## UNDERWATER PAINT MARKING OF PORPOISES[1]

Identification of individual animals has always been a problem in cetacean behavioral research. Only a small part of the animal is ordinarily visible, and individuals within a pod of whales or porpoises may all look very much alike, and, for that matter, very much like all the individuals in all neighboring pods. How does one mark (or label) an animal at sea?

Our radio tagging experiments and flashing light systems (Schevill and Watkins[2]) were designed to provide a partial solution to this problem, and, more recently, radio transmitters have been attached to animals by means of harnesses or other fastenings (Evans 1974; Norris and Gentry 1974; Norris et al. 1974). Conspicuous visual marks have often been suggested, and a few have been successfully contrived for particular experiments, including freeze-branding, brightly colored buoyant lines, buoys, and plastic numbered buttons toggled through dorsal fins (Norris and Pryor 1970; Evans et al. 1972)

We have been loath to use acoustic tags on animals that react to the noise of ships, and even to low-level pingers (Watkins and Schevill 1975). Frequencies that are above their hearing would be useful only at short ranges because of attenuation of high frequencies in seawater.

Ideally, we wanted a mark that was highly visible, that could be varied, that had no effect on the behavior of the animal, that would last for long periods of time, and that was easy to apply at sea. Even a temporary mark permitting positive identification for only a few hours would be a boon. Paint seemed an answer (Schevill 1966).

### Materials and Methods

Several standard paint formulations were tried; some could be applied to a wet surface, and some would set relatively quickly underwater. Application of these paints was easiest by pressurized spray. We experimented with spray volumes, velocities, propellants, and methods of controlling the paint. A propellant that mixed well with the paint carried it in a discrete stream, preventing immediate mixing with the water, and higher volumes of the paint mixture provided more effective displacement of the water on the surface to be painted. In our most satisfactory marking system, we used 186-g (6-ounce) pressurized cans of paint with a fire-extinguisher type of valve to deliver short bursts of paint at about 125 g/s. A nozzle 3 cm long with a 3.5-mm orifice was fabricated to actuate the valve and direct the paint in a coherent stream (in air, 2 or 3 m horizontally). An internal modification to the standard container removed the dip tube so that the can could be used in an inverted position. For ease in handling and to allow the stream of paint to be brought close to a passing animal (as from the bow of a ship), a holder for the paint can was mounted at the end of a pole.

Paint bounced off most hard-surface materials before it could set underwater, unlike human or porpoise skin which appeared to have approximately equivalent temporary reactions to paint. But paper masking tape (3M-Scotch 183),[3] which has a softer surface, reacted somewhat like skin to both the paint and the water, and was used as an underwater test surface.

Two paints were selected: a red lacquer based on a nitrocellulose/alkyd vehicle and a red-orange fluorescent based on an acrylic ester resin vehicle.[4] These paints solidify by removal of the solvents rather than by oxidation, as in the usual paint preparations. The paint containers were capped at about 4.2 kg/cm$^2$ (60 lb/in$^2$) at room temperature. A 5% change of pressure can be expected with each 5°C change in ambient temperature; can temperature is critical for adequate pressure.

Tests were conducted in a 3-m$^3$ tank of flowing seawater, and water temperatures were controlled from 20.9°C in steps of a degree or less to 3.45°C, and a comparison was made for each temperature at several depths. Both paints penetrated the water in a coherent stream, adhered to the test surface, and set (hardened) underwater. The red lacquer set within a second or two, but was considerably dulled when applied through the water. The fluorescent red-orange was largely unaffected by underwater application, except that its setting time was extended by 10-15 min. Patches of both

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[2]Schevill, W. E., and W. A. Watkins. 1966. Radio-tagging of whales. Unpubl. manuscr., 15 p. Woods Hole Oceanogr. Inst. Ref. No. 66-17.

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

[4]These two paints are similar to formulation AL-98 and V-129 by Lenmar, Inc., 150 South Calverton Road, Baltimore, Md. These and other formulations and colors recommended by Lenmar have been tested and appear to have equivalent underwater characteristics.

paints applied underwater and kept immersed for 13 days and 7 h at 3.5°C showed only slight differences from short-term tests. There was little difference in the painted surfaces down to a temperature of 4.0°C. Below this, less paint adhered, and the color of the painted surface was duller. The paint maintained a coherent stream to greater depths in warmer water, perhaps because of associated higher air temperature and therefore greater pressure in the can. With the apparatus above water, penetration and marking (at 15°C) occurred to a depth of about 40 cm, and with increasing depth progressively less paint adhered. Comparisons of application of these paints in both seawater and fresh water showed little difference, at least on a short-term basis.

Since only a portion of the paint actually adhered underwater, the residue of these paints floated as an inert scum in temperatures of 5°C or warmer, generally not sticking to anything. This was in sharp contrast to many other paints that often floated as soft globules on the water, and for hours thereafter would coat any objects they contacted.

## Results

On 16 December 1974, we tested both paints on a captive *Tursiops* (one of two in a tank) at the Naval Undersea Center, San Diego, Calif. The porpoise swam slowly past with all but its dorsal fin underwater. The holder for the paint can was hand-held about 20 cm above the water, and the paint stream was directed downward at the animal, about 20° from the vertical. The stream penetrated the water by as much as 15-20 cm, marking a streak 6-8 cm wide (at each pass) on the animal's back, as well as on the right side of the dorsal fin.

The paint contrasted sharply with the dark gray color of the animal and provided a conspicuous mark that was brightly visible 8 h after application, although patches of it had disappeared. Twenty-four hours after painting, only a small strip of paint (at the leading edge of the dorsal fin) remained, and much of this residue was still there 56 h after application, though quite dulled.

Of the two *Tursiops* in the tank only one was painted, yet no obvious behavioral changes could be noted; they both seemed to ignore the whole process and behaved as before. There was no obvious reaction to either the painted animals or to the excess paint floating on the water.

A *Lagenorhynchus acutus* was successfully marked in the open ocean on 8 May 1975, 8 to 10 km northeast of Race Point, Cape Cod, Mass. Though *L. acutus* usually is shy of ships and difficult to approach (Schevill 1956), we found about 30 of these animals and were able to get close to a subgroup of six porpoises. They would not surface within reach of our vessel (13-m RV *Asterias*), so the paint was applied through 15 to 20 cm of water. The paint mark was a 10-cm circular red spot at the after part of the buff-colored stripe on the right side. We were able to follow this porpoise for only 30 min, but during this time, the mark provided a highly visible tag which permitted rapid identification of the marked individual as well as the subgroup of animals. This subgroup appeared to stay together even when mingling with others of the larger porpoise aggregation. Again, the paint mark appeared to be ignored by all of the animals. The next day, two schools of *L. actus* (probably including the same animals) were studied, but no mark could be found.

## Discussion

We suppose that the paint on the leading edge of the dorsal fin of the captive porpoise persisted longer than elsewhere because of the roughness and scarring of the skin there. The disappearance of the paint from the smooth surfaces on both the captive and wild animals was apparently because of the normally rapid sloughing of surface layers of skin. Palmer and Weddell (1964: 555) noted that cells in *Tursiops* skin undergo mitosis 250 to 290 times as rapidly as human skin, and Harrison and Thurley (1972) also reported that cells in the surface layer are desquamated in large numbers. Presumably, the paint came loose because the surface cells sloughed off. The relative stiffness and greater mass of the cells coated with paint would have accelerated their removal, but after the paint had worn off, no difference in the skin surface could be noted. We could find no indications of any adverse effects. Since the paint lasted so much longer on the rough part of the fin, we anticipate that similar nonsloughing surfaces on the other cetacean species also would hold a paint mark well (e.g., the highly barnacled portions of a gray whale, or perhaps right whale bonnets). In addition, we anticipate that such paints could usefully mark other aquatic animals (turtles, seals, manatees, etc.).

Little is known about color vision in porpoises, though it has been assumed that they could see color because of the relative numbers and arrangement of rods and cones in the retina of *Tursiops* (Perez et al. 1972). But since very little in the animals' open ocean experience involves much color, the painted marks may hold small significance for them.

Since our purpose was to test the feasibility of paint marking of porpoises, no attempt was made to create an ideal paint, though a paint formulated specifically for marking doubtless would have been better than those we used. Our experiments began with available paints, and those that were found to coat wet surfaces were modified for use in pressurized containers with high volume valves. Paint manufacturers generally are prepared to process only large volume orders, but we found that smaller specialty companies were able to prepare formulations to order and modify small quantities of pressurized paint containers.

### Conclusions

Paint marking of porpoises provides a satisfactory short-term tag that can be applied at sea. The paint has not modified the animals' behavior and it seems not to be detrimental in any way. The high visibility of the colors we tried often made it possible to locate the marked animal when other porpoises of the school were obscured. The underwater paint marking technique would appear to be potentially useful in the study of other aquatic animals.

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## GRAZING OF FRESHWATER AND ESTUARINE, BENTHIC DIATOMS BY ADULT ATLANTIC MENHADEN, *BREVOORTIA TYRANNUS*

The diet of the Atlantic menhaden, *Brevoortia tyrannus* (Latrobe), varies with stages in metamorphosis and the availability of food resources, but it has been characterized consistently in the literature as derived from the particulate organic components of planktonic ecosystems (Reintjes 1969; June and Carlson 1971; Jeffries 1975; Peters and Kjelson 1975; Durbin and Durbin 1975). Menhaden larvae feed primarily by selective predation on the larger estuarine zooplankters. Their metamorphosis into prejuveniles brings about the