A COMPARISON OF AERIAL, SHIPBOARD, AND LAND-BASED SURVEY METHODOLOGY FOR THE HARBOR PORPOISE, *PHOCOENA PHOCOENA*

A review of the status of harbor porpoise, *Phocoena phocoena*, in the U.S. waters of the western North Atlantic identified substantial information gaps in our knowledge about this species, and raised serious questions about the health of the North American population (Prescott and Fiorelli 1980). Significantly, no population estimate exists for *P. phocoena* in the western North Atlantic. Gaskin's (1977) estimate of 4,000 in the Bay of Fundy region is admittedly preliminary, and includes only a portion of the known range. Prescott and Fiorelli (1980) used winter stranding records from a single year to postulate a minimum mid-Atlantic regional population of 726 to 1,525 (between Long Island Sound and Cape Hatteras), but acknowledged that no information on stock or population discreteness exists for U.S. coastal waters.

Harbor porpoise are one of the smallest oceanic cetaceans, reaching a maximum size of about 2 m (Gaskin et al. 1974). They are also behaviorally innocuous, seldom leaping from the water, are usually found in small groups of 2-4, and generally avoid motor vessels (Amundin and Amundin 1974). These factors frustrate attempts to study the species, and it was necessary to establish and test survey methodology prior to undertaking a full-scale survey. An experiment was designed to estimate the fraction of visible harbor porpoises observed from aircraft, shipboard, and land-based survey platforms.

Between 4 and 12 August 1980, 30 to 34 persons from College of the Atlantic, the University of Guelph, and the New England Aquarium took part in this experiment in Head Harbor Passage, a narrow channel running NE-SW, bounded by Campobello Island (N.B.) on the east and a series of small islands and ledges on the west (Fig. 1). Head Harbor Passage was chosen for three reasons: 1) Harbor porpoise regularly inhabit the passage; 2) the passage is only 800 to 1,000 m wide, with many identifiable landmarks, which permits accurate orientation and navigation; and 3) the northwestern coast of Campobello Island provides easy access to land observation stations of nearly uniform height.

Methods

Four transect lines were established at 200 m intervals for a 5 km section of Head Harbor Passage (Fig. 1). Each transect line was surveyed by the survey vessel, the RV *Beluga*, a 12 m power vessel provided by the College of the Atlantic, and by the survey aircraft, an amphibious Cessna 185[1] provided by the U.S. Fish and Wildlife Service. Because of the difference in survey speed, the experiment required that the aircraft cover all four transects for each one the boat completed. For example, while the RV *Beluga* was enroute along Transect 3, the aircraft would survey Transects 1, 2, 3, and 4, in that order, and then break off until the boat had started surveying Transect 4. At that time the aircraft would cover all four transects again (Table 1).

Six land stations were set up on the coast of Campobello Island at about 500 m intervals. These stations were supplemented by additional stationary observation points at 500 m intervals on or near Spruce Island (across the passage). Two observers were posted at each station, to record location and movement of all harbor porpoise within sight. All land stations were oriented to true northwest, in order that overlapping sightings could be identified later. Sighting distances were estimated by the observers, based on a series of known distance calibration trials completed the first day using the vessel and a wooden life-size harbor porpoise model. During each transect, the 200 m interval made by the RV *Beluga* provided additional distance calibrations. In the final analysis of the data, only those observations from the 4 km survey area in view of the six Campobello Island land stations have been utilized, since the consistency of position and orientation of the boat stations across Head Harbor Passage were more variable and tide dependent.

Vessel transects were conducted with two observers and a recorder stationed on the bow (approximate height of eye about water = 2.5 m). Each observer was responsible for surveying 95° of horizon, from a point directly abeam of the survey vessel to a point 5° off the opposite bow. This pattern provided an

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 1.—Summary of experiment on survey methodology for harbor porpoise, August 1980.

Date	Completed vessel transects	Completed aircraft transects	Operating no. of land stations
4 August	4	12	7
5 August	5	14	9
7 August	8	32	8
8 August	8	36	7
11 August	8	40	8
Total	33	134	

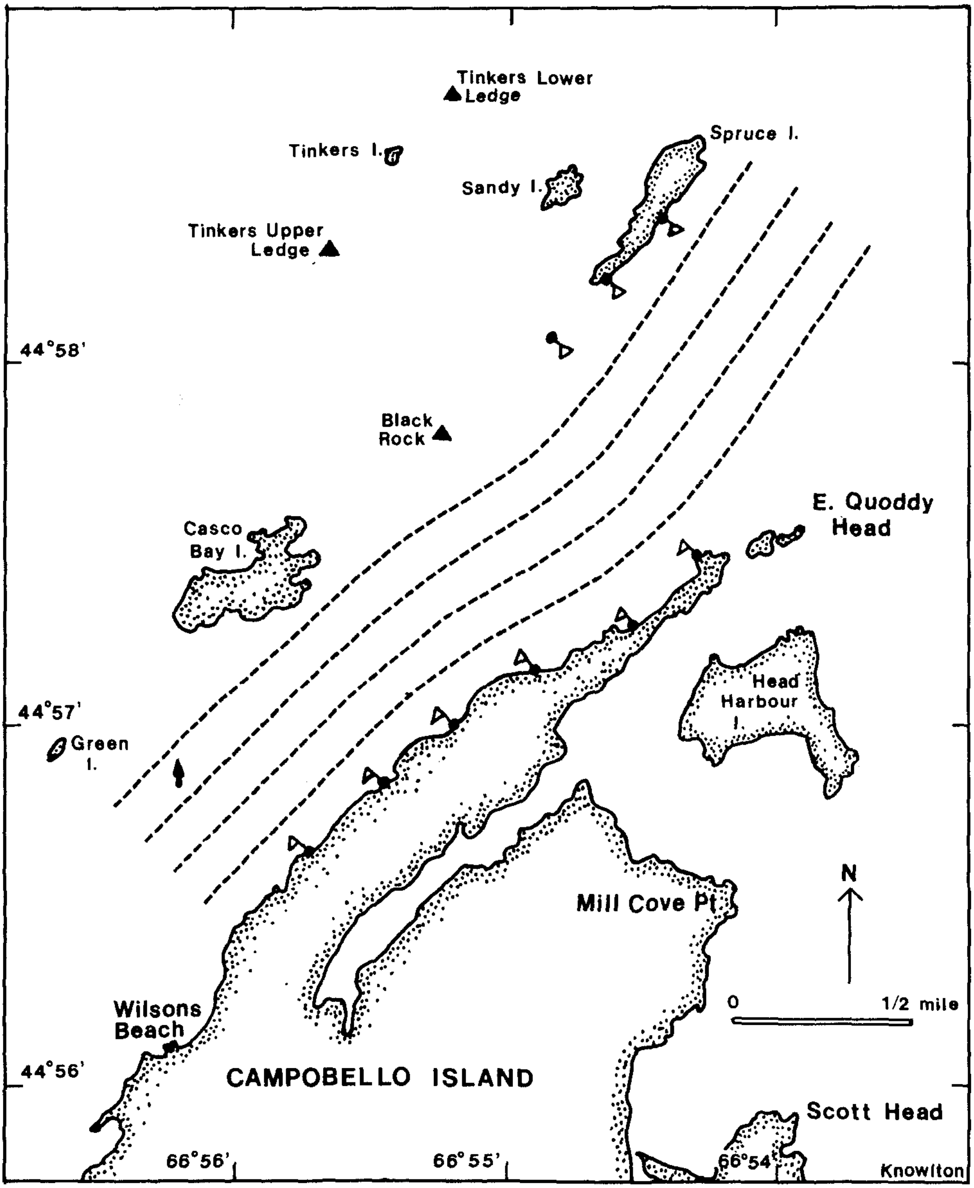

FIGURE 1.—Experimental survey transects through Head Harbor Passage are indicated by the dotted lines. Flags indicate the observation stations on each side of the passage.

overlap in viewing fields of 10°. Observers were changed after each transect to reduce fatigue. Navigation was accomplished by the use of radar and triangulation with landmarks. Vessel speed was 9 ± 2 kn, its variability caused by the strong tidal currents in Head Harbor Passage.

Aircraft transects were flown at an altitude of 229 m at 90-100 kn. Two experienced aerial observers and a recorder participated in each flight. Navigation and sighting locations were accomplished by triangulation on landmarks, including large orange markers at each land station. Visual survey techniques were similar to those employed in standard aerial surveys (Scott and Gilbert 1982). Because observers were looking specifically for harbor porpoise and because the survey area was limited by land masses, observers' search scans were restricted to within 630 m of the transect line. On two days of the experiment, observers noted the right angle distance of each sighting from the transect line by a handheld Suunto inclinometer, categorizing sightings by 90° to 40° (< 200 m from the transect) or 40° to 20° (between 200 and 630 m from the transect).

Species identification problems were not a factor during the experiment since 1) all aerial and shipboard observers were experienced in *P. phocoena* observations; 2) land-based observers reported no other cetacean species in the vicinity during the entire week; 3) *P. phocoena*, although sometimes difficult to spot, once sighted has clear and unique field marks that make it easy to identify.

Results

Triangulation of land station sightings resulted in accurate plots of the harbor porpoise movements through the area for every set of four transects. Aircraft and shipboard sightings were then plotted using the same methods over the same time periods. The number of sightings made by aircraft and shipboard platforms were then compared independently against the number of sightings made by ground stations to test sightability from each platform. A "sighting" represents one or more porpoise. Analysis of observations by all platforms on all days show that average "sighting" group size was 1.94 to 2.39 porpoise per group (Table 2). Reported group size from moving platforms was generally lower than observed from the shore.

Comparison between aircraft and ground counts of the number of sightings of harbor porpoise groups indicated that the aircraft observers consistently sighted only 10 to 20% of the harbor porpoise groups available in the passage (Table 3). The shore-based observers, using aircraft sightings for comparison, were estimated to sight about 80% of the available harbor porpoises.

Comparison between shipboard and ground observations was more inconsistent because of smaller sample size (Table 4). Shipboard observers sighted about 50% of the harbor porpoises in the area and ground-based observers about 60%.

TABLE 2.—Mean number of harbor porpoise per group, as observed from the ground, boat, and aircraft, August 1980.

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

Discussion

Analysis of the data shows that shipboard observers are more likely to see harbor porpoise than aircraft observers. Although vessels may not be as efficient as aircraft in terms of the amount of area covered, aircraft observers tend to miss porpoise because of their small size, the high survey speed, and limited effective survey width. Aircraft effectiveness appears to rise in high-density porpoise areas. However, the results suggest that shipboard surveys are the superior method in estimating harbor porpoise dis-

TABLE 3.—Numbers of groups of harbor porpoise observed by ground observers and from the air in Head Harbor Passage, New Brunswick, August 1980.

Observed from ground	Observed from aircraft: 5 August Yes	5 August No	7 August Yes	7 August No	8 August Yes	8 August No	11 August Yes	11 August No	Total Yes	Total No
Yes	2	19	0	7	4	23	8	37	14	86
No	0	—	0	—	1	—	2	—	3	—
	[1]P = 0.10		P = 0.00		P = 0.15		P = 0.18		P = 0.14	
	[2]G = 1.00		G = 1.00		G = 0.80		G = 0.80		G = 0.82	

[1]P = calculated probability of sighting from aircraft.
[2]G = calculated probability of sighting from around

TABLE 4.—Numbers of groups of harbor porpoise observed by ground observers and from shipboard in Head Harbor Passage, New Brunswick, August 1980.

Observed from ground	Observed from shipboard: 5 August Yes	5 August No	7 August Yes	7 August No	8 August Yes	8 August No	11 August Yes	11 August No	Total Yes	Total No
Yes	7	3	1	0	1	5	2	2	11	10
No	2	—	1	—	0	—	4	—	7	—
	[1]S = 0.70		S = 1.00		S = 0.20		S = 0.50		S = 0.52	
	[2]G = 0.78		G = 0.50		G = 1.00		G = 0.33		G = 0.61	

[1]S = calculated probability of sighting from shipboard.
[2]G = calculated probability of sighting from ground.

tribution and abundance. In analysis of survey data, these results are a first approximation of correction factors that could be applied to aircraft and shipboard observations to provide more accurate estimates of harbor porpoise abundance, although caution should be exercised because of variable sighting conditions or animal behavior.

Further work on survey methodology should examine the effect of eye height, survey speed, and meteorological conditions upon survey results. Gaskin (1977) has discussed sea state and cloud coverage as factors in survey results, and Scott and Gilbert (1982) have examined several variables affecting aerial surveys, but the effects of glare on shipboard surveys and observer variability merit further attention. Also, the estimation by observers of distances from sighted porpoise to survey vessel needs clear definition for open-ocean surveys (Eberhardt 1978). Nevertheless, if survey methods similar to those described here are adhered to during the course of a survey, the results reported here are applicable, and useful in estimating porpoise abundance more accurately.

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TOLERANCE OF FIVE-DAY-OLD WINTER FLOUNDER, *PSEUDOPLEURONECTES AMERICANUS*, LARVAE TO THERMAL SHOCK[1]

The winter founder, *Pseudopleuronectes americanus* (Walbaum), is an important commercial and recreational fish generally found in waters with temperatures of 0° to 25°C and salinities of 4 to 30 ‰ (Pearcy 1962). The winter flounder ranges from northern Labrador to Georgia, but is most commonly found from the Strait of Belle Isle, northern shore of the Gulf of St. Lawrence, to Chesapeake Bay. A separate spawning population, or race, is found on Georges Bank (Bigelow and Schroeder 1953). Smith et al. (1975) indicated that there is a progression in spawning time from south to north initiated by increasing water temperature. Spawning generally occurs in estuaries and shoal waters in winter and early spring (Bigelow and Schroeder 1953) at temperatures of 3° to 10°C and salinities of 15 to 35‰ (Rogers 1976).

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