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FIXED-WING AERIAL PHOTOGRAPHY SURVEYS OF PLASTIC DEBRIS ON AN ALASKAN BEACH

by

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ABSTRACT

Fixed-wing aerial photography surveys were conducted on a 1-km section of beach near Juneau, Alaska, to determine the feasibility of identifying man-made debris that washes ashore. Surveys were flown in July 1990, and in June and August 1991. Photographs were taken with four different cameras at a range of flight altitudes (20-402 m) and flight speeds (72-139 km/h), using black and white or color film. A variety of debris items (e.g., trawl web, plastic bottles, rope, floats) were placed on the beach before each aerial survey. Most of these debris items could not be positively identified in any aerial photographs because of image smear. Exceptions were large, brightly colored items like some fragments of green trawl web (>1 m^2), orange buoy bags (60 cm diameter), and white buckets (20 L). Photographs taken at the lowest altitudes (<120 m) and slowest flight speeds (<100 km/h) were best for identifying debris items. Color film was better than black and white because it allowed the bright colors of some plastics to contrast sharply with the sand substrate. A camera equipped with a forward-motion compensator will be tried next in an effort to reduce image smear and improve clarity of individual debris items in photographs.

CONTENTS

INTRODUCTION

Plastic debris discarded at sea is hazardous to marine animals and, when washed ashore, mars the scenic quality of beaches (Wallace 1985; Laist 1987; Pruter 1987). Annual national beach cleanups provide valuable information on the types and sources of plastic debris washed ashore (O'Hara 1990). Beach surveys conducted more frequently (2-4 times a year), however, and tagging of certain plastic debris items provide more detailed information on deposition rates and trends in abundance (Johnson and Merrell 1988; Johnson 1989, 1990; Cole et al. 1990). In Alaska, ground surveys can be difficult because of the remoteness and inaccessibility of many beaches. Aerial photography may be a method of quantifying the distribution and abundance of plastic debris on beaches in these remote areas. The objective of this study was to determine the feasibility of using fixed-wing aerial photography to identify individual plastic debris items commonly found on Alaskan beaches.

STUDY SITE

Aerial photography surveys were conducted on a 1-km section of Eagle Beach, approximately 35 km northwest of Juneau, Alaska (Fig. 1). The beach is sandy, has moderate gradient, is nearly void of drift logs, and is approximately 50 m wide extending from mean low water to the upper limit of high tide (seaward limit of terrestrial vegetation).

METHODS

A Cessna 180 equipped for aerial photography (underbelly camera port, anti-stall flaps, high lift) was flown in each survey and was manned by a pilot and a cameraman. A camera with mount was installed on the inside of the plane; the mount was cushioned to reduce vibration and improve camera stability. All photographs were taken from an underbelly view port (46 cm diameter) on the underside of the aircraft. Aerial photography surveys were conducted on 20 July 1990, 21 June 1991, and 13 August 1991. All surveys were conducted between 1100 and 1700 hours on sunny days with light winds (<8 km/h). Each survey took about 1 h for the aircraft to complete.

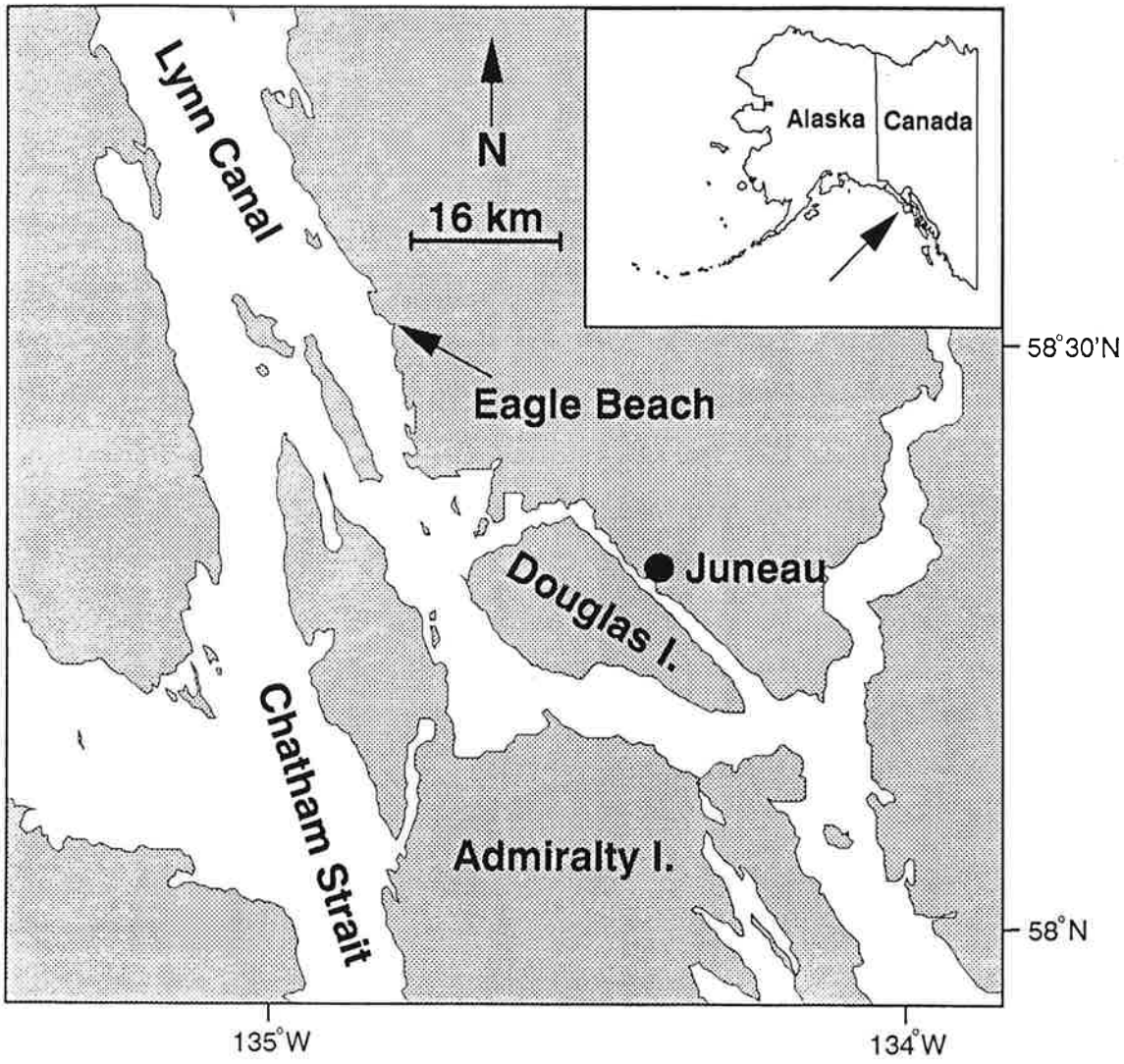

Figure 1.--Location of Eagle Beach near Juneau, Alaska, where aerial photography surveys were conducted in 1990 and 1991 to identify plastic debris placed on the beach. Arrow in inset map points to the approximate location of study area (enlarged) in northern Southeast Alaska.

In July 1990, aerial photographs were taken with a Park[1] camera and Kodak Aerocolor 2445 print film. Photographs were taken at five altitudes from 91 to 402 m and at flight speeds from 96 to 136 km/h (Table 1). Scale of photographs varied depending on altitude; 23-cm x 23-cm prints were used for analysis.

In June 1991, aerial photographs were taken with a Zeiss RMK-A high-precision camera and Kodak Aerocolor 2445 print film. Photographs were taken at nine altitudes from 88 to 381 m and at flight speeds from 72 to 139 km/h (Table 1). Scale of photographs varied depending on altitude; 23-cm x 23-cm prints were used for analysis.

In August 1991, two cameras were used to take aerial photographs. A Wild-Heerbugg RC-8 camera with AGFA black and white film was used at three altitudes from 91 to 168 m and at flight speeds from 80 to 104 km/h (Table 1). Scale of photographs varied depending on altitude; 23-cm x 23-cm prints were used for analysis. A Hasselblad camera with Kodak 120 color film was used from the side of the aircraft. The door of the aircraft was removed, the camera was held by hand, and photographs were taken at an oblique angle to the beach. Photographs were taken during two passes, both at an altitude of approximately 20 m and a flight speed of 72 km/h (Table 1); 13-cm x 13-cm color prints were used for analysis.

Before each aerial survey, two or three people arranged 10 or 11 transects spaced every 100 m along the survey beach. Each transect was perpendicular to the shoreline and was identified by a piece of black or orange plastic sheeting (1 m x 9 m). A number (1 to 11) was painted on each piece of sheeting so it could be seen from the aircraft and in the photographs. A variety of plastic debris items of various sizes, shapes, and colors were scattered on the beach around each transect marker (Table 2). All items were mapped according to their position near the transect marker, and photographs of the debris and markers were taken on the ground. The types of debris scattered on the beach and the number of transects were the same for all aerial surveys.

I examined all photographs three ways: by naked eye, under magnification (8-10X), and with stereoscopes (some photographs at elevations >300 m were taken in stereo). A few photographs, and in some cases individual transects within a photograph, were enlarged (5-10X) to aid in identifying plastic debris.

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

Table 1.--Specifications of aerial photography surveys for identifying plastic debris on Eagle Beach, near Juneau, Alaska. Photographs were 23-cm x 23-cm prints except for the Hasselblad camera that produced 13-cm x 13-cm prints. Lens settings and shutter speeds with the Park, Zeiss, or Wild cameras were F6.3 and 1/10th second with color film and F8.0 and 1/8th second with black and white film.

Flight Altitude (m)	Flight Speed (km/h)	Photo scale 2.5 cm = _____ m	Film	Camera
		July 1990		
402	136	67	Kodak Aerocolor-2445	Park[a]
180	120	30	"	"
189	112	31	"	"
183	112	30	"	"
91	96	15	"	"
		June 1991		
381	136	63	Kodak Aerocolor-2445	Zeiss RMK-A[b]
381	139	63	"	"
191	104	32	"	"
213	104	36	"	"
107	88	18	"	"
88	80	15	"	"
119	72	20	"	"
274	120	46	"	"
274	112	46	"	"
		August 1991		
158	88	27	AGFA-Black & White 200 EAFS (Pan 200 PE1)	Wild RC-8[c]
168	80	28	"	"
91	104	15	"	"
~20	~72		Kodak 120 Color	Hasselblad[d]
~20	~72		"	"

[a]Bausch & Lomb 152 mm Cartogon lens.
[b]Zeiss 152 mm lens.
[c]Wild-Avigon 152 mm lens.
[d]70 mm lens.

Table 2.--Type and size of plastic debris placed on Eagle Beach, Alaska, and photographed from a fixed-wing aircraft in 1990 and 1991. Items varied in color and included blue, black, red, orange, yellow, green, and white.

Type	Size
six-pack yokes, strapping bands, bottles, lids, rope fragments, bags, toys, shoes, floats, styrofoam cups, small fragments of trawl web and gill net (5-6 meshes), buckets, pails, buoy bags, etc.	<1 m^2
large fragments of trawl web and monofilament gill net, plastic sheeting, anchor line, some bags, etc.	≥1 m^2

RESULTS

July 1990 Survey

Most plastic debris items could not be identified in aerial photographs taken with the Park camera in July 1990. Image smear or lack of "crispness" of individual debris items in photographs limited identification. Clarity of photographs taken at all altitudes was similar. A few larger or brightly colored debris items, however, were identifiable in photographs taken at the lowest altitude (91 m) and slowest flight speed (96 km/h). For example, with the naked eye or hand-held magnifying lens (8X), I could distinguish some green fragments of trawl web (>1 m^2), white buckets (20 L), and orange and white buoy bags (60 cm diameter). Identification of these few debris items was possible primarily because the bright colors contrasted with the sand. Most other debris items, especially those with lighter and less contrasting colors (yellow, clear)--such as plastic bags, rope, and plastic bottles--could not be identified. Colors of some debris items were visible in photographs, but individual items could not be distinguished. Because most individual debris items did not have a clear outline in any photograph, enlargement of already blurry images only compounded the resolution problem.

June 1991 Survey

Identification of individual plastic debris items improved slightly in aerial photographs taken with the Zeiss camera in June 1991. In photographs taken at the lowest altitudes (88-119 m) and slowest flight speeds (72-88 km/h), I could identify some orange and white buoy bags (60 cm diameter), a blue pail (4 L), some green and blue fragments of trawl web (>1 m^2), white buckets (20 L), a red jerry jug (10 L), and some gill net fragments with floats attached (>1 m^2). Image resolution of these debris items was better than in photographs taken with the Park camera in June 1990, but was still not "crisp" and required a trained eye for interpretation. Colors of many other debris items were visible (e.g., black trawl web), but individual items could not be distinguished. For example, black trawl web could easily be mistaken for a pile of seaweed and vice versa. Debris items such as packing straps, rope, and caps or lids could not be identified in any photograph. Enlarging (5-10X) some photographs taken at the lower altitudes aided in positively identifying some debris items visible in the 23-cm x 23-cm prints but did not help in identifying other debris.

August 1991 Survey

Image resolution did not improve substantially in aerial photographs taken with the Wild camera and black and white film in August 1991. Although image smear appeared slightly reduced with the Wild camera compared to photographs from earlier cameras, the use of black and white film allowed no color contrast between debris items and the beach background, precluding identification of items distinguished in earlier color prints. Again, photographs taken at the lowest altitude (91 m) offered more opportunity to identify plastics than any of the higher-altitude photographs.

A few debris items could be identified in color prints taken with the Hasselblad camera. These included orange buoy bags (60 cm diameter), some green fragments of trawl web (>1 m^2), and white buckets (20 L).

DISCUSSION

Most plastic debris items placed on Eagle Beach could not be positively identified in aerial photographs. A few exceptions were large, brightly colored items like green trawl web (>1 m^2), orange buoy bags (60 cm diameter), and white buckets (20 L). The various colors of many debris items placed on the beach were visible in photographs, but

because of image smear they could not be identified as to individual debris type (is it a gill-net float or a bottle?). Most small plastic debris (<1 m^2) such as bottle caps, rope fragments, strapping bands, six-pack yokes, and styrofoam cups were impossible to identify in aerial photographs from any camera or flight altitude. Different beach substrates may affect identification of debris items in aerial photographs; some items not visible on a sandy beach may be more visible on a cobble beach and vice versa.

The Zeiss and Wild cameras provided only slightly better image resolution than the Park camera. This was surprising considering that the Zeiss and Wild cameras are much more expensive ($250,000) than the Park camera ($50,000), yet the resulting photographs from all cameras did not differ greatly. Photographs taken at an oblique angle to the beach with the Hasselblad camera warrant further study. More debris items might have been positively identified in photographs from the Hasselblad camera had the initial flights been more directly over the beach.

Color film was better than black and white because it allowed the colors of some plastics to contrast sharply with the light-colored substrate. Black and white film was used because its fine grain is more suitable for enlarging than color film. Black and white prints, however, lacked the color contrast present in color prints and precluded positive identification of any plastics.

Aerial photographs taken at the lowest altitudes (<120 m) and slowest flight speeds (<100 km/h) were best for identifying plastic debris. At slow flight speeds, however, the aircraft tended to vibrate more, causing the camera to shake. We will attempt to improve camera stability and reduce vibration in future surveys. Also, with the help of the National Ocean Service, a camera equipped with a forward-motion compensator (FMC) will be tested in 1992. The FMC adjusts for the forward motion of an aircraft during filming and greatly reduces image smear.

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