbled Murrelets: inland and at sea. Northwest Natural. 75, in press.

CAMPBELL, R. W., N. K. DAWE, I. MCT. COWAN, J. M. COOPER, G. W. KAISER, AND M. C. E. MCNALL. 1990. The birds of British Columbia Vol. 2. Can. Wildl. Serv. and Royal British Columbia Mus., Victoria, British Columbia. 636 pp.

CARTER, H. R., AND R. A. ERICKSON. 1992. Status and conservation of the Marbled Murrelet in California, 1892–1987. Pp. 92–108, *in* H. R. Carter and M. L. Morrison, eds. Status and conservation of the marbled murrelet in North America. Proc. West. Found. Vert. Zool. Vol. 5.

———, AND S. G. SEALY. 1990. Daily foraging behavior of Marbled Murrelets. Pp. 93–102, *in* S. G. Sealy, ed. Studies in avian biology, No. 14, Cooper Ornithol. Soc., San Diego, California.

EISENHAWER, A. E., AND T. E. REIMCHEN. 1990. Inland flight patterns of marbled murrelets, *Brachyramphus marmoratus,* on the Queen Charlotte Islands, British Columbia. Can. Field-Nat. 104:439–444.

FERGUSON, R. S. 1980. A technique for live-trapping nesting Horned Grebes. J. Field Ornithol. 51:179–180.

KAISER, G. W., T. E. MAHON, AND M. D. FAWCETT. 1991. Studies of Marbled Murrelets in marine habitats, during 1990. Tech. Rep. Ser. No. 131, Can. Wildl. Serv., Delta, British Columbia.

KEYES, B. E., AND C. E. GRUE. 1982. Capturing birds with mist nets: a review. N. Am. Bird Bander. 7:2–14.

LENSINK, C. J. 1957. Use of a gill net in trapping waterfowl. J. Wildl. Manage. 21:103–104.

MAHON, T. E., G. W. KAISER, AND A. E. BURGER. 1992. The role of Marbled Murrelets in mixed-species feeding flocks in British Columbia. Wilson Bull. 104:738–743.

MARSHALL, D. B. 1988. The Marbled Murrelet joins the old-growth forest conflict. Am. Birds 42:202–212.

MEYERS, J. M., AND K. L. PARDIECK. 1993. Evaluation of three elevated mist-net systems for sampling birds. J. Field Ornithol. 64:270–277.

PATON, P. W. C., C. J. RALPH, H. R. CARTER, AND S. K. NELSON. 1988. Surveying marbled murrelets at forested inland sites: a guide. Gen. Tech. Rep. PSW-120. Berkeley, California: Southwest Research Station, Forest Service, U.S. Dep. Agri. 9 pp.

———,———, AND J. SEAY. 1991. A mist net design for capturing Marbled Murrelets. N. Am. Bird Bander 16:123–125.

RODWAY, M. S., H. R. CARTER, S. G. SEALY, AND R. W. CAMPBELL. 1992. Status of the marbled murrelet in British Columbia. Pp. 17–41, *in* H. R. Carter and M. L. Morrison, eds. Status and conservation of the marbled murrelet in North America. Proc. West. Found. Vert. Zool. Vol. 5.

SEALY, S. G. 1975. Aspects of the breeding biology of the Marbled Murrelet in British Columbia. Bird-Banding 46:141–154.

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