USE OF MIST NETS TO CAPTURE MARBLED MURRELETS OVER THE WATER

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ABSTRACT—Radio telemetry, banding, and genetic studies of marbled murrelet (*Brachyramphus marmoratus*) populations depend on the ability of researchers to catch adequate samples of birds. We present 2 methods of catching murrelets using arrays of mist-nets set over water. One method, which is suitable for use in shallow (< 30 m), sheltered water, is light and easily portable. The other method allows nets to be anchored in water ≤ 500 m deep and is able to withstand strong winds, currents, and large tidal differences. Using these methods in 1991–1994, we captured 314 marbled murrelets in British Columbia and south central Alaska.

The marbled murrelet (*Brachyramphus marmoratus*) is listed as threatened or endangered throughout its range south of Alaska (Rodway 1990, U.S. Fish and Wildlife 1992). Conservation plans require an understanding of breeding habitats, foraging range, and population structure (Kaiser et al. 1994). This information has been difficult to obtain, in part because reliable and efficient live-capture techniques for murrelets have not been developed. In recent years, a variety of methods have been tried with variable success. These include dip-nets, spotlighting at night, sunken gill-nets, mist-nets in the forest canopy, and net guns (Paton et al. 1991; Quinlan and Hughes 1992; C. J. Ralph, unpubl. data; D. H. Varoujean, unpubl. data). Our objectives were to develop mist-net systems to capture successfully the large numbers of murrelets necessary for population studies. We describe the construction and use of 2 methods for setting arrays of mist-nets over water, which captured murrelets reliably. One method (deep-water system) copes with the strong winds, currents, and tidal differences of the deep fiords along the British Columbia and Alaska coasts. The other method (shallow-water system) is constructed of lighter materials and is more suitable for sheltered areas.

METHODS

In 1991, we tested the effectiveness of the deep-water system in Mussel Inlet (52° 55′ N, 128° 02′ W), a fiord in the western hemlock (*Tsuga heterophylla*) zone on the central coast of British Columbia. The inlet is 11 km long, 1.7 km wide and 280 m deep. Maximum tidal range in the inlet is about 6 m. The walls of the inlet rise steeply to more than 1100 m. In 1992, we also tested the system in Kynoch Inlet (52° 46′ N, 128° 03′ W), 13 km south of Mussel Inlet. This inlet is 18.5 km long, 1.0 km wide, and 360 m deep with terrain similar to that of Mussel Inlet. Each year from 1990 to 1993, we estimated that at least 500 murrelets occurred in each of these inlets during the breeding season (Kaiser et al. 1991, Prestash et al. 1992). In 1993 and 1994, we (RAB and LMP) tested this system in Unakwik Inlet (60° 53′ N, 147° 32′ W; Burns et al. 1994), Port Nellie Juan (60° 36′ N, 148° 7′ W), and Naked Island (60°40′ N, 147°28′ W) in Prince William Sound, south central Alaska. Unakwik Inlet is 33 km long, 3.5 km wide, and 308 m deep. The walls of the inlet range from 740 m at the mouth to 2847 m at the head. Port Nellie Juan is an inlet 46.2 km long, 3.0 km wide, and 370 m deep, with walls ranging from 390 m at the mouth to 1,410 m at the head. Naked Island has rolling hills up to 400 m and is surrounded by an underwater shelf up to 90 m deep.

We tested the shallow-water system in 1991 in Theodosia Inlet (50° 05′ N, 124° 40′ W). The inlet is 3.5 km long and narrows to 200 m near its mouth.

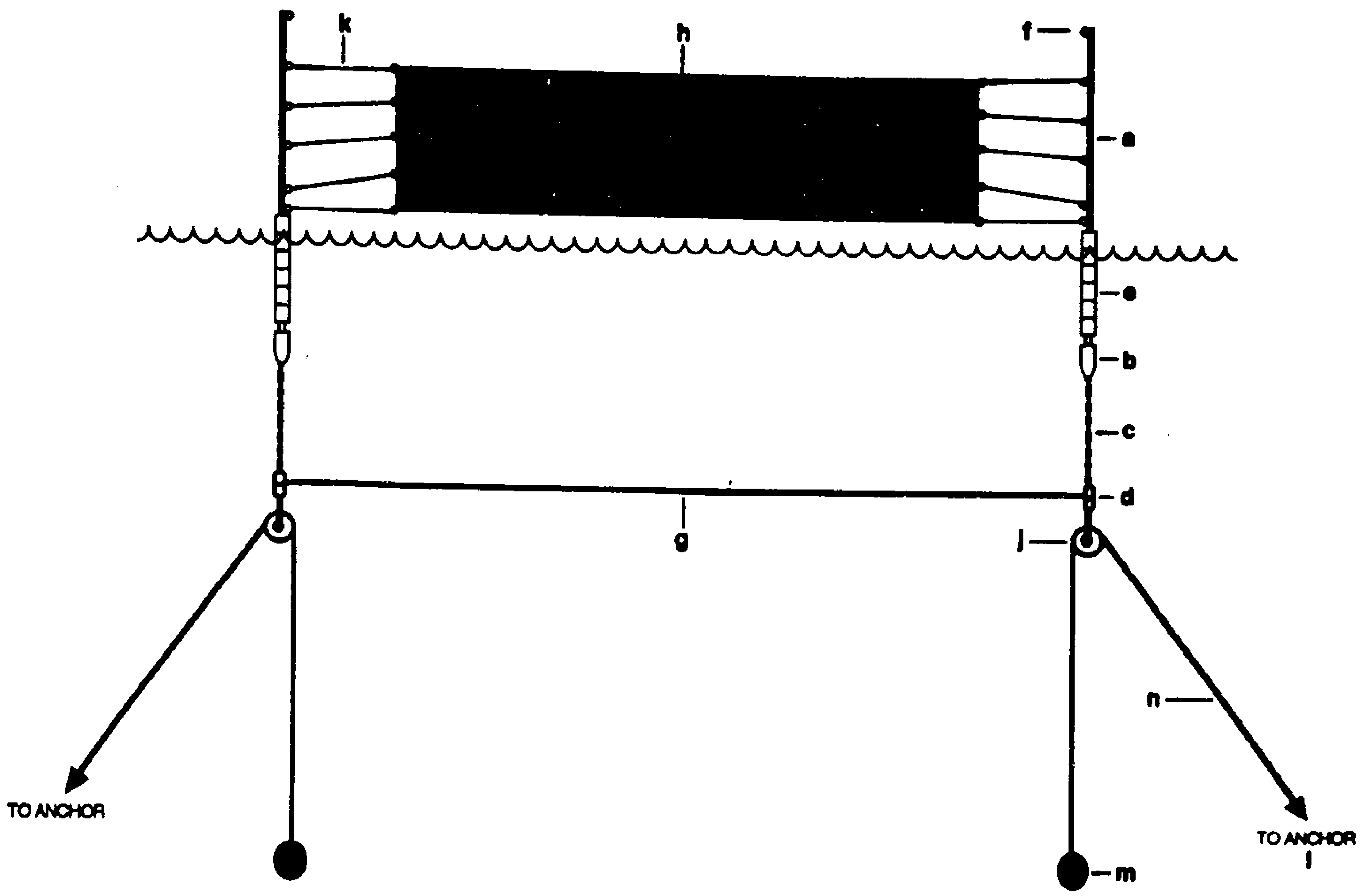

FIGURE 1. Net supports and anchors compensate for changes in water level when using the deep-water system. We constructed the deep-water system from commercial fishing gear: (a) 6-m bamboo pole [2], (b) 4.5-kg lead end-weight [2], (c) 2-m long, 7.5-mm chain [2], (d) jaw and eye stabilizer swivel [2], (e) 15-cm x 30-cm cylindrical polyethylene foam float [12], (f) 2.5-cm nylon rings [12], (g) 25-m long, 7.5-mm rope, (h) nylon mist net (2.8 m x 18 m, 6-cm mesh, 4 ply, 210 denier from Avinet Inc.), (j) 10-cm nylon pulley [2], (k) 30 m twine, (l) 16-kg halibut kedge anchor plus and 18-kg lead ball [2], (m) 11-kg lead ball [2], (n) 360-m long, 7.5-mm neutral buoyancy knot-free polypropylene rope [2], (o) 60-cm float (not illustrated) [2]. One bamboo support system for 1 net cost about $300 US.

The center of the inlet is 37 m deep but in the narrows, the channel is only 5 m deep and has strong tidal currents. The inlet is surrounded by low (200 m) hills that rise to the Dogtooth Range (1000 m) in the east. There are some patches of original forest on steep terrain and at higher elevations but much of the forest is 20-yr old second growth. We estimated that at least 350 murrelets occurred in Theodosia and adjacent inlets during the 1990 breeding season (Kaiser et al. 1991). In 1993, G. W. Kaiser tried the system in Kootenay (52° 52′ N, 132° 15′ W), Botany (52° 45′ N, 131° 58′ W), Douglas (52° 57′ N, 132° 14′ W) and Security (53° 03′ N, 132° 19′ W) inlets, and in Wilson Bay (52° 46′ N, 131° 19′ W) on the west coast of Moresby Island in the Queen Charlotte Islands (Kaiser et al. 1995). The inlets range from 5.5 to 7.5 km in length and have widths that narrow to less than 370 m. Wilson Bay is 2.2 km long and 1.0 km wide. Water depths of less than 20 m are frequently encountered and terrain rises steeply from sea level to 925 m in all these locations.

Deep-Water System

We constructed the deep-water system from commercial fishing gear that had been painted grey and black (Fig. 1). On 24 May 1991, we set out the net supports in the middle of Mussel Inlet along a line perpendicular to a flight path that was previously determined to be used by murrelets. To deploy the net, we first set a weighted anchor (l) on a 400-m neutral buoyancy rope (n) and secured the excess rope to a large float (o) (Fig. 1). We set the second weighted anchor 125 m away. We carried the excess rope from this anchor to within 40 m of the float from the first anchor, attached another large float and cut off the remaining rope. We then ran the first rope to within 40 m of a spot above the second anchor and cut off that remaining rope. This provided a 45° angle between the floats and the anchors and left sufficient rope to attach the counter weights (m).

We attached the poles (a) to the anchor lines by detaching the floats and running the lines through the pulleys at the end of the pole assemblies (Fig. 1).

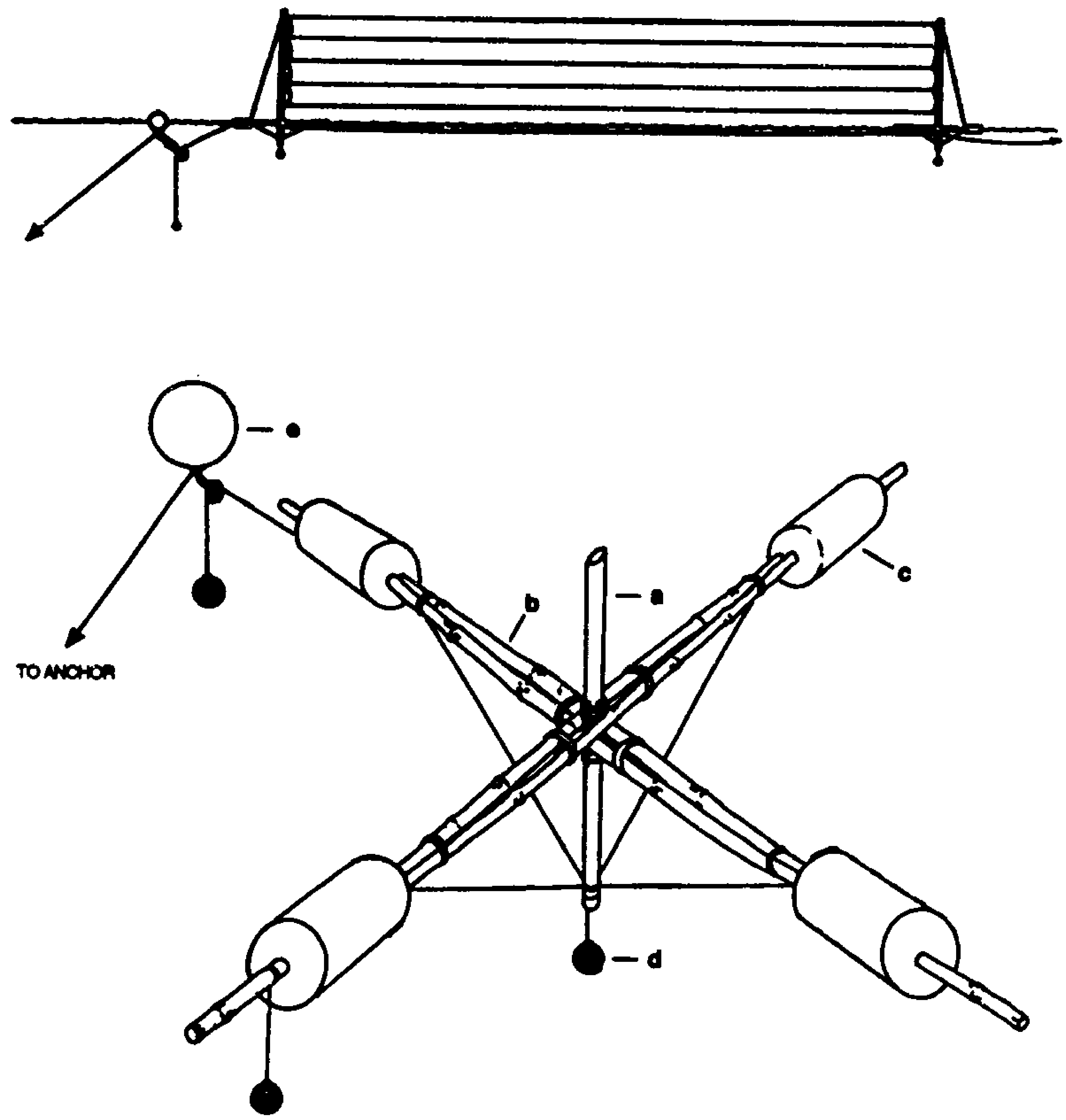

FIGURE 2. Assembly of a raft to support a net pole and the deployment of a net in the shallow-water system. We constructed the this system from sport-fishing gear, garden supplies and a conventional mist-netting system: (a) 2 m of 15-mm aluminum tube [2], (b) 2-m bamboo poles lashed together [2 sets], (c) 15-cm x 30-cm cylindrical polyethylene foam floats [8], (d) 2-kg lead ball [6], (e) 30-cm float [1]. Total cost was about $50 US to support 1 net, and $100 US for a three-net array.

When the floats were re-attached, the poles floated on their sides about 40 m apart. To maintain the correct distance (slightly > 1 net-length) between the poles, we attached a 25-m line (g) to the stabilizer swivels (d). When we attached the counter weights (m), the poles floated vertically with only the top 2 floats visible. It was essential to release the counter weights slowly so that the lines did not tangle and were able to run through the pulleys smoothly. Changes to the deployment sequence made it difficult to maintain the correct distance between the poles. The floats must have sufficient buoyancy to support the combined weights of both the anchor and counterweight to avoid loss of the array if the anchor is moved by currents or winds into deeper water.

The mist-net (h) was attached to 1 pole by tying twine from the nylon rings (f) on the poles to the loops at one end of the net's shelf strings (Fig. 1). We unwound the net from a storage board and attached the end to the second pole. Tension in the twine was adjusted so that the shelf strings were almost straight and the bottom bag hung about 0.3 m above the water. At the end of each netting session we untied the net and wrapped it onto a board but the anchored poles were left in place.

In 1992, the bamboo portions of this system were replaced by more robust aluminum pipe (Burns et al. 1994, Kaiser et al. 1995). The conversion of the deep-water system to aluminum costs about $750 US for a single net (and $375 US for each additional net in a string).

Shallow-Water System

The shallow-water system was constructed from gardening and sport-fishing supplies (Fig. 2). After trial runs on 26–27 June, in an open area in Malaspina Inlet, 2 km west of Theodosia Inlet, we selected a narrower site in the mouth of the latter inlet. At that site, we deployed and retrieved the system each night. To deploy the net system, we began by anchoring a float with a pulley about 3 net-lengths from shore. The line ran from a point in a slight bend of the channel so that the net array would be difficult for the birds to see against the background of trees. We assembled the rafts on shore and set nets on the poles. To avoid tangles we furled the nets until the rafts were properly deployed. We used a rope from the shore that ran through a pulley at the float to tow the assembled rafts into position and then unfurled the nets. This system was stored on shore between netting sessions.

Initially, we used a counter-balance weight at the float to compensate for tidal changes but because we selected low and high slack-tide periods the counter-balance proved unnecessary. Tension in the nets was controlled by adjusting the distance between the rafts. We attached lead weights (2–5 kg) on some arms and at the centers of the bamboo rafts to prevent gusts of wind, currents, and tension in the nets from tipping over the array. In 1993, we constructed the rafts with aluminum pipe, therefore extra weights on the arms were no longer necessary (Kaiser et al. 1995). The 4 aluminum rafts needed for a 3-net array in the shallow-water system cost about $700 US.

To adjust the nets and retrieve birds, we pulled ourselves along the line to the float in an inflatable boat. The stability of inflatable boats enabled us to stand and reach the top shelf of the net.

RESULTS

Deep-Water System

Capture Success.–In Mussel Inlet, the murrelets usually flew the length of the inlet, < 2 m over the water. We set a net across their path in 275 m of water. We made the first captures at 2215 hr on 24 May 1991 when 3 birds hit a net set at 1700 hr. Because only 2 of us were present (RAB and LMP), we did not reset the net until additional help arrived on 5 June. That night we set the net at 2100 hr and kept it open until 0530 hr. At 2145 hr, we caught 2 more murrelets.

We (RAB and LMP) returned to Mussel Inlet in 1992 and 1993. In 1992, we also worked in nearby Kynoch Inlet. Using 1 net (except on 1 occasion when 2 nets were set), we caught 7 murrelets in 28 attempts in 1992, all in Mussel Inlet. Between 26 April–20 June 1993, in Mussel Inlet, 4–6 nets were spread along 3.6 km on 44 nights and we caught 21 murrelets. We used this system in Prince William Sound, Alaska, and caught 9 marbled and 1 Kittlitz's murrelet (*Brachyramphus brevirostris*) in July 1993 (Burns et al. 1994), and 44 marbled murrelets in July 1994.

Between 1992 and 1994, we captured 63 shorebirds, ducks, and seabirds representing 14 species in the nets (details available from the authors). Two songbirds and 1 bat were also captured during netting sessions.

Deployment Effort.–With the deep-water system, 2 people set up 1 net support in 2 hr and tied on the net in one more hour. After the net had been set once and all of the twine cut to the proper length, nets could be set in 10 min. It took about 10 min to dismantle the net. Because we worked in remote areas, we were able to remove the net each day and leave the supports in place for the duration of the project.

Shallow-Water System

Capture Success.–We first set up the shallow-water system on 26–27 June 1991, with a string of 3, 18-m nets at Lion Rock in the mouth of Malaspina Inlet and caught 1 murrelet on 27 July at 2205 hr. A few minutes later we were forced to dismantle the nets quickly to accommodate an approaching tug and barge. From 2 July, we set up a string of 3 nets in Theodosia Inlet on 5 nights and caught 20 more murrelets. In May 1993, we explored the west coast of the Queen Charlotte Islands for likely netting sites and eventually caught 9 murrelets in Security Inlet (Kaiser et al. 1995). In July, we returned to Theodosia Inlet for 3 days and caught another 15 murrelets. In June 1994, we deployed the nets in Prince William Sound near Naked Island and captured 7 murrelets. In 1991 and 1994 we also caught 7 pigeon guillemots (*Cepphus columba*) and 1 belted kingfisher (*Ceryle alcyon*).

Deployment Effort.–With practise, a team of 4 was able to set the anchor and deploy the shallow-water system in 30 min. We occasionally required an additional 45 min to mount and adjust the nets but allowed 2 hr to cope with deployment problems such as adjusting the distance between rafts and accidents caused by currents. We switched to aluminum piping in recent years because the light bamboo rafts tended to overturn abruptly when wind and current were in opposite directions. Attaching lead weights to the bamboo prototype was a marginal improvement that required additional time and adjustment. We dismantled the nets in about 20 min and left the rafts on shore, strung together and ready for re-deployment.

DISCUSSION

The shallow- and deep-water systems we designed were highly successful in capturing marbled murrelets in British Columbia and south central Alaska. The success of both netting systems depended on predicting general movements of the murrelets and selecting effective trapping sites to intercept the birds. In Mussel Inlet, we caught birds because there were hundreds of birds present; in Theodosia Inlet and Prince William Sound, there were large numbers in the general area but only small numbers near the netting sites. We were able to capture murrelets primarily because birds regularly flew through narrow passages. These systems may be less successful in open water areas (*i.e.* south of British Columbia) if birds do not fly low over the water in narrow passages.

We did not calculate rates of capture success for the 2 netting systems, therefore we did not compare the effectiveness of the shallow- and deep-water systems or compare our systems with those previously tested (Paton et al. 1991; Quinlan and Hughes 1992; C. J. Ralph, unpubl. data; D. H. Varoujean, unpubl. data). There were 3 reasons why we did not calculate capture rates. First, the physical differences between netting locations affected capture rates. Second, the amount of effort expended varied between the 2 systems. The deep-water net system was deployed for long periods of time (usually over night), while the shallow-water system was used for shorter periods of time around dawn and dusk. Third, the deep-water system was used exclusively for radio tagging murrelets and if too many birds were caught during a short period of time efforts were made to prevent further captures, either by patrolling nets in a rubber boat to deflect birds away from the nets or by closing the nets until the backlog of birds was processed. In British Columbia, the shallow-water system was used mainly for banding purposes and more birds were handled during shorter periods of time than the deep-water system.

These systems were not without problems both for the net operators and the birds. It was difficult and hazardous to work from open boats at night, especially in wilderness areas, and birds can be easily injured during capture. Darkness, winds, waves, and currents hampered the extraction of birds from the net. It was often easier on the bird to cut a few strands of net to release the bird quickly. The number of skilled net-handlers will always limit the number of nets that can be set at 1 time, but operational difficulties can be overcome by careful planning and practice before the field work begins.

Some birds hit the net with tremendous force, distending it up to 5 m. Three birds died during 314 captures with these systems (Prestash et al. 1992, Burns et al. 1994, Kaiser et al. 1995). The cause of death was cervical fracture or other injuries associated with netting. Many other species were captured but the only mortality was 1 western sandpiper (*Calidris mauri*).

Rain and high winds delayed some operations because of concern for the birds' safety but both systems proved to be structurally robust. We usually used 3 nets with the shallow-water system because we were limited by the width of the channels. In contrast, we successfully set 5 nets on the deep-water system in more open areas. Tidal currents in narrow inlets were often strong and the limitation on the shallow-water system was the number of rafts that could be retrieved quickly once the tide began to run. The deep-water system remained stable through large tidal fluctuations (15 m) and strong winds (> 50 km/hr). Currents were only a problem when the drag on the lines moved the anchors. The counter-balance weights maintained the correct net-tension and the net did not sag into the water when birds were caught.

Both systems need to accommodate boat traffic. The deep-water system was set with all lines at least 4 m below the surface to reduce the hazard to passing boats. Mussel Inlet is extremely remote but in more heavily travelled areas, lights should be attached to the poles on nights when the nets are not in use. In Theodosia Inlet, we were present at the nets at all times and able to warn away approaching boats.

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