ASPECTS OF THE BEHAVIOUR AND ECOLOGY OF VANCOUVER ISLAND GRAY WHALES, *ESCHRICTIUS GLAUCUS* COPE

by

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ABSTRACT

This study examines selected aspects of the behaviour and ecology of gray whales, Eschrictius glaucus, especially of summer residents along the west coast of Vancouver Island. Work was centered on Wickaninnish Bay and adjacent waters from March, 1975 to October, 1976 with most observations during March to October each year. The northward migration of gray whales from the Baja calving lagoons lasts from mid-February until mid-June peaking in early April. During the spring migrations whales closely followed the Vancouver Island coast. The southward migration passes Vancouver Island from late November until mid-January. Whales present in the summer between the north and south movements were considered to be residents. During some winters whales are also resident between periods of annual movement. Many individuals were identified by photographs of skin pigmentation patterns. At least 65% of the 1975 summer residents returned in 1976. Some individuals have been sighted in the study area for 5 and 6 successive summers. Estimates of summer resident populations were 26 in 1975, 34 in 1976 and 42 over both summers (9 seen only in 1975, 17 in both years and 16 only in 1976). Variation was probably due to the home range of summer residents being larger than the study area. Movements during the summer were associated with travel, between feeding areas, to a tide-rip sand bar area and in and out of the study area. In both 1975 and 1976 resident whales were scarce in late July and early August. Length measurements of three individuals, using aerial photogrammetry

techniques, suggested that the summer population includes adults, juveniles and young of the year, apparently recently weaned. Previously described feeding behaviour, a method unique to gray whales whereby sand and associated infauna are sucked into one side of the mouth and subsequently separated by forcing the water and sand out through baleen plates, was observed many times. In parts of the study area examined the dominant component of the benthos was a polychaete tubeworm Onuphis elegans. Other behaviours included rubbing on a sand bar in a tide-rip area, resting and a variety of social interactions including paired swimming and homosexual behaviour.

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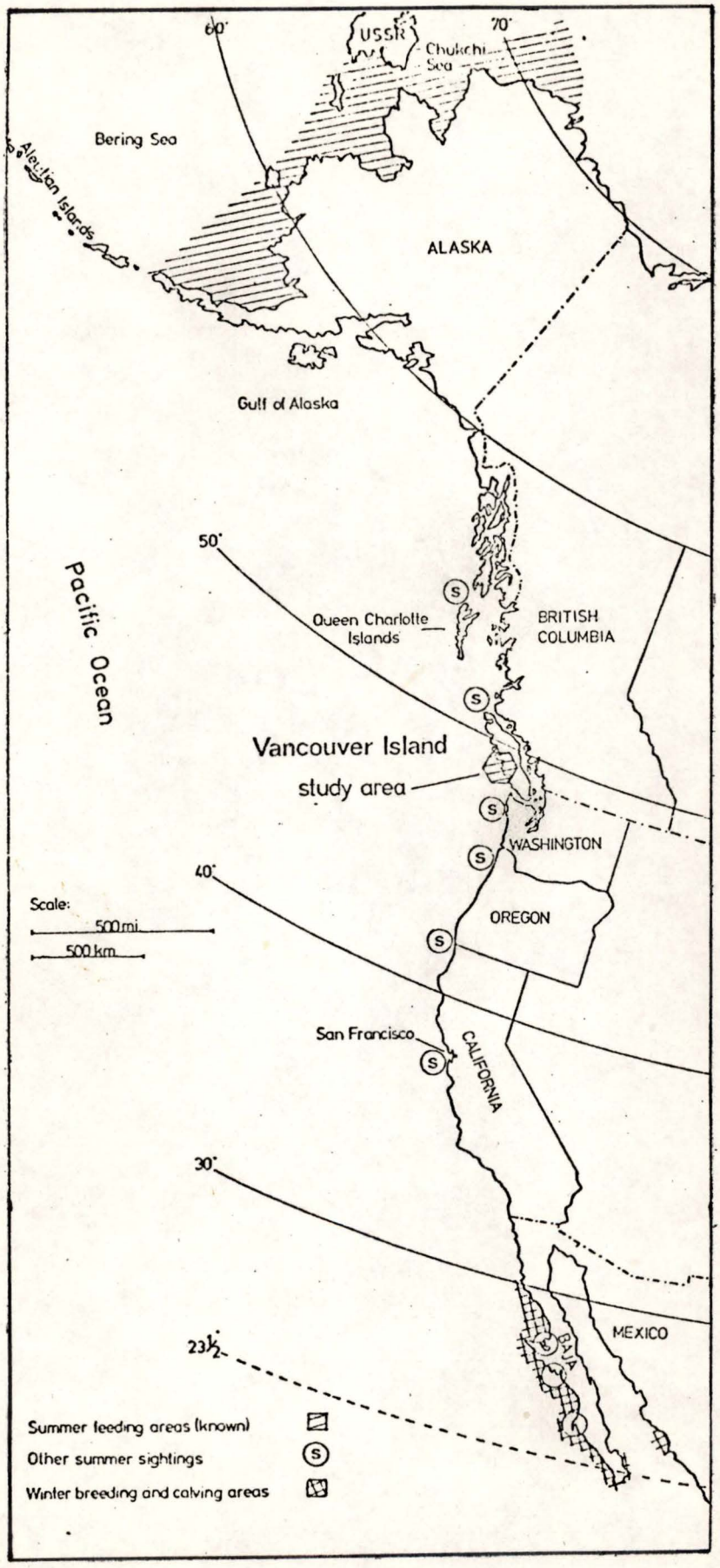
INTRODUCTION

The eastern Pacific or California herd of gray whales ranges along the west coast of North America from the Baja, California peninsula to the pack ice of the Arctic Ocean (Scammon, 1869; Rice and Wolman, 1971). An estimated 11,000 whales migrate between winter calving lagoons at the southern end of their range and summer feeding grounds in the Bering and Chukchi Seas, and apparently along the rim of the north-east Pacific basin (Rice and Wolman, 1971; Hatler and Darling, 1974) (Fig. 1). Rice and Wolman (1971) summarized isolated sightings of gray whales on the British Columbia, Washington, Oregon and California coasts during the summer months and concluded that not all gray whales migrate to the Arctic in the summer. The published record is summarized in Table 1. Along the outer coast of Vancouver Island gray whales are seen regularly during the summer months (Hatler and Darling, 1974). They are the subject of this study.

Gray whales have become the most familiar of baleen whales due mostly to their inshore migrations past the large population centers of southern California, the close proximity of their breeding and calving lagoons, and ease of observation. The researches of Walker (1949), Hubbs (1950, 1959) and Gilmore (1955, 1956, 1960a, 1960b) re-established the interest in the gray whale held earlier by whalers who hunted them to near extinction in the late 1800's and early 1900's (Gilmore, 1956). They, and others, have censused the herd during its migration,

Fig. 1 The distribution of the eastern Pacific herd of gray whales.


60°
USSR
70°
Chukchi Sea
Bering Sea
Aleutian Islands
ALASKA
Gulf of Alaska
50°
Pacific Ocean
Queen Charlotte Islands
BRITISH COLUMBIA
Vancouver Island
study area
WASHINGTON
40°
Scale:
500 mi
500 km
OREGON
San Francisco
CALIFORNIA
30°
MEXICO
BAJA
23½°
Summer feeding areas (known)
Other summer sightings
Winter breeding and calving areas

Northeast Pacific.

SOURCE	AREA	REMARKS
Gilmore 1960a	Northern California and southern Oregon	"a few regularly spend the summer in the vicinity of St. George Reef and Pelican Bay"
Gilmore 1960b	Southeast Alaska, Oregon and northern California	Although he reports some individuals linger all summer in these areas, Gilmore feels these are not part of the main herd.
Pike 1962	B.C.	"Gray whales occur along the coast and in protected waters of B.C. from June through September. At this time the direction of travel is not constant; these whales are probably summer residents of the area and do not migrate"
Carl 1967	Victoria, B.C.	seen on several occasions through the summer of 1967.
Pike and MacAskie 1969	Queen Charlotte Islands	"several gray whales reported near Langara, Queen Charlotte Island in late August and early September of 1959 and 1960)
	Vancouver Island, B.C.	One young male stranded near Ucluelet, Vancouver Island, August 1966.
Rice and Wolman 1971	Lapush, Washington	"some" seen in June & July 1961 (C. Munsen) "some" seen in July 1967 (A. Wolman)
	Kalaloch, Washington	"a few" in July 1968 (A.M. Johnson)
	Cannon Beach, Oregon	one in July 1969 (Fiscus)
	off San Francisco	whalers occasionally see gray whales during the summer
	Farallon Islands, Ca.	a few through summer 1964. They remained until late September or early October (L. Newton, Captain of catcher boat, Lynann)
	Bahia Magdalena, Baja, Mexico	on June 11, 1965, one small gray (K. Balcomb)
Hatler and Darling 1974	Wickaninnish Bay, Vancouver Island	gray whales seen regularly, apparently feeding, during each of nine summers 1965-1973.

and described migratory times, routes and behaviours, especially during the southward migration past California. Also during the 50's and 60's the calving lagoons were explored, mating and calving behaviours described and gray whale sounds recorded (Eberhart and Evans, 1962; Gilmore and Mills, 1962; Eberhart and Norris, 1964; Rasmussen and Head, 1965; Eberhart, 1966; Asa-Dorian and Perkins, 1967; Cummings, Thompson and Cook, 1967, 1968; Gilmore et al. 1967; Hubbs and Hubbs, 1967; and Poulter, 1968). More recently Rice and Wolman (1971) produced a definitive work on the life history and ecology of the gray whale based on a decade of research and summarizing almost all previous work. Yet, the northern summer life of the gray whale is all but unknown. Virtually all research leading to the 'story' of the gray whale has been carried out in the southern one third of its range covering about one quarter of the whales' year.

Pike (1962) produced the only comprehensive report on the gray whale migrations through the northern two thirds of its range, and also discussed all available data on food and feeding. Prior to Pike's (1962) report, Gilmore (1956, 1960b) had postulated that gray whales take the shortest route directly across the Gulf of Alaska, from Vancouver Island to the Aleutians on the way north and the Aleutians to the Oregon coast on return. Pike (1962), later supported by Pike and MacAskie (1969) and Hatler and Darling (1974)

concluded instead that the migrations probably follow the coastline of British Columbia and Alaska in a manner similar to descriptions for the California coast. Sightings by these authors of whales moving in both directions past the Queen Charlotte and Vancouver Islands, those by Wilke and Fiscus (1961) of north-bound whales along the Kodiak Islands, and the absence of offshore sightings have all but negated Gilmore's postulate. Substantial evidence of inshore versus offshore routes for the southward migration is still lacking. Much of the remaining information on whales in the northern portions of their range comes from observations made incidental to other work. Scammon (1869), Bailey and Hendee (1926), Maher (1960), Wilke and Fiscus (1961), Fay (1963) and Sauer (1963) document sightings in the Bering and Chukchi Seas during the summer, feeding, and in the cases of Fay (1963) and Sauers' (1963) reports, participation in apparent sexual behaviour. Feeding data comes mostly from the examination of stomach contents of dead gray whales and some benthic surveys conducted mostly by Japanese and Russian researchers (Pike, 1962; Zenkovich, 1934a, 1934b, 1937; Tomlin, 1937; Rice and Wolman, 1971). Apparently gray whales populate the shallower regions of the Bering and Chukchi Seas, and bottom feed, predominantly on gammaridean amphipods (Rice and Wolman, 1971). No in depth population, feeding or other behavioural studies have been made in the northern two thirds of this species range.

Hatler and Darling (1974) in their documentation of gray whales in Wickaninnish Bay, Vancouver Island, earlier

observations by Pike (1962) and Pike and MacAskie (1969) and some field work in the study area prior to 1975 provide four general significant observations on which this study is based: 1) both northbound and southbound migratory whales pass along the Vancouver Island coast (Pike, 1962; Pike and MacAskie, 1969; Hatler and Darling, 1974); 2) gray whales are seen regularly through the summer months in Wickaninnish Bay and adjacent waters (Hatler and Darling, 1974); 3) the number of whales in Wickaninnish Bay varies through the summer indicating movements over a larger area (Hatler and Darling, 1974); 4) the same individual whales, recognized by natural markings, were seen in Wickaninnish Bay regularly through a single summer and over several years (Hatler and Darling, 1974).

Rice and Wolman (1971) in the introduction to their work on the gray whale state, "individual whales cannot be observed repeatedly therefore knowledge of most aspects of their life history must be deduced from data provided by examining a large series of specimens". Their sampling of over three hundred gray whales and piecing together of the "life history and ecology" of this species by exhaustive anatomical and histological study provided a wealth of useful information.

By contrast whale studies in the 1970's, have depended on some scheme of individual recognition by natural markings. Payne (pers. comm. 1976) recognized individual southern right whales (Eubalaena australis) off the Argentine coast by patterns of calosities on their heads, and has completed

extensive population and behavioural research. Bigg, MacAskie and Ellis (1976) have identified individual killer whales (Orcinus orca) by irregularities in dorsal fins and saddle patches and have used this for studies of abundance and movements on the British Columbia coast. Kraus and Katona (1977) have been identifying humpback whales in the western Atlantic by pigmentation patterns on the underside of the tail flukes. Individual identification provides the singular advantage of repeated observations of the same whale or whales.

Hatler and Darling (1974) describe a gray whale with a large orange scar on its lower left side photographed in 1970, 1973 and 1974 and one with an obvious white patch just below its dorsal hump on its right side photographed in 1972 and 1973, both whales in Wickaninnish Bay. These have become known as Orange Scar and Whitepatch respectively. Whitepatch was also photographed in 1974 and that year two 'new' whales were identified. One had a saddle shaped white marking on its right side just before its dorsal hump, now known as Saddle and another had a large white oval low on its right side and was named Big White. These last two individuals as well as Orange Scar and Whitepatch were seen several times over the summer of 1974 (and as reported in this study in 1975 and all, except Orange Scar, in 1976).

A summary of individual identification prior to 1975:

Orange Scar	1970	1972*	1973	1974
Whitepatch		1972	1973	1974
Saddle				1974
Big White				1974

*Seen but not photographed.

Also a whale photographed in 1971 by W. Campbell (pers. comm., 1975 was present in 1975 and 1976.

With the realization that individual whales could be recognized by a variety of permanent natural markings, and the potential for building a system of photographic identification the following goals were established.

These were to determine the number of whales summering in the area and to investigate their permanence, movements, age and sex, and behaviours. Abundance and movements were of primary interest. Their study necessitated being able to differentiate between migrant and non-migrant animals, therefore the northern migration was studied intensively. Methods of aging and sexing the whales were explored and general behaviours, particularly feeding, described.

MATERIALS AND METHODS

A. Study Area

Vancouver Island, British Columbia extends from a notch in the continental coastline approximately halfway between the calving lagoons and northermost feeding ground of the gray whale (Fig. 1). This study is centered on a 24 mi. (38.5 km.) stretch of the outer coastline of Vancouver Island (Fig. 2, 3 and 4). The limits of the study area were set mainly by the range of area which could consistently be reached with a small boat, not by any known whale distribution limits.

The main study area extended from Wickaninnish Bay (and inconsistently Wreck Bay) northwest up the coast to Ahous Bay, Vargas Island (Fig. 3 and 4). This includes Wickaninnish Bay, Schooner Cove, Radar Beaches, Cox Bay, Chestermans Beach, Templar Channel, Duffin Passage and the entrance to the Tofino Inlet system, Wickaninnish Island and Ahous Bay, Vargas Island. The village of Tofino lies approximately in the center of the study area and daily operations usually began there. Some effort was made to reach Flores Island, Kanim Lake area, and Estevan Point, 10 mi. (16.1 km.), 22 mi. (35.4 km) and 26 mi. (41.8 km.) northwest of Ahous Bay respectively and Pachena Bay, 29 mi. (46.7 km.) southeast of Wickaninnish Bay (Fig. 8). One flight was made along the coastline from Tofino to Winter Harbor, Quatsino Sound, 130 mi. (210 km.) distant (Fig. 2). With the cooperation of Vancouver Island lightstation

Fig. 2 Vancouver Island, showing the location of the study area and west coast lightstations.

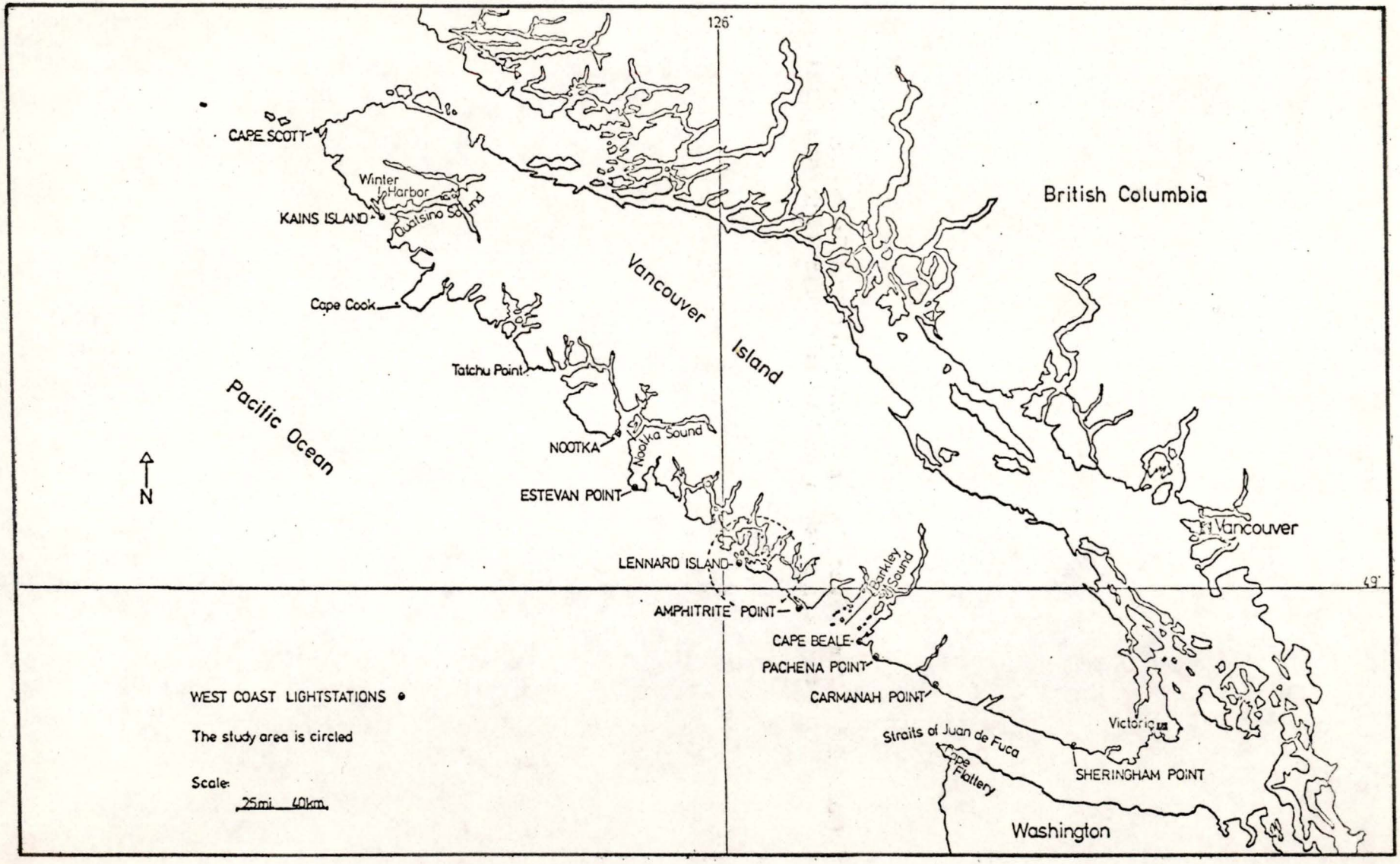

126°
CAPE SCOTT
Winter Harbor
KAINS ISLAND
Queisino Sound
Cape Cook
Tatchu Point
Pacific Ocean
Vancouver Island
British Columbia
NOOTKA
Nootka Sound
ESTEVAN POINT
N
LENNARD ISLAND
Barkley Sound
AMPHITRITE POINT
CAPE BEALE
PACHENA POINT
CARMANAH POINT
Straits of Juan de Fuca
Cape Flattery
SHERINGHAM POINT
Victoria
Vancouver
49°
Washington
WEST COAST LIGHTSTATIONS •
The study area is circled
Scale:
25mi 40km

Fig. 3 The study area.

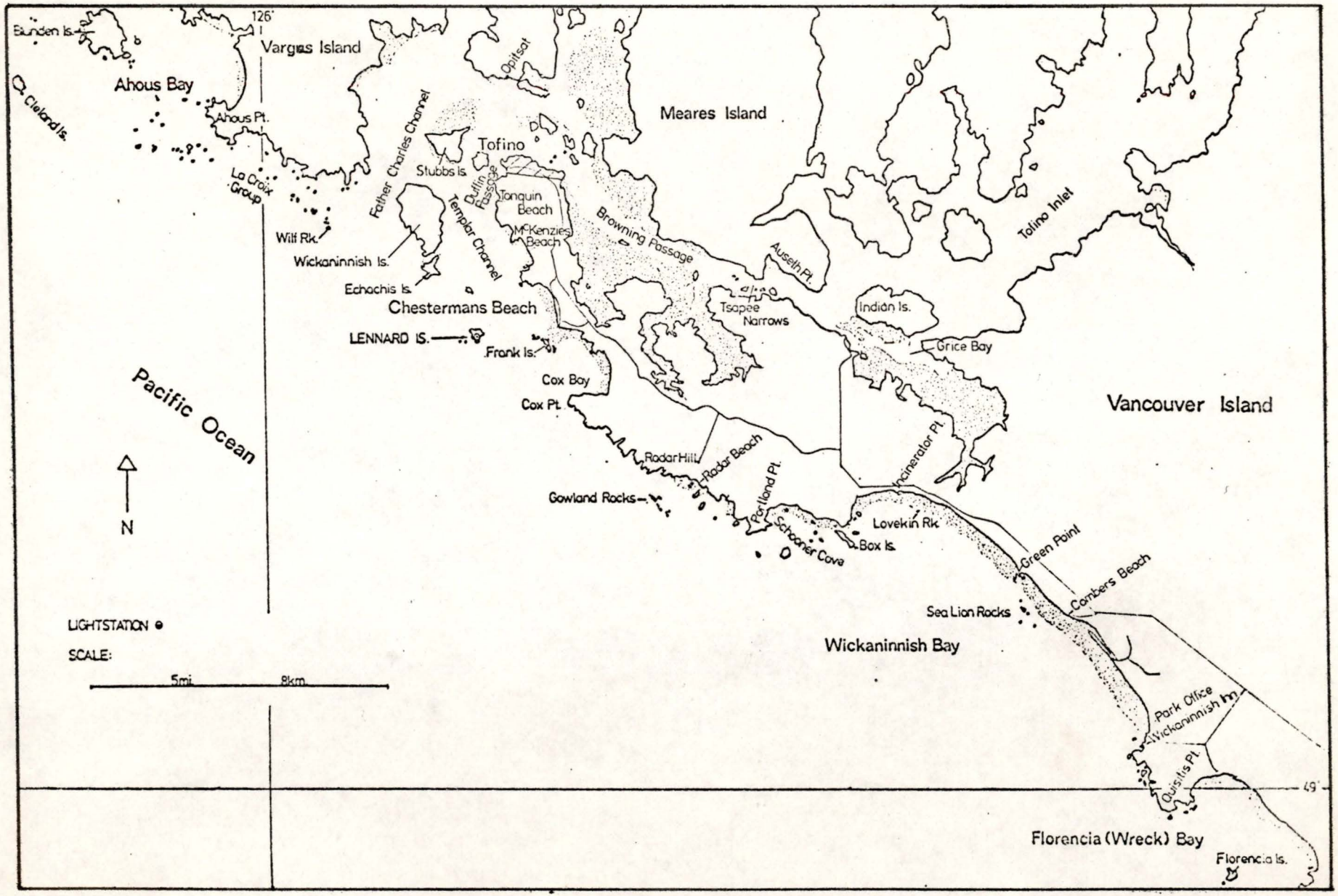

126°
Vargas Island
Flinders Is.
Ahous Bay
Cleland Is.
Ahous Pt.
La Croix Group
Wilf Rk.
Wickaninnish Is.
Echachis Is.
Father Charles Channel
Templer Channel
Stubbs Is.
Dublin Passage
Tofino
Opitsat
Meares Island
Tonquin Beach
McKenzies Beach
Browning Passage
Chestermans Beach
LENNARD IS.
Frank Is.
Cox Bay
Cox Pt.
Pacific Ocean
N
Radar Hill
Radar Beach
Portland Pt.
Gowland Rocks
Schooner Cove
Ausetlh Pt.
Tsapee Narrows
Indian Is.
Grice Bay
Tofino Inlet
Incinerator Pt.
Vancouver Island
Lovekin Rk.
Box Is.
Green Point
Combers Beach
Sea Lion Rocks
Wickaninnish Bay
LIGHTSTATION
SCALE:
5mi
8km
Park Office
Wickaninnish
Quisitis Pt.
49°
Florencia (Wreck) Bay
Florencia Is.

Fig. 4 The study area.

A. Ahous Bay, Vargas Island.

B. La Croix Group reefs off Vargas Island; Wickaninnish Island, Tofino, and Chestermans Beach in the background.

C. Wickaninnish Bay, Vancouver Island.


A


B


C

personnel from Sheringham Point, Carmanah Point, Pachena Point, Cape Beale, Amphitrite Point, Lennard Island, Estevan Point, Nootka, Kains Island and Cape Scott the entire west coast of the island was monitored during the migrations, November to May (Fig. 2). All observation was coastal; no offshore surveys were attempted.

The west coast of Vancouver Island is mountainous over most of its 300 mi. (483 km.) length. Numerous fjord-like inlets wind amongst 4,000-7,000 ft. peaks and the larger Barkley, Nootka, and Quatsino Sounds extend well into the heart of the island (Fig. 2). The narrow Estevan coastline plain separates the base of the Insular mountain range from the Pacific and is widest in the Long Beach area. The exposed coastline is characterized by sandy bays and beaches (Long Beach, Wickaninnish Bay is 7 mi. (11.3 km.) in length) separated by rocky headlands or long stretches of rocky coast and cliffs (Fig. 4). The larger coastal islands such as Vargas, Flores and Nootka create a fairly extensive system of protected waterways between them and Vancouver Island. Sandy beaches are common on the exposed sides of these islands (Fig. 4).

Limiting factors in this research were the weather and sea conditions. The west coast of Vancouver Island is exposed to the full force of North Pacific swells, prevailing westerly and southeast storm winds. Mean annual precipitation at Tofino airport, directly behind Wickaninnish Bay, is 307.3 cm.

(121 in.) (B.C. 1966). Southeast storms, with winds 15-30+ knots and rain are common during the winter and not infrequent in the summer. Usually a storm will pass in 2-4 days. A series of storms may last for weeks. When the weather stabilizes, particularly during the summer, extensive fog banks build and remain either on or very close to shore until it rains again. Even during the summer the weather and ocean conditions permitted observation from boats on only about 50% of available days.

B. Methods

1) Annual Migrations

Lightstation personnel on the west coast of Vancouver Island were asked to record sightings of gray whales from their stations during the migratory period, November through May. Forms were provided on which sighting date, number of whales seen, direction of movement, number of days of poor visibility, and any other comments could be recorded (Appendix III). Return-addressed stamped envelopes were included so that forms could be returned to the University at the end of each month. Lightstation personnel were not expected to spend hours watching for whales, but simply to record those they noticed. Lightstations contacted were Sheringham Point, Carmanah Point, Pachena Point, Cape Beale, Amphitrite Point, Lennard Island, Estevan Point, Nootka, Kains Island and Cape Scott. This method of monitoring the migrations was used in 1972-73

(reported in Hatler and Darling, 1974), 1973-74 and 1975-76.

The spring migration was observed from shore positions in the study area and, when weather allowed, from small craft. Shore positions included Frank Island, Radar Hill, Box Island, Incinerator Point, Green Point, Combers Beach, and Wreck Bay (Fig. 3). Box Island was the most regularly used shore observation point. Boatobservation ranged either, from Tofino southeast along the coast to Wickininnish Bay or from Tofino northwest to Blunden Island and Ahous Bay, Vargas Island.

The southward, winter, migration was observed sporadically from shore. Some residents of the study area, particularly park naturalists recorded any incidental sightings.

2) Summer Observations

Day to day location and observation of whales was usually done from a boat, either a 13 or 16 ft. Boston Whaler. Once whales were located, their position, movements, companions, and behaviours were recorded. Numerous reefs, islands and points in the study area allowed fairly accurate positioning by landmark. Whales were photographed whenever possible (discussed below). Cameras included a 35 mm. Canon Ftb with 100-200 mm. zoom lens and a 35 mm. Olympus OM1 with 300 mm. lens. When shooting black and white, Kodak TRI - X Pan was pushed to 1200 ASA and shot with a shutter speed of 1,000th of a second. Much of the identification photography was in black and white (Kodak Tri-X Pan). Highspeed

Ektachrome and Kodachrome were used for color slides. Once an animal was photographed its skin patterns were sketched on the data chart beside its position and the film frame number noted. Whenever possible both sides of the whale were photographed. About 4,500 photographs were taken.

In 1976 some flying, for the purpose of counting, positioning and experimenting with aerial identification photography was carried out. A regular course was flown over the study area once a week, May through August. Usually a Cessna 185 was used and the observer would sit behind the pilot so as both could see the animal being observed. Its position and behaviour were recorded. Aerial photographs were taken with the Olympus with a 300 mm lens and motor drive unit using either TRI-X (developed at 1200 ASA and 1000th of a second) or Highspeed Ektachrome (160 ASA often shot at 250th and F.8).

Observation from shore during the summer was usually due to poor weather, boat breakdown, or to check counts made from the air.

3) Counting Techniques

Whales were counted from shore, boat and plane and each of these means had its advantages and disadvantages. The advantages of the boat were that an area could be slowly cruised, stops made near the whales and individuals recognized so that errors of duplication were minimal. Also areas behind islands or rocks and those difficult to reach from shore

could be censused. Another advantage was that the engine could be turned off and whales not yet seen could often be heard as the sound of the blow travels well across water. The major disadvantage was that being low, close to the water, whales any distance away or in another direction from which one is looking were difficult to see. On shore the advantage was a high position so that a large area could be surveyed. Errors of duplication probably increased from shore, especially if the whales were close together and identification was possible only with high-powered scopes. Flying was quite different from either shore or boat observation and its advantages many: large areas inaccessible from shore or even boat in rough seas could be reached, accurate counts of whales in a close group if they were surfacing simultaneously could be made, and whales could be identified photographically once a system of recognition was established. The overwhelming disadvantage was cost, which sometimes led to spending less time over an area than one might have liked to assure count accuracy. Also the ability to see whales from the air varied markedly with weather and sea conditions. On clear calm days gray whales which were underwater could be found by circling an area where the feeding whale had disturbed the sand, often quite visible from the air, until it surfaced. On gray, or windy days it was much more difficult to see the sand so the accuracy of the count depended on the whales surfacing sometime during the flight above them. Aerial searches were graded A-D applying to flights where conditions

were ideal (i.e. clear sky, calm seas, good visibility in the water) to flights in fog, rain or high winds or all three. Any flight with a grade below C+ was not used in analysis. Using this rule, data from two flights out of twelve in 1976 were discarded. On two occasions it was possible to check counts made from the air with counts made from a boat the same day. On May 3, five whales were seen in Ahous Bay from the air in the morning, flight grade was B+ and that afternoon 5-6 whales were counted from the boat. On May 31, three whales were seen in Wickaninnish Bay in the morning, flight grade B and three whales were counted that afternoon by boat. Thus different census methods produced comparable results. Census by air was begun in 1976 to, as well as locate and count whales, test its potential for covering larger areas of the coast than have been regularly covered in the past. On clear, calm days counts from the air seem quite satisfactorily accurate, however, this accuracy drops quickly as weather or sea worsens.

4) Identification Technique

Several authors have used natural markings to identify individual gray whales. Leatherwood (1974) reports using natural markings to identify three gray whales seen on successive days off the southern California coast to calculate their speed of movement. The markings he described were "white brush markings on the tail stock and flukes", "all white tail flukes with a wide band across its tail stock" and "an unusually dark" yearling. Sauer (1963) also, in describing apparent sexual activity at the St. Lawrence Island, Alaska, states

that individual whales could be recognized by skin patterns.

Although some whales might be more easily recognized by scars, most, if not all, have varying patterns of natural skin pigmentation on their backs. Usually the marking is light, white or gray, on a darker background and shows clearly on a photograph. Some markings are large and obvious, others are small and/or subtle. That these markings are pigmentation patterns and not a surface growth was determined by looking at a cross section of a marking on the skin of a dead whale. The pigmentation patterns vary in degree from whale to whale and most are quite individually recognizable (Figure 5a & b). Figure 6 (a-d) shows the same animal; its left and right side over two years. The smallest details of the patterns are constant (arrows). Some circular or moon shaped marks (circled) are present on the left side of this whale in the 1976 photograph but not there in 1975. Similar superficial, non-permanent marks have been noticed on other whales also. Although this whale (named Collage) has approximately symetrical markings on both sides, this is not always the case. It is important to photograph both sides of the whale, to avoid counting sides instead of whales.

Scars can also serve as a basis for identification as in the case of Hatler and Darling's (1974) "Orange Scar". On this whale the scar remained obvious from at least 1970 - 1975, the years it has been recorded in Wickaninnish Bay. No substantial change in the scar was noted but there were some

Fig. 5 Examples of skin pigmentation patterns used in identification.

A. A whale called Blackjack.

B. A whale called McKenzie.

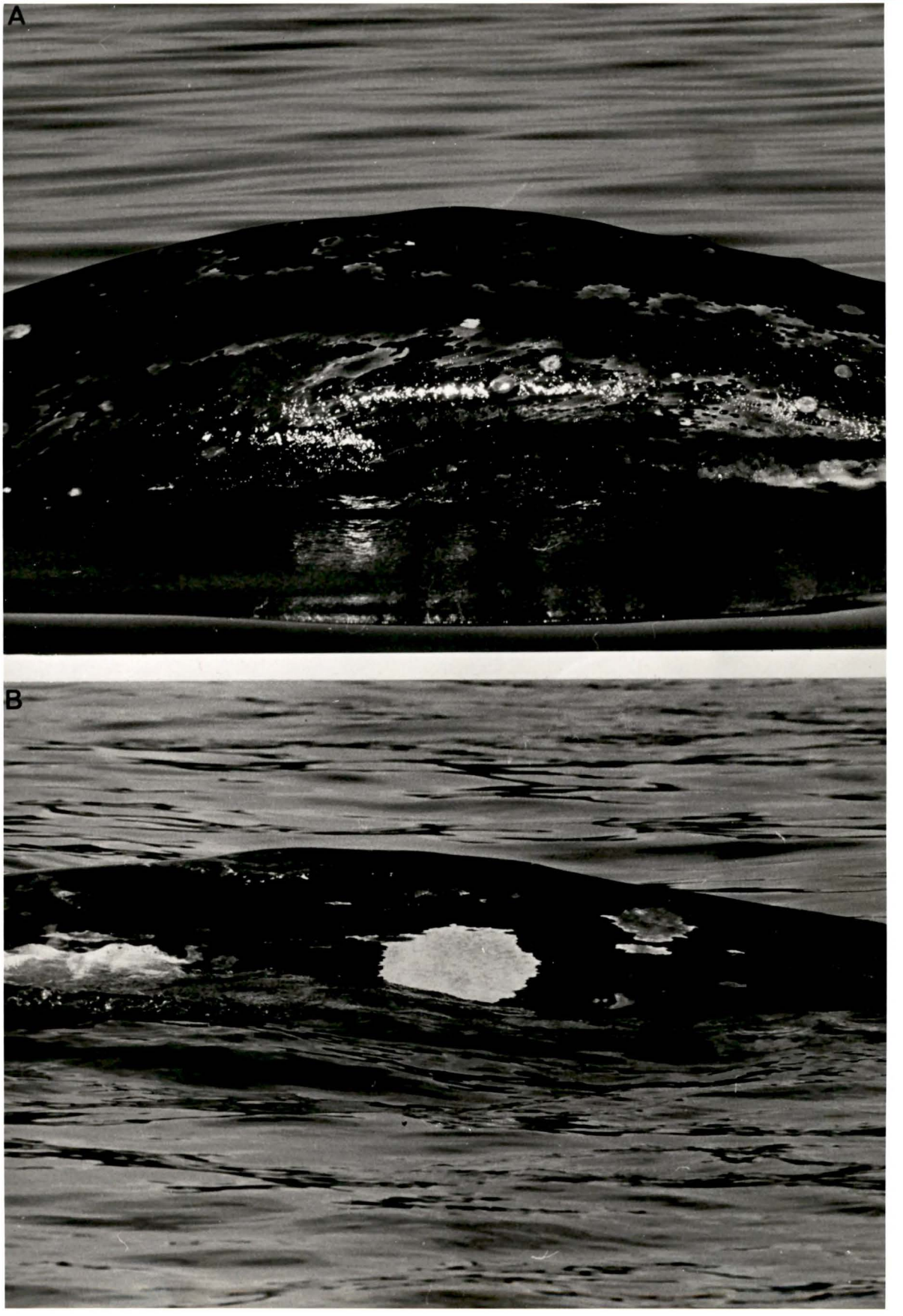

A
B

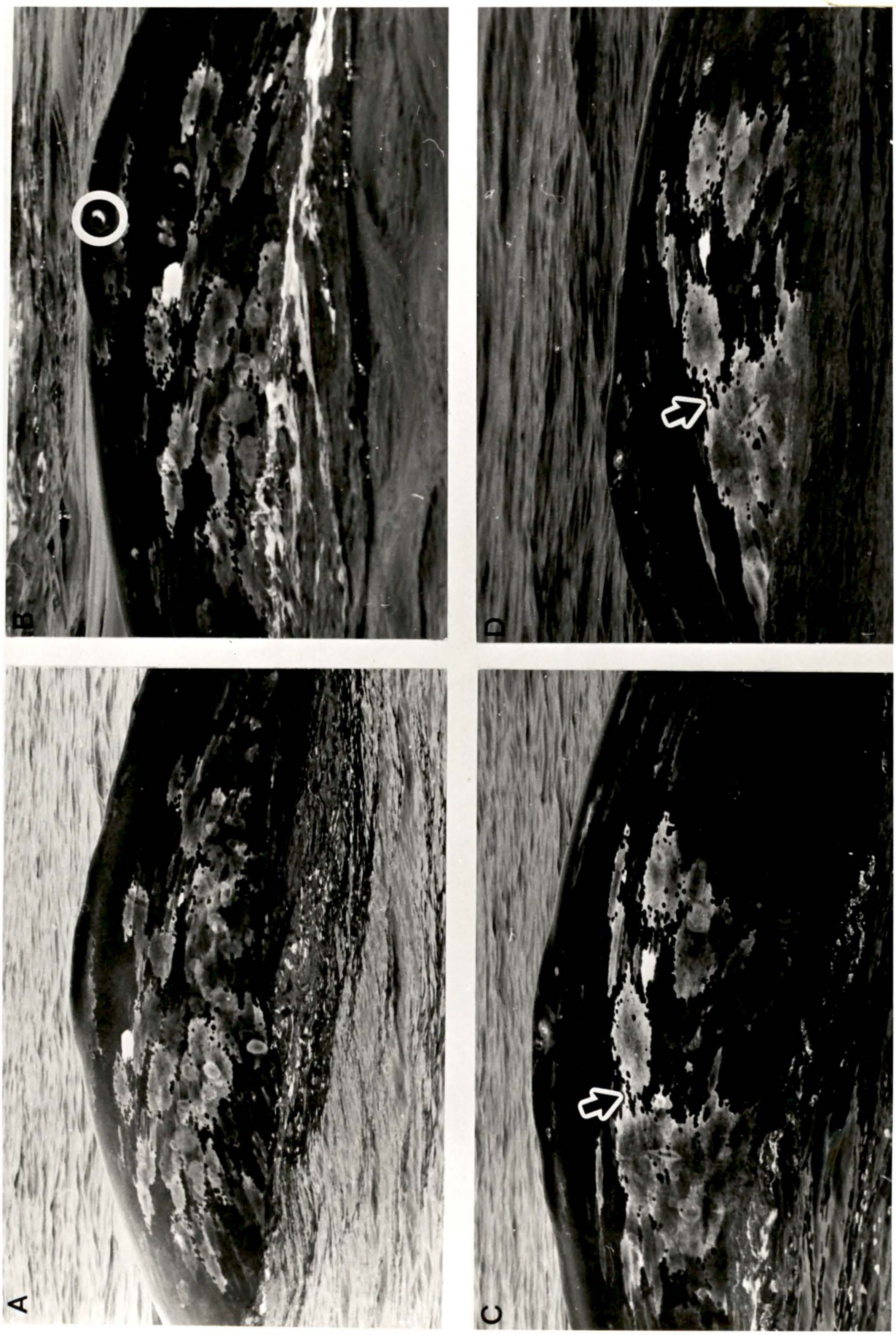
Fig. 6 Skin pigmentation patterns of the same whale, both sides, over two years.

A. Left side 1975 B. Left side 1976

Note the half-moon shaped markings (circled) not present in 1975.

C. Right side 1975 D. Right side 1976

Arrows indicate the same point on the whale. Even the most intricate patterns are permanent.


A
B
C
D

subjective feelings that it was decreasing in size (Fig. 22).

Gray whales have barnacle (Cryptolepus rhachianceti) patches especially on their heads and the most anterior part of their back, and cyamids (C. scammoni, C. ceti, C. kessleri) particularly around the barnacles and on wounds (Rice and Wolman, 1971). The orange color on scars is probably due, at least in part, to the cyamids. Barnacles and cyamids were not used for individual recognition.

All identified whales were numbered by order of sighting and by year (i.e. 170 was the first animal identified in 1970). Many of those regularly sighted were also named. It was easier to deal with a descriptive name such as 'Saddle' or 'Whitepatch' than with a number.

5) Measuring Technique

The technique used in measuring whales was that developed by Whitehead and Payne (1976) for southern Right whales (Eubaleana australis) in Argentina. The whale is measured by photogrammetry using an object of known size next to the whale. A white disk one meter in diameter was painted on a sheet of plywood and tied to the bow rail of the boat. The boat was then placed beside a whale to be measured and both photographed in the same frame from the air. Generally a motor drive sequence of photographs were taken. The length of the whale was calculated by comparing its measured length on the negative and that of the maximum diameter of the desk. A correction was applied in cases where the distances, camera

to whale and camera to disc were different.

The length of the whale is given by

$$L = \frac{l}{u}\left[1 \pm \frac{h}{v}\sqrt{\left(\frac{u}{s}\right)^2 - 1}\right]$$

Using a + (plus) sign if the whale is further than the disc from the camera and a - (minus) sign if the whale is closer to the camera than the disk.

lmm = measured length of whale on negative in mm.
umm = measured maximum diameter of disc on negative.
hmm = measured distance from center of whale to center of disc on negative
umm = image distance of camera lens.
smm = measured diameter of disc which when extended passes through the center of the whale.

Further discussion of the method, correction factor and errors is included later with the Results and in Appendix II.

Measuring whales by this technique was attempted five times in 1976. The planes used were, a Cessna 150 three times, Cessna 185 once and a Beaver once. The same pilot flew each time. It was found that the smaller and quieter the plane the better, so the small Cessna 150 was used whenever possible. In that case the photographer sat beside the pilot as there were only two seats; in the larger planes the photographer sat behind the pilot so both could see the animal they were circling. The photographer was in radio contact with the boat operator. Photographs were taken with a 300 mm lens, through an open window, at about 300 ft. altitude.

C. Effort

Between March 27, 1975 and September 19, 1976 whales were sought on 200 days (Fig. 7). The majority of observation took place between March and September each year. Only 22 were in the winter months (5 days in October, 3 days in November, 2 days in December and 6 days in each of January and February).

Table 2 shows that work from a boat was carried out on 137 days (2-6 hours/day), from a plane on 18 days (1-1½ hours/day) and from shore on 61 days (1-6 hours/day). These do not add up to 200 as observation might be made by two or all three means on the same day. Photographs were taken from the boat on 107 days and on 18 days of flying.

Table 2 and Figure 8 summarize effort by geographic area. Wickaninnish Bay, Wreck Bay and Chestermans Beach area can be reached from land, as well as by boat and plane, and whales were sought in Chestermans Beach and Wickaninnish Bay from shore 61 days and in Wreck Bay 25 of those 61. In surveys by boat or plane the areas enroute were covered as well as the destination. Chestermans Beach area was covered on 105 days, Wickaninnish Bay on 96 days, Wreck Bay on 20 days and Pachena Bay on 2 days. In a northwest direction from Tofino, Ahous Bay in Vargas Island was reached 62 days, the southeast beaches of Flores Island on 8 days, Rafael Point, Flores Island 2 days, Kanim Lake area 4 days and from Estevan Point to Winter Harbor on one day (Fig. 8).

Fig. 7 Study effort; number of days per month whales were sought.

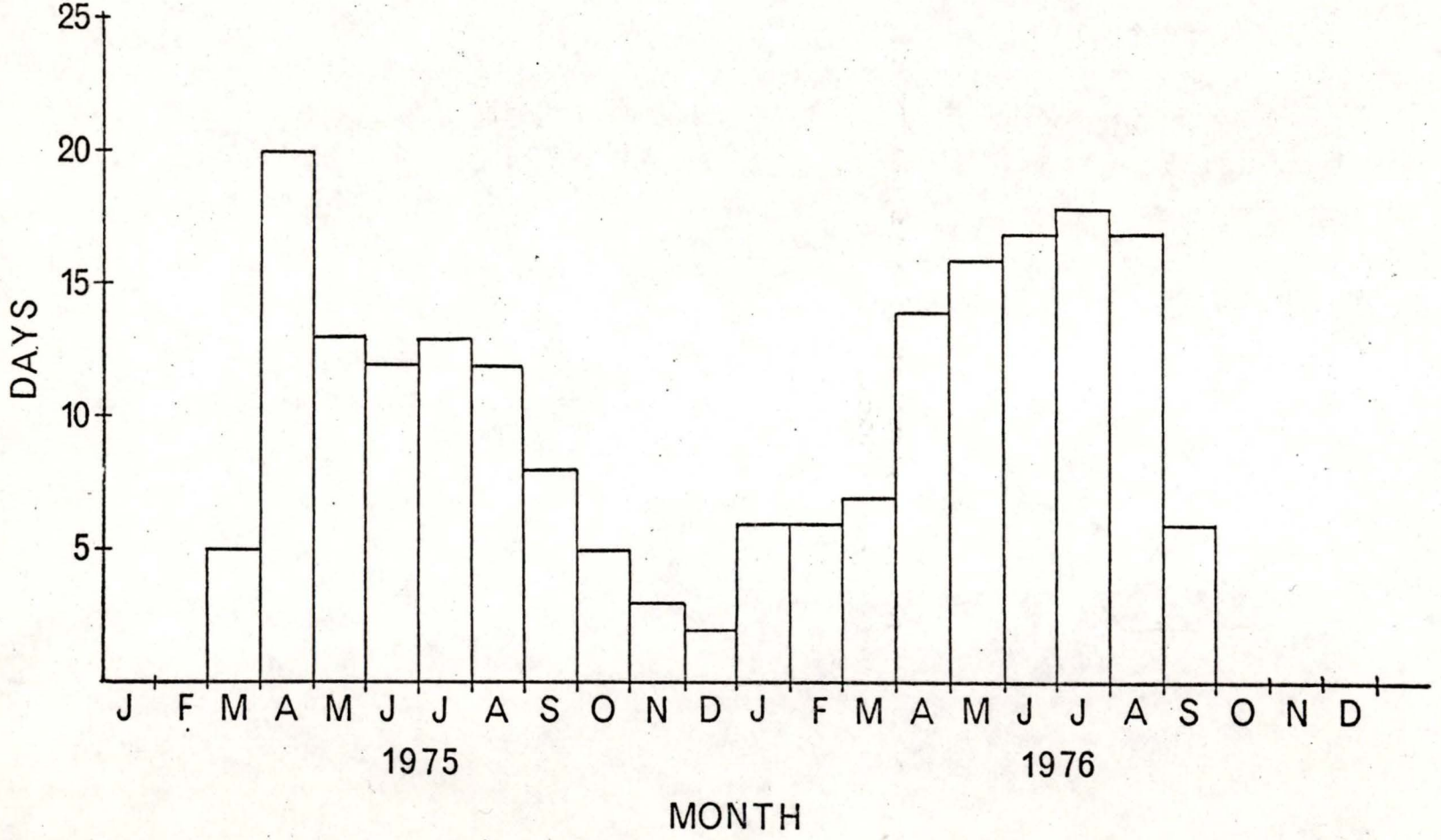
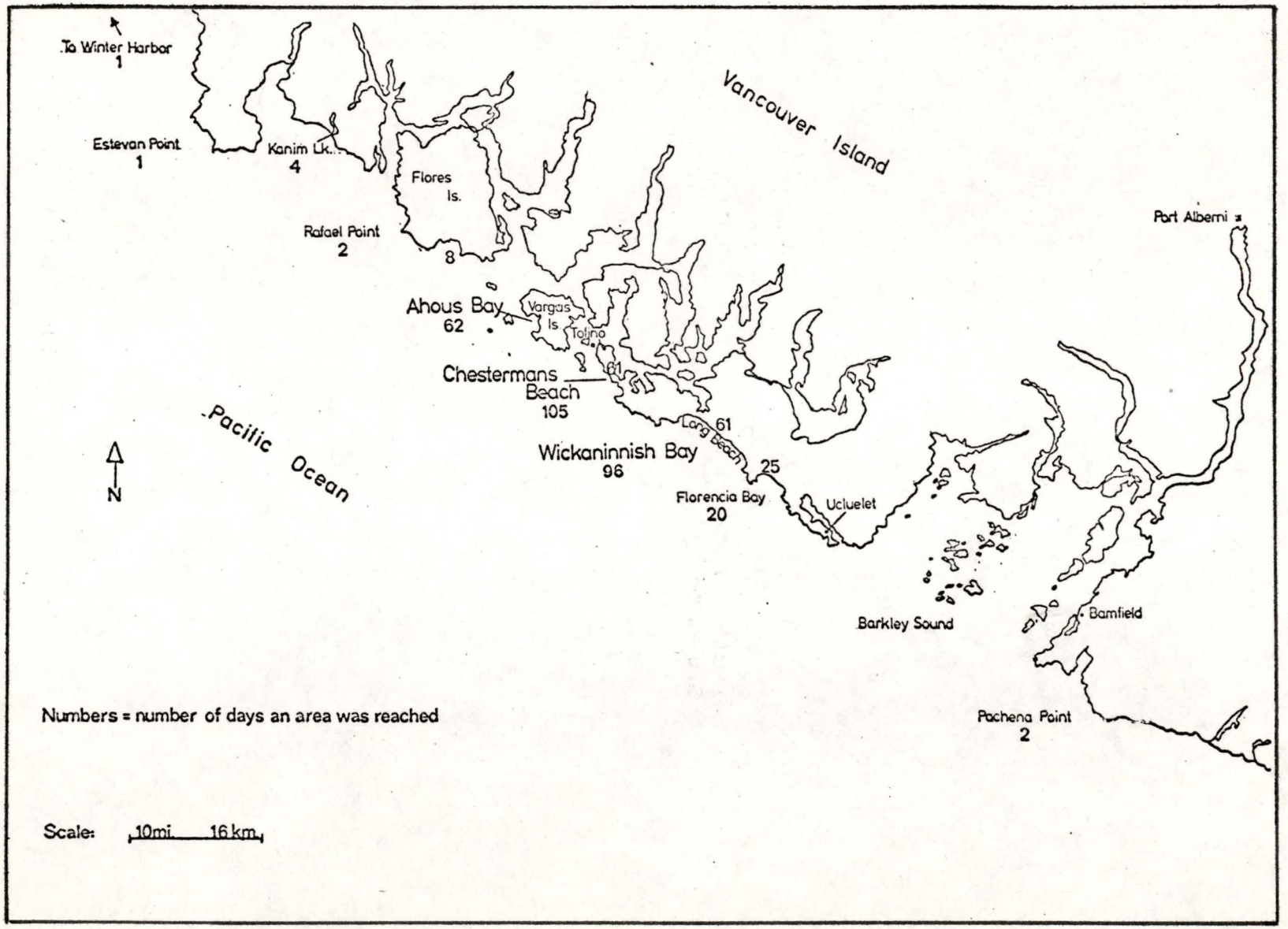

25
20
15
10
5
DAYS
J F M A M J J A S O N D J F M A M J J A S O N D
1975
1976
MONTH

Table 2. Study effort from March 27, 1975 to September 19, 1976.

	Number of Days		
	1975	1976	Total
Whales sought:	93	107	200
From: shore	28	33	61
boat	63	74	137
plane	0	18	18
Whales photographed:	53	54	107
Whales measured:	0	5	5
Area covered:			
From shore at Chestermans Beach	28	33	61
Wickaninnish Bay	28	33	61
Wreck Bay	11	14	25
From boat or plane,			
Tofino to Chestermans Beach	46	59	105
to Wickaninnish Bay	40	46	96
to Wreck Bay	7	13	20
to Pachena Point	1	1	2
to Ahous Bay	20	42	62
to Flores Island	3	5	8
to Rafael Point	0	2	2
to Kanim Lake Area	0	4	4
to Estevan Point	0	1	1
to Winter Harbor	0	1	1

Fig. 8 Study effort; number of days an area was reached between March 27, 1975 and September 19, 1976.


To Winter Harbor
1
Estevan Point
1
Kanim Lk.
4
Flores
Is.
Rafael Point
2
8
Vancouver Island
Port Alberni
Ahous Bay
62
Vargas
Is
Tofino
Chestermans
Beach
105
61
Long Beach
61
Wickaninnish Bay
96
25
Florencia Bay
20
Ucluelet
Pacific Ocean
N
Barkley Sound
Bamfield
Pachena Point
2
Numbers = number of days an area was reached
Scale: 10mi 16 km

The major effort was directed between Wickaninnish Bay and Ahous Bay.

In addition to personal observations, lightstation personnel helped in the sighting effort from November to May 1975-76; consistency and efficiency of effort was not evaluated.

Throughout the study period numerous friends, residents and fishermen, familiar with gray whales also provided sightings and observations.

RESULTS AND DISCUSSION

A. General Timing of Migrations and Intervals Between Migrations

The majority of the eastern Pacific herd migrates northward along the North American coastline in the spring and southward in the winter (Rice and Wolman, 1971). Both south and northbound whales pass along the Vancouver Island coast (Pike, 1962; Pike and MacAskie, 1969; Hatler and Darling, 1974). The northern migration past the island begins in late February, peaks during the first two weeks of April and continues until late May or early June. Hatler and Darling (1974) report sightings of southbound migrants in late November, December and early January; Pike (1962) and Pike and MacAskie (1969) suggest the southern passage may begin as early as October or in late September.

For the purposes of this study the migrations past Vancouver Island were observed mainly to determine when they were not occurring. Being primarily interested in gray whales which summer along the Vancouver Island coast it was essential to determine the interval between northbound and southbound movements. Differentiating between migrating and summering animals was important and to this end the northern migration, particularly the latter half, was observed intensively. Of lesser interest was the winter interval, between the last southbound and first northbound animals.

In order to establish migratory times past the island all reporting light stations were treated as one, that is "the west coast of Vancouver Island". Total migratory sightings,

Fig. 9 Northerly migrating gray whale passing Lennard Island lightstation, April 12, 1976 (photograph is of the underside of the tail fluke).

for each two-week period, November 15 to May 1, from the three winters (1972-73, 1973-74, 1975-76) were averaged. This gives the average number of animals seen in each two week period through the winter and an estimate of migratory duration and peak times past the island (Table 3)[1]. The resulting graph (Figure 10A) amplifies Pike's (1962) Pike and MacAskie's (1969) and Hatler and Darling's (1974) earlier information. The first northbound whales pass Vancouver Island after mid-February, peak in numbers the first two weeks in April, then decline. Lightstation sightings were not reported after April, however there were still some whales moving north through May and early June as will be shown below. Southbound migrants pass Vancouver Island from late November to the middle of January with a peak the last two weeks in December. In the period from mid-January to mid-February sightings were rare although whales have been seen during this interval and this is also discussed below. Fewer whales were sighted during the southward migration than during the northward migration and the difference may be due to inclement weather or to movements further offshore (Pike, 1962; Hatler and Darling, 1974; Gilmore, 1960b).

Intensive observations of the northern migration in the study area began in March of both 1975 and 1976, and sightings were recorded from late February 1976 by B. Campbell (pers. comm., 1976). To further delineate the spring migratory

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[1]Due to variations in weather, sighting effort, and efficiency detailed statistical analysis of this information is not warranted. However, the information does provide a reasonable index of the temporal pattern and relative magnitude of the migratory movements.

Table 3. Lightstation reports of whales migrating past the west coast of Vancouver Island.

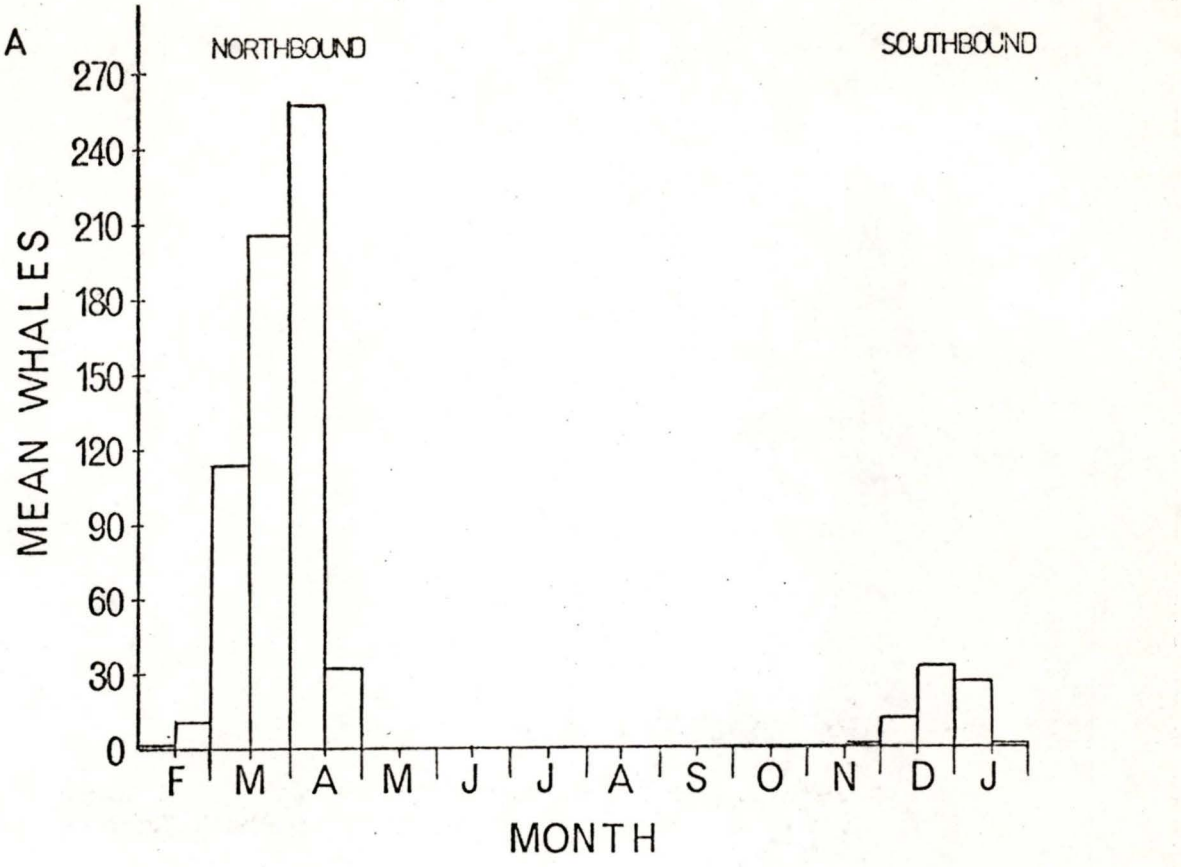
	Date	Number of whales sighted 1972-73	1973-74	1975-76	Total	Average (rounded to nearest one)
Southbound	November 1-15	0	-	0	0	0
	16-30	1	3	0	4	1 (1.3)
	December 1-15	30	3	4	37	12 (12.3)
	16-31	8	22	36	66	33
	January 1-15	18	30	30	78	26
	16-31	0	2	-	2	1 (.66)
	February 1-15	0	-	5	5	2 (1.66)
Northbound	16-28	13	1	22	36	12
	March 1-15	86	28	230	344	114 (113.6)
	16-31	183	162	271	616	205 (205.3)
	April 1-15	364	100	311	775	258
	16-30	55	35	11	101	33

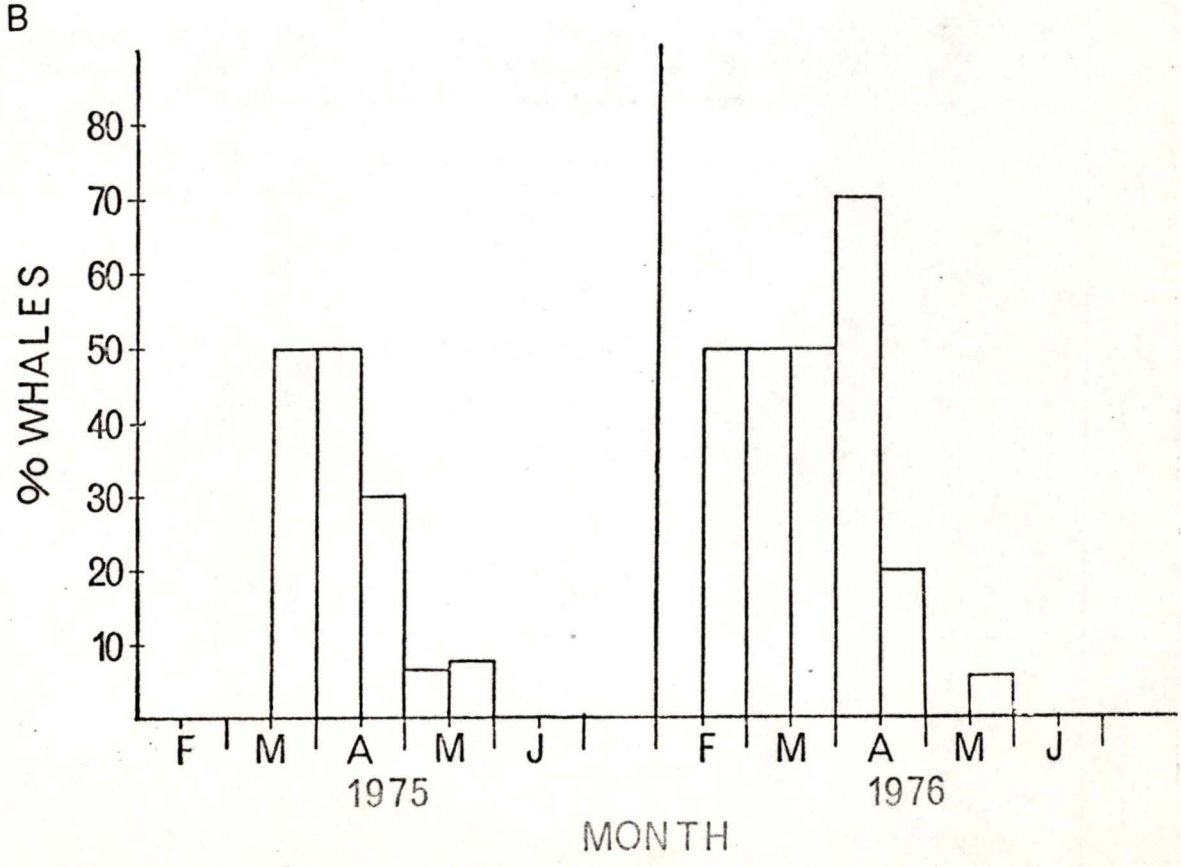
Lightstations reporting were Sheringham Point, Carmanah Point, Pachena Point, Cape Beale, Amphitrite Point, Lennard Point, Estevan Point, Nootka, Kains Island and Cape Scott. Dash marks indicate no reports.

Fig. 10 Migratory sightings.

A. Lightstation sightings of migratory whales (from 9 west coast Vancouver Island lightstations).

B. The percentage of the total number of whales observed in the study area (two week periods) which were obviously migrating northward.


A
NORTHBOUND
SOUTHBOUND
MEAN WHALES
270
240
210
180
150
120
90
60
30
0
F M A M J J A S O N D J
MONTH


B
% WHALES
80
70
60
50
40
30
20
10
F M A M J F M A M J
1975
1976
MONTH

period records were kept of the total numbers of whales seen during each observation period as well as the numbers of those obviously moving north (Table 4). During this period whales may be steadily moving north, slowly and sporadically moving north or lingering in the area. The number of whales obviously moving north compared to the total number sighted, over each two-week period during the migration is shown in Figure 10b.[2]

Absolute counts have little significance due to varying observation times and sighting conditions. Through late March and the first half of April, 1975 approximately 50% of the whales seen were moving and half appeared to be stationary. In late February and through March, 1976 the same was true. During the first two weeks of April, 1976 the majority (70%) of whales sighted were cruising north, and in the last two weeks of April in both years the majority, 70% in 1975 and 80% in 1976, appeared to be remaining in the area. In May of both years most whales sighted (90-94%) appeared stationary; a few were still obviously migrating. A cow and calf appeared in Wickaninnish Bay June 2, 1976 and remained until June 5, 1976. When observed they were not travelling but feeding; they were gone on June 6 and probably moved northward. This was the latest record of a probable migrant. Most of the whales recorded as

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[2]This comparison does not indicate the actual number of migrants compared to number of stationary animals. The stationary whales may remain in the area for hours or longer while a steady stream of migrants pass. The comparison only indicates the relative likelihood of seeing migrant or stationary animals during any observation period.

Table 4. Proportion of obviously migrating whales to total number of whales sighted during two-week periods of the northern migration in 1975 and 1976.

Period	Year	Total Number	Number Obviously Migrating	Ratio (to nearest 1)
February 16-26	1975	-		
	1976	2	1	.5
March 1-15	1975	-		
	1976	40	21	.5
March 16-31	1975	48	24	.5
	1976	26	14	.5
April 1-15	1975	197	97	.5
	1976	174	120	.7
April 16-30	1975	138	45	.3
	1976	26	5	.2
May 1-15	1975	46	3	.1 (.07)
	1976	59	0	0.
May 15-31	1975	46	4	.1 (.08)
	1976	54	3	.1 (.06)

'not migrating' were feeding. Many of those seen in March and April did move on before May or June.

Intensive observation of the study area during the southward migration was not undertaken so that further refinement of migratory times determined by lighthouse reports is not possible. Migrant animals have been recorded from Wickaninnish Bay in December and January as would be expected by lightstation data: 6 on January 9 and 'several' on January 10, 1972 (Hatler and Darling, 1974); 5 on December 17, 1975 and 4-8 on January 5, 1976 (B. McIntyre and B. Campbell, pers. comm., 1976). Hatler and Darling (1974) report apparent feeding whales in Wickaninnish Bay in November, December, January and February of 1971-72 and 1972-73. In 1975, apparently feeding whales were seen on November 21 and December 5 and 18 but not in January or early February 1976, discussed below. Whereas during the spring migration 10 or more whales feeding in Wickaninnish Bay was common, no more than 4 have been seen during the winter at any one time. This may support Hubbs' (1959), Gilmore's (1960b), Pike's (1962) and Andrews' (1914) conclusions that southbound gray whales do not slow or stop to feed. Apparently feeding gray whales have been sighted in Wickaninnish Bay during late January and early February, in two out of three winters that regular observation has been attempted. Migratory data from lightstations, and California indicate the majority of gray whales are south of Vancouver Island during this period (Rice and Wolman, 1971). Hatler and Darling (1974) reported sightings during this period, on January 19 and February 3, 1972 and February 6

and 7, 1973 and ventured that, "since feeding animals have been observed in the months preceding this period it is tempting to speculate that some animals actually spend the winter in Wickaninnish Bay and do not make the full migration south". However, the interval is short (one month or less) between southbound and northbound migrants and it is possible that the whales sighted were successive groups of migrating animals, southbound or northbound. In late January and early February, 1976, no whales were seen in Wickaninnish Bay, in twelve days of searching and with exceptionally good weather conditions, indicating that winter presence is not necessarily a recurring feature. Possibly the last southbound animals meet the first northbound in the general area. If this occurs the laggards in the southern migration may simply turn around. Some support is provided by the following information. From lightstation and study area migratory sightings in 1972-73 and 1973-74 an interval between southbound and northbound whales is apparent from roughly mid-January to mid-February. The last southbound animals were seen on January 9 and 10, 1973 in Wickaninnish Bay and January 12, 1974 from Kains Island Light and the first northbound from Cape Beale Light on February 20, 1973 and February 27, 1974. However, in 1974 two gray whales were sighted from Kains Island on January 24 moving in no apparent direction. Since whales are not generally seen summering near Kains Island these were probably migrants. During the winter 1971-72 and 1972-73 (no observation in 1973-74) whales were observed in Wickaninnish Bay feeding (Hatler and Darling, 1974). Both these and the January 24, 1974

Kains Island sighting suggest that some whales are not moving south of Vancouver Island during the winter. Whether these are animals which summer in the area or are from further north and do not complete the southward migration is not known.

Lightstation data together with observation from the study area give a good idea of the timing and duration of the northern migration and a somewhat roughter approximation of the southern migration. In summary, the northward migration begins in mid-February, peaks in early April and is over by mid-June. Animals present in the study area between late June and October are probably summer residents. The southward migration begins in November and lasts until mid-January. In some winters a few animals may be present during the short interval between south and northward migrations. These migratory times and peaks correlate well with migratory times and peaks documented from 1,200 miles farther south along the southern California coastline. Leatherwoods' (1974) data, which agrees with Hubbs (1959), Gilmore (1960b) and Rice and Wolman (1971) shows the earliest animals moving south in the third week of December and the latest moving north during May.[3] The largest numbers of whales seen were during the first two weeks of January, southbound, and the last two weeks of March, northbound. The migratory peak past the southern California coastline is respectively, two weeks after that on Vancouver Island on the southern migration and two weeks before during the northern migration.

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[3]Apparent migrant gray whales were seen off Los Angeles southbound as early as November 10, 1975 and northbound as late as June 5, 1976 (D. McIntyre, pers. comm., 1977).

B. Behaviours During the Northern Migration Along Vancouver Island

1) Route

Northbound gray whales leave the Washington coast at Cape Flattery and cross the Straits of Juan de Fuca in a generally norhterly direction before changing course to follow the west coast of Vancouver Island (Pike, 1962). Lighthouse personnel from Carmanah Point, Pachena Point, Cape Beale, Amphitrite Point, Lennard Island, Estevan Point, Nootka, Kains Island and Cape Scott have all seen whales from their stations enroute along the island's coast (Fig. 2). Intensive observation of this migration was only carried out in the study area, Wreck Bay to Ahous Bay, however, the route along the island's coast described by Pike (1962) with several new observations is summarized below (Fig. 11 inset).

Hatler and Darling (1974) have pointed out the relative lack of migratory sightings at Carmanah Point compared to Pachena Point, 18 mi. (29 km.) north, in 1972-73 lightstation reports, and that no sightings at all were reported from Sheringham Point (the next lightstation down the Straits from Carmanah, 42 mi. (67.6 km.) distant. They concluded that most of the whales arrive at the Vancouver Island coast between Pachena and Carmanah Point. Lightstation reports from 1973-74 and 1975-76 support this conclusion. Although no sighting reports were received from Pachena Point for these years, Cape Beale, 7 mi. (11.3 km.) north of Pachena, reports significantly more sightings than Carmanah, 152 compared to 5 in March, 1974; 107 compared to 24 in April, 1974 and 114 compared to 6 in April, 1976. Sheringham

Point has reported no sightings to date. However, four different sightings of gray whales have been made at Jordan River, 7 mi. (11.3 km.) north of Sheringham Point, in the springs of 1975 and 1976. These sightings were made by two surfers, both familiar with gray whales. Directly off Jordan River, two gray whales were seen on April 19, 1975 (D. Palfrey, pers. comm., 1975), one on March 29, 1976 (D. Gamble, pers. comm., 1976) and three on April 11, 1976 (D. Palfrey, pers. comm., 1976). One young female gray was found dead on the beach about half a mile north of Jordan River by Palfrey on April 25, 1976. This whale may have died further northwest and drifted down the straits. Apparently a few gray whales swerve southeast after leaving Cape Flattery and are seen along the Vancouver Island shores south of Carmanah and the entrance to the straits. Whether or not these animals eventually reverse direction and head northwest up the coast is unknown. Carl (1967) reports one whale apparently summering in the Victoria area, at the southeast tip of Vancouver Island in 1967. One gray whale was sighted in Burrard Inlet (Vancouver, B.C. harbour) on March 22, 1970 (pers. comm., Robin Best) indicating that occasionally they move around to the east side of Vancouver Island.

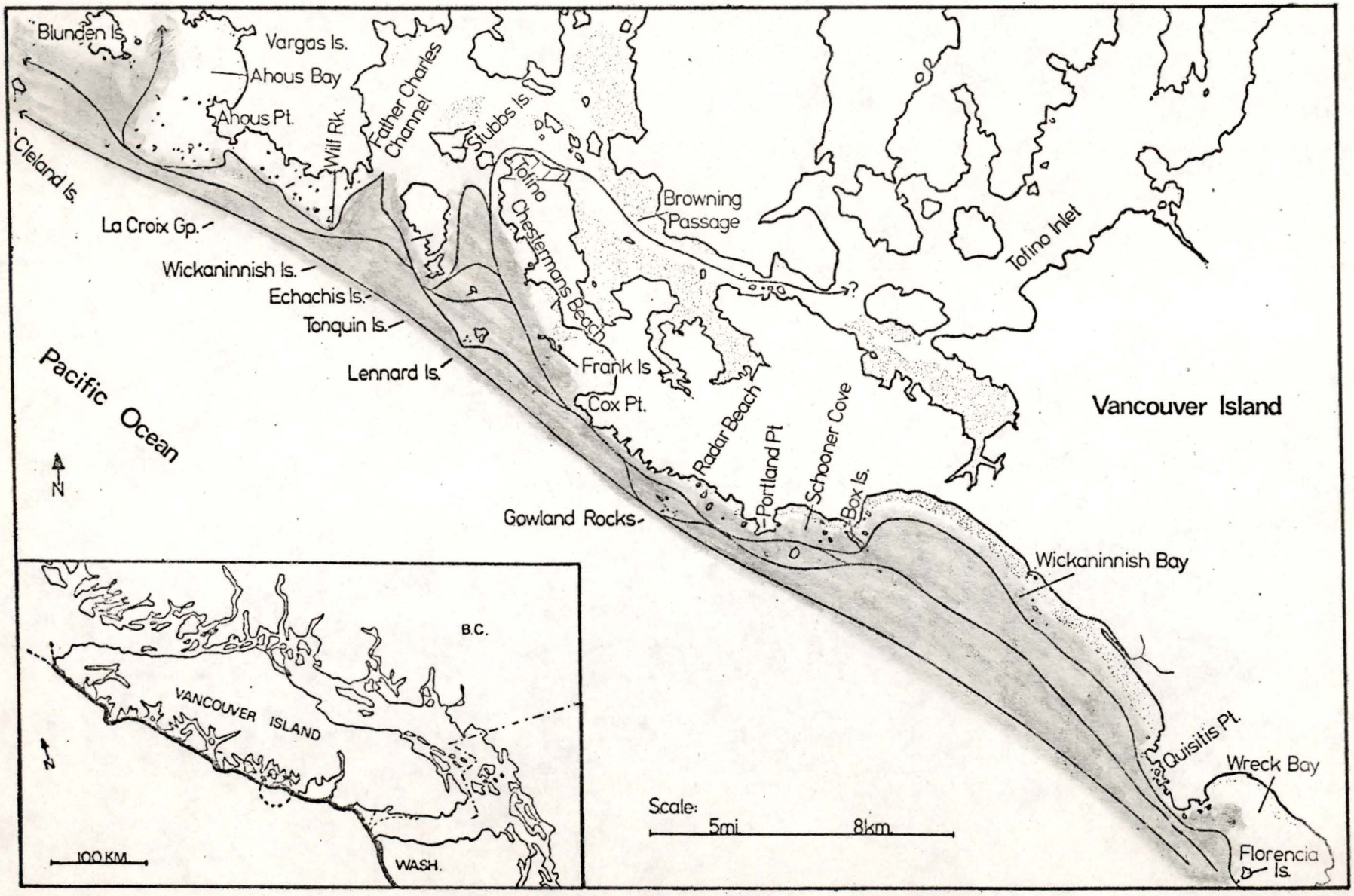
Pike (1962) has described the whales' route up the coast of the island in some detail. Basically, they follow the coastline, until they reach the mouthes of bays or sounds when they either cut straight across to the next headland or may swerve in slightly before resuming a northerly

heading. Pike (1962) reports that once they pass Cape Beale and reach the entrance to Barkley Sound they may enter the sound for a short distance or proceed directly across the 15 miles (24 km.) towards Amphitrite Point. Pat Thompson (pers. comm., 1976), Cape Beale resident, writes that most of the whales heading into Barkley Sound swim towards Folger Island, a few go toward Amphitrite Light. Miriam Haylock (pers. comm., 1975) of Bamfield Marine Station reports some whales rounding Cape Beale and following the southeast shore of the sound inland 6-7 mi. (9.7-11.3 km.) as far as Dixon Island. Dr. J. McInerney (pers. comm., 1976) of Bamfield Marine Station, reports two inside Bamfield Harbour (for a few minutes) on April 11, 1976. Once across Barkley Sound, most pass shoreward of a buoy which lies about one mile off Amphitrite Point Light (Pike, 1962), then continue up the rocky coastline about six miles to Wya Point, Wreck Bay and the area of this study.

Wreck Bay - Ahous Bay

The migration route through the study area is shown in Figure 11. Through March and April a constant stream of whales pass through this area; singly or in groups of two or three with the occasional group as large as 4-6. In Pike's (1962) description of the migration past Long Beach he states that no gray whales are seen more than 2 mi. (3.2 km.) offshore, although activity and ship traffic are fairly heavy during the migratory period. Certainly all gray whales sighted through this study were less than 2 mi. (3.2 km.) off any headland, most less than

Fig. 11 The migratory route through the study area - northbound whales (inset of route past Vancouver Island).


Blunden Is.
Vargas Is.
Ahous Bay
Ahous Pt.
Wilf Rk.
Father Charles Channel
Stubbs Is.
Tofino
Chestermans Beach
Browning Passage
Tofino Inlet
Cleland Is.
La Croix Gp.
Wickaninnish Is.
Echachis Is.
Tonquin Is.
Lennard Is.
Pacific Ocean
Frank Is
Cox Pt.
Radar Beach
Portland Pt
Schooner Cove
Box Is.
Vancouver Island
Gowland Rocks
Wickaninnish Bay
Quisitis Pt.
Wreck Bay
Florencia Is.
N
Scale:
5mi
8km
B.C.
VANCOUVER ISLAND
100 KM
WASH.

one mile (1.6 km.) and often within 100 ft. (30 m.) off points. However, whales were not looked for farther than the horizon from any observation point. Rice and Wolman (1971) found that the majority of gray whales migrate within a few kilometers of shore when passing points, headlands, and sectors of coastline where the continental shelf is narrow and there are no off-lying islands, but they are known to pass as much as 200 km. off the California coast through the Channel Islands. Manzer (1954) observed gray whales moving northward in March and April, 1952 off northern California and Oregon, and none were sighted more than 10 mi. from the nearest point of land, although distances of up to 100 miles off shore were searched. Wilke and Fiscus (1961) report 200 gray whales 5-15 miles off the Washington coast in April, 1959. On April 17, 1975, when returning to Tofino from Wickaninnish Bay, a course about 2 mi. (3.2 km.) offshore was followed and no gray whales were seen. On the trip to Wickaninnish Bay several hours earlier travelling with 1/2 mile (.8 km.) from shore 20 whales were sighted, 8 moving northwest. Whales moved northward literally touching the coast at some points. Often they cut between the reef just off Box Island and Box Is. (Fig. 11), so closely that on April 2, 1976, whale blows disturbed oyster catchers resting on the rocks just above the water.

Most gray whales move just outside Florencia Island in a line parallel to the Quisitis Point coastline (Fig. 11). Occasionally some are seen inside Florencia Bay, as on April 19, 1975, apparently feeding. Once off Quisitis Point whales either continue on a straight line course towards the

next headland, the larger island off Schooner Cove, at about the 7-10 fathom line off Long Beach, or may swerve into Wickaninnish Bay to varying degrees. They may slightly alter the straight line heading to swing into the curve of the bay, or may follow the surfline around the bay's perimeter. Whales entering Wickaninnish Bay may cruise straight through, meander their way through or linger for varying periods of time, feeding. At the northwest end of Wickaninnish Bay those still travelling will wrap around Box Island, often between the reef and the island's point, then go either inside or outside the large island in Schooner Cove, moving towards Portland Point. They then continue just outside or in amongst the series of rocks leading to Gowland Rocks which may be passed seaward or shoreward, and continue along the same line until reaching Cox Point. Here whales will either angle out towards the outside of Lennard Island, or move in between this island and Chestermans Beach, and appear to be heading towards the gap between Wickaninnish and Stubb Islands, or Duffin Passage (Tofino harbour entrance). All observed whales have changed course before reaching either of these channels and moved outside between Lennard and Tonquin or Tonquin and Echachis Island, ending up on the same course as those animals which went outside Lennard Island. Whales have not been sighted in the channel between Wickaninnish and Stubbs Island which is relatively shallow (2-2½ fathoms), but some have apparently gone through into Tofino harbor as is discussed below. Continuing northward, whales pass the

outside of Echachis Island (once a Nootka whaling camp) very close to the rocks then in a northwest line past Wickaninnish Island to the entrance of Father Charles Channel. Again, whales which are travelling outside maintain a straight and constant northwest course; those which are closer to shore may cross the channel and run into the reefs off the south corner of Vargas Island. Some may initially turn north up Father Charles Channel, then reverse direction; others move into the shoal areas, hesitate, perhaps circle for a moment, then move seaward and turn northwest within a few meters of Wilf Rock. They then move just along the outside of the Vargas reefs (La Croix group), swinging inward where there are gaps, then if they run into shallows, will hesitate and turn outwards again. When the southeastern entrance to Ahous Bay is reached some might initially head for that channel, but eventually reverse course and turning northwest again around the most outer reef off Ahous Point. The outside of these reefs are then followed towards the gap between Blunden and Cleland Islands. Some may enter Ahous Bay from its south entrance, then pass between Blunden and Vargas into Brabant Channel. One obvious note is that some whales stay outside of all the rocks and shoals, moving straight northwest, others wind their way in and out.

Several sightings further north indicate the whales follow the same type of route. From Vargas Island some turn into Brabant Channel and cross over to Flores Island inside of the islands at the entrance to that channel. Four or five

were seen following this course on April 20, 1975 (P. Hood, pers. comm., 1975) and one on April 9, 1976 (H. Henderson, pers. comm., 1976). A. Oliver (pers. comm., 1975), reports about eight congregated on the southeast corner of Flores Island on April 20, 1975 and 4-5 south off Estevan on the same day. Estevan Point Light reports whales passing just outside the reefs off that point, Oliver saw one inside Friendly Cove Harbor (Nootka) on April 6, 1975 and Pike (1962) describes them rounding Cape Cook, Brooks Peninsula inside Solander Island and then crossing the entrance of Quatsino Sound. The whales leave Vancouver Island at Cape Scott and are next sighted along the Queen Charlotte Islands (Pike, 1962; Pike and MacAskie, 1969; Hatler and Darling, 1974). G. Trentholm (pers. comm., 1976), crab fisherman and pilot, regularly flies portions of the island's west coast and on April 11, 1976 observed, "you can fly from one end of Vancouver Island to the other and see whales every few minutes, except for south of Pachena Point, where numbers tend to peter out."

Inlets

On April 8, 1975, a gray whale, first sighted in Browning Passage (up inlet from Tofino) was subsequently followed southeast through Tsapee Narrows and further to Auseth Point, Meares Island, where it was lost (Fig. 11). In order to reach the area where first sighted, it must have moved through Tofino Harbor. Other sightings of gray whales in Tofino harbor during the migratory period are: two on April 9, 1976 (G. Trentholm, pers. comm., 1976) and one on

April 11, 1976 (K. Budd, pers. comm., 1976), both from Trentholm's Wharf in Tofino, and one on April 10, 1976, off Opitsit, a village across the bay from Tofino (L. Gibson, pers. comm., 1976). (Another inlet sighting was made by A. Oliver on May 8, 1975, of a whale which appeared to be turning into Stewardson Inlet from Sydney Inlet north of Flores Island.) It is not known if these whales are in the inlets deliberately or if they took a wrong turn somewhere. Other summer sightings of gray whales in the inlets behind Tofino exist and these will be discussed later in this paper.

2) Orientation

Gilmore (1960a) and Norris and Prescott (1961) suggested gray whales orientate by sighting coastal landmarks, both above and below the water and by following depth contours along the coastline. Pike (1962) agrees that visual contact might aid the animals in direction finding. Whales regularly spying, i.e. lifting their heads out of the water, then re-orientating course-wise as Gilmore (1960a) described, were not seen during this study. However, breaching whales were a fairly common sight during the migration. On one occasion a whale breached 4 times just before a decision had to be made on which side of a reef to go around off Vargas Island (April 20, 1976).

Several observations made in the study area indicate that depth is an important guide. As discussed above, migratory animals reaching the channel between Wickaninnish and Stubbs Island, turned, retraced part of their route and moved outside

into deeper water (Fig. 11). The same was observed of whales off Vargas Island reaching the southeast entrance of Ahous Bay where depth changes from 7 fathoms to between 2 and 3 (Fig. 11). On two occasions, whales which were migrating inside Gowland Rocks towards Cox Point were observed making an obvious change of course from Gowland Rocks side of the channel to the shoreline side of the channel on a diagonal in apparent agreement with an abrupt depth change from 3½ to 6-8 fathoms (Fig. 11). This was so noticeable it was recorded immediately (April 21, 1975; May 26, 1975). In two instances the change led the animal into deeper water and in one instance into shallower water. In agreement with Gilmore (1960a) and Norris and Prescott (1961) depth contours may be an important guide with any change in depth rather than absolute depth being the key factor.

The animals closely follow the coastline, some further offshore in straight unbroken headings, some inshore almost rebounding off rocks and underwater shoals. It seems reasonable that whales would use sight, sound, and depth clues to follow the coast and some may be more experienced at it than others. Certainly the crossing of wide channels, the entrances to sounds, or straits create some confusion for at least some of the whales (i.e. Juan de Fuca Straits and Barkley Sound). If the sightings off Jordan River, Victoria, Vancouver and in the inlets behind Tofino are of whales which have reached these points unintentionally then some piloting errors may be made.

3) Feeding

Observations of gray whales feeding off the California coast during the migrations are rare. Rice and Wolman (1971) report that the stomachs of all 180 southbound migrants and those of 134 of 136 northbound migrants, sampled off that coast, contained no traces of food. Hubbs (1959) suggests that whales may feed at times on the northern migration but Gilmore (1960a, 1969) and Pike (1962) agree that the grays do very little feeding on the southern run. During the northern migration in 1958, Pike (1962), and in 1960, Pike and MacAskie (1969) describe gray whales feeding off Long Beach. Pike (1962) examined the stomachs of ten gray whales taken off Vancouver Island in April, 1958 and although he found them empty there were intestinal contents and concluded that they had probably done some feeding. Wilke and Fiscus (1961) report that some whales were 'feeding' as well as 'resting' and 'playing' while migrating north off the Washington coast. Hatler and Darling (1974) include an observation by H.D. Fisher of three grays at Rose Spit, Queen Charlotte Islands on April 11, 1973 causing 'upwellings of sand and mud from the bottom', perhaps feeding. In describing the migrations of the western Pacific herd of gray whales, Andrews (1914) states that although the greater proportion of the herd goes straight northward, some are reported feeding in Broughton Bay, Korea in April and May and have apparently broken the migration by a sojourn in the Bay.

Certainly by the time northbound whales reach Vancouver

Island many are feeding. An average day in April might have 8-15 whales feeding in Wickaninnish Bay, as well as a steady stream moving north across the mouth of the bay. As Andrews (1914) describes on the Korean coast and Pike and MacAskie (1969) for the Vancouver Island coast, some whales do take time out from the migration to feed.

Feeding behaviour was observed as follows: The whale blew 2-5 times, remaining almost stationary, moving in a semi-circle, or moving very slowly in one direction then arched its back and dove. Rarely were tail flukes seen off Long Beach where the water is relatively shallow (5-15 m.); however in deeper bays flukes sometimes showed above the water. After 2-5 minutes the whale surfaced again close to the same location, and on the first blow sand could be seen streaming from either side of its mouth, apparently forced through its baleen. It seems reasonable that the repetive sequence of surfacing, diving and forcing sand through the sides of the mouth is feeding. The release of sand was obvious when observing close by in a boat or from a plane, for example on March 15, 1976 a whale near Incinerator Point was observed from a plane leaving streams of sand behind it on surfacing; on April 21, 1975 a group of five whales were moving sporadically in a northwesterly direction through Wickaninnish Bay and on some surfacings sand was released from the mouths of some of the whales. It is the rule rather than the exception to look out into Wickaninnish Bay and see gray whales apparently feeding anytime in March or April.

Identification photographs of whales feeding in Wickaninnish Bay during the migratory period have been taken and many of these were not seen again through the summer months, suggesting only a feeding break in migration. On May 19, 1976 and June 2-5, 1976 cows with calves were observed feeding off Long Beach. They apparently moved north as they were not seen again for the remainder of the summer. No precise data on how long northbound whales might stay in the area feeding before continuing their migration is available but it probably varies from just taking an occasional mouthful as they move through (as on April 21, 1975 above) to as long as the 4 days spent by the cow and calf, on June 2-5, 1976. There is a possibility that some northward migrating whales remain for several weeks in the study area and this is discussed later in this paper.

Hatler and Darling's (1974) suggestion that some or all migratory whales feed in suitable habitats along the migration route is upheld, at least for the northern migration. How important the food available in Wickaninnish Bay and adjacent areas is to migratory whales is unknown.

4) Sexual Behaviours

On April 10, 1975 a group of what initially appeared to be two but turned out to be three whales was observed near Sea Lion Rocks, Wickaninnish Bay orientated belly to belly, with half the tail fluke and one pectoral fin out of the water, rolling on the longitudinal axis with splashes and turbulence caused by movement of the flukes (Fig. 12A).

Observation was continued from several meters distant. The whales were involved in various contortions all seemingly related to contact between their genital areas. Often two would be orientated belly to belly and the third, its belly to one of the others' backs or two would be in contact on the surface, and the other below or a few feet away changing orientations. Postures included; two whales rising out of the water, 2 meters into the air, head first, throat to throat, belly to belly, then falling over on their side; one whale thrusting its head out of the water, often against a whale lying horizontally on the surface (Fig. 12F); the twisting of whales on their sides with parts of the flukes and pectoral fins out of the water (Fig. 12D); the rolling of one whale over the back or head of another (Fig. 12C); occasionally a rather vigorous shaking of whatever parts of the flukes or pectoral fins that were above the surface when all three whales were in close horizontal contact (Fig. 12B & E). Several times a whale would roll, belly up and a large flesh-colored penis, (1-1.5 m.) in length, perhaps 25-35 cm. across the base and narrowing to a slim point, erected in an arch, would show. At one point two whales rolled simultaneously both showing penes. These two lay side by side, belly up, with one's penis on the other's underside (Fig. 13A). Then they intertwined penes for several minutes (Fig. 13B). The third whale at this time was underneath these two or close by. Following several more minutes of similar activity all three whales rolled belly up simultaneously and all with semi-erect penes. All three were males.

Fig. 12 Sexual behaviours observed during the northern migration.

A. Whale on its side, with a pectoral fin and half of its fluke showing.

B. Three whales on their sides; pectoral fins and half flukes showing.

C. Two heads; the whale on the left is rolling over the other.

D. Two or three whales; the underside of half the fluke and pectoral fins showing.

E. Two whales on their sides, belly to belly; moving their flukes back and forth.

F. A whale's head rising from the water; resting on another whale lying horizontally.

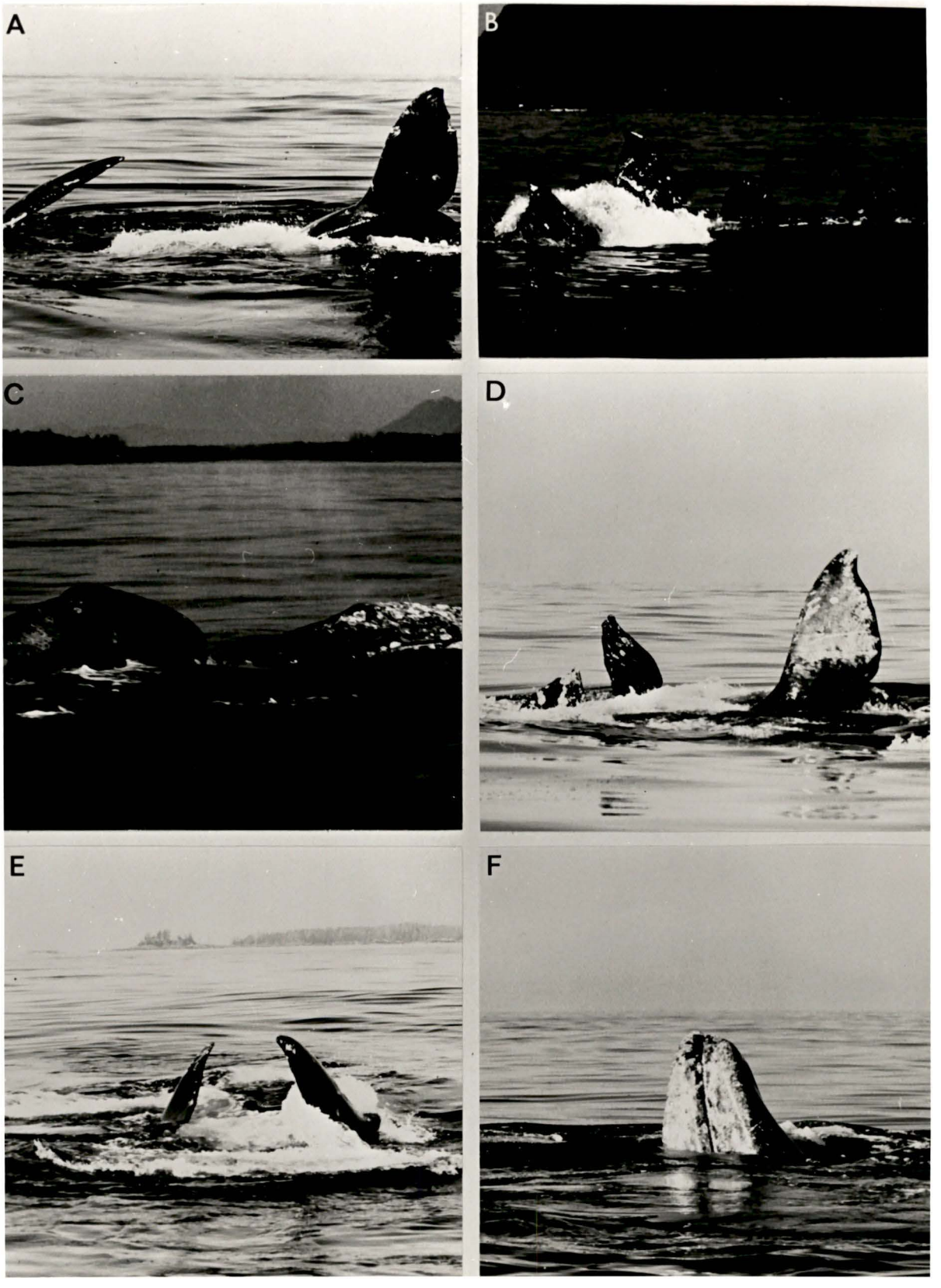
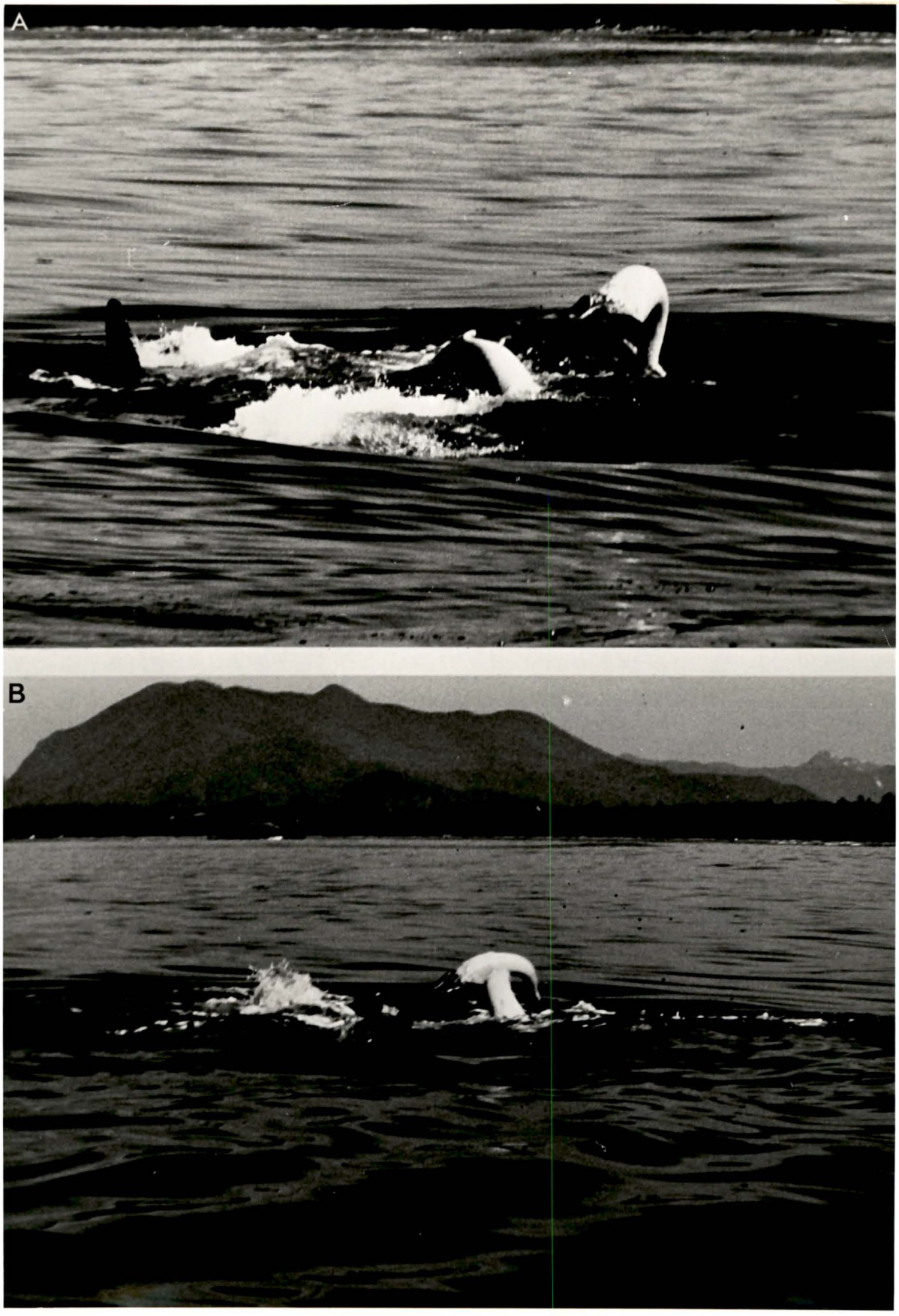

A
B
C
D
E
F

Fig. 13 Sexual behaviours observed during the northern migration.

A. Two whales with erected penes; one penis lying on the other whale's belly.

B. Intertwined penes.


A
B

These whales were observed from 9 a.m. to 10:40 a.m., the activity was continuous and mostly on the surface. The whales blew and moved more or less simultaneously but remained down no more than 45 seconds to 1 minute. Observation was from no further than 50 feet away and twice the action moved to underneath the boat, where the whales with erections could be seen approximately 15 feet below. After 1 hour and 40 minutes the whales stopped this behaviour, which was in progress before I arrived, and moved out and to the north-west. I followed to the outside of the bay then lost them. Either they moved off below the surface, or dispersed amongst the other whales in the bay. At the time this behaviour was observed 16 other whales were in Wickaninnish Bay, either feeding or migrating through, and apparently paying no attention to these three. Table 5 summarizes sightings of animals involved in similar behaviour along the Vancouver Island coast.

There are several accounts in the literature of sexual activity observed during the northern migration and in the Arctic, and these were assumed to be bisexual. Hatler (Hatler and Darling, 1974) describes, now familiar activities he witnessed in Wickaninnish Bay on April 26, 1971.

> ..."Two gray whales were engaged in vigorous activity. At least one of the animals frequently rolled over on its back with its flippers protruding from the water. There was much rolling and sounding, the latter frequently occurring with the flukes coming high out of the water and slapping the water surface with a large splash... Then one followed the other, both close to the surface and blowing often... On several occasions the males' conspicuously pink, erect penis showed clearly as the animal

Table 5. Apparent sexual activity off Vancouver Island during the northern migration in 1975 and 1976.

Date	Location	No. of Whales	Behaviour
Apr. 9/75 (a.m.)	Cox Point	2 (?)	Two whales were on their sides orientated belly to belly, each with one pectoral fin and half its tail fluke in the air; lots of splashing. After 10 mins. of observation they seemed to move off in a NW direction.
Apr. 9/75 (p.m.)	Wickaninnish Bay	2 (?)	Two whales rolling over each other; one or both on their sides with the pectoral fin and half the flukes out of the water. Observation was for about 1 hour from shore. The whales remained in the same general location during that time.
Apr. 10/75	Wickaninnish Bay	3	Three whales involved in vigorous activity including belly on belly and belly to back orientations, rolling over each other, pectoral fins and tail flukes out of the water, raising their heads out of the water, and rolling belly up showing semi-erect penes. All three whales rolled simultaneously, all showed penes and obviously were all males. Observation was from 9 a.m. to 10:40 a.m. at which time these behaviours stopped.
Apr. 18/75	Wickaninnish Bay	3	Three whales off Incinerator Point were rolling on their sides, pectoral fins and half tail flukes out of the water, orientated belly to belly, and raising their heads above the surface. Observation was from shore for about 30 mins.
Apr. 20/75 (10:30 a.m.)	Wickaninnish Bay	4-5	Whales were off Box Island, splashing, rolling on the surface, flukes and flippers out of the water. Observation from the air (A. Oliver, pers. comm., 1975).

Table 5. (cont'd)

Date	Location	No. of Whales	Behaviour
Apr. 20/75 11 a.m.	south of Estevan Pt.	4-5	Same activity as immediately above. Observation from the air (A. Oliver, pers. comm., 1975).
Mar. 5/76	Lennard Is.	2-3	Two whales rolling frequently, splashing about with tails and flippers waving above the surface, belly to belly orientations and one rolled with an erected penis. Observation from lightstation from 8:30-9:00 a.m. as whales were moving northwest (M. D'Een, pers. comm., 1976).
Mar. 19/76	Wickaninnish Bay	3 (?)	Whales were blowing simultaneously rolling over each other, parts of flukes and flippers visible above the water, much splashing. Observation from Box Island for about 30 mins. as whales moved slowly northwest.
Mar. 28/76	Lennard Island	3	Similar activity as observed Mar. 5/76 from the lightstation, although not as active or excited motions (M. D'Een, pers. comm., 1976).
Mar. 29/76	Lennard Island	3	Observation from the lightstation of similar activities as in Mar. 5/76 (M. D'Een, pers. comm., 1976).
Mar. 31/76	Wickaninnish Bay	3	Three whales just off Incinerator Point showing half tail flukes and pectoral fins, rolling on their sides, belly to belly orientations and much splashing. Observation from shore for 30 mins.
Apr. 1/76	Wickaninnish Bay	3	Whales were just south of Sea Lion Rocks, splashing, rolling on their sides with pectoral fins and tail flukes out of the water and rolling over each other. Observation was from shore (Green Pt.) for 30 mins. as whales moved slowly northwest.
Apr. 1/76	Outside Wreck Bay between Florencia Is. and Quisitis Pt.	3-4	Whales were moving across the mouth of Wreck Bay, splashing with fins and flukes out of the water. After 15 mins. they moved northwest around Quisitis Pt. and out of sight.

Table 5. (cont'd)

Date	Location	No. of Whales	Behaviour
Apr. 2/76	Wickaninnish Bay	4-5	Behaviour varied in apparent excitement over the 1 hour of observation. Whales would blow then arch their backs, as if to dive, but roll onto their sides and part of the pectoral fin and fluke would show above the surface. This was accompanied by splashing and turbulence from the flailing of tail flukes. Whales would split up for a few minutes then begin again. Four whales followed each other in a single file for a few moments. Observation was from Incinerator Pt.
Apr. 12/76	Cox Point to Lennard Island	4	Whales were observed from boat for 1½ hours as they were slowly moving northwest. The group was usually in contact, on their sides with pectorals and flukes out of the water, and the flukes flailing back and forth. One of the whales slapped the surface of the water with its tail several times. One penis was seen on three different occasions as a whale rolled over. Observation from 12 noon - 1:30 p.m.
Apr. 12/76	Wickaninnish Bay	3-4	Whales splashing, with tails and fins visible above the water - moving slowly northwest past Park Naturalist Office. Observation from 8:45 to 10:00 a.m. (B. Campbell pers. comm. 1976).
Apr. 17/76	Off Radar Beaches	some	Whales were splashing, rolling over, with flukes and fins out of the water. Observation from Radar Hill (A. Dorst pers. comm., 1976).
end of Apr./76	Cape Scott	-	"Towards the end of April they tend to stay around a few days before moving on with some courting behaviour" (?) (Cape Scott Lightstation personnel, pers. comm., 1976).

> rolled over on the surface." "Once the other animal's head emerged from the water and nudged the penis." "Heads were seen frequently but always one at a time."

These whales maintained continuous activity for 1½ hours.

Rice and Wolman (1971) report apparent courtship off the coast of Washington, during the northern migration, as late as April.

Fay (1963) and Sauer (1963) describe sexual activity off St. Lawrence Island in the Bering Sea in June - August, 1969.

Sauer's (1963) descriptions include,

> "They preferred to swim in a lateral position, belly to belly and frequently showed one flipper above the water ... From time to time the female, less often the male, came to a halt; held the head high above the water and watched the partner and/or the surroundings (sex was tentatively determined by size) ... while synchronizing with the female in rolling to the side belly against belly for copulation. A very brief shaking indicated the end of the copulation..."

Houck (1962) describes what he believed to be a mating on the northern California coast on March 17, 1958. Two whales, one conspicuously smaller than the other, which he presumed to be a cow with a calf, were swimming in a northerly direction followed by another larger whale. When what he presumed to be the adult male came alongside the female the migration halted and,

> "Several times both larger whales surfaced together ... Both sexes occasionally surfaced separately, rolled over on their sides and extended one of the flippers into the air. Sometimes they made a complete revolution. On three separate 'rolls' the penis of the male was plainly visible. The penis as observed was large, light or flesh-colored and erected into approximately a half circle ... After about twenty-five minutes this 'play' ended and all three resumed their northward migration."

Houck (1962) states he was informed by R.M. Gilmore that

matings or attempted matings have been observed in the waters near Santa Barbara and Monterey while this species was enroute north.

On April 10, 1975, as discussed above, three males were involved in homosexual 'play' behaviour while enroute north. Certainly they were all males, certainly the behaviour was sexually orientated, and quite positively there were only three involved. This is the only observation of this behaviour where all the participants were positively sexed. It means that when whales are involved in obviously sexual activities, if one is a male, it does not necessarily follow that a female is present. Of course, it is not known if a female was involved in any or all of the other observations recorded in this paper. Hatler and Darling's (1974), Rice and Wolman's (1971) and Houck's (1962) descriptions of possible mating or courtship activity on the northern migration could also describe the homosexual-play behaviour. If Houck's presumption that a cow with calf was involved in his observation is correct, then both participants were sexed in his observation and the behaviour is bi-sexual. However, this behaviour seems out of character for a cow with calf. Fay's (1963) and Sauer's (1963) descriptions might also fit the homosexual behaviour. One difference between Sauer's (1963) description of copulation and Samaras's (1974) description of copulation in the calving and breeding lagoons, is that Sauer relates it as occurring with the whales on their side, belly to belly, while Samaras

shows indisputable photographs of it occurring with both animals belly up, the penis arched into the vulva. This might not be a significant difference.

Because of year to year consistency in timing of the sexually active whales off Vancouver Island during the spring migration it seems possible that all are homosexual groups of males. Rice and Wolman (1971) state that there is a partial temporal segregation of gray whales according to sex, age and reproductive status during the migration. It is possible immature males travelling more or less together could be involved in this behaviour. This would agree with Rice and Wolman's (1971) histological conclusions that reproductively functional breeding occurs before the spring migration. Bisexual play, I suppose, is just as likely, or female homosexual play.

5) Cows with Calves

Until Leatherwood's (1974) report on the gray whale migration along the southern California coast, published observations of cows with calves after leaving the calving lagoons are rare. Rice and Wolman (1971) state simply that the route taken by females with calves during the spring migration is unknown, reporting only three such groups sighted during their hunts for gray whales from 1959 to 1969, covering most of the coastline from Baja, California to Washington. These were, one pair seen March 15, 1969 near Point Reyes, California, and two pairs seen on February 10, 1968 heading northwest near San Clemente Island. Also reported is Morejohn's

(1968) observation of a cow with calf avoiding killer whales at Moss Landing, California on May 2, 1967. Rice and Wolman (1971) agreed with Hubbs' (1959) suggestion that cows with calves take a more offshore route during the northern migration. However, Leatherwood (1974) sighted 23 northward migrating groups containing cows with calves in aerial observations carried out from February, 1969 to July, 1972. The earliest sighting of cows with calves was February 18 and latest, May 18 and the majority of sightings were inshore (although he states this may reflect the heavy sighting effort inshore in 1972 during times of the northern migration). He does report the few sightings of cows with calves late in the season were more offshore.

North of California, Hatler and Darling (1974) report that one cow with a calf occupied Wickaninnish Bay, Vancouver Island for most of the summer of 1969 (W.R. Campbell, pers. comm.) and probable cow-calf pairs were seen in Wickaninnish Bay on June 29 and July 19 & 20, 1972. Pike and MacAskie (1969) report that Pike sighted 3 grays, two adults and a calf, moving northward along the east coast of Queen Charlotte Islands in March, 1963. Fay (1963) mentions seeing isolated adults with calves feeding along the St. Lawrence Island coast in the Bering Sea during the summer.

During the period of this study the cow-calf groups seen have been either obviously or apparently migrating through the area. The sightings reported in Table 6 are positive. Often

Table 6. Sighting of cows with calves in the Wickaninnish Bay area, 1975-76.

Date	Location	Group Size	Behaviour
May 1/75	Wickaninnish Bay	3	Travelling north-west
May 15/75	Wickaninnish Bay	3	Travelling north-west
May 15/75	Wickaninnish Bay	2	Travelling north-west
May 25/75	Radar Beach	3	Travelling north-west
May 19/76	Wickaninnish Bay	2	Remaining in the area feeding and/or nursing
June 2-5/ 76	Wickaninnish Bay	2	Remaining in the area feeding and/or nursing

during the migration a group of whales will only be observed momentarily and one is unsure if a pair is a cow with calf or two adults. Other sightings made were of probable cows and calves such as on April 20, 1975 one 'small' whale breached four times before rounding a reef, however, I was a long way off and the animal was silhouetted against the sun. On May 11, 1976 what appeared to be a cow holding a calf on the top of her head in front and over her blowhole was seen from Box Island. It was very windy, with a big swell and it was difficult to be sure.

In Table 6 all four positive sightings in 1975 on the 1st, 15th and 25th of May were of animals moving slowly in a northwesterly direction. On May 1 another adult accompanied the mother and calf, moving alongside 20 or 30 yards away.

This group was first sighted off Sea Lion Rocks and was followed to just off Lovekin Rock, where I left them to photograph another animal. They were sighted again, about half an hour later just northwest of Portland Point moving towards Gowland Rocks. On May 15 two different cow-calf groups were sighted in Wickaninnish Bay, travelling northest. One pair was accompanied by another adult. One group was observed outside Sea Lion Rocks the other inside just off Combers Beach. Apparently cow-calf groups may cut directly across the outside of Wickaninnish Bay or swerve in along the shoreline as do other migrants. On May 25, 1975 another group of three, a cow, calf and accompanying adult, were sighted moving northwest off the Radar Beaches. They travelled inside of Gowland Rocks and one of the three breached twice off the most northwest Radar Beach, then the group, side by side, continued on their heading towards Cox Point.

Of Leatherwood's (1974) 23 cow-calf observations, 18 were either by themselves or with other cows and calves. In 4 instances they were in the company of other adults. Of the 6 groups reported in Table 6, 3 were by themselves, 3 were accompanied by another adult. The sex or function of the other adult is not known. When present it is obviously a member of the group, though less closely associated with the calf than the mother is.

Perhaps more significant are our sightings of cows and calves on May 19, 1976 and from June 2-5, 1976. In both

cases the pair was not travelling when they were observed, but feeding in Wickaninnish Bay. The May 19 pair were not in the bay on May 18, which was an excellent day for observation and twelve other whales in the bay were identified, but were sighted immediately on entering the bay on the 19th. They remained there until at least noon on the 19th. On May 20 and 21 it rained and the weather remained poor until June 1, by which time they were no longer present. On June 2 another cow and calf were sighted in Wickaninnish Bay (through identification by skin pigmentation patterns not the May 19 pair). These were not present on June 1. This pair remained in the bay for 4 days, the 2nd, 3rd, 4th and 5th, but were absent on the 6th. On June 6 the weather was excellent and most likely they would have been spotted if they were in the area. Therefore, some cows with calves enter Wickaninnish Bay and stay up to four days, feeding and perhaps resting before continuing the trip northward.

The general behaviour of the May 19 and June 2-5 pairs was similar. Although on May 19, 6-8 other adult whales were in Wickaninnish Bay and on June 2-5, 10-12 other whales were present the cow and calf pair were easily distinguished both by their separation from the other whales and their behaviour (one exception is discussed below).

Both pairs were inside, closer to shore than the other adult whales, usually in water from 4-8 m deep (Fig. 14A). The pair stayed in one spot for 10-20 minutes, when the cow appeared to be feeding on the bottom. Often the water was

Fig. 14 Cow with calf in Wickaninnish Bay.

A. Cow and calf swimming along Long Beach.

B. Calf's head and half of its mother's fluke showing above water. The cow is feeding on the bottom in water shallower than she is long.

C. Calf spying; cow is underwater nearby. Long Beach is in the background.


A
B
C

so shallow that half her tail fluke could be seen above the surface (Fig. 14B) (see Feeding Behaviour, this study). The calf might dive for a portion of the cow's down time then surface and blow, sometimes surfacing back first (rather than blowhole first) and then rolling backwards, tail down and thereby raising its head above the surface, as if to look around (Fig. 14C). At times the calf splashed around its mother, swinging its flukes back and forth, orientating with its head towards its mother's underside, as if it might be trying to suckle. Then, the cow would move along the shore 50-75 yards, the calf by its side, both blowing simultaneously, until the cow dove again, the calf either remaining on the surface or diving also. It appeared the cow was trying to feed and the calf was attempting to play or suckle at the same time. Thus the pair moved up and down the shoreline of Long Beach. The mother's movements may have been caused by the calf or the boat.

At one point on June 4 the calf appeared to be suckling. The mother was lying on her side, half of her tail fluke and pectoral fin out of the water and the calf was at right angles, head toward the cow's mammary area. The majority of time, however, the cow was feeding on the bottom, as were the other adults in the area; the baby generally within 30 m. of the mother.

Generally the cow and calf were separate from the other whales in the bay except on June 4, a second and possibly third adult were feeding beside the mother for about 30 minutes,

occasionally so close they could be mistaken for the calf until one saw their size.

On June 2 two Stellar sea lions (Eumetopias jubatas) were observed very close to the cow and calf. The whales were close to shore, just outside 3-4 feet (approximately 1 m.) breaking waves in perhaps 10-15 feet (3½-4½ m.) of water. The sea lions were noticed dolphining and splashing in the area and once one appeared to jump the tail stock of the calf. This continued for 2-3 minutes just at the surf line, the sea lions doing all the splashing but within a few feet of the whales, the whales then moved off a little in one direction, the sea lions in the opposite direction.

6) Summary

The northern migration follows the Vancouver Island coastline through the study area. Most whales are within 2 mi. (3.2 km.) and many within 1 mi. (1.6 km.) of the shore. Some whales follow a direct course just outside of the headlands, outer islands and reefs, others swerve in and out of bays and channels. Depth contours may aid orientation. Migrants may linger in Wickaninnish Bay and at other locations in the study area and feed for varying lengths of time before continuing north. Apparent sexual play, homosexual in at least one case, is a common activity among some of the northbound migrants before May; 2-5 animals involved at one time. Cows with calves pass through the study area, most are travelling when sighted,

but at least two pairs in 1976 spent up to 4 days in Wickaninnish Bay feeding, in late May and early June.

C. Summering Whales

1) Arrival and Departure

As shown above, the majority of northward migrants bound for summer feeding grounds reach Vancouver Island from February until June. Observation of the migration through the study area began on March 27, 1975 and March 11, 1976. Identification photography was begun in April each year. From these photographs individual whales which were identified the previous year(s) and those not previously identified but subsequently found to be summering in the study area were recorded. Examples of the earliest dates that local summering whales were identified in the study area are as follows:

1975

Apr. 8	11	12	16	17	May 1	15
Two Dot Star Whitepatch Orange Scar ?	Flores	Orange Scar	Saddle	McKenzie	Squirl	#1575 Streak

1976

Apr. 12	May 3	8	15	16
McKenzie #476	Blackjack	Streak	Dots	Two Dot Star Whitepatch Saddle

Since these are only the earliest dates seen they may have been present earlier and not found or photographed. Since many migrating whales pass through or linger in Wickaninnish Bay to feed, to come across a local whale, particularly in March or April, requires some luck. In contrast, most migrants pass by the outside of Ahous Bay (Fig. 11) and the arrival of those more permanent whales may be more obvious. The second to last day in 1975 that whales were sought in Ahous Bay was October 23 and five, all previously identified, were present. The next search of Ahous Bay was on December 5 and no whales were sighted. In early 1976 Ahous Bay was reached on January 24, February 4, March 14, March 15, and April 11 but no whales were present although the last three days are during the northern migration. On April 29 2-3 whales were found feeding in Ahous Bay; on May 3 the first local identified was Blackjack. In this instance, if these whales arrived directly from their migration, they reached the study area in mid-late April.

As Figures 18 and 19 show 'new arrivals' to the study area are a regular occurrence through May and June and previously unidentified whales appear throughout the summer. It seems probable that the later into the summer whales arrive the more likely it is they are arriving from other parts of their summer range rather than terminating their northward migration.

On the southward leg ofthe migration the majority of whales

pass Vancouver Island from November to mid-January (Pike, 1962; Pike and MacAskie, 1969; Hatler and Darling, 1974, this study). Apparent southbound migrants may be seen off Los Angeles as early as September or October, although the earliest in 1975 was November 10 (D. McIntyre, pers. comm., 1977). These extra early sightings off Los Angeles raise the possibility of a least a few whales, if they summered in northern waters, passing or departing from Vancouver Island quite early in the fall.

Data indicating when whales which summer off Vancouver Island might leave for the winter is sketchy because intensive observation in the study area ended in September when many were still present, and the unusual deterioration of weather in the fall making regular observation difficult. Also, when a whale leaves the study area it is uncertain whether it is only moving to another location in its summer range (a regular occurrence over the summer as discussed below) or if it is actually leaving for Mexico.

The latest sighting of a whale known to summer in the area was on December 14, 1972 when Whitepatch was photographed feeding in Wickaninnish Bay. Other whales photographed in the area after the summer were:

1975

October 12	23
Orange Scar	Collage Little Vargas I Little Vargas II Blackjack Dots

Summer residents were present at least through October in 1975, and as discussed above those identified in Ahous Bay on October 23 were absent by December 5. It should be noted, however, that Ahous Bay can also be empty of whales in the summer. That these whales departed southward on their winter migration between October 24 and December 5 is not wholly conclusive.

In summary, the first northbound migrant reaches Vancouver Island in late February, the peak passage was not until early April and at least some of the population which summers off Vancouver Island were present in April. The earliest identification of a summer resident was on April 8, 1975. Summer residents continued to arrive at least through May and June. The latest sighting and identification of a summer resident was on December 14, 1972, there is evidence that summer residents remain through October and an indication that at least some may depart by early December. The southern migration off Vancouver Island declines after early January suggesting any that are leaving will have departed by then.

2) Abundance

After the influx, and passage of most migrants in the spring, a number of whales are left in the study area and along Vancouver Island's coastline. The question of how many is really two:

a) How many whales are present at any one time in the study area, i.e. their density. This may vary with seasons, days or hours.

b) How many whales include the area under study as part of their summer range, i.e. the population size. This figure once arrived at should be somewhat constant, at least for one summer.

Since the entire summer range of the study whales was not covered, or is not yet known, any estimate of population size requires individual identification. That is, the number of animals sighted in one day may equal the number sighted another day but the same individuals are not necessarily present. If six whales are counted one day and four the next, the most a census without individual identification can tell is just that, whereas anywhere from six to ten animals may have ranged through the area.

Straight counts give an estimate of the relative numbers of animals present at any one time, over the period of time the counts are made. In this study, consistent counts were made May to September both years, 1975 and 1976. Individuals were identified whenever possible from April to October, 1975 and April to September, 1976 and this has allowed estimations of population size, the amount of time individuals spent in the area, and some analysis of their movements.

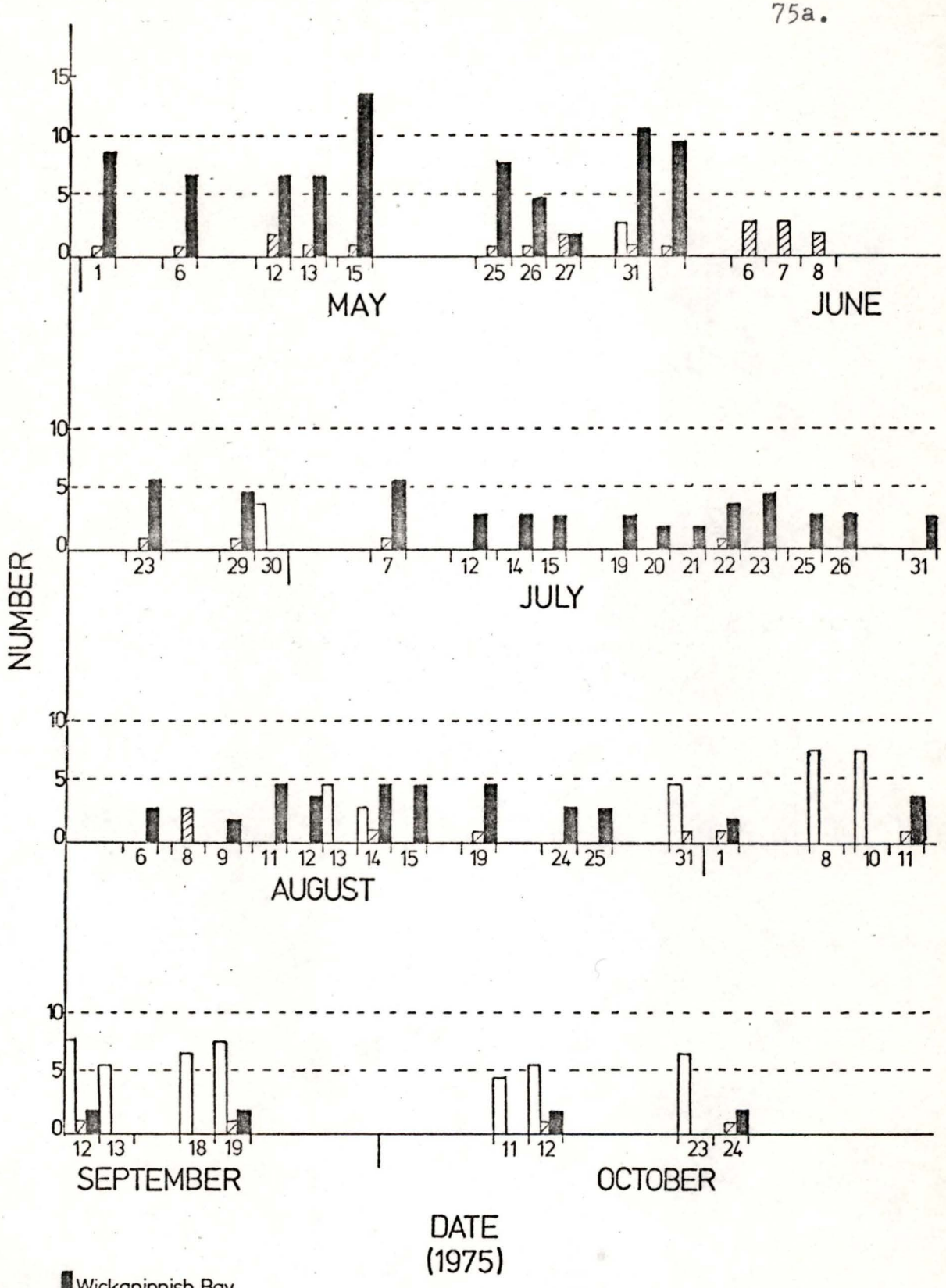
i. Counts. Two possibilities or error arise when counting whales. First, whether or not all the whales present are seen, and second whether or not duplication occurs. The first factor depends on observation time and conditions such as weather and sea state. The second depends on the experience

of the observer, on whether the count is being made from shore, boat, or plane as well as the closeness of the whales to each other. From shore it was difficult to tell if two blows were two whales or one whale blowing twice and when 4-5 whales were close together the possibility of error increases, even from a boat. Counting feeding gray whales was relatively easy because they remained more or less stationary for fairly long periods of time. They rarely stayed down longer than five minutes so that by observing for even 30 minutes in one area no whales were likely to be missed.

The counts presented in Figures 15 and 16 do not include days when the area was not satisfactorily covered because of weather, time, or other reasons. All counts are minimal. That is, if it was difficult to tell if 4 or 5 whales were present, 4-5 were recorded but 4 used in the analysis. The counts were made of animals in the locations named, not of those travelling between or just outside the areas although these are presented elsewhere. A few counts used were made by other experienced whale watchers.

The results for three areas; Wickaninnish Bay, Chestermans Beach and Ahous Bay are summarized in Figures 15, 16 and 17. For two reasons these areas are treated separately. First, rarely were all reached on one day, except when flying, making a total count impossible and second, the pattern of presence

Fig. 15 Counts of gray whales in Wickaninnish Bay, Ahous Bay and Chestermans Beach, May to October, 1975.


NUMBER
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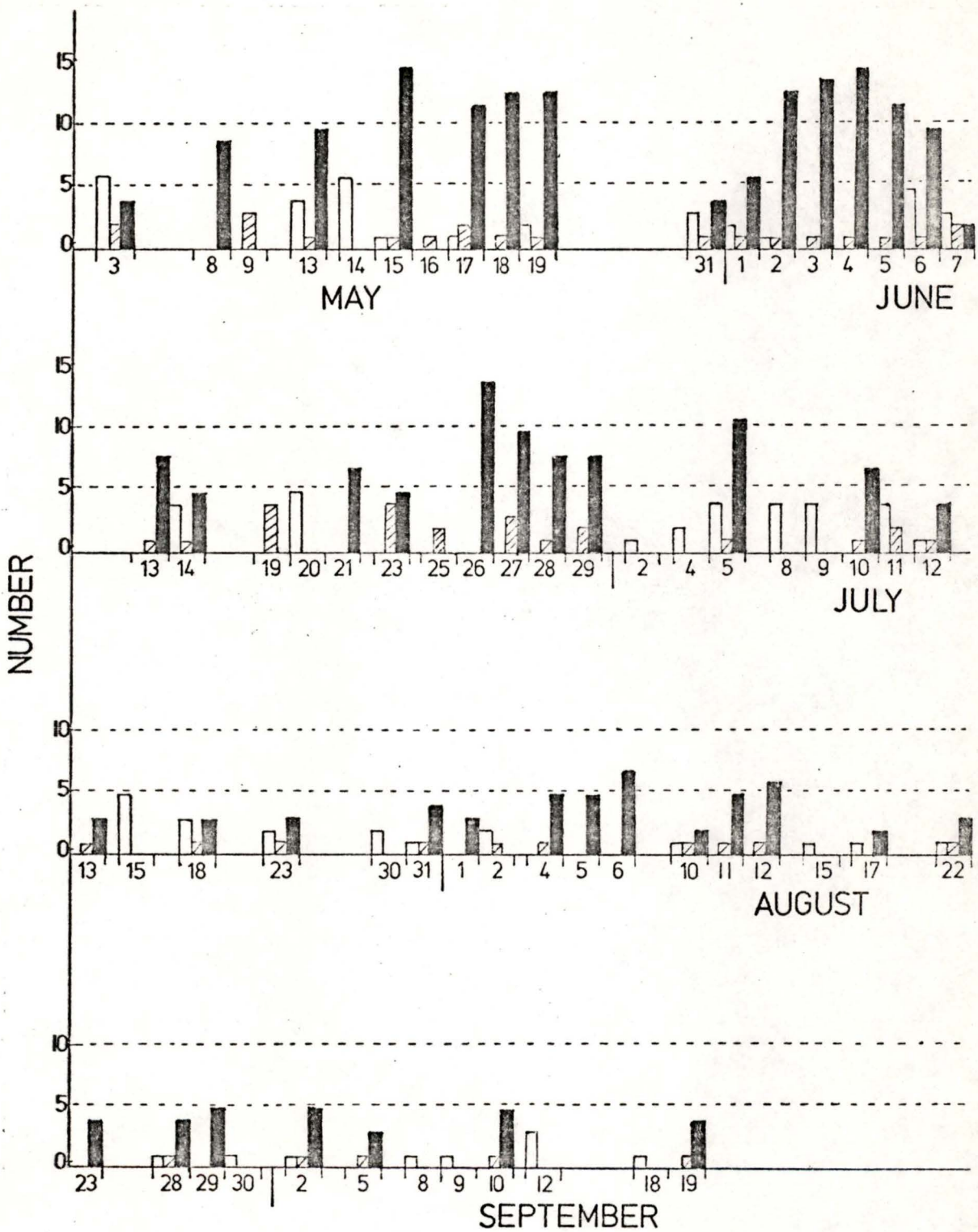
10
5
0
1
6
12
13
15
25
26
27
31
6
7
8
MAY
JUNE
10
5
0
23
29
30
7
12
14
15
19
20
21
22
23
25
26
31
JULY
10
5
0
6
8
9
11
12
13
14
15
19
24
25
31
1
8
10
11
AUGUST
10
5
0
12
13
18
19
11
12
23
24
SEPTEMBER
OCTOBER
DATE
(1975)
Wickaninnish Bay
Chestermans Beach
Ahous Bay

Fig. 16 Counts of gray whales in Wickaninnish Bay, Ahous Bay and Chestermans Beach, May to September, 1976.


NUMBER
15
10
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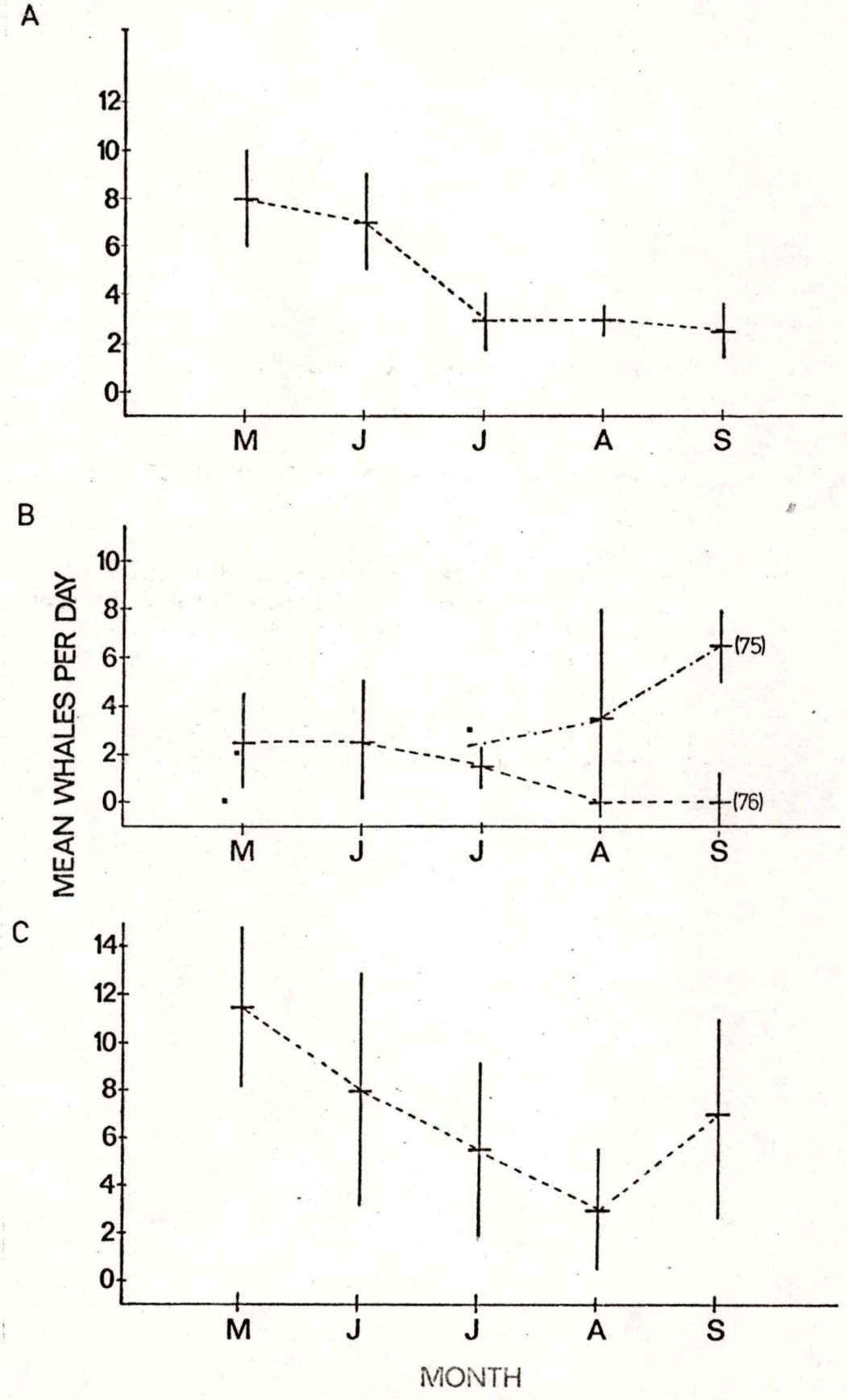
0
3
8
9
13
14
15
16
17
18
19
31
1
2
3
4
5
6
7
MAY
JUNE
13
14
19
20
21
23
25
26
27
28
29
2
4
5
8
9
10
11
12
JULY
13
15
18
23
30
31
1
2
4
5
6
10
11
12
15
17
22
AUGUST
23
28
29
30
2
5
8
9
10
12
18
19
SEPTEMBER
DATE
(1976)
Wickaninnish Bay
Chestermans Beach
Ahous Bay

Fig. 17 Mean whales per day per month.

A. Wickaninnish Bay
Both years (1975 & 1976) were averaged.

B. Ahous Bay
Years (1975 & 1976) were treated separately. Counts were made on only three days from May to August, 1975. These are shown as points on the graph.

C. Entire study area - Wreck Bay to Ahous Bay. (Counts were made in 1975 and 1976)


A
12
10
8
6
4
2
0
M
J
J
A
S
B
MEAN WHALES PER DAY
10
8
6
4
2
0
(75)
(76)
M
J
J
A
S
C
14
12
10
8
6
4
2
0
M
J
J
A
S
MONTH

or absence varied from area to area and combining them would hide these differences. Counts which were made over the entire study area are also discussed.

Wickaninnish Bay

Obvious in both 1975 and 1976 are the larger number of whales present in Wickaninnish Bay through May and June than the remainder of the summer (Figs. 15, 16 & 17, Table 7). Only three satisfactory counts were made in June, 1975 and although these compare well with those in June, 1976 much of what may have happened as far as numbers of whales is concerned was missed. The mean number of whales seen per day for each month, May through September, for both years is given in Table 7. The means with their 95% confidence limits are graphed in Figure 17. The wide range of counts, particularly in May and June (1-14 whales counted per day), and the relatively small number of useful counts per month led to large standard error and wide confidence limits. With suitable observation conditions at least one whale was seen every day, May to September in both years. Also summarized in Table 7 are the numbers of days in the study months that less than five, five to ten and greater than ten whales were seen in the bay. The 10 days on which more than 10 whales were counted all occurred in May and June. Of the 22 days when 5-10 animals were recorded, 18 were in May and June, and of the 52 days when less than 5 whales were seen in Wickaninnish Bay, 44 were from July to September. The range from the highest to lowest daily count within a month varies over the summer.

Date	No. of days whales sought	No. of days counts made <5	5-10	>10	Range of counts/day lowest to highest	Mean whales per day	Mean* and S.E. both years
May 75	10	2	7	1	1-13	6.7	8.0 ± .92
76	8	2	2	4	3-14	9	
June 75	3	1	2	0	4-4	6	7.0 ± .90
76	15	3	7	5	1-14	8.1	
July 75	12	11	1	0	1-5	2.3	3.0 ± .49
76	7	6	1	0	2-10	4	
August 75	9	9	0	0	1-4	2.9	3.0 ± .27
76	12	10	2	0	1-6	3.2	
Sept. 75	4	4	0	0	1-3	1.5	2.5 ± .46
76	4	4	0	0	2-4	3.2	

83

*(rounded to nearest .5)

Table 8. Counts of gray whales off Chestermans Beach from May to September 1975 and 1976.

Year	No. of days whales sought	No. of days whales present	Range (in no.s/day	Numbers in May	June	July	Aug.	Sept.	Longest stay
1975	24	6	1-2	2	3	0	1	0	May 5-8
1976	43	10	1-3	3	6	1	0	0	June 19-29*

67

*(seen on 27th and 29th, but not 28th.)

In May and June the range is from 1-14/day; for the remainder of the summer this range decreases generally to between 1 and 6 whales per day (with one count of 10 made in early July, 1976) (Figs. 15 and 16, Table 7). This suggests a greater degree of movement in and out of Wickaninnish Bay in May, June and early July than during the remainder of the summer. From the counts made in October, November and December it seemed the trend in numbers of whales per day in Wickaninnish Bay from July to September remained steady. Counts made on October 12, and 24, November 21, and December 5 and 18 were of 1, 1, 3, 2 and 2 whales respectively.

As discussed earlier in this paper, apparent migrants may still be moving through Wickaninnish Bay as late as early June. It seems reasonable that the larger numbers and range of counts in May and June compared with later in the summer is explained by the last of the northward migrants passing through the area.

Chestermans Beach

Chestermans Beach was usually checked for whales while enroute to Wickaninnish Bay. Whales sighted were in the north Chestermans to McKenzie Beach area (Fig. 3). In contrast to Wickaninnish Bay whales were sighted on 6 out of 24 days, they were sought during May through September, 1975 and 10 out of 43 days during the same period in 1976 (Table 8). In 1975, 5 of the 6 sightings were in May or June and 1 in August. In 1976, 9 of the 10 sightings were in May and June and 1 in July.

Daily counts ranged from 1-3 animals. The longest period the area was inhabited was four days, May 5-8 in 1975 and possibly 10 days, June 19-29, 1976. During those periods whales were seen on May 5, 7 and 8 and June 19, 23, 25, 27 and 29 (but not the 28th). Data on movements to and from the Chestermans Beach area are discussed below.

Ahous Bay

Counts made in Ahous Bay for the two years are treated separately, due to a difference in counting effort and an obvious variation in the presence and absence pattern between the years. Counts of whales in Ahous Bay from May to September, 1975 are few (2 in May, 1 in June and 3 in August) and little more than general presence can be assumed with 0 and 2 whales counted in May, 3 in June, and 2, 4 and 4 in August. During September, 1975 and May to September, 1976 counts were more consistent and the results are summarized in Table 9 and Figs. 15, 16 and 17B. The numbers recorded during May to July of both years are comparable (although the 1975 data is limited). Counts increased during August and September, 1975 but decreased during the same period in 1976. From August through September, 1976 whales were looked for on 12 days and seen on two; August 2 and September 12, 1 and 2 animals respectively. Generally there were no whales in Ahous Bay during that period (Figs. 16 & 17B, Table 9). Through October, 1975 counts remained relatively high, 4 on the 11th, 5 on the 12th and 7 on the 23rd. Apparently some whales did return to

Table 9. Counts of gray whales in Ahous Bay [illegible]

Date	No. of days whales sought	No. of days counts were made 0	1-5	5-10	Range of counts lowest-highest	Mean* and S.E. whales/day
May 75	2	1	1	0	0-2	-
76	7	2	4	1	0-5	2.5 ± .81
June 75	1	0	1	0	3	±
76	6	1	5	0	0-4	2.5 ± 1.00
July 75	0					
76	13	3	8	0	0-4	1.5 ± .40
Aug. 75	3	0	3	0	2-4	3.5 ± 1.12
76	7	6	1	0	0-2	0 ± .31
Sept. 75	6	0	1	5	5-7	6.5 ± .62
76	5	4	1	0	0-2	0 ± .45
	50					

*(rounded to the nearest .5)

Table 10. Counts of gray whales made over the entire study area, Wreck Bay to Ahous Bay on the same day, May to September, 1975 and 1976.

1975 and 1976	No. of days whales sought	Wickaninnish Bay	Chestermans Beach	Ahous Bay	Other (incl. Wreck Bay)	Total	Range of Counts	Mean* and S.E. in whales/day
May	7	62	2	13	5	82	5-16	11.5 ± 1.34
June	5	31	1	10	0	42	4-13	8 ± 1.76
July	5	21	0	6	1	28	3-14	5.5 ± 1.36
Aug.	4	11	0	2	1	14	2-6	3 ± .87
Sept.	3	6	0	14	1	21	5-8	7 ± 1.00
	25							

*(rounded to the nearest .5)

Ahous Bay between late September and November, 1976 as 6 were counted there on November 6 by P. Horton (pers. comm., 1976). In 1976 the range of counts for every month includes 0 and it seems whales were less permanent in that bay that year than the previous year. The range indicates that whales moved in and out of the bay fairly regularly through May, June and July then stayed out for most of August and September. Individuals 'missing' from Ahous Bay were not seen in Wickaninnish Bay or Chestermans Beach. The interesting point about this area is the difference in residence pattern over the two years and what may regulate the presence and absence of the whales. The most likely factor is food or food related.

Wreck Bay

Whales were present on 3 of 8 observation days in 1975 (1 whale on May 31, 2 on June 5 and 1 on July 8). In 1976, Wreck Bay was checked on 9 occasions through the summer and whales seen on 2 (2 on June 20, and 1 on July 5). Whales do enter Wreck Bay through the summer, apparently to feed, but are absent more often than not, a pattern similar to that of Chestermans Beach area.

Entire Study Area: Wreck Bay - Ahous Bay

The average whale count per month for the entire study area is shown in Fig. 17C (information based on 25 observation days in 1975 and 1976 when the entire study area from Wreck to Ahous Bays was censused (Table 10). While the data shows the same seasonal decline in abundance from May to August it differs

from Wickaninnish Bay in showing a noticeable increase in September. This late season upswing was due to more whales in Ahous Bay in September, 1975 and to persistently high counts in Wickaninnish Bay in September, 1976. On September 9, 1976, off Rafael Point, Flores Island, approximately ten miles north of Ahous Bay, 13 whales were sighted. Of the 13, 7 had been identified in Wickaninnish Bay earlier in the season. If these were included in the calculations for average whales/day in September the upswing would be even greater than shown in Fig. 17C. Thus the September increase may be a regular seasonal phenomenon although current data are too limited to allow firm conclusions. The matter is discussed further in connection with whale movements.

The sighting of the whales at Rafael Point probably indicates the area from Wreck Bay to Ahous Bay is too small an area to provide an adequate census of whales summering on the west coast of Vancouver Island.

ii. Summer Population Size

Since the summer range of the Vancouver Island gray whales probably extends over an area larger than the study area, only a minimum estimate of population size can be obtained. The estimate is based on the number of whales which ranged in and out of the study area during the summer months, May through September, plus those few identified elsewhere on the coast, all of which were apparently summering on the west coast of Vancouver Island.

Summer resident whales were defined as those which 1) are seen more than once over a period longer than 4 weeks, including those identified both years even if seen only once each year and/or, 2) those seen in July, August or September. The first category excludes those animals which may be lagging in the northward migration, such as some of those identified in May or June. The second category includes whales which may have been missed earlier in the season and those found in seldom-reached areas. It seems unlikely that whales sighted in July, August or September would be migrating animals.

In 1975, 40 whales were identified; of these 26 were considered resident. In 1976, 55 were identified and 34 were considered to be summer residents. The identification effort in 1975 was less intensive through May, June and July therefore the estimate is probably low (Figs. 18 and 19, Table 11).

Of the 34 in 1976, 17 of these were also present in 1975. If it can be assumed that most summer resident whales return as just over half are shown to do, then the minimum population estimate would be 42 animals, 9 identified in 1975, 17 identified both years, and 16 identified in 1976 (Table 12). Over two summers, at least 42 different whales ranged along the west coast of Vancouver Island. All five whales identified prior to 1975 were present in 1975 (Fig. 22).

Figs. 20 and 21, showing the rate of discovery of 'new' whales

Table 11. Numbers of whales identified, number considered migrant or summer resident and areas in which they were seen, years separate.

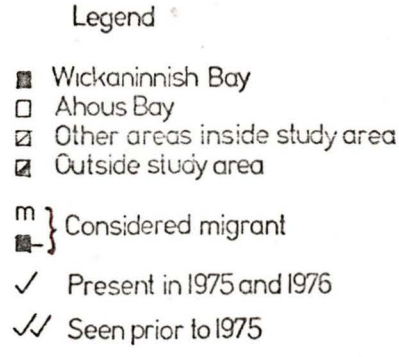
Year	Total No. identified	Migrants	In Wickaninnish Bay	Only in Ahous Bay	In other parts of study area	Only outside study area
			SUMMERING WHALES			
1975	40	14	17	6	2	1
1976	55	21	22	3	2	7

Table 12. Numbers of 'new' whales identified, number considered migrant or summer resident and areas in which they were seen, years cummulative.

Year	Total 'new' identified	Migrants	In Wickaninnish Bay	Only in Ahous Bay	In other parts of study area	Only outside study area
			SUMMERING WHALES			
1975	40	14	17	6	2	1
1976	37	21	8	1	2	5
TOTAL	77	35	25	7	4	6

Fig. 18 Summary of data on identified whales, 1975.

Dotted lines join actual consecutive sightings and indicate periods when the whale was probably in the study area. The longer lines on the bottom axis indicate days on which whales were identified.



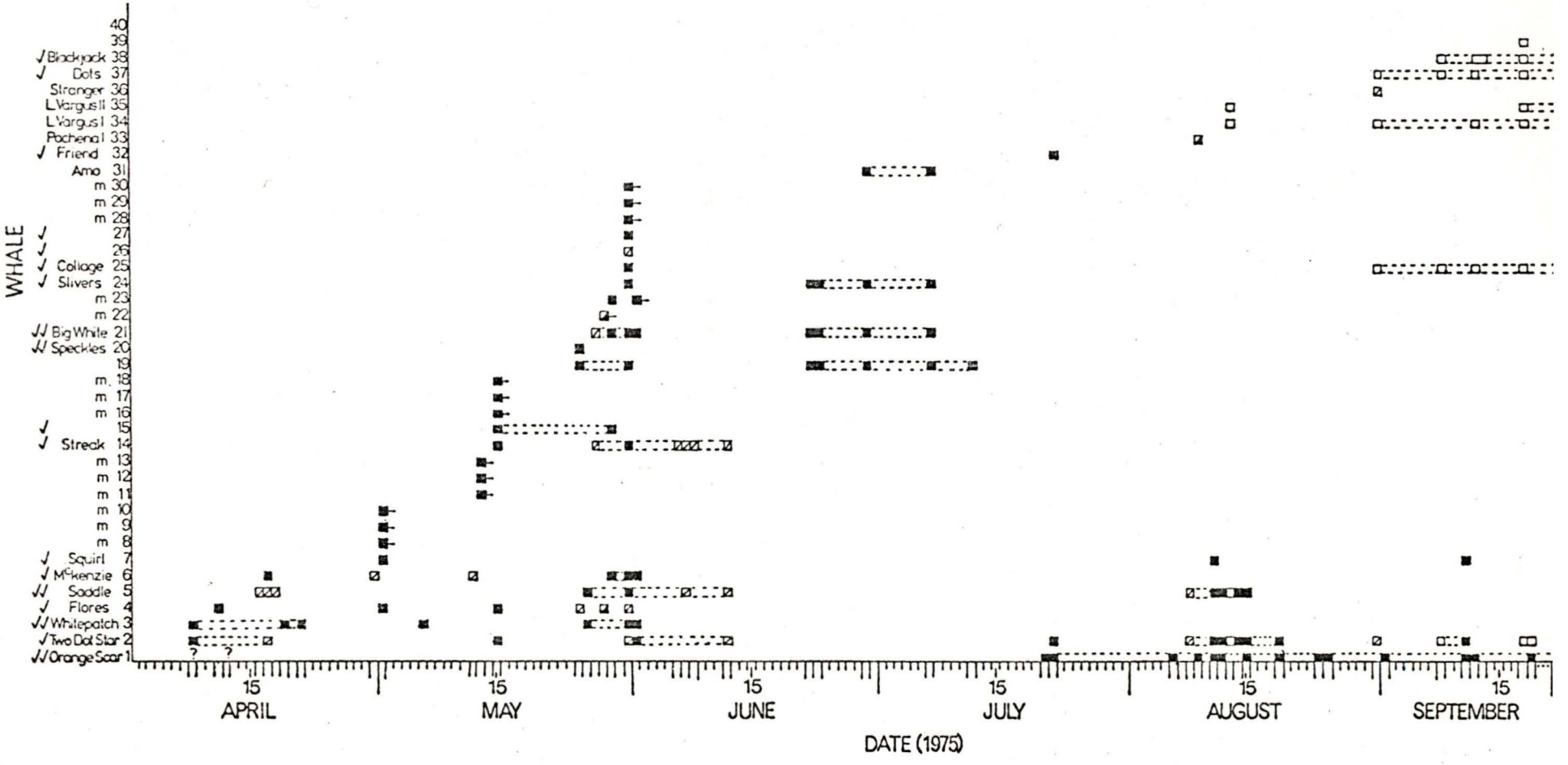
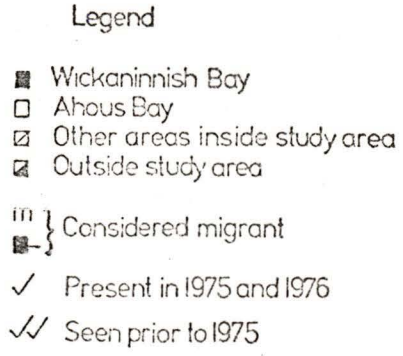

WHALE
40
39
Blackjack 38
Dots 37
Stranger 36
L'Vargus II 35
L'Vargus I 34
Pachena I 33
Friend 32
Amo 31
m 30
m 29
m 28
27
26
Collage 25
Slivers 24
m 23
m 22
Big White 21
Speckles 20
19
m 18
m 17
m 16
15
Streak 14
m 13
m 12
m 11
m 10
m 9
m 8
Squirl 7
McKenzie 6
Saddle 5
Flores 4
Whitepatch 3
Two Dot Star 2
Orange Scar 1
15
APRIL
15
MAY
15
JUNE
15
JULY
15
AUGUST
15
SEPTEMBER
DATE (1975)

Fig. 19 Summary of data on identified whales, 1976.

Dotted lines join actual consecutive sightings and indicate periods when the whale was probably in the study area. The longer lines on the bottom axis indicate days on which whales were identified.



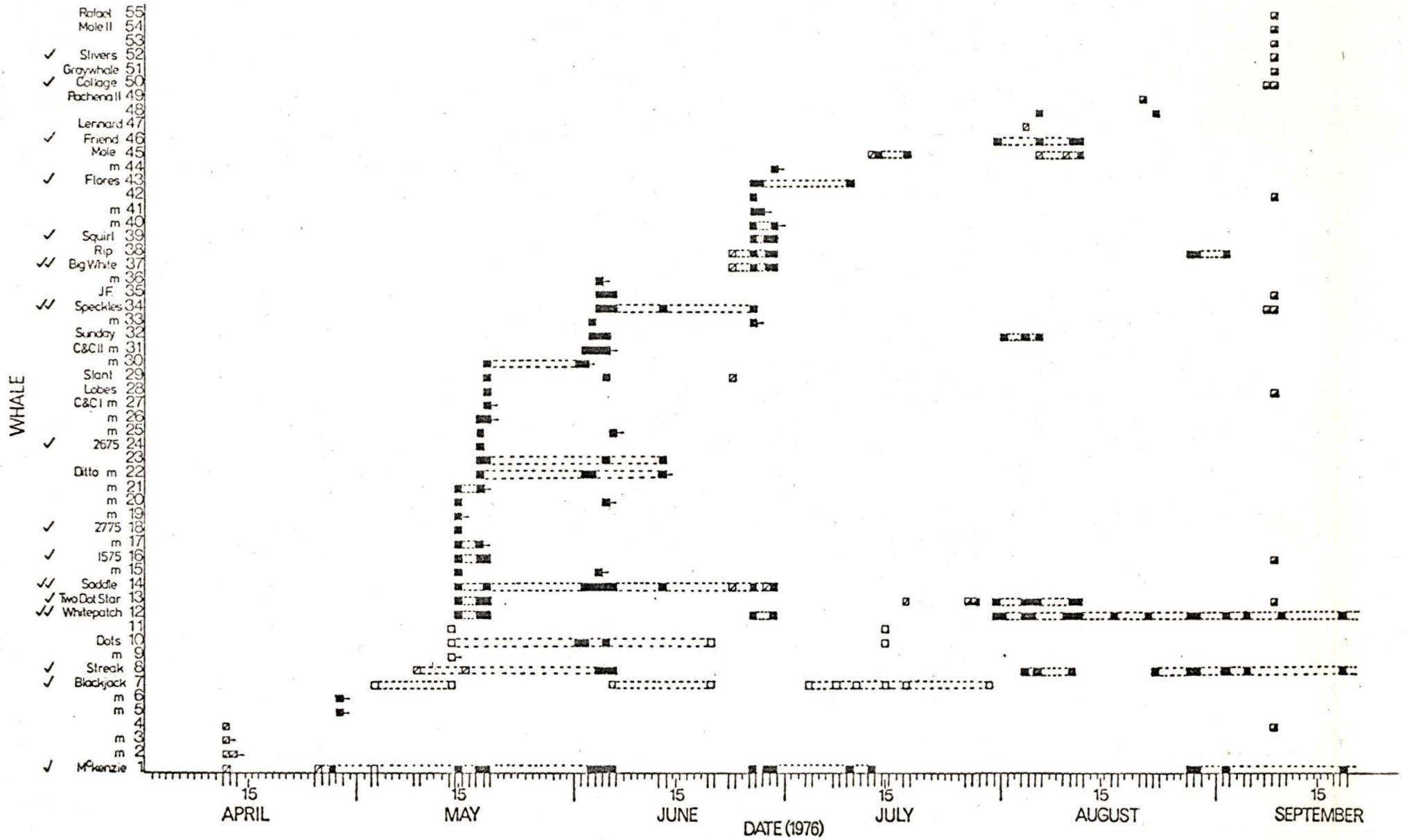

WHALE
Rafael 55
Mole II 54
53
✓ Slivers 52
✓ Graywhale 51
✓ Collage 50
Pachena II 49
48
Lennard 47
✓ Friend 46
Mole 45
m 44
✓ Flores 43
42
m 41
m 40
✓ Squirl 39
Rip 38
✓✓ Big White 37
m 36
JF 35
✓✓ Speckles 34
m 33
Sunday 32
C&C II m 31
m 30
Slant 29
Lobes 28
C&C I m 27
m 26
m 25
✓ 2675 24
23
Ditto m 22
m 21
m 20
m 19
✓ 2775 18
m 17
✓ 1575 16
m 15
✓✓ Saddle 14
✓ Two Dot Star 13
✓✓ Whitepatch 12
11
Dots 10
m 9
✓ Streak 8
✓ Blackjack 7
m 6
m 5
4
m 3
m 2
✓ McKenzie 1
15
APRIL
15
MAY
15
JUNE
15
JULY
15
AUGUST
15
SEPTEMBER
DATE (1976)

Fig. 20 Rate of discovery of 'new' whales.

A. 1975.

B. 1976.

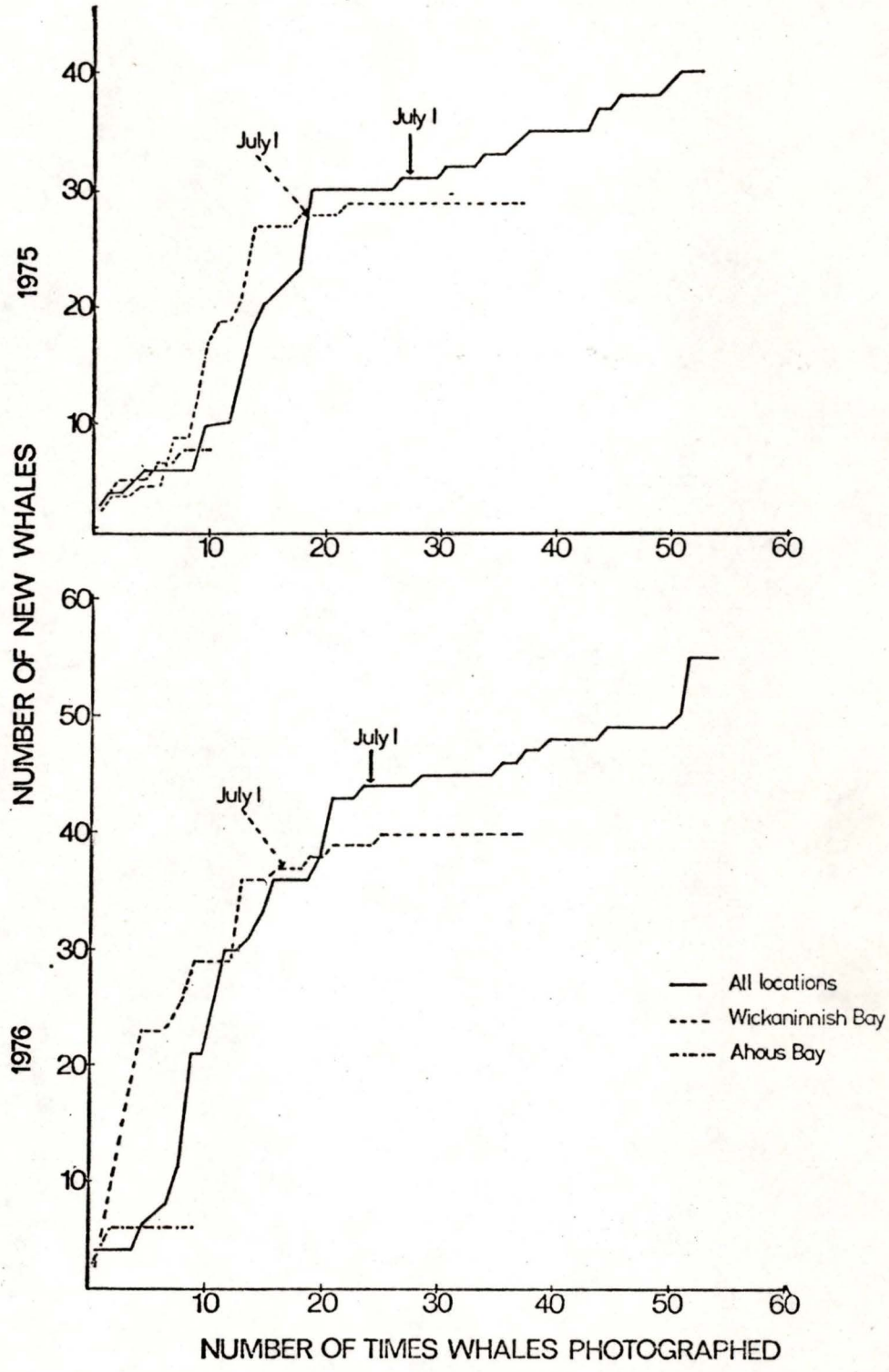
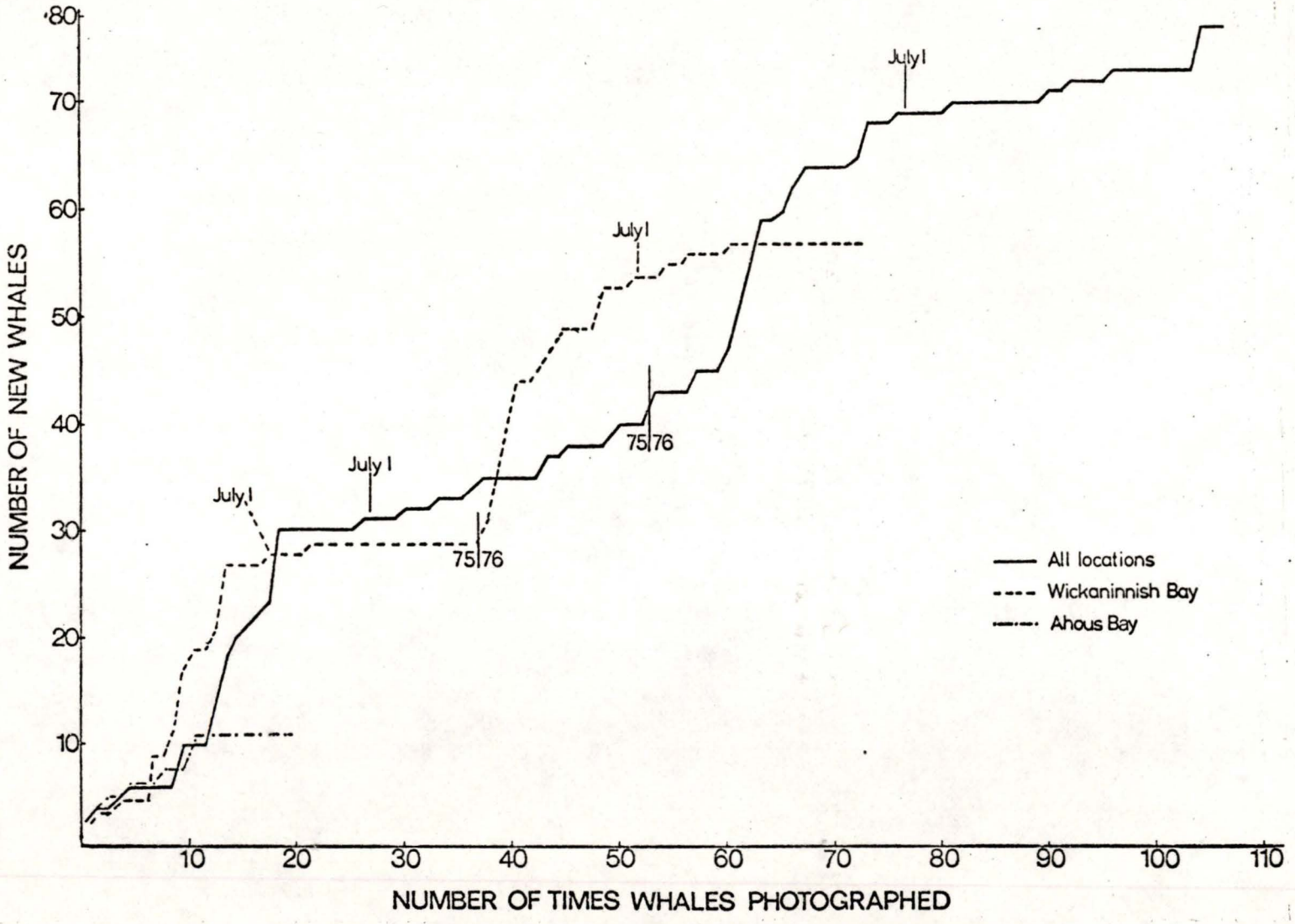

1975
July 1
July 1
40
30
20
10
10
20
30
40
50
60
1976
July 1
July 1
60
50
40
30
20
10
10
20
30
40
50
60
NUMBER OF NEW WHALES
NUMBER OF TIMES WHALES PHOTOGRAPHED
All locations
Wickaninnish Bay
Ahous Bay

Fig. 21 Rate of discovery of 'new' whales - years cumulative (1975-1976).


NUMBER OF NEW WHALES
80
70
60
50
40
30
20
10
July 1
July 1
July 1
July 1
75 76
75 76
All locations
Wickaninnish Bay
Ahous Bay
10
20
30
40
50
60
70
80
90
100
110
NUMBER OF TIMES WHALES PHOTOGRAPHED

indicate that unidentified whales were still being found until the end of each summer although the rate of discovery slowed after June (post-migration) each year. This suggests an incomplete census of summering animals on the Island's west coast. However, Wickaninnish Bay (Fig. 21) data indicates that no 'new' whales were discovered after mid-summer. A complete annual census therefore seems likely. In 1975, 17 and in in 1976, 22 summering whales were identified in Wickaninnish Bay (Table 11). Combining the data for two years, 8 whales not seen in 1975 were identified in 1976 giving a two year total of 25 identified whales (Table 12). Of the 17 individuals seen in 1975, 15 were again recognized in 1976 (14 in Wickaninnish Bay, 1 off Rafael Point) leaving 2 seen only in 1975 and 8 recorded only in 1976. The sporadic appearance of gray whales in the smaller Ahous Bay makes a similar analysis impractical. This year to year variation suggests that the figures for Wickaninnish should be treated as minimum though much more refined estimates than those available for the total study area.

In 1975, 3 whales not seen in either Wickaninnish or Ahous Bay were identified, 2 inside the study area and 1 elsewhere (Pachena Point). Of the 2 seen inside the study area but not in Wickaninnish Bay in 1975, 1 was identified in Wickaninnish Bay in 1976. In 1976, 9 whales not seen in Wickaninnish or Ahous Bay were identified, 2 inside the study area and 7 outside (6 at Flores Island and 1 at Pachena Point). Those inside the study area include whales feeding in Chestermans Beach or

other areas and those apparently passing through in mid-summer. Of the 7 seen only outside the study area in 1976, 2 had been identified in Wickaninnish Bay in 1975. Therefore 6 whales in two years were seen only outside the study area, 1 in 1975 and 5 in 1976. These account for the continued discovery of new whales at the end of the study period (Table 12).

Some additional evidence suggests that the foregoing estimates should be considered minimal. In 4 cases in 1976 a whale was seen once or twice in April, May or June then not again until September 9 when 13 whales were found at Flores Island (Fig. 19). If these September 9 whales had not been sighted, 4 more whales now classed as summer residents would have been called migrant (Table 11). It is unknown how many of the 14 in 1975 and 21 in 1976 classed as migrant were summering elsewhere on the island's coast, but only occasionally moving into the study area.

iii. Summary

Counts varied in the three localities of the study area: 1) Wickaninnish Bay had a larger number of whales present in May and June ($\bar{X}$ = 7-8 whales/day) than in the remainder of the summer (3 whales/day in July and August and 2.5 whales/day in September). The higher estimates in early summer can probably be explained by northward migrants lingering in the area. The larger range in counts during the same period is probably due to the larger number of arrivals and departures of migrants. Each day that satisfactory searches at Wickaninnish Bay were possible during 1975 and 1976 at least one whale was present.

2) In Ahous Bay summer counts varied greatly between 1975 and 1976. Although data is sparce until August, 1975, there were probably between 2 and 4 whales present through most of May, June and possibly July (no counts in July in 1975). From late August through September and October 1975 counts increased to 5-7 whales/day whereas from early August through September, 1976, usually no whales were present. Why this area showed the greatest year to year variability is not known.

3) Chestermans Beach showed a distinct pattern of counts, similar in each year. Whales were present only about one quarter of the times the area was searched and most often in May and June. The longest recorded stay was about 3 days in 1975 and possibly one of 10 days in 1976. The most whales recorded at any one time was three. Wreck Bay, although not consistently searched, showed the same pattern.

4) Over the entire study area counts showed a decline in the numbers from May through August (mean whales/day of 11.5 ± 1.34 in May, 8 ± 1.76 in June, 5.5 ± 1.36 in July and $3 \pm .89$ in August) and an increase in numbers in September (7 ± 1.00 whales/day). The standard error is high. If Rafael Point sightings in September, 1976 were taken into account the rise in numbers in September would be more dramatic.

5) Estimates of population size (i.e. those whales summering on the coast) are 26 in 1975, 34 in 1976 and 42 over the two years (9 were identified in 1975 only, 17 both years and 16 in 1976 only). The estimates are minimal since the range

of the whales was evidently larger than the study area. Some whales whose home range included part of the study area may have mistakedly been identified as migrant.

6) Wickaninnish Bay estimates of 17 in 1975, 22 in 1976 and cumulatively 25 whales with no new animals found after early August of either year are sufficiently consistent to suggest an accurate estimate of whales ranging into that area. Longer term studies of Ahous Bay would be necessary to firmly establish patterns of occurrence.

3) Movements

i. Annually Returning Whales. Eighteen individual whales were recognized in the study area over two or more years (Fig. 22 and 23). One of these, Orange Scar, was seen in 1970, 1972 (no photograph), 1973, 1974 and 1975 but not in 1976 (Fig. 22). The remaining 17 were recorded in or near the study area in 1975 and 1976. Four of these 17 were also seen in years prior to 1975: Saddle, 1974; Big White, 1974; Whitepatch 1974, 1973, 1972; and Speckles, 1971 (Fig. 22). Two of the 17 sighted in 1975 and 1976 did not return to the study area but were discovered off Rafael Point approximately 10 miles (16.1 km.) north. These sightings raise the possibility that some of the other whales considered summer locals in 1975 returned to the coast of the island in 1976 but not necessarily to the study area. This combined with the chances that other whales may have returned to the study area and were missed indicates that the 18 known returnees represents a minimum estimate of returning

Fig. 22 Whales identified in the study area earlier than as well as in 1975 and/or 1976.

Example:

Whitepatch
1972-76

1972

1973

1974

1975

1976

Orange Scar

1970,
1973-75

Saddle

1974-76

Big White

1974-76

Speckles

1971,
1975-76

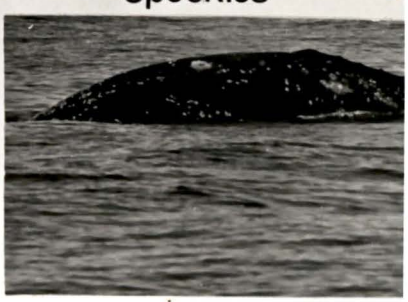


Fig. 23 Whales identified in the study area in both 1975 and 1976.

McKenzie

Dots

Two Dot Star

Blackjack

Streak

Squirl

Collage

Friend

Flores

Slivers

2675

2775

1575

animals.

The maximum period that a summer range is repeatedly occupied is unknown. Orange Scar had returned at least 6 years (1970-1975) and Speckles may have for 6 years (1971-1976). Orange Scar was not seen in 1971 (no one looked) and Speckles was not identified in 1972-1974 (no effort was made to photograph all the whales). Whitepatch has been identified each of five years (1972-1976), Saddle and Big White for 3 consecutive years. These repeated sightings may provide a means of establishing individual minimum estimates of age.

The fact that a large proportion of the animals (at least 65%) seen in 1975 were present in 1976 is note-worthy. Originally, Hatler and Darling (1974) documented two returning whales; with 16 more now whose summer home range includes the study area this represents a major biotic feature of Vancouver Island's west coast. It seems reasonable that most whales having summered in a particular area one year would return to that area the next.

ii. Summer Movements. Whales were observed to move from one location to another into, within and out of the study area. To date there is no record of an individual identified in Wickaninnish Bay spending the entire summer there, nor was this true of whales identified in Ahous Bay in 1975 or in other areas. A whale might return to a particular location like Wickaninnish Bay several times over the summer after varying periods of absence. It is apparent that the summer

range of the whales extends beyond Wickaninnish or Ahous Bays and the study area. It is possible that some whales have a very restricted range for at least part of the summer: this is discussed below.

Exact data on times of movements, and length of stay is difficult to obtain. Unless a whale is seen leaving, enroute, arriving, or an area is checked on consecutive days, timing can only be approximated within the limits of the most recent check. Ideally, an area would be searched daily to determine presence or absence of individuals but this is impractical because of weather and sea conditions and because of the large area to be searched. Hypothetically, if an area was carefully checked on June 1, 6, 12 and 25 and the same whale was identified June 1 and 25, it seems likely the whale had moved elsewhere in the intervening period. Since it will be shown that individuals enter and leave an area like Wickaninnish Bay in as few as two days during the summer, weekly surveys provide limited information on movements. The movements recorded in the study area are therefore the <u>least</u> that take place. Where observations were made on consecutive or near consecutive days as it was through some periods within the summer the picture is much more detailed.

Information on movements is summarized in Fig. 18 and 19. Examples of individual whales are given in Appendix I. Some whales have been identified in more than one location on a regular enough basis to determine approximate travel times, and/or enroute. These indicate some of the possibilities of

destination, routes, mobility and other characteristics of local travel. Less informative data simply indicates periods of presence and absence in Wickaninnish Bay. Some whales have been seen only once within the study area and others only outside the study area providing only fragmentary information.

General Characteristics

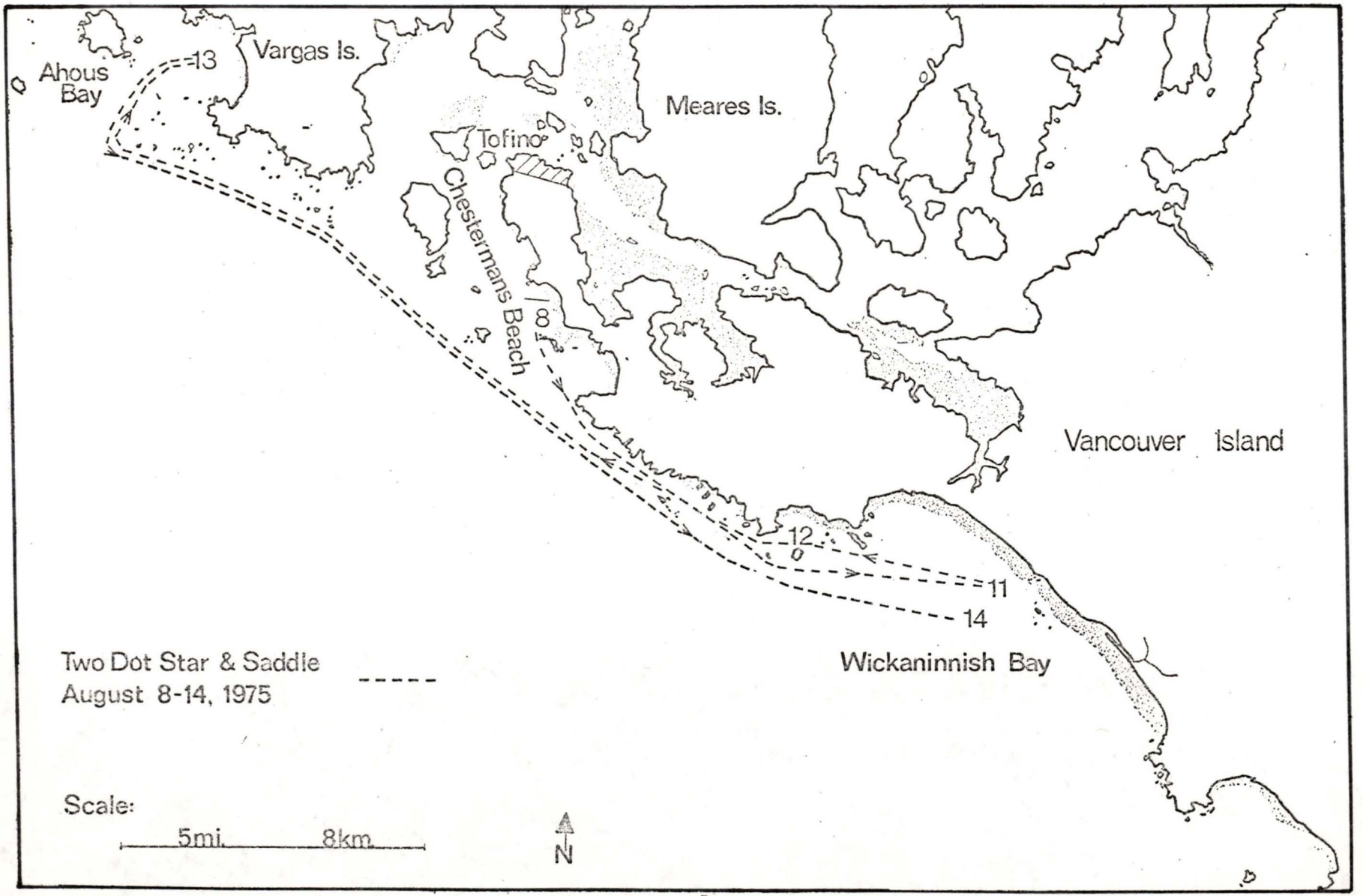
Travel was often between known feeding areas. Within the study area whales may travel between Wickaninnish Bay, Chestermans Beach, and Ahous Bay. Whales known from the study area have also been seen in the large outside bay of Flores Island, off Rafael Point, Flores Island and in the Kanim Lake area between Hot Springs Cove and Estevan Point (Fig. 32). Identified animals were observed feeding in those areas. Whales have also been sighted in numerous other locations up and down the coast, however, there is as yet no proof they are whales from the study area (Fig. 29). Apparently whales may stop at any location where food is available and have been observed off Cox Point (May 27, 1975 off Vargas Cone, just southeast of Cox Point (May 31, 1975) and off the Radar Beaches (June 29, 1976) feeding, although these areas are not regularly inhabited (Fig. 32). Whales have been known to enter Tofino harbor and move up Browning Passage to Grice Bay (Fig. 3). In these areas most sightings were during the migration in March and April, however Hatler observed one feeding in Grice Bay on October 27, 28, 29, 1971 (Hatler and Darling, 1974). Also on June 28 or 29, 1974 one was seen by Rod Palm (pers. comm., 1974) off his barge located in Tofino harbor,

and after blowing once or twice appeared to be heading out of the harbor towards open sea. On May 15, 1976 three were sighted off the Esso fuel dock at the entrance to Tofino harbor and they appeared to be heading out, having come from further up the inlet. Except for the October 1971 sighting, it is not known where these whales had been.

Actual routes which whales followed are mapped in Fig. 24. Whales moved to and from the tide rip area in Duffin Passage (June 6, 12, 1975) as well as between feeding areas. Routes generally follow the coastline closely. The furthest offshore sighting was of one whale travelling northwest about 1-1.5 mi. (1.6-2.4 km.) offshore (Lennard, August 4, 1976) (Fig. 24).

Travel varies from slow, broken and wandering movements, to slow but constant and direct, to faster, seemingly more purposeful 'steaming' along the coast. On June 7, 1975 when Saddle and Streak moved from Chestermans Beach through the Channel between Tonquin and Echachis Island their movement was slow (1-2 knots), the route often winding back on itself. Twice they stopped and performed two blow-dive sequences in the same location (Fig. 24). The most common movement observed was slow (3-5 knots) but constant and direct. The whale(s) blew 2-3 times, made a shallow dive, without showing tail flukes, stayed under 2-3 minutes then surfaced again often in a direct line from where they dove 50-75 meters away. This was descriptive of the movements of Two Dot Star and Stranger on August 31, 1975 from Cox Point to Cleland Island and beyond and Saddle and Rip on June 29, 1976 moving from Radar Beach

Fig. 24 Routes of travelling whales.


Ahous Bay
13
Vargas Is.
Tofino
Meares Is.
Chestermans Beach
Vancouver Island
12
11
14
Wickaninnish Bay
Two Dot Star & Saddle
August 8-14, 1975
Scale:
5mi
8km
N

to Long Beach (Fig. 24). In both cases one could point the boat in the direction they were heading on submergence and if the same speed was maintained they would appear beside it on next surfacing. On July 18, 1976 three whales, one Two Dot Star, the others unidentified, were followed for a short distance along the Vargas Reefs northwest (Fig. 24). They were moving faster (approx. 8 knots) than in the other examples, blowing almost simultaneously and when diving, arching their backs and showing tail flukes. There seemed to be much more energy exerted in this case, and it was difficult to know where they would surface next. Finally they lost us near Blunden Island. Although whales were observed travelling alone, they often travelled in pairs or trios (Table 13). Three trios, 6 pairs and 6 single whales were recorded. The single whales observed were generally moving slowly, in a direct route. Two of the three trios were followed; one group moved very slowly, the other quickly up the coast. Trios did not seem to be as closely knit as pairs although they swam more or less parallel to each other and blew nearly simultaneously. Some gray whales formed pairs for varying lengths of time, where they swam side by side, their pectoral fins almost touching, blowing and diving simultaneously. Feeding pairs were also observed. On August 8, 11, 12, 13, 14, 15, 1975 Saddle and Two Dot Star were paired and although never seen enroute they moved from Chestermans Beach (8th) to Wickaninnish Bay (11th), then to Ahous Bay (14th), then back to Wickaninnish Bay (15th) during that time period (Fig. 25). As Two Dot Star and Stranger were followed from Cox Point to Cleland Island (on August 31,

Fig. 25 Movements of Two Dot Star and Saddle, August 8-14, 1975.

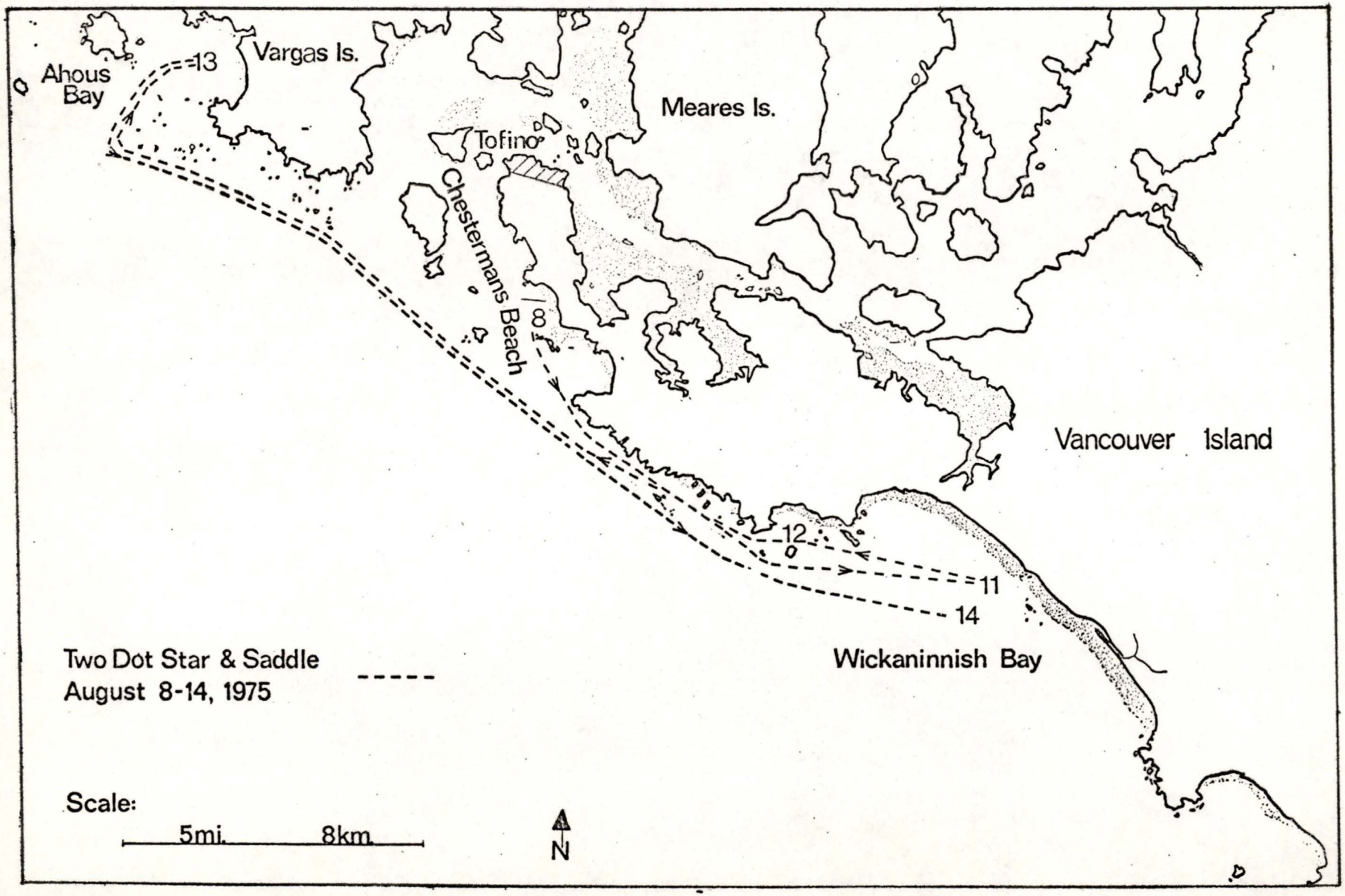

Ahous Bay
13
Vargas Is.
Meares Is.
Tofino
Chestermans Beach
Vancouver Island
12
11
14
Wickaninnish Bay
Two Dot Star & Saddle
August 8-14, 1975
Scale:
5mi.
8km
N

Table 13. Recorded Travelling Groups (Non-Migratory) in 1975 and 1976.

Date	# of Whales	Names if Known	Date	# of Whales	Names if Known
May 25/75	2	Saddle + 1	May 15/76	3	-
June 6/75	1	Streak	June 28/76	2	Saddle + 1
June 7/75	2	Streak, Saddle	June 29/76	1	-
June 8/75	1	Streak	June 29/76	1	-
June 12/75	3	Saddle, Streak, Two Dot Star	June 29/76	2	Saddle, Rip
Aug 8,11,12 13,14,15/75	2	Saddle, Two Dot Star	July 18/76	3	Two Dot Star
Aug 31/75	2	Two Dot Star, Stranger	Aug 4/76	1	Lennard
			Sept 2/76	1	-

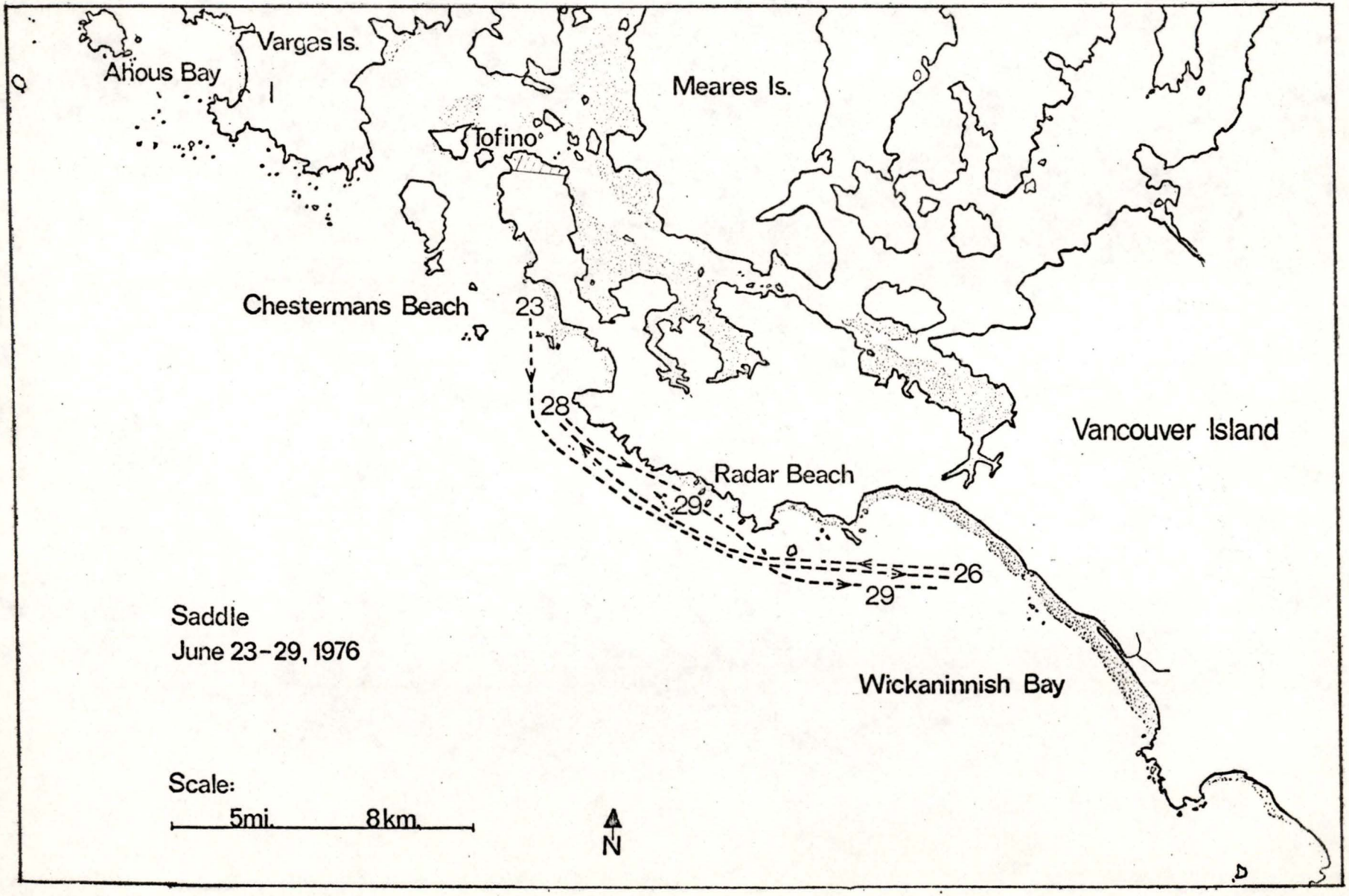
1975), at one point off Lennard Island one of the whales rolled sideways and underneath the other, possibly rubbing bellies. This only happened once so it was difficult to be sure. On June 29, 1976 as Saddle and Rip were making their way from Radar to Wickaninnish Bay, at one point after two slightly underwater blows, the whales momentarily faced each other, then one whale breached once. This break from the travelling lasted no more than five minutes then both members of the pair took up side by side positions and continued southeast into Wickaninnish Bay. Once in the bay, Rip dropped behind Saddle, followed on the same course for about ten minutes, then falling further behind, appeared to slow and separate. Saddle continued further up the bay then also slowed and began to feed. These observations suggest that in some cases there may be some social

interaction between members of the pair while travelling, although its purpose is not known.

Some evidence exists for large group movements. On May 14, 1976 six whales were observed feeding in Ahous Bay, and by May 15, 1976 all were gone. They may have left together or in smaller groups. Off Rafael Point, Flores Island, 3 whales were counted on September 8, and by September 9 there were 13 present, including the original three. Apparently 10 whales entered the area overnight.

Variation in mobility ranged from spending two to three days or less in a specific area to up to 3 months or more. Two Dot Star and Saddle during August, 1975 showed some of the quickest movement recorded (Fig. 25). At most they spent 3 days in Wickaninnish Bay (9-11), the 12th they were in Schooner Cove, possibly beginning to move northwest, the next day they were in Ahous Bay (13th) and on the 14th were back in Wickaninnish Bay. Saddle, in June 1976 showed the same mobility. This whale moved from Chestermans Beach on June 23 to Wickaninnish Bay by June 26, then must have left shortly after as it was seen again returning to Wickaninnish Bay from Chestermans Beach direction on June 28-29 (Fig. 26). Two Dot Star

Fig. 26 Movements of Saddle, June 23-29, 1976.

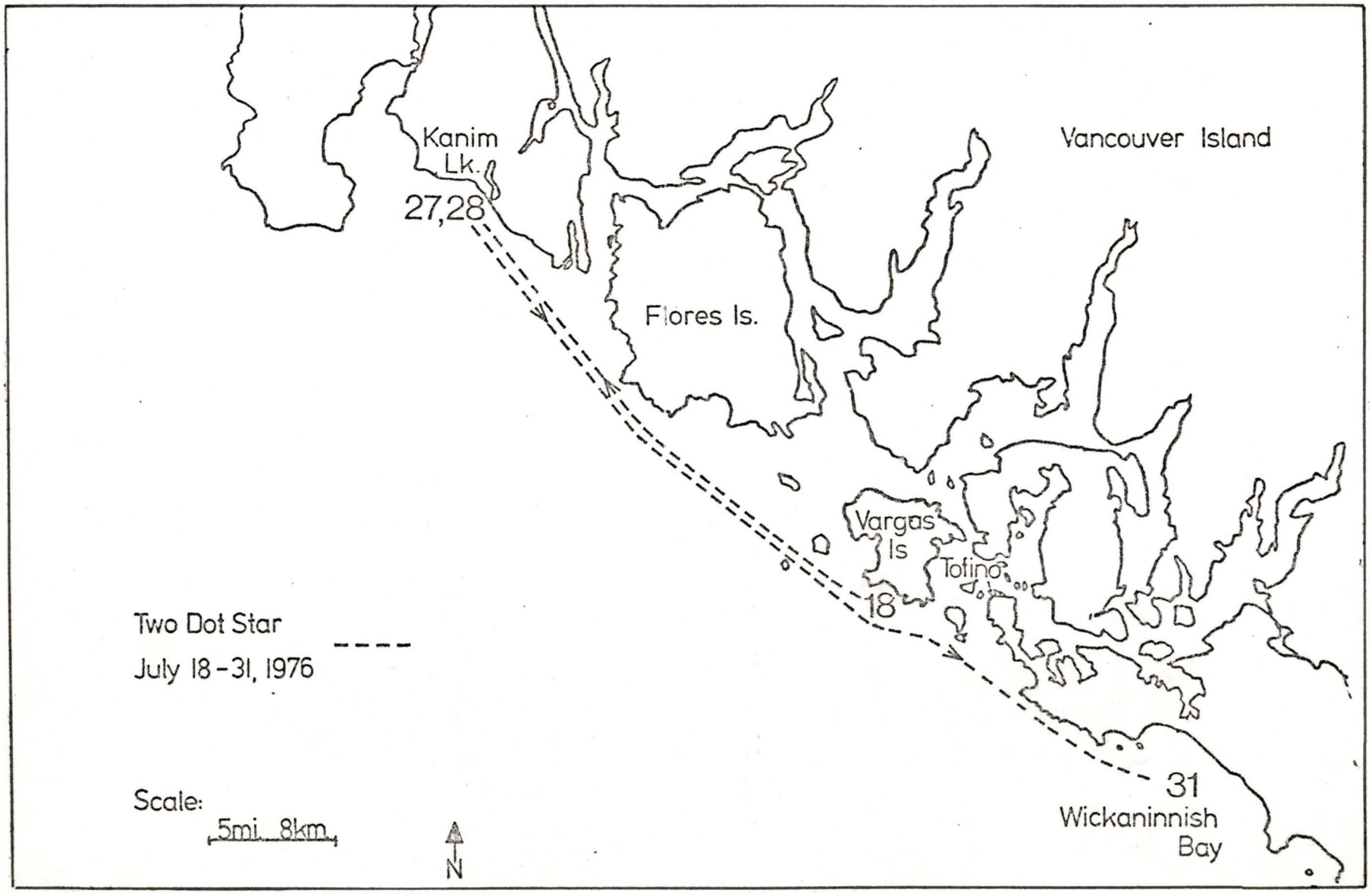

Vargas Is.
Ahous Bay
Meares Is.
Tofino
Chestermans Beach
23
28
Vancouver Island
Radar Beach
29
26
29
Saddle
June 23-29, 1976
Wickaninnish Bay
Scale:
5mi.
8km.
N

was spotted moving northwest off the Vargas reefs on July 18, 1976, at Kanim Lake on July 27-28 and was in Wickaninnish Bay by July 31 (Fig. 27). It is not known if these relatively quick movements back and forth from one area to another and back again are a regular occurrence. The almost daily travelling done by Two Dot Star and Saddle in August, 1975 over a distance of about 10 mi. (16.1 km.) from Chestermans to Wickaninnish Bay and about 16 mi. (25.8 km.) from Wickaninnish Bay to Ahous Bay and back again would seem, in the context of feeding, to be somewhat un-productive.

In contrast, there is sufficiently consistent data on a few whales to show they may restrict their activities to a limited area (in Wickaninnish Bay) for several months. For example, the records for Orange Scar in Wickaninnish Bay from July 21, 1975 to at least October 12, probably October 24 and longer. The same is true for Whitepatch from July 31 to at least September 19, 1976 when observation was terminated. If these whales made no short excursions, as Saddle and Two Dot Star have shown they are capable of, Whitepatch remained in one area for at least 51 and Orange Scar for at least 91 days (Appendix I).

Two Dot Star, on August 31, 1975, showed that travelling whales don't necessarily travel from one known feeding area to another in sequence as they move up and down the coast. This whale and its companion bypassed Ahous Bay, where 4 other whales were feeding, enroute somewhere further north-

Fig. 27 Movements of Two Dot Star, July 18-31, 1976.


Kanim
Lk.
27,28
Flores Is.
Vancouver Island
Vargas
Is
Tofino
18
31
Wickaninnish
Bay
Two Dot Star
July 18 - 31, 1976
Scale:
5mi 8km
N

west (Two Dot Star was seen 9 days later in Ahous Bay, September 8, with the whales it bypassed). Two Dot Star and two other whales showed the same thing on July 18, 1976, apparently bypassing Ahous Bay enroute further north. Other whales were present in Ahous Bay on this date also. Whales therefore may bypass known feeding areas, where other whales are feeding, apparently enroute to a specific location. These groups of travelling whales apparently either had a specific destination in mind or at least knew where they did not want to go. If they were wandering, opportunistically looking for food, one might expect they would check out all the known feeding areas. In contrast, as reported earlier, whales are sighted feeding in between the regular larger feeding areas like Wickaninnish Bay, Ahous Bay or Chestermans Beach. It is likely Saddle and Rip sighted off Cox Point on June 28, 1976 moving south, lingered in the Radar Beach area feeding until June 29, 1976 when they were observed moving to Wickaninnish Bay. Possibly in some cases the whales have predetermined destinations; at other times are more or less wandering.

Presence and Absence

Several general trends can be tentatively based on postulated patterns of presence and absence of individual whales. One is of whales present in the study area relatively early in the summer, departing, then returning to, or near to, the same area relatively late in the season (Table 14). Without the September 8 and 9, 1976 sightings off Rafael Point, Flores Island this pattern would not have been noticeable. The supporting data is very limited and should be examined for a minimum of 5 years

Table 14. Whales (considered summer locals) sighted only early and late in the summer.

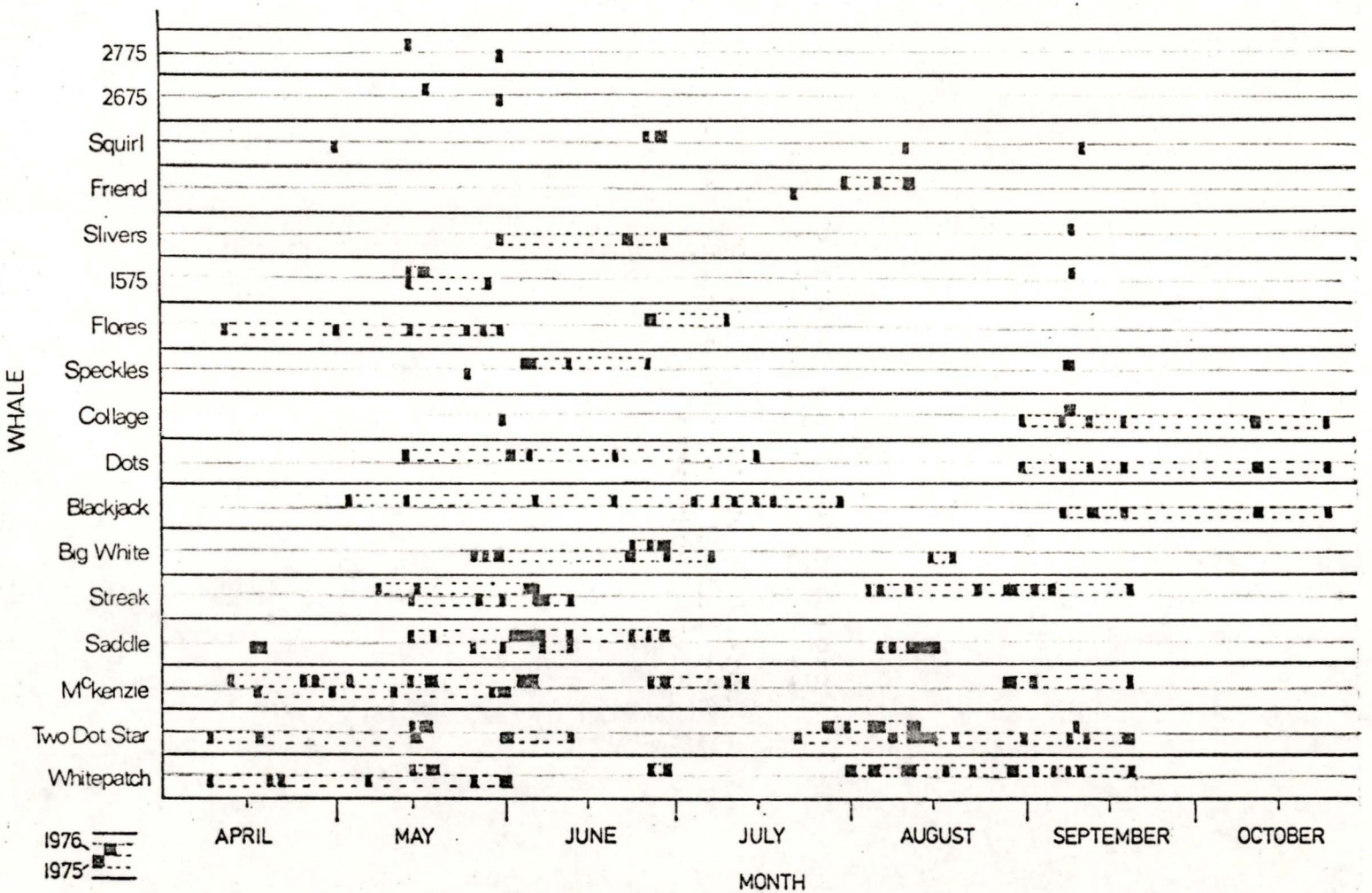
Whale	Year	Date & Location Early Sighting	Date & Location Later Sighting
Collage	1975	May 31 - W. Bay	Aug 31 - Ahous Bay
Squirl	1975	May 1 - W. Bay	Aug 11 - W. Bay
#476	1976	Apr 12 - Chest. B.	Sept 9 - Rafael Pt.
#1575	1976	May 15,18,19 - W. Bay	Sept 9 - Rafael Pt.
Lobs	1976	May 19 - W. Bay	Sept. 8,9 - Rafael Pt.
Yellow Tinge	1976	June 4,5,6,13,26 - W. Bay	Sept 9 - Rafael Pt.
JF	1976	June 4,5,6, - W. Bay	Sept 9 - Rafael Pt.
#4276	1976	June 26 - W. Bay	Sept 9 - Rafael Pt.

with more extensive geographic coverage. It is tempting to imagine a northerly surge of whales, other than the obvious migrants, passing through the study area early in the season and returning later in the summer. If this pattern of movement respective to the study area is significant, it seems not to be characteristic of all the whales. Some whales are sighted fairly regularly in restricted areas as described above (Fig. 18 and 19).

Fig. 28 compares the dates of absence and presence of individuals sighted in both 1975 and 1976 in the study area. The September 8 and 9, 1976 sightings off Rafael Point are included. Several points are worth noting.

Fig. 28 Comparison of dates of presence of whales seen in both 1975 and 1976 in the study area.

Dotted lines join actual consecutive sightings and indicate periods when the whale was probably in the study area.


WHALE
2775
2675
Squirl
Friend
Slivers
1575
Flores
Speckles
Collage
Dots
Blackjack
Big White
Streak
Saddle
McKenzie
Two Dot Star
Whitepatch
1976
1975
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
MONTH

If whales are arbitrarily divided into rarely seen (< 5 times) and regularly seen (≥ 5 times) many of the whales which are rarely seen one year were rarely seen the next and the reverse, those regularly seen one year were regularly seen the next. Rare whales included Speckles, Squirl, 1575, Slivers, 2675, 2775 and Friend and regular whales would be Whitepatch, Saddle, Two Dot Star, McKenzie, Streak, Blackjack and Dots. Some whales were seen regularly one year and rarely the next: Big White, Flores, Collage (Fig. 28).

Of the rare whales 6 of the 7 were seen early and/or late in the summer. Some were seen early in both years (2775,2675), or early one year and late the other (Slivers) or early and late one year and just early the other (Speckles, Squirl) or early and late one year and just late the other (1575). One of the rare whales was observed only in mid-summer (July 15 - August 15) both years (Friend).

Of the regular whales most sightings were still either side of the mid-summer mark (July 15) (Fig. 28). Times of presence of these whales in the study area varied from one summer to the next. Some whales were present approximately at the same time each summer (i.e. Two Dot Star), others at entirely different times (i.e. Dots, Blackjack) (Fig. 28).

A feature of the graph is the rarity of sightings of these whales in the last two weeks of July. Hatler and Darling (1974) state that a recurring feature in Wickaninnish Bay has been a temporary scarcity or absence of whales in late July and August (1965, 1966, 1973). Of the whales present in

1975 and 1976 only three have been seen in Wickaninnish Bay during that period, Friend on July 22, 1975 and July 31, 1976; Two Dot Star on July 22, 1975 and July 31, 1976 and Whitepatch on July 31, 1976. In Ahous Bay Blackjack was present on July 18 and 30, 1976.

The data indicates that many of the whales known to return over at least two years are more likely to be present in the study area either before or after late July. Some are seen regularly, others rarely, to the point that some could be described as only being present early and late in the summer. Two of the whales present in both years were identified in the area in late July both years. These were Two Dot Star and Friend, the latter being present only in late July and early August both years.

Some whales appear to have preferred areas, at least preferred locations in particular areas. Although most, if not all, whales left the study area sometime during the summer, when present, an individual was often more likely to be in one area than another. Blackjack was only seen in Ahous Bay over the two summers (16/16 sightings) and Dots was in Ahous Bay 9 of 12 sightings (3 in Wickaninnish Bay). The Little Vargas whales (2) identified in 1975 were only seen in Ahous Bay (6/6 times for one and 5/5 times for the other). Other whales like Whitepatch and Orange Scar appear to prefer Wickaninnish Bay when in the study area, having only been sighted there (Whitepatch 27/27 times, Orange Scar 18/18 times). Two Dot Star has been sighted 30 times over the two years,

17 in Wickaninnish Bay, 2 in Chestermans Beach, 4 in Ahous Bay and 7 times elsewhere; McKenzie has been sighted 26 times in the past two years, 21 times in Wickaninnish Bay, 4 times in Chestermans Beach and 1 time in Ahous Bay; Saddle has been sighted 25 times, 15 times in Wickaninnish Bay, 5 in Chestermans Bay, 1 in Ahous Bay and 4 elsewhere. The significance of these apparent preferences is unknown.

The general pattern of 'rare' and 'regular' whales and the possibility of preferred locations suggests a major individual variation in summer range characteristics.

Summer Range

Data on the varying abundance of whales during the summer, and individual times of presence, absence, and/or movements clearly indicate that the range of most if not all the study whales extends outside the arbitrary limits of the study area. Counts of whales made in any or all locations varied over the summers, often day-to-day, and in Wickaninnish Bay a continuing turnover of animals is apparent with some leaving, others appearing, and still others returning after periods of absence. Whales are shown to come and go from Ahous Bay. Whales absent from one location were rarely seen in another location inside the study area. Two questions arise regarding summer range: size, and individual variation.

The minimum range may be quite small. There are no conclusive records of an individual whale spending the entire summer in one bay or within the area of study, however a

possibility exists that some 'small' (young) whales might. This is further discussed below. Also some large whales may spend up to several months in the study area (McKenzie, 1976, 80+ days; Whitepatch, 1976, 50+ days; Orange Scar, 1975, 80+ days) (Fig. 18 and 19).

The maximum range is unknown. What is known is that identified whales leave the study area for periods of a few days to several months. It is possible that long absences are not correlated with extensive movements but rather with longer periods of residence close by. Summer locals known from Wickaninnish Bay are known to travel at least as far as the southeast corner of Flores Island (Flores on May 28, 1975), at least as far as Rafael Point, Flores Island (9 of 13 whales on September 9, 1976) and at least as far as the Kanim Lake area (Two Dot Star on July 27 and 28, 1976). The Kanim Lake sighting is the furthest of an identified whale from Wickaninnish Bay, approximately 40 mi. (64 km.) distant. At the time of this sighting only two whales were in Wickaninnish Bay; one a summer local and one unidentified. The location of 33 other whales considered summer locals that year (1976) was not discovered.

Gray whales have been sighted during the summer months in other areas along the Vancouver Island coastline from Tsusiat Falls approximately 20 mi. (32 km.) southeast of Barkley Sound to Cape Scott at its northern tip (approximately 225 mi. or 362 km. one from the other) (Table 15, Fig. 29). Also Carl

Table 15. Summer sightings of gray whales on the Vancouver Island coast, not in the study area.

Location	Date	Number
SOUTHEAST OF THE STUDY AREA		
Pachena Bay-Point	June 19, 1975	1 (B. Bach)[1]
	August 9, 1975	1
	August 21, 1976	1
West Coast Trail:		
Tsusiat Falls to Tsuquadra Point	July 20, 1975	several (B. Bach)
Pachena to Klanawa River	July 25, 1975	several (B. Bach)
Michigan Creek	August 2, 1975	2 (B. Bach)
Pachena to Flat Rocks	August 3, 1975	several (B. Bach)
Tsusiat to Pachena	August 16, 1975	several (B. Bach)[2]
Klanawa River area	Sept 19-22, 1975	1 (B. McIntyre)
Victoria	June-Nov. 1967	1 (Carl, 1967)
NORTHWEST OF THE STUDY AREA		
Flores Island-Rafael Point	May 28, 1975	2
	May 17, 1976	3
	May 21, 1976	1
(July 15/76-no whales present)	July 23, 1976	1 (D. Banks)[3]
	Sept 8, 1976	3
	Sept 9, 1976	13
Kanim Lake area	July 20, 1976	1 (D. Banks)
	July 27, 1976	1
(Aug 5/76-no whales present)	July 28, 1976	2
Estevan Point	July 20, 1975	1 (A. Oliver)[4]
	July 30, 1976	2 (J. Hudnall)[5]
	August 5, 1976	2
(On September 3, 1976 a fisherman reported that a lightkeeper had told him he had been seeing 15 gray whales each day in Barchester Bay just north of Estevan Point.)		
Tatchu Point	July 19, 1975	1 (A. Oliver)
	July 16, 1975	3 (I. Campbell)[6]
	August 5, 1976	1
Cape Scott	Sept 10-11, 1975	3 (lightstation keeper)

[1] B. Bach - sightings via the Park Warden Service, Pacific Rim National Park.

[2] B. McIntyre - pers. comm., 1976

[3] D. Banks - pers. comm., 1976

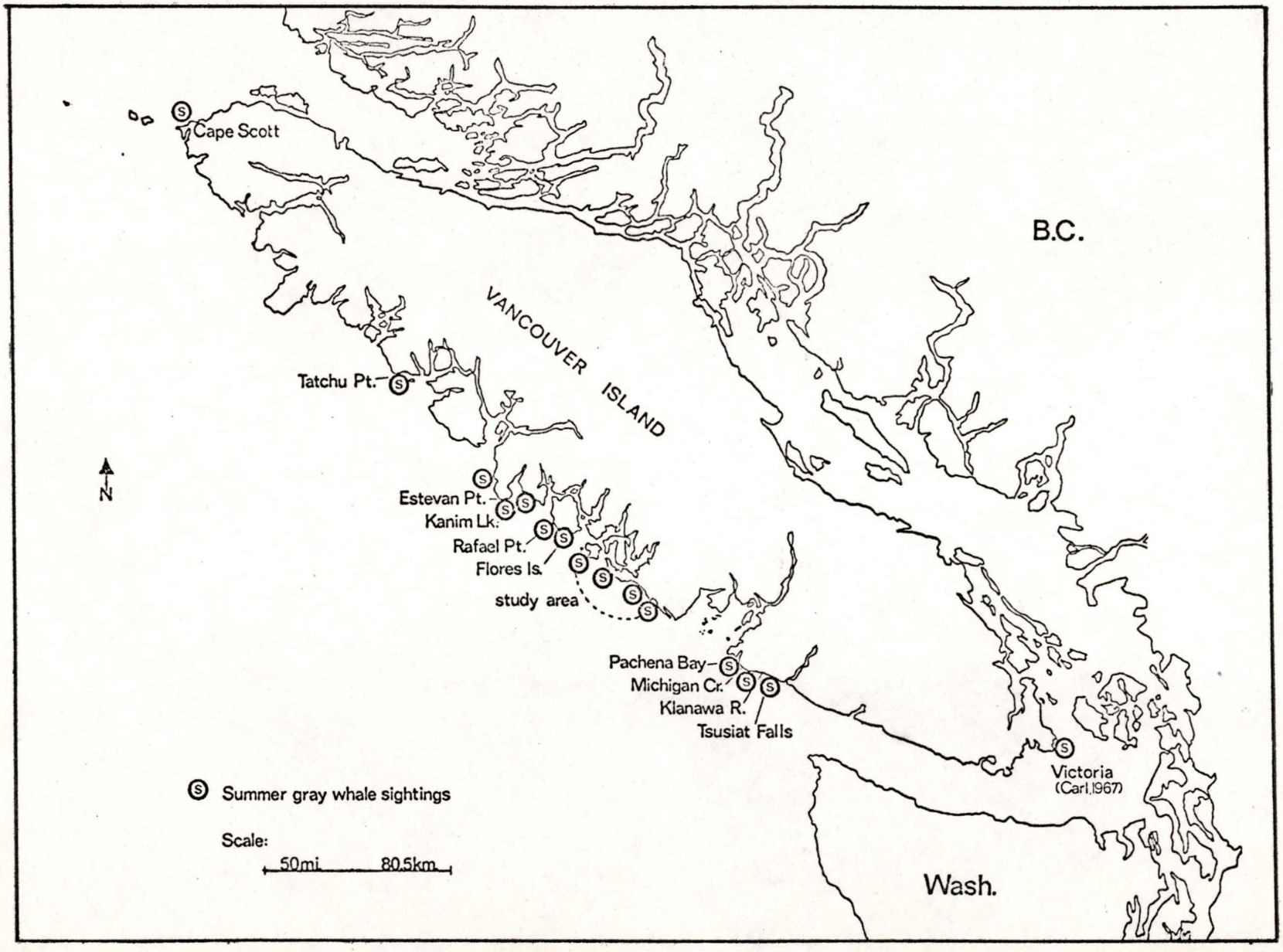
[4] A. Oliver - pers. comm., 1975

[5] J. Hudnall - pers. comm., 1976

[6] I. Campbell - pers. comm., 1976

Fig. 29 Locations of summer gray whale sightings along Vancouver Island's west coast.

(All sightings were in 1975 and 1976 except the one off Victoria; Carl, 1967).


Cape Scott
B.C.
VANCOUVER ISLAND
Tatchu Pt.
N
Estevan Pt.
Kanim Lk.
Rafael Pt.
Flores Is.
study area
Pachena Bay
Michigan Cr.
Klanawa R.
Tsusiat Falls
Victoria
(Carl,1967)
Summer gray whale sightings
Scale:
50mi
80.5km
Wash.

(1967) reports one gray whale apparently summering off Victoria. Areas, other than the study area, where whales have been sighted are: along the West Coast Trail from Tsusiat Falls to Pachena Bay, on the outside of Flores Island, in the Kanim Lake area between Hot Springs Cove and Estevan Point, off Estevan Point, near Tatchu Point at the entrance to Esperanza Inlet and off Cape Scott (Fig. 29). The numbers rarely exceed 3 at any one sighting, the exception being the 13 off Rafael Point, Flores Island on September 9, 1976 (also a report of about 15 near Estevan Point about a week earlier were probably the same group). These sightings are spread out over a relatively long time each year and it would easily be possible for the same whales to be sighted in different locations. Therefore the numbers in Table 15 are not an indication of numbers of whales along the coast, outside the study area. The whales sighted elsewhere on the island's coast are not necessarily the 'missing' study area whales as evidenced in cases where identification has been possible. On August 9, 1975 and August 21, 1976 at Pachena Point, neither whale had ever been seen in the study area and on September 9, 1976 at Rafael Point 4 of the 13 were 'new' whales.

Circumstantial evidence, discussed in the section on movements, suggests that range size may vary from whale to whale. The evidence is this: at least some whales appear to have preferred areas within the study area, Ahous Bay over Wickaninnish Bay or the reverse; individual whales which returned to the study area over two summers could be separated

into those seen regularly or rarely, many of the whales falling into the same category both years; some of these have been seen only early and late in the summers; some whales are only seen outside the study area suggesting their range is different than those ranging through it. Further to the discussion on preferred areas, several small whales have been present on the island coast both summers (see Age, below). The two whales sighted near Pachena Point were both small (two different whales in exactly the same kelp bed over two years). Two small whales (Little Vargas I, Little Vargas II) are known to have spent at least part and possibly all the summer of 1975 in Ahous Bay. Possibly younger whales maintain a smaller summer range than larger, older whales. One other smaller whale discussed below in the section on age, was sighted near Portland Point on July 13, 1976, in Schooner Cove on July 14, in Wickaninnish Bay on July 18, was not seen again until August 6 off Portland Point, August 10 off Radar Beach and August 12 in Schooner Cove and then not seen again. This whale remained in an area not frequented by most whales and was present when most whales were not (late July and early August).

If these differences in presence, absence and position of whales are more than random occurrences, they suggest that some whales spend the summer in different areas, travelling over different ranges and exhibiting different degrees of localness.

iii) Summary

1. At least 65% (17 of 26) of whales present during the summer of 1975 returned to or near the area in 1976. Two whales have been seen over six summers. One of these from 1970-1975 but not in 1976; the significance of this is unknown. One other whale was seen over 5 summers, two over 3 summers and the remainder over 2 summers.

2. During the summer whales travelled into, within, out of, and outside the study area. Some whales identified in the study area have been found elsewhere on the coast, others were seen outside the study area. Most travel appears to be between feeding areas. Routes generally follow the coastline closely. Whales may travel in pairs and trios as well as alone and travel may range from patterns that are slow and 'wandering' to quick and direct. Whales may spend as little as 2-3 days in one area then move to another (as many as 4 destinations in one week) or remain in one bay for 3 months or more. Travel is not necessarily from one feeding area to the next along the coast and travelling whales may bypass feeding whales enroute. In other cases whales may stop and feed wherever food is available.

3. Seasonal patterns were apparent. Some whales were seen only early and late during the summer. Whales present both summers could be divided into those seen rarely or regularly and all but 3 of 17 fell into the same category each year. The rare whales were seen early and late or

just early or late or in one case only in mid-summer each year. The regular whales were generally seen either side of the mid-summer period. Besides suggesting the existence of preferred areas, these patterns may indicate a difference in individual range characteristics.

4. The size of the summer range is unknown. Gray whales have been sighted along most of the Vancouver Island coastline in the summer as well as in the Queen Charlottes and on the Washington and Oregon coasts. It is possible that some whales range further than others; and that small (young) whales maintain a small range for at least part of the summer.

4) Population Structure

i. Age

Rice and Wolman (1971) have estimated age in dead gray whales by examining the number of growth layers in the ear plugs, corpora albicantia in the ovaries and growth zones in the baleen plates. These authors concluded that: growth layers in the ear plugs have limited use for age determination in the gray whale because of uncertainty in counting them, because not all individuals have readable plugs and that they provide a minimum age estimate because laminae produced early in life may disappear in older whales. The number of corpora in the ovaries appears to be a more reliable method in adult females and growth zones in the baleen plates are of little use in age determination because of the rapid wear

on the plates. Rice and Wolman (1971) have analyzed their sample of 316 gray whales by one or more of these methods and have correlated their estimates of age with length.

Age can be estimated in living whales by measuring their length, and if available, comparing it with known age length correlations. If age-length correlations are not available records of calf lengths, yearling lengths and adult lengths can be built up and measured whales whose age status is not known compared with these. Some whales can be placed into broad age categories by behaviours, such as a female with calf, or by some sexual activities.

Rice and Wolman (1971) determined there was no significant difference between the sexes in body length of near term fetuses but females grow more rapidly after birth and are larger on the average than males at any given age. This is true for all other species of baleen whales. According to these authors the mean length of gray whales at birth in January is about 4.9 meters, calves grow to a mean length of about 8.5 meters at weaning in August and to 9.3 meters by the following winter. Rice and Wolman (1971) further conclude that with the first year's growth of 90% of size at birth the females attain 66% of their ultimate body length and males 72%. The growth rate drops to 7% during the second year and continues to decline in subsequent years. The mean length at puberty is 11.1 meters in males (10.56 m. - 11.75 m.) and 11.7 meters in females (10.92 m. - 12.92 m.) and is reached at a mean age of 8 years

(5-11 years). The mean length at physical maturity is 13 meters in males and 14.1 meters in females at a mean age of about 40 years (Rice and Wolman, 1971).

Lengths of the study whales were determined by a photogrammetry technique whereby a disk 1 meter in diameter in a boat next to the whale was photographed (Fig. 30). This procedure was developed by Whitehead and Payne (1976) for measuring southern right whales, Eubalaena australis, and is described in the Methods. During 1976, five attempts led to three successful measurements. Three variations of the photogrammetry technique are discussed by Whitehead and Payne (1976); two of the three were used. The first experimented with by these authors is the analysis of photographs containing both the disk and the whale but only when the whale is perpendicular to the line joining it and the camera. If the disk is not horizontal, as was the case in two measurements we made, the whale must be in this orientation to the camera to avoid foreshortening problems which cannot be compensated for. The length of the whale is then calculated by comparing the measured length of the photograph to that of the maximum diameter of the disk. A correction factor has been worked out by Whitehead and Payne (1976) and is applied in cases where the distance camera to whale and camera to disk are different. The length of the whale (L) is given by:

$$L = l/u \left[1 \pm h/v\sqrt{(u/s)^2 - 1}\right] \text{ meters}$$

using a + (plus) sign if the whale is further than the disk

Fig. 30 An aerial photograph of a whale and measuring disk.

from the camera and a - (minus) sign if the whale is closer to the camera than the disk.

lmm = measured length of whale on the negative.
umm = measured maximum diameter of disk on negative.
hmm = measured distance from center of whale to center of disk on negative
umm = image distance of camera lens
smm = measured diameter of disk which, when extended, passes through center of whale.

The correction factor and theoretical errors are discussed in Appendix II. Whitehead and Payne (1976) calculated a theoretical error of about 3% for measurements determined by this technique.

The lengths of Mole, and one unidentified whale were determined in this way. The whale called Mole was 7.7 $\pm$ .23 meters long, and the unidentified animal 9.2 $\pm$ .27 meters in length. The second variation of the technique is usable under conditions when the disk is held horizontal during the measuring. Any dimension of the whale can be obtained by simply measuring it against whatever diameter of the disk was parallel to it. (A disk shows a correctly foreshortened diameter for measuring any line parallel to the chosen diameter and in the same plane as the disk). In one case in measuring the study whales, when the photograph obtained did not show the whale, perpendicular to a line joining it and the camera, the disk was horizontal therefore the animal's length could be calculated. This whale's length was 12.5 $\pm$ .37 meters.

The third variation of the photogrammetry technique discussed by Whitehead and Payne (1976) is the use of parallel whales. If a whale of known size is swimming parallel to another whale then the length of the latter can be determined by comparison. This technique has not been used to date.

The small whale (7.7 $\pm$ .23 meters) is well below the mean length at one year (9.3 meters) and below the mean length at weaning (8.5 m) given by Rice and Wolman (1971) (Table 16). The whale had apparently recently been weaned and was either left in or found its way into the study area. At no time was it accompanied by another larger whale, or any whale which might have been its mother, therefore was apparently weaned by the middle of July. Assuming it was born by mid-January, it was weaned within 7 months; this less than Rice and Wolman's estimate of weaning at 8 months and possibly explaining its smaller than mean weaned size. This whale was covered with scars, and had what appeared to be a deformed back, almost a hunch-back, possibly having been attacked by killer whales. On first sighting, this whale was noted as 'small' and the measurement provides substantiation of that description. There is a poss-ibility that this injured whale was older than its size indicated; the injury having affected its normal growth. Other 'small' (uninjured) whales have been noted in the study area in both 1975 and 1976 and described as such. As discussed in the previous section, 2 conspicuously smaller whales were noted in Ahous Bay through the summer of 1975. On June 23,

Table 16. Calculated length of study area whales and their probable age class (as determined by Rice and Wolman, 1971).

Whale	Date Measured	Length ± 3% (meters)	Age Class
Mole	August 12/76	7.7 ± .23	less than 1 year - recently weaned
Unknown	June 28/76	9.2 ± .27	yearling
Unknown	June 27/76	12.5 ± .37	probably an adult, i.e. sexually mature

Statistics from Rice and Wolman (1971):

Mean length at birth:	4.9 meters
Mean length at weaning (approx. 8 mo.):	8.5 meters
Mean length at one year:	9.3 meters
Mean length at puberty (5-11 years; 8 years):	
males: (10.56-11.75m)	11.1 meters
females: (10.92-12.92m)	11.7 meters
Mean length at physical maturity (approx. 40 years):	
males:	13 meters
females:	14.1 meters

and July 19 and 20, 1975, smaller whales were recorded in Wickaninnish Bay (neither identified). The two whales sighted and identified near Pachena Point, one on August 9, 1975 and the other on August 21, 1976 were both obviously smaller whales. Pike and McAskie (1969) report a young gray whale stranded in Wreck Bay on August 16, 1966; it was a male 8.25 m (27 ft.) in length. It appears whales recently weaned are present on the Vancouver Island coast at least in July and August and probably (although the whales have not been measured) in June, September and October. How they arrive in these locatios and what their relationship is to the other whales is not known. The only cows with calves seen in 1975 and 1976 were in May and June and

were apparently migrating (see Cows with Calves). Of the calves identified with cows in the late spring and early summer, none were those seen later, alone, in or near the study area.

One whale (unidentified) measured was 9.2 $\pm$ .27 meters long and, since Rice and Wolman give 9.3 meters as the average length of a yearling, was probably that age (Table 16).

The third measured whale was 12.5 $\pm$ .37 meters in length. This was either an adult male or female well over the mean length of 11.1 meters for males and 11.7 meters for females given by Rice and Wolman (1971) for length at puberty. It could possibly have been an older, immature female since the range of length given by Rice and Wolman (1971) for that age category is from 10.92 - 12.92 meters (Table 16).

The largest whales classed as summer locals have not yet been measured. As one is able to notice an obviously smaller animal, the same is true for a particularly large animal.

Minimum ages can be deduced from the number of years a whale has been seen in the area. Orange Scar and Speckles were at least six years of age (1970-1975 and 1971-1976 respectively) and Whitepatch was at least five years old (1972-1976).

A larger sample size is necessary to draw any conclusions as to the age make-up of the population. It is apparent that different aged whales are present in the study area during the summer, some very young, some juvenile, and some older.

ii. Sex

None of the summering whales have been sexed. In 1975, some effort was made to obtain small skin samples, the cells of which would be histologically searched for sex chromatin bodies and hence sex determined on a cellular level (Winn et al. 1973). However, a satisfactory method of obtaining a skin sample was not developed. A scraping device on the end of a long pole was found to be impractical. Winn et al. (1973) successfully obtained small skin samples by shooting a biopsy dark from a gun or crossbow into the animal; with no harm to the whale. This method was not attempted.

In 1976, it was hoped that at least a few whales could be sexed by sight or behaviour. If a whale rolls it is possible to tell sex by the arrangement of urogenital openings and/or mammary slits. Whales do occasionally roll over in the study area, but usually quickly and to catch a glimpse of the underside much less take a photograph requires a lot of luck. In the calving and mating lagoons (when most activities are sexual or birth orientated) sexing by behaviour is somewhat easier than in feeding grounds.

During the northern migration males involved in sexual play with erected penes and cows with calves have been observed in Wickaninnish Bay. In the summer months, with whales considered summer locals no such pair behaviour was observed. Hatler and Darling (1974) report a cow with calf spending most of summer 1971 in Wickaninnish Bay and two probable cow-calf sightings in

late June and July, 1972. The whale which washed in on Wreck Bay August 16, 1966 was a male (Pike and McAskie, 1969) therefore at least both sexes have been recorded in the area in the summer.

iii. Summary

1. Of the three whales measured in 1976, one was 7.7 $\pm$ .23 meters in length and apparently recently weaned (approx. 7 months old), one was 9.2 $\pm$ .27 meters and likely a yearling, and one was 12.5 $\pm$ .37 meters, probably an adult (possibly a sexually immature female). Other 'small' whales have been recorded in the study area and nearby and were possibly also less than a year old, as is the one discussed above. The largest animals considered summer locals have not yet been measured. Different aged whales are present in the study area during the summer months.

2. None of the whales considered summer locals have been sexed. Cows with calves have been reported in the study area during the summers of 1971 and 1972, and a young male was found stranded at Wreck Bay in August, 1966, indicating both sexes have been present in the study area in the summer months (Hatler and Darling, 1974; Pike and McAskie, 1969).

5) Behaviours

Following are descriptions of behaviours observed off Vancouver Island during the summer months. The descriptions

are qualitative and for the most part superficial. In-depth behavioural study was not attempted in this research. With these few data interpretation of the behaviours is tentative. Further investigation into the behaviours will require the use of methods which do not disturb the animal (i.e. spotting scope from land) and, quantitative observation.

Two behaviours often described in the literature are breaching when the whale leaps 2/3 or more out of the water and lands on its side or back, and spy-hopping when the whale rises head first from the water so as its eyes are above or just below the surface (Figs. 31A and 31B). These occasionally occur during the summer but not regularly. Breaching has been interpreted as a release of excess energy, or used for rubbing barnacles and whale lice off, or perhaps communication in some species (Gilmore, 1961; Payne, pers. comm., 1976). Spy-hopping is generally interpreted as a deliberate visual survey by the whale (Gilmore, 1960a; Payne, pers. comm., 1976). Both behaviours are described below within longer behavioural sequences. Perhaps the purpose of the breach or spy-hop differs with the context in which it is performed.

i. Feeding and Food

The most common activity of the whales which summer on the Vancouver Island coast is feeding. Gray whales are probably unique amongst baleen whales in that they are mainly, if not exclusively, bottom feeders (Rice and Wolman, 1971). The relatively shallow (<15 meters) sandy bays along the coast are

Fig. 31 Behaviours.

A. Spyhopping.

B. Breaching.


A


B

apparently suitable feeding grounds. Feeding gray whales showed a general feeding behaviour as follows. In water which is 2-15 meters deep, a whale would blow 2-5 times, remaining almost stationary, moving in a semi-circle, or moving slowly in one direction, then arch its back and dive. Rarely were the tail flukes exposed in Wickaninnish Bay where the water is relatively shallow (5-10 meters), however in deeper areas the flukes were often raised out of the water on diving. After 2-5 minutes the whale surfaced again close to the same spot it went down, and on the first blow sand was seen streaming from either side of its mouth, apparently forced through its baleen. It is almost certain that whales which were forcing sand through the sides of their mouth had been feeding on the bottom. This expulsion of sand is obvious from the boat close by the whale and from the plane observation. Whales engaged in this activity may spend hours in the same general location. Hatler and Darling (1972) give a similar description of the feeding.

During the summer, gray whales were observed feeding in Wreck Bay, Wickaninnish Bay, Schooner Cove, Radar Beach, in between Gowlands Rocks and Cox Point, off Cox Point, in the north end of Chestermans Beach, off McKenzie Beach, outside Wickaninnish Island, in Ahous Bay and in Grice Bay (Hatler and Darling, 1974), inside the study area. Also feeding whales were observed southeast of the study area in Pachena Bay and apparently along the West Coast Trail at least as far south as Tsusiat Falls (B. Bach, pers. comm., 1975) and north-

west of the area at Flores Island, near Kanim Lake in between Hot Springs Cove and Estevan Point and off Estevan Point (Fig. 32). Whales sighted at Tatchu Point, and Cape Scott were probably also feeding. Simply, gray whales were likely to be observed feeding almost anywhere along the Vancouver Island coast. In the study area, waters off the beaches in Wickaninnish Bay, Chestermans Beach and Ahous Bay were those most regularly inhabited. It should be noted that Grice Bay in which a whale was observed feeding on October 27, 38 and 29, 1971 is a shallow (3-4 m.) mud bottom bay which is part of the inlet system of protected waters 'behind' Long Beach (Hatler and Darling, 1974) (Fig. 32). It was not uncommon to see feeding gray whales in waters shallower than their length, with half the tail fluke sideways above the surface slicing or waving back and forth (Fig. 33A & 33B). With close observation from boat or plane, detailed feeding behaviour could be observed. On June 8, 1975, April 12, 1975 and July 23, 1976 the following behaviour was observed in water 3-5 meters deep off Chestermans Beach. When on the surface the whale remained fairly stationary blowing 2-3 times then dove and turned to one side to descend headfirst and sideways much like a fighter plane. The whale rested the side of its head and mouth on the bottom and the remainder of its body was on an angle towards the surface, such that if the water was shallow enough, half the tail fluke showed. There was no forward movement when in this position, but the flukes and pectoral fins were waving, seemingly to maintain the

Fig. 32 Areas in and near the study area in which gray whales have been observed feeding.

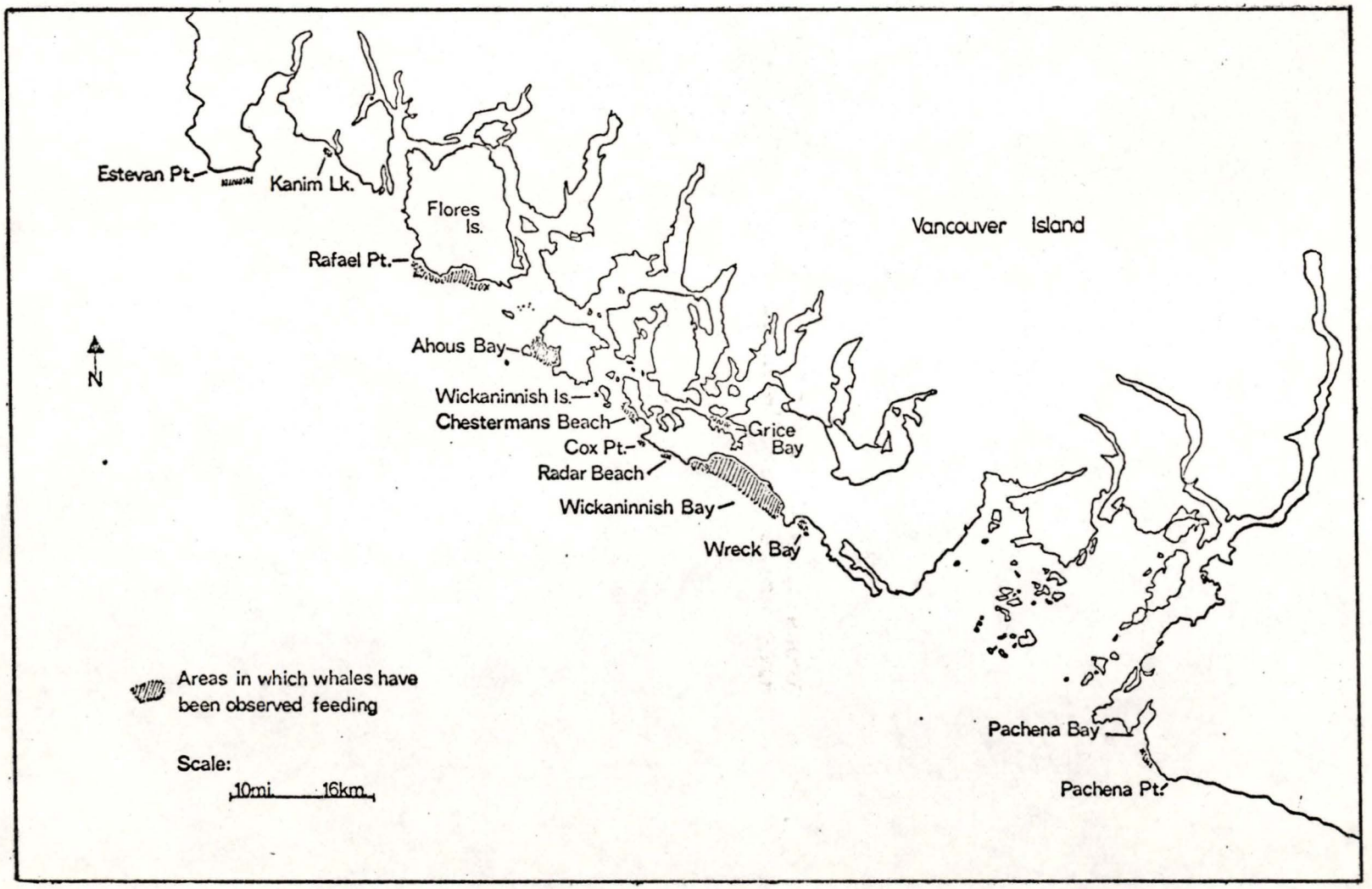

Estevan Pt.
Kanim Lk.
Flores Is.
Rafael Pt.
Vancouver Island
N
Ahous Bay
Wickaninnish Is.
Chestermans Beach
Cox Pt.
Radar Beach
Wickaninnish Bay
Wreck Bay
Grice Bay
Areas in which whales have been observed feeding
Scale:
10mi 16km
Pachena Bay
Pachena Pt.

Fig. 33 Feeding gray whales.

A. A gray whale feeding in 1-2 meters of water in Ahous Bay. The whale is on its side and the pectoral fin and tip of the fluke is showing above the surface (photograph by J. Ford).

B. Two whales feeding in 3-6 meters of water off Chestermans Beach. Half the fluke of one is above the surface; its head would be on the sandy bottom. The other is breathing, 'in between' mouthfuls.


A


B

posture and to keep the side of the head flush with the sand. Also the whale's head moved back and forth slightly. After 2-5 minutes the whale surfaced and on the first blow, sand and water was flushed from the baleen. Whatever was not pressured out through the baleen was probably swallowed. The whale then repeated this behaviour.

On two occasions whales were observed feeding in very shallow water 2-3 meters deep in Ahous Bay, May 14, 1976 from the boat and June 7, 1976 from the air. On May 14, 3 whales were in water so shallow that one whale lying on its side on the bottom had its upper side, pectoral fin and tail fluke exposed before it wriggled into slightly deeper water (Fig. 33A). These whales were consistently observed on their sides, apparently with one side of the mouth on the bottom in the 35 minutes they remained in the shallows. On June 7 two whales were feeding in slightly deeper water but shallow enough so that the activities could be seen clearly from the air. Shown in Fig. 34A-D is sequence of a whale lying on its side, with part of tail fluke above the surface, the tail stock and fluke moving back and forth, then the whale in an upright position having ejected the sand from the sides of its mouth. The plane circled at the time the sand actually was being expelled so there is a gap in the sequence.

Ray and Schevill (1974) describe the feeding of a young female gray whale held in captivity:

Fig. 34 Aerial photographs of a feeding gray whale.

A & B The whale, in 2-3 meters of water, has rolled on its side and its head is resting on the sandy bottom. Its tail fluke is sculling back and forth.

C. Still with the side of its head on the bottom half the fluke is above the surface as in Fig. 33.

D. In a gap in the sequence, when the plane circled, the whale righted itself and from the sides of its mouth released the cloud of sand (seen behind it).


A


B


C


D

> First the whale rolls over far enough so that the cheek is about parallel with the bottom, and its lip is opened as the tongue, pressing against the palate, pushes the gular region away so that it expands, producing an inflow which brings in the epibenthic food. Then the tongue relaxes and the gular musculature tightens, reducing the size of the mouth cavity and expelling water; the food is trapped in the baleen fringes. We do not know exactly what happens next; perhaps a slight renewed suction of the water removes the food from the baleen fringes, and swallowing presumably follows.

This description corresponds well with the observations in the wild. Since no gouging or digging was observed, the whale probably sucks in a mouthful of sand and its contents, and then the sand is expelled, as Ray and Schevill (1974) describe, with the water. The sand forced through the baleen is under considerable pressure; it almost shoots out.

Walker (1971), in a National Geographic article, described gray whales feeding in the calving lagoons by plowing the bottom; the lower jaw serving as a scoop. This behaviour was not observed in this study as no forward movement was a characteristic of the feeding whales. Rice and Wolman (1971) suggest they might stir up the bottom sediments with their snouts, then filter the turbid water immediately above the bottom. It seems that if this was the case the amount of sand consistently seen expelled from the whale's mouth on surfacing, in our observations, would not be collected. Wilke and Fiscus (1961) describe feeding whales in the Chukchi Sea

as making a large muddy blotch on the water as they come to the surface to blow, and surmise that in feeding on the bottom the whales gathered mud along with their food and were expelling it through their baleen as they rose to the surface. It is likely the gray whales have more than one method of feeding and the description above is that most commonly observed in the study area. It is not known for how long a period of time a whale will feed. Day-long periods of active feeding were not uncommon and on one night spent with the whales in Ahous Bay (September 20 - 21, 1975) the characteristic 'feeding' blow-dive rhythm continued throughout, although it was too dark to see if any sand was expelled.

It is apparent from observations described above and from Rice and Wolman's (1971), Pike's (1962), Zenkovich's (1934a, 1934b, 1937c), and Tomlin's (1937) (the latter two reported in Rice and Wolman, 1971) examinations of stomach contents of gray whales in the Bering and Chukchi Seas that they feed primarily on infaunal benthic species. The largest percentage of the stomach's contents reported by all the investigators were gammaridean amphipods (95% of Rice and Wolman's 1971 sample) particularly Ampelisca macrocephala. Other amphipods included Ampelisca eschrichti and Aronyx nugax in Pike's (1962) examination and Atylus carinatus in Zenkovich's (1934a, 1934b, 1937c) and Tomlin's (1937) whales. Other species reported in the stomach are bottom-dwelling isopods, mysids (Mysis oculata), mollusks (Buccinum sp.), polychaetes (Travisia forbesi) and

hydroids (Sertularidae) by Zenkovich (1934a, 1934b, 1937c) and Tomlin (1937); decapod crustaceans (including Chionoecetes baudi, Hyas coartius and Liocyma fluctuosa), cumaceans, polychaetes (Pectinaria sp.), tubes, gastropods, and ascidians by Pike (1962); and cumaceans, an unidentified polychaete tube, and unidentified holothurian and tunicates by Rice and Wolman (1971). A quantity of extraneous material was also found in the stomachs of the examined whales including sand, silt, bits of wood, pebbles, and kelp frond fragments. Howell and Huey (1930) found Euphausia pacifica in the baleen of a gray whale killed in northern California on July 21, 1926 but they did not examine the stomach.

Although no stomachs have been examined in the study area, and no exhaustive benthic survey has been attempted, the most obvious feature of the study area's infauna is a tube dwelling polychaete worm, Onuphis elegans. In areas of Wickaninnish Bay and Chestermans Beach which have been examined, the worm tubes literally cover the bottom extending 2-3 inches out of the sand. At low tide on Chestermans Beach several of these worms were collected and identified (by K. Hobson, pers. comm., 1975) (Fig. 35).

Other benthic worms collected in the area included Arenicola sp., Scolelepsis sp. and Nephtys californiensis; also amphipods (Orchestoidea californiana), shrimp (Crangon sp.), and mollusks, particularly Siligua patula (razor clams) and Olivella biplicata (purple olive shells) were found in the

Fig. 35 Probable food of the gray whales.

A. Worm tubes extending from a sandy bottom.

B. A portion of the polychaete worm, Onuphis elegans, in its tube.


A


B

benthos.

Onuphis elegans is a relatively large carnivorous worm up to 350 mm long and 8 mm wide, and is found in subtidal zones from California to Vancouver Island (Pettibone, 1963; Berkeley and Berkeley, 1948). Broken tubes of this species wash in on Long Beach in large quantities. A 20 mm long portion of one of these worms was found squirming on the surface in the exact area a whale was feeding in shallow water off Chestermans Beach on June 8, 1975. Rice and Wolman (1971) suggest that because so few polychaete worms and molluscs, which are usually dominant in the infauna, are found in the stomachs of whales examined in the Arctic that the gray whales are selective feeders. They further suggest, as discussed above, that the whales might stir up the bottom sediments with their snouts, then filter the turbid water immediately above the body from which the heavier molluscs have settled out, and that the worms presumably retreat deep into their tubes and burrows, whereas the amphipods swimming freely are trapped in the baleen plates. There is no evidence that gray whales actually swallow the predominant worms in the study area benthos, however, if suction is used, which seems probable, to obtain a mouthful of the bottom perhaps worms are sucked in with or from their tubes. It seems the whales could not avoid eating these worms (Onuphis elegans), along with other infaunal species, considering their density in at least some of the feeding areas. If this worm is the major food of the Vancouver Island gray whales,

it is interesting to note that whales in the Arctic are depending on an entirely different food source; gammaridean amphipods (Rice and Wolman, 1971).

ii. Tidal Rip Behaviour

At the seaward entrance to Duffin Passage and Tofino Harbour, adjacent to Tonquin Beach, a tidal rip occurs with each tidal change to and from the extensive inlet system 'inland' from this location (Figs. 36A-C). In this area a significant sill or sand bar winds off Tonquin Beach out into the channel (Figure 36A). The position of the sill is obvious during ebb or flood tides from the turbulence waves caused by the water flow over it (Figure 36C). During periods of slack tide there is no turbulence. Over the sill the water is approximately 3-4 meters deep at low tide whereas on either side it is approximately 6-8 meters deep.

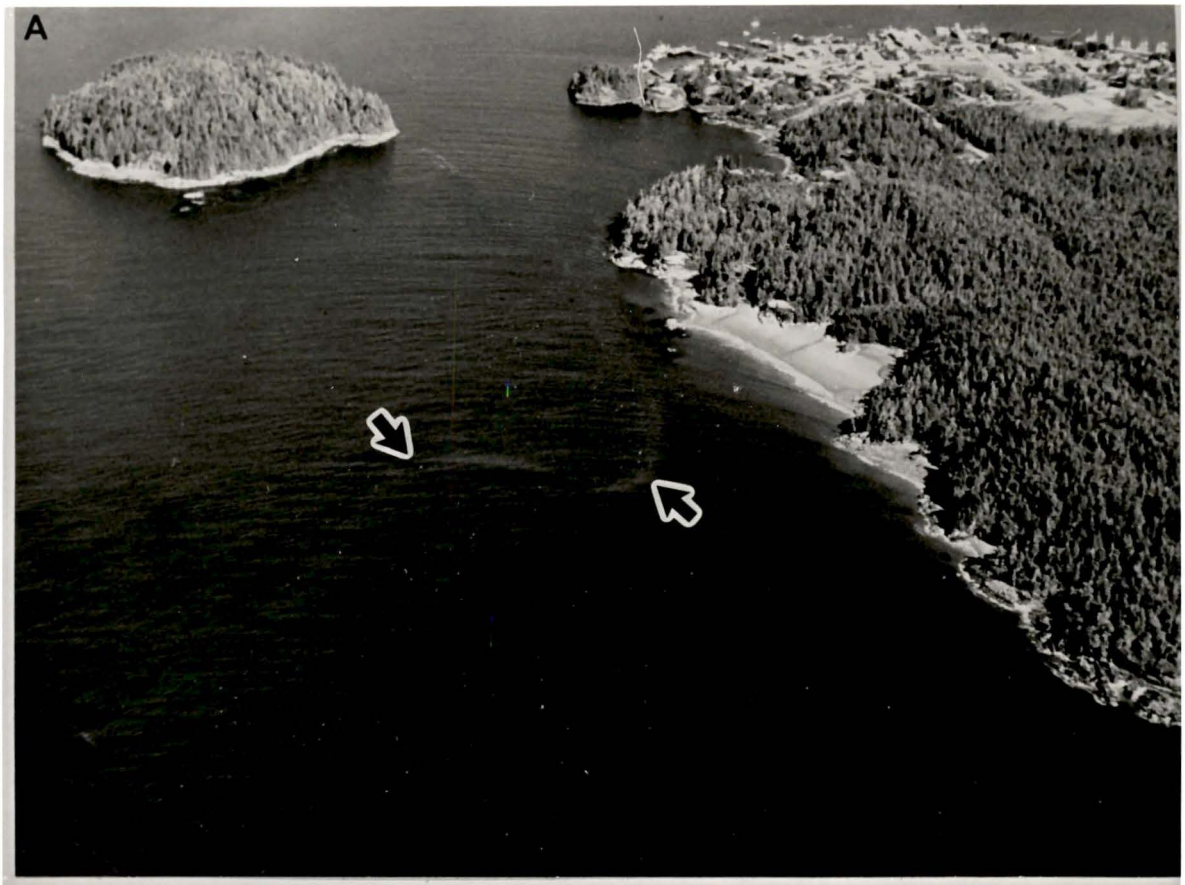
This tidal rip-sill area is popular with the gray whales. Table 17 gives the recorded sightings of whales in this area in 1975 and 1976. The behaviour of the whales there is somewhat stereotyped and different from any other witnessed in the study area. The whales were usually just to one side of the turbulence waves, apparently to the seaward side on an incoming tide and were, on the only occasion sighted on an outgoing tide on the opposite (harbour) side. Whales seemed to stop the behaviour and leave the area when the tide slackened and consequently the turbulence diminished. The following activities were generally observed.

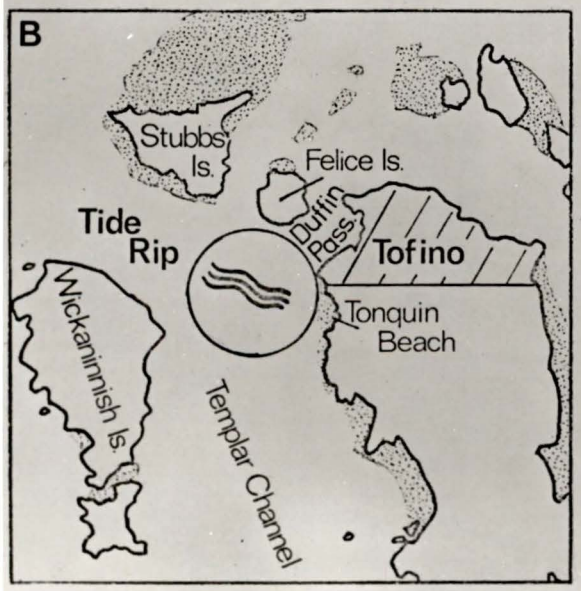
Fig. 36 Tidal Rip near Tofino (in Duffin Passage).

A. Aerial photograph of the tidal rip area showing the sand bar (arrows).

B. Location of the tidal rip area.

C. Surface turbulence caused by the tide running over the sand bar.


A


B
Stubbs Is.
Felice Is.
Duffin Pass
Tofino
Tide Rip
Tonquin Beach
Wickaninnish Is.
Templar Channel

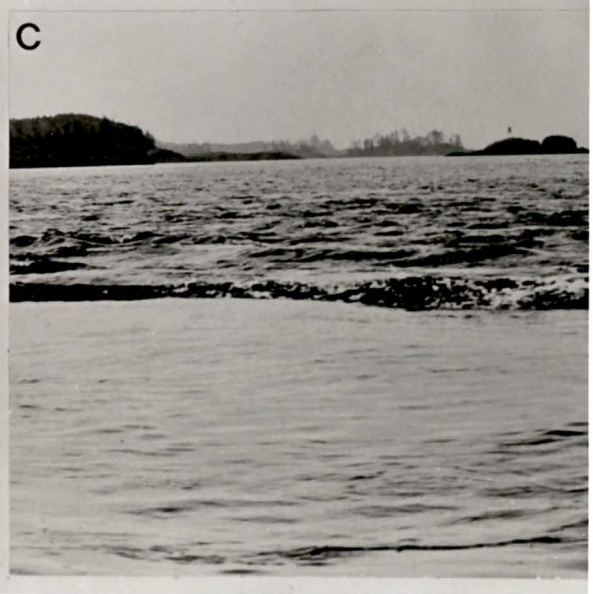

C

Table 17. Sightings of gray whales in the tidal rip at the seaward entrance to Duffin Passage, 1975-1976.

Date	Time	Tide Flow	Position Relative to Turbulence	Number	Whales
Apr 8/75	0700-0730	incoming	not recorded	1	-
June 6/75	0930-0955	incoming	seaward	1	Streak**
June 12/75	0745-0800	outgoing	harbor side	3	Streak Saddle* Two Dot Star
Apr 13/76	1005-1040	incoming	seaward	3	-
June 27/76[1]	am	incoming	not recorded	1	-
Aug 28/76	? -1230	incoming	seaward	1	Rip

*seen departing area
**seen arriving and departing area

[1]Sighting by D. Palfrey (pers. comm., 1976).

1. The whale would blow once or twice normally then sink down. On next sighting, a few moments later, the whale would have rolled over, so its ventral side was up, the throat grooves on the underside of the head and sometimes the distal end of a pectoral fin above the surface, as it propelled itself forward. Usually the whale was at an angle such that its head was higher than the remainder of its body and above water, its length behind its pectoral fins below water. After moments in this posture the whale would roll over and blow again (Fig. 37A-C).

Fig. 37 Behaviours of the gray whales in the tidal rip.

A. Head out of the water, this whale is moving to the right and 'falling' to the position of swimming on its back as in B.

B. The whale is swimming on its back (ventral surface up) with throat grooves and one pectoral fin exposed.

C. Pectoral fin of a whale swimming on its back just below the surface.

D. Having fallen over sideways from a head up position, the whale is swimming on its side.

E & F. Heads well out of the water these whales may be pushing off the bottom with their flukes.


A


B


C


D


E


F

2. A whale would come out of the water head first and either fall over sideways (Fig. 37C-F) then move forward with the side of its head on the surface, or hold the head up position for a few seconds, motionless, then lower it into the water again. Occasionally the whale would 'fall' over backwards from the head up position. Twice on April 13, 1976 a whale may have been pushing off the bottom with its tail flukes, i.e. the whale pushed its head out 2-3 meters above the surface, held it there for several seconds, then rose up higher so its pectoral fins were just out of the water then fell over on its side.

These were the predominant behaviours. Occasionally half of a tail fluke was flailed above the surface but only momentarily. The whales were not below the surface for more than 30 seconds to 1 minute. The behaviours varied in speed from a slow lolling around to quite quick and sudden. Single whales and groups of three were recorded in the area; at least two of each group of three stayed side by side (June 12, 1975; April 13, 1976). Apparently migrants as well as summer locals partake in this activity. The three present on April 13, 1976 were identified and were considered migrant; locals including Saddle, Streak, Two Dot Star and Rip were identified in the area (Table 17).

One observation of the tidal rip behaviour included the whale travelling to and from the area (Streak, June 6, 1975).

Streak was first sighted that morning heading north between Chestermans Beach and McKenzies Beach. This whale made its way to the tidal rip and once alongside immediately rolled belly up, raised its head above the water and continued with the behaviours described above for about 30 minutes. By that time the turbulence had diminished and the whale very slowly cruised southwest in Templar Channel, then circled once, returned to the area where first sighted and began feeding. On June 12, 1975 the three whales, Streak, Saddle and Two Dot Star were followed, once the behaviour was over, slowly, along the southeast shore of Wickaninnish Island, and out between Echachis and Tonquin Islands then were 'lost'. In both cases the departure consisted of a very slow 'relaxed 1 blow-down-1 blow' swim, south down Templar Channel (Fig. 24).

On April 18 and 19, 1976 gray whales were reported in 'the tide rip off Catface coming out head first' (D. Hopkins, pers. comm., 1976). This tidal rip occurs in Calmus Passage between Catface mountain and Vargas Island and apparently the whales perform similarly there.

Hatler and Darling (1974) report one in Duffin Passage on April 30, 1969 and that the late R. Folker had seen gray whales 'rubbing themselves' on a gravel bar at that location several times in the past. 'Rubbing themselves' certainly may be one purpose of the behaviour. The whales did not appear to be feeding or at least no sand or water was observed streaming from the sides of the mouth as was evident during feeding.

Observation to date has been totally opportunistic as the tidal rip area must be passed through on leaving or entering Tofino harbour. From a boat, at close range, with poor visibility into the water, it is difficult to determine what exactly is happening; planned observation is all but impossible as the behaviour does not seem to be a regular occurrence.

iii. Small Whale Behaviour

Small (young) whales exhibited some differences in behaviour to that of the larger (older) summer locals. These differences were subtle and/or relative but generally are sufficient to strike the observer as 'unusual' in comparison to the behaviour of the larger whales. If all the small whales were recently weaned (as at least one apparently was) the variation in the general behaviour is understandable. Further observation is required to determine the purpose of the behaviours and the degree it is affected by the presence of the boat.

Of the five smaller whales identified, 2 were found near Pachena Point, one each year (Pachena I on August 9, 1975 and Pachena II on August 21, 1976), one in the area between Radar Beach and Wickaninnish Bay (Mole in last half of July and first half of August, 1976) and two in Ahous Bay (Little Vargas I, Little Vargas II through the summer of 1975). The Pachena area was reached only one day each year therefore the permanence of the small whales there is unknown. The one present in 1976 remained for at least a week to 10 days after August 21 when it was observed by students taking a Bamfield Marine Station course

on marine mammals (D. Dunn, pers. comm., 1976). Both the Pachena whales and the Mole (sighted first at Portland Point on July 13, Schooner Cove on July 14, Wickaninnish Bay July 18, Portland Point August 6, Radar Beach August 10 and Schooner Cove August 12) were sighted in areas not frequented by larger feeding whales (other than Mole on July 18). The small Ahous Bay whales were often alone in the bay until the end of August, 1975 when between 3-5 other larger animals were regularly present. The small whales, or at least some, appeared to have an affinity for kelp beds (Nereocystis spp.). Both Pachena whales were found in and around the same kelp bed. At one point on August 21, 1976 the whale rose head first from the midst of the kelp, mouth open, with what may have been a piece of kelp draped through it (Fig. 38A). On August 13, 1975 one small whale was found in amongst kelp at the base of some cliffs in Ahous Bay. Kelp fronds have been found in the stomachs of gray whales (Rice and Wolman, 1971), photographs in National Geographic (Scheffer, 1976) show a gray whale with kelp hanging from its mouth, and Payne (pers. comm., 1976) has observed southern right whales, Eubalaena australis, playing with kelp. It is unknown if any nutrition is being derived from this algae.

The observations of the small whales did not always include seeing the discharge of sand through the baleen on surfacing which is characteristic of the other feeding whales. It did occur and possibly the rarity was a result of the whales'

Fig. 38 Behaviours.

A. Young whale in a kelp bed (Nereocystis spp.). The whale is rising out of the water head first with its mouth open and possibly has a piece of kelp draped through it (photograph by C. Dundon).

B. A pair of whales.


A


B

concern about the boat. However, when in the areas apparently not chosen for feeding by the larger whales and/or in kelp beds which would probably have a rocky bottom, the small whales, if feeding, may be feeding in a different manner than that described earlier. If they actually were feeding, the food and how is unknown.

Generally the small whales showed more concern about the presence of the boat than the older whales. Often they were more shy and elusive, but occasionally more inquisitive. Small whales have just swam away when approached (June 30, 1975, Ahous Bay) or kept their distance (July 13, 1976, Portland Point) or reacted as this whale on August 9, 1975 at Pachena Point. The whale spy-hopped on initial sighting kept its distance from the boat for 15-20 minutes, then approached, spied again, altered its direction and swam slowly southwest, allowing us to follow relatively close to its side. Generally the older whales appeared to ignore the boat or at least did not alter their feeding behaviour in any noticeable way. Most of these points are relative, as adult whales were found in apparent marginal feeding areas, in kelp beds, were not necessarily feeding, and occasionally did show interest in the boat. However, if these are all recently weaned animals the variations in behaviour may be significant and have distinct purpose.

iv. Resting Behaviour

Only three sightings of apparent resting whales were

made during this study. Scammon (1869) described whales as lying on the water quite motionless, keeping in one position for an hour or more in the calving lagoons. On April 13, 1976 at Chestermans Beach one whale was observed lying fairly low in the water, just the top of its back above the surface, motionless, with wavelets breaking white over its back and blowing quietly at regular intervals. It seems the low-lying motionless posture and breaking waves are characteristic of an inert whale. One whale was observed from the air lying motionless with little waves breaking over it in a kelp bed off Flores Island on September 12, 1975 (A. Oliver, D. Palfrey, pers. comm., 1975). Another whale seen from the air in Wickaninnish Bay was lying in kelp just below the surface, motionless, on June 28, 1976 (C. Dundon and D. Banks, pers. comm., 1976). The duration of these apparent rest periods is not known. Payne (pers. comm., 1976) has observed southern right whales (Eubalaena australis) apparently 'sleeping' as such for several hours.

v. Social Behaviour

Social behaviours other than the cow-calf relationship and the loose feeding aggregation did occur during the summer months. Sauer (1963) describes apparent sexual activity between gray whales from June through August off St. Lawrence Island in the Bering Sea. Nothing as dramatic or consistent was observed off Vancouver Island. Whales did, however, form pairs and trios, which fed and travelled together, and some behaviours which hint at competition or possibly

courting were observed.

Whales were considered paired when side by side, often close enough for pectoral fins to be touching, blowing and diving simultaneously (Fig. 38B). Trios did not seem to be as close-knit as pairs regarding orientation one to another or in simultaneous movements. Paired whales were a regular occurrence through the summer, feeding and/or travelling together. Trios are not quite as common (Table 18). Another whale might join a pair to make a trio (Saddle and Streak, June 7, 1975 to Saddle, Streak plus Two Dot Star, June 12, 1975) or a member of a trio may leave a pair (Big White, Saddle and Rip, June 23, 1976 to Saddle and Rip, June 29, 1976). Formation of a pair was observed several times, where one of two whales feeding separately approached the other and the two began behaving simultaneously (August 6, 1976, Two Dot Star and Streak). Break-up of the pair was observed on two occasions. On August 6, 1976 Two Dot Star and Streak simply separated after about 20 minutes and began individual feeding rhythms. On June 29, 1976 Saddle and Rip, having been followed from Radar Beach to Wickaninnish Bay as a pair, separated on reaching Wickaninnish Bay with Rip falling behind Saddle and eventually both began to feed in different locations. Duration of the bond apparently lasts from minutes (Two Dot Star and Streak, August 6, 1976) to at least 8 days (Two Dot Star and Saddle, August 8-15, 1975). Whales may change partners in a moment. On initial sighting on May 15, 1976 McKenzie was

Table 18. Pairs and trios of whales 1975-1976.

1975

Date	Pair or Trio
May 26, 1975	Saddle - Whitepatch
May 31, 1975	Whitepatch - McKenzie
June 1, 1975	Whitepatch - Two Dot Star
June 7, 1975	Saddle - Streak
June 12, 1975	Saddle - Streak - Two Dot Star
July 7, 1975	Amo - Slivers
July 22, 1975	Friend - Two Dot Star
August 8, 1975	Saddle - Two Dot Star
August 11, 1975	Saddle - Two Dot Star
August 12, 1975	Saddle - Two Dot Star
August 13, 1975	Saddle - Two Dot Star
August 14, 1975	Saddle - Two Dot Star
August 15, 1975	Saddle - Two Dot Star
August 31, 1975	Two Dot Star - Stranger
September 11, 1975	Two Dot Star - Squirl
September 11, 1975	Two Dot Star - Orange Scar

1976

May 15, 1976	McKenzie - Whitepatch
May 15, 1976	Whitepatch - Two Dot Star
May 18, 1976	Whitepatch - Two Dot Star
June 3, 1976	McKenzie - Ditto
June 23, 1976	Big White - Saddle - Rip
June 29, 1976	Saddle - Rip
July 31, 1976	Two Dot Star - Friend
August 5, 1976	Two Dot Star - Whitepatch
August 6, 1976	Two Dot Star - Streak
August 11, 1976	Two Dot Star - Streak
August 11, 1976	Whitepatch - Friend
August 12, 1976	Whitepatch - Two Dot Star
September 19, 1976	Whitepatch - Streak

paired with Whitepatch, and Two Dot Star was in the area but separate. Several minutes later Whitepatch swam off with Two Dot Star and McKenzie remained alone. Whitepatch and Two Dot Star were still paired on May 18 although the bond may have been broken between sightings. As Table 18 shows some whales may have a number of partners over the summer or even a week (Whitepatch with Saddle, McKenzie, then Two Dot Star on May 26, May 31 and June 1, 1975 respectively). If only opposite sexes paired the whales should be dividable into two groups, i.e. if Whitepatch is paired with Saddle and later Two Dot Star, the latter two should be the same sex and a Saddle - Two Dot Star pair would not be expected. This is not the case, indicating the pair is not necessarily a bisexual bond (Table 18). The same individuals were observed paired in both years (i.e. Whitepatch - Two Dot Star, June 1, 1975 and May 15, 1976). Even if not paired, some individuals have been loosely together, in the same area, for at least three summers (Saddle - Whitepatch 1974-75-76) and most of the summer residents must be familiar with each other.

Few behaviours between members of the pair when feeding or travelling were observed other than their side-by-side orientation. As mentioned in the discussion of travelling, while following Two Dot Star and Stranger on August 31, 1975 one of the whales appeared to rub its belly against that of the other once. Also when Saddle and Rip were travelling from Radar Beach to Wickaninnish Bay on June 29, 1976 the whales

turned to face each other momentarily then one whale breached once, then the side-by-side travelling continued. The question arises of whether some travelling in pairs is a result of the pairing rather than the two whales wanting to reach a destination. There is no conclusive evidence for or against this, however, the possibility arises from observations of paired whales travelling but not going anywhere. That is, whales swam side-by-side, on the surface or just below, but swam back and forth from one end of Wickaninnish Bay to the other for hours. The major observation of this behaviour occurred on September 11, 1975 between Orange Scar and Two Dot Star in Wickaninnish Bay after some interaction with another whale, Squirl. At first sighting (0900) Two Dot Star and Squirl were paired, blowing and diving simultaneously, feeding, and about 50 meters away from Orange Scar who was alone. Minutes later Two Dot Star and Squirl moved towards Orange Scar and all three, side-by-side, swam seaward on the surface, until one of the three (unable to tell which one) rolled sideways and dove under the other two, possibly rubbing its belly on one or both of them. Immediately all three began moving quicker and at least two breached simultaneously. Then, having reversed direction by this time, Orange Scar and Squirl separated from Two Dot Star and moved away several hundred meters. Squirl then breached, Orange Scar and Squirl moved quickly, side-by-side, up the bay for about 1 km. slowed and turned back. Two Dot Star who had been stationary since being left, then swam directly

to Orange Scar and the two of them paired and swam off together for the remainder of the day (approx. 10:00). Squirl was not seen again. The pair swam side-by-side, slowly, often on or just below the surface, from Lovekin Rock to Box Island, then turned and swam to Sea Lion Rocks, turned again and swam back towards Lovekin Rock. On leaving, at 1600 hours they were continuing. They did not stop or feed, Orange Scar sometimes swam deeper than Two Dot Star, blowing once for every three of Two Dot Stars. Several times Orange Scar dove under Two Dot Star and rolled sideways but it was not determined if they rubbed bellies. The next day Orange Scar was alone in Wickaninnish Bay, feeding.

Several similar behaviours were observed but lasted for shorter lengths of time. On September 12, 1975 one lone whale breached then immediately swam to another, rolled sideways, the two paired and dove. On September 18, 1975 in Ahous Bay a pair of whales began swimming quickly, lunged for several blows, then one of them breached; they moved a short distance further together and split up. On July 15, 1976 in Ahous Bay three whales (Blackjack plus two others) were observed swimming side-by-side, very close and blowing in unison. At one surfacing it appeared that one was either on its side or belly up and the other two were in very close to or touching it. The three swam together for approximately 15 minutes eventually ending up at the southeast corner of Ahous Bay. Then suddenly, two of the the three (Blackjack and one other) moved in a pair seaward

and one whale breached twice. The pair moved to the outside of the reefs off Ahous Point, Blackjack rounded the corner and began to move southeast along the reefs, the other whale turned back momentarily then turned again and followed Blackjack about 75 meters behind.

The nature of these behaviours, even if they are similar, is unknown. Possibly they are competitive or courtship oriented. Rice and Wolman (1971) determined that male gray whales have a marked seasonal sexual cycle, with a peak of spermatogenetic activity in late autumn or early winter and that this period correlates closely with the time the females come into estrus. This may explain some of the activity in September, 1975 (11, 12, 18).

vi. Summary

1. Feeding is the primary behaviour observed in the study area and is common in its shallow sandy bays. The whales are bottom feeders, and have been observed lying at an angle off the bottom, on their sides, with a cheek and the mouth against the sand possibly sucking in a mouthful. The benthic infauna is rich in the area; the most predominant invertebrate is a tube-dwelling polychaete worm, Onuphis elegans.

2. Other behaviours observed were whales apparently rubbing themselves on a sand bar in a tidal rip current, whales resting or sleeping on or just below the surface of the

water, motionless and blowing at regular intervals, and some social behaviours particularly pairing -- pairs of animals feeding or travelling and behaving simultaneously.

3. Smaller (younger) whales show some differences in general behaviour than the older feeding whales. They may be found in areas not frequented by the older animals, may have some affinity for kelp beds, and may not feed as regularly or in the same consistent rhythm as the older animals.

DISCUSSION

Fundamental to the study of how or why something occurs is knowing what occurs. Before analysis of causes of the variations in abundance, or movements, or behaviours of the gray whales they must be described with some accuracy, the primary purpose of the study. Two seasons of regular observation have led to this report; consistent observation in the first was interrupted for two and a half months by other work. Although some description and conclusions can be made with reliability from this work and work prior to 1975, many of the trends in abundance and movements which have become apparent have arisen from considering only two comparative observations, one from 1975 and the other from 1976. In some areas limited data provides no more than additional perspective and hypotheses for future study. Many of the results are discussed above. The following is a discussion of what is known, what is apparent and must be further investigated, including new questions arising from the research to date.

Lightstation records from the west coast of Vancouver Island along with observations of the northern migration from the study area have allowed a refining of the gray whale calendar along Vancouver Island. This agrees closely with published migratory times both along the Vancouver Island and California coasts (Pike, 1962; Leatherwood, 1974). Whales pass northbound from mid-February until mid-June with the majority

passing in March and April. The summer interval extends approximately from late June through October. Whales known to summer in the Vancouver Island area are present by April. Through April, May and early June, both these and whales apparently moving further north are found in the study area. By late November the first southbound migrants are seen off Vancouver Island by lightstation personnel. Apparent migrants have been sighted off southern California as early as October and November indicating that some may pass Vancouver Island in early autumn (D. McIntyre, pers. comm., 1977). The majority of southbound migrants are seen in December and early January and some in late January and February. The first northbound whales are seen in February, indicating a very short winter interval between last southbound and first northbound whales off Vancouver Island. In two of the three winters regular observation has been attempted, gray whales have been sighted feeding in Wickaninnish Bay when most of the herd is known to be south of the area (late January and early February) (Hatler and Darling, 1974). Whether these are some of the whales which summered in the area which do not make the trip south or are some part of the migrant stream is not known. That whales were not sighted in Wickaninnish Bay all three winters suggests that the winter presence is not necessarily a regular characteristic. Since the summer range of the summering whales extends beyond the study area the fact that a whale is not seen in the study area in the winter does not necessarily mean it is absent from its entire summer range.

Summering whales have been identified in the area as late as December 14, 1972 in one case. This date is not surprising in terms of the migration since many southbound migrants do not pass until the last weeks of December. Other evidence indicates that whales present in Ahous Bay in late October were gone by early December and were not seen again until late April of the next year although the area was searched on six occasions between those sightings. The problem is that we know when they were present but do not know when they were not present, since the whales' summer range was larger than the researchers'.

The northern migration through the study area is easily observed from shore as many of the whales pass within 1 km. of headlands. During April, particularly the first two weeks, a steady stream of northbound whales pass. This migration includes a variety of behaviours. Whales can be seen travelling, feeding, involved in sexual activities, probably homosexual and play orientated, and nursing in Wickaninnish Bay. Rice and Wolman (1971) determined that, at least off the California coast, migrants are temporally segregated according to sex, age and reproductive status. It would be interesting to know what other behaviours could be correlated with different segments of the migration as nursing and possibly homosexual behaviour (young males) was. What proportion of the migrants stop to feed in Wickaninnish Bay and whether this available food is critical to a success-

ful migration is not known. A census of the herd on its northward migration conducted from one or several of the lightstations would be worthwhile, and especially interesting when compared to southern California censuses of the southern migration. Visitors to Pacific Rim National Park, which includes Wickaninnish Bay can observe the migration from shore, its routing, whales lingering to feed in the bay, sexual 'play' and cows with 5-6 month old calves nursing just outside the surf line or passing the headlands of Long Beach.

The southern migration has not been observed from the study area in any deatil. If it were, it is possible that courtship behaviour would be evident. Rice and Wolman (1971) conclude that the males' peak of spermatogenetic activity is in late autumn and early winter, correlating closely with the time the females come into estrus, and the time many whales are passing Vancouver Island. Apparently those whales seen courting and copulating in and near the calving lagoons in January correspond with the second estrus cycle of those few females not impregnated during the first cycle. On days of clear calm weather in December and early January (which can be rare) courtship behaviour might be observable in the migration past Vancouver Island.

Data from the study period and years prior to, indicate a strong permanence in the membership of the population summering off Vancouver Island. At least 65% (17 of 26) of the animals present in 1975 were also present in 1976.

Some individuals have been photographed in the study area over five and six summers. Gilmore (1960b) discussed whales which linger all summer in northern California, Oregon and southeast Alaska and he felt that these animals "found themselves too far behind to get to the Bering Sea on time thus stayed in feeding grounds a quarter to half the distance. To have attempted to reach the Bering feeding grounds would have resulted in inadequate time to store enough fat for the long trip south and north again." The returning nature of the Vancouver Island population and the fact that they are present in April during the peak of the migration contradicts this explanation. It does seem reasonable that a whale, having summered in a particular area one year would return to that area the next. The significance of one whale (Orange Scar) not being seen in 1976 although in 1970-1975 (except 1971 - no observation) is not known. That is, it is not known if an individual necessarily returns to the same area every summer of its life. This whale may have died, may be seen in the study area in subsequent summers, or may have moved permanently. It is known that whales return to the same section of the Vancouver Island coast at least over as long as six years. The question now is how typical the area with its returning population is. Hatler and Darling (1974) speculate as to whether pockets of habitat occur between southern Vancouver Island and Alaska which are regularly inhabited by gray whales. Gray whales have been sighted in the summer months in California, Oregon, Washington and along the

Queen Charlotte Islands. Although noted in the literature by only one or two isolated sightings, these should not be passed over lightly. Before Hatler and Darling's (1974) report on the Wickaninnish Bay gray whales the only accounts in the literature of these whales in the study area during the summer were a record of one stranded in Wreck Bay in 1966 (Pike and MacAskie, 1969) and a mention by Sterling (1968) of gray whales feeding in Wickaninnish Bay while discussing the general natural history of the Long Beach area. Even Hatler and Darling (1974) indicate that at most only 7 whales were seen in Wickaninnish Bay at one time. At the outset of this study I had no idea 4-5 times that number would spend a portion of their summer in that area. This is probably not the case in all the areas south of the Bering Sea where gray whales are sighted during the summer but it may be in some. Or, these sightings in the Queen Charlottes, Washington and Oregon could be of whales also seen off Vancouver Island. They should be investigated.

Estimates of the numbers of whales summering in the area required a definition separating those from others apparently passing through the area enroute further north. Since during April, May and June both whales still migrating and those we have termed summer residents as present in the study area, only those seen subsequently over a 4-week period were considered to be in the resident category. Any whales seen in July, August and September were considered a summer resident, even if only seen once, as it is doubtful they would be moving much further north.

This allows inclusion of whales found in areas just outside the study area which were only reached once or a few times during the summer as well as those found in the study area which may have been missed earlier. Minimum estimates of the number of whales which summer on the west coast of Vancouver Island are 26 in 1975, 35 in 1976, and 42 different whales over the two summers. Twenty-six is probably low due to gaps in the consistent identification effort in 1975. Therefore, at least 35 in 1976 and 42 over two summers are the best minimum population estimates to date. They are minimum due to the fact that 'new' whales were still being discovered on the coast in the late stages of the study period. These could have been a result of having missed these animals early in the summer (May or June) or of reaching areas outside the main study area and finding animals which do not range inside it. Also, whales photographed early and considered migrant may have been missed later in the summer if they were present in areas other than the study area but on the island's coast. This possibility was emphasized when of 13 whales found on September 9, 1976 off Rafael Point, Flores Island, 4 would have been considered migrant and would not have been included in the population estimate without that sighting. How many more whales which are considered migrants were elsewhere on the island's coast is unknown. The only factor which would make the population estimate an overestimate would be if migrant whales are counted, however, I believe the definitions discussed above are weighted against this possibility. Considering these points, probably

somewhere between the 35 whales classed as summer locals in 1976 and around 50 whales are present on the island's coast during the summer, or at least include the island's coast as part of their summer range. To refine this estimate, summer range movements will have to be understood. It is now an estimate of the number of whales which range into or nearby the study area between April and September, which fit into the category of summer residents. The whales identified in the study area range outside it but how far is unknown. Most of the whales leave and return again to the study area during the summer at least once, indicating that travel is not necessarily only part of the major migration and not necessarily very far. There is not even a speculative estimate of how many gray whales might be spread along the coastline south of the Bering Sea during the summer. Certainly the majority of the estimated 11,000 animals in the California herd are probably feeding in the Bering and Chukchi Seas (Rice and Wolman, 1971). Although no complete census has been attempted in these northern seas, Wilke and Fiscus (1961) report at least 100 feeding over several square miles of the Chukchi Sea in early August, 1959, 172 were counted off the northwest coast of St. Lawrence Island on August 2, 1955 (Ichihara, 1958), and approximately 150 were seen on the east coast of St. Lawrence Island and a few scattered northward to Bering Strait in August, 1958 (Nasu, 1960).

The data on presence, absence and movements of individuals

over the summer season, albeit tentative and/or fragmentary, indicate summer range characteristics may vary for individual whales and this creates some interesting possibilities. With another season of observation and/or an increase in the study area, these may be revised or discarded. In considering only the 17 whales which were present both summers of the study, and dividing them arbitrarily into those seen rarely (<5 times) and regularly ($\geq$ 5 times), all but three fall into the same category both years. Of those seen rarely they may be seen early and late in the summer both years, or some combination of early and late over the two years. Considering those whales in 1976 shown to be present in the study area in April, May or June then not again until September, this pattern of 'early and late' is supported. One of the animals seen rarely both years was seen only in mid-summer (late July and early August) each year. Generally the regular whales are also seen in May, June and September as well as in early July and August, that is they are likely to be seen in the study area over a longer period of time. Counts made over the whole study area (Wreck Bay to Ahous Bay) indicate larger numbers in May and June than in July and August, then an increase in September, accounted for at least in part by 'returning' whales present earlier in the season. This decrease in the number of whales present from May and June to mid-summer and the increase again in September is only obvious in counts made over the entire study area. Any smaller section covered does not show the

two peaks in counts early and late in the summer. This illustrates the possibility that a very sketchy view of movements was obtained by looking at a small area. Since the entire study area was rarely covered at one time (in one day), the sample size of counts over the whole area is small and variation large enough to create a large standard error. However, due to the identification effort, it is known whales not present since May or June are 'appearing' again in later summer, and 'new' whales not yet identified also have added to the count in late summer (these may have been present in early summer and missed). The analysis of counts over the entire study area do not include 13 whales found together off Flores Island (approximately 10 mi., 16 km., north of Ahous Bay) on September 9, 1976. If they did, the rise in numbers in September would be dramatic.

There was a period in mid-summer (last half of July) during which summering whales became scarce. This pattern, not conclusive, reminds one of the larger picture of spring and winter migrations and summer interval, the obviously greater number of animals being present either side of the summer season. The apparent fluctuation in numbers and individual presence may be in some kind of continuum with the migration or may be occurring in an isolated pocket. The indication that some whales are seen more often than others, to the point some are only seen early and late, as well as the vague symmetry of presence around a mid-summer

period, and one whale seen both years in the study area only in mid-summer complicates any explanation. The rare and regular patterns suggest that some individuals may range further than others. However some of the 'regulars' were seen only one side of the mid-summer line in a summer, not known to return by September or October to the study area and may have travelled just as far. Further location and identification of whales north and south of the study area and learning the distance individuals might travel, as well as another season of presence and absence records from the study area is necessary to pursue this description of range characteristics. Supposing there is a variation in range characteristics whale to whale, why? There is some indication that young whales (recently weaned) maintain a smaller range than some older animals. Perhaps age is an important key to range differences, or sex?

Three whales were successfully measured in 1976 for the purpose of estimating their ages. A larger sample size is necessary both to determine the error factor and to even speculate on the age composition of the population. However, from these three whales it was learned that very young animals (recently weaned), juveniles, and probably adults are present in the study area during the summer. The most intriguing result of the measuring to date was the finding that one small whale was well below the length of a yearling and even below the mean length at weaning (given by Rice and Wolman, 1971). This whale appeared in mid-July, alone, and was measured on

August 12, 1976. Apparently it was about 7 months old, recently weaned and had either been left in or found its way to the study area. Other whales conspicuously smaller than the majority have been noted in and near the study are in both summers. Numerous questions arise concerning these little whales. How and when do they arrive? Are they dropped during the migration? Where and who are their mothers? There appears to be a tendency for the smaller whales to hang around areas not frequented by adults. In both summers one small whale was discovered in a kelp bed near Pachena Point alone, Mole the whale measured, spent a lot of time at the Portland Point - Radar Beach area alone, and two small whales seen in Ahous Bay were often together and present when larger whales were not. Is this significant? There appears to be, at least in some cases, an affinity of these little whales for kelp beds. If so, why? Baldridge (1972) reports a cow and calf, attacked by killer whales, retreating to a kelp bed for refuge. Is it usual or unusual for young whales to be 'left' in areas along the coast south of the Bering Sea? Fay (1963) reports cows with calves near St. Lawrence Island in the Bering Sea in the summer so they are not all 'dropped' on the way up. In any case these youngsters are an important part of the whale population along the island's coast. How they relate to the other animals and to the returning nature of the population is still a mystery.

None of the whales considered summer locals have been

sexed, although data in the literature indicate both sexes are present during the summer (Hatler and Darling, 1974; Pike and MacAskie, 1969). Sexing of the whales may shed some light on the various patterns of movements, and is necessary for interpretation of most social behaviours. Even a few of the regular whales sexed would significantly add to the basis for the general description of the population. Probably sex will have to be determined at a cellular level after a skin cell sample is obtained. Sexing by behaviours is not generally useful in the summer since the vast majority of behaviour is feeding and not sexually orientated.

Whale activities in the study area itself have been fairly well documented. Primarily they feed and travel between feeding areas, within and outside the study area and occasionally to a tidal rip-sand bar area in Duffin Passage, performing behaviours unique to that type of area which may be maintenance oriented (i.e. rubbing on the sand bar). It is not uncommon to find whales paired, behaving simultaneously, and a few observed activities hint of competitive or preliminary courtship behaviour.

Whales feed regularly in Wickaninnish Bay and Ahous Bay and not uncommonly off Chestermans Beach or in Wreck Bay. They have also been observed feeding in areas between these larger sandy bays, and in Grice Bay, a protected mud-bottomed inlet, reachable only by a journey through Tofino harbour and down an inside passage. They feed on the bottom, on the

infauna, by lying with the side of their mouth against the sand, probably sucking in a mouthful, then expelling all that will go through their baleen (sand and water) and swallowing the rest. The predominant member of the infauna, at least in some areas the whales are known to feed, is a polychaete tubeworm, Onuphis elegans, which reaches a length of up to 38 cm. (Berkeley and Berkeley, 1948). Other worms, arthropods and mollusks are also present in the sand. It is important to survey what species inhabit the benthos where whales are known to feed, and document their life cycles and sensitivities. The reason the whales are present may be solely because of the availability of food and anything affecting that will directly affect the whales. Eventually it should be possible to determine the biomass of food available, the amount consumed by the whales in a summer, and thus their energy requirements.

Results of counts in three locations in the study area, Wickaninnish Bay, Chestermans Beach and Ahous Bay indicate different patterns of 'use' of these areas by the whales. Wickaninnish Bay is most regularly inhabited and variations in the number present were similar both years. On the average, more whales are present in May and June ($\bar{X}$ = 7-8 whales/day) than in the remainder of the summer $\bar{X}$ = 2-3 whales/day). The larger numbers earlier in the summer can be explained partially by apparent migrants passing through the area. The number of summer locals known to range into Wickaninnish Bay during the

summer was 17 in 1975, 22 in 1976 and 25 over the two years. The presence of whales in Chestermans Beach was intermittent, more often occurring in May or June each year, and there about one-quarter of the times the area was searched. Ahous Bay differed from the other two areas in that it was significantly different in pattern of presence and absence one year to the next. In 1975 (although the area was checked rarely) 2-3 whales were present in May and June and early August but in late August and September the number jumped to 5-7 consistently present. In 1976, 2-4 whales often inhabited Ahous Bay until the end of July but generally none were present in August or September. What factors determine a whale's presence in an area and why the different presence patterns area to area or from one area year to year is unknown. Perhaps simply the size of the feeding ground determines the numbers of whales populating it but why the intermittency and/or turnover (one whale leaving and another arriving in the same area). There is some indication some whales prefer one area over another when in the study area. Some have only been seen in Wickaninnish Bay, some only in Ahous Bay and others most of the times in one or the other. Whales have been observed bypassing areas where other whales are feeding apparently enroute elsewhere, perhaps to a specific destination.

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Appendix I. Examples of individual movements.

A) Two Dot Star

1975 Sightings

April 8	Wickaninnish Bay	August 12	Schooner Cove
April 17	Chestermans Beach	August 13	Ahous Bay
May 15	Wickaninnish Bay	August 14	Wickaninnish Bay
May 31	Near Cox Point	August 15	Wickaninnish Bay
June 1	Wickaninnish Bay	August 19	Wickaninnish Bay
June 12	Tidal rip near Tonquin Beach (probably absent from study area)	August 31	Cox Point to Cleland Island
		Sept. 8	Ahous Bay
July 22	Wickaninnish Bay	Sept. 11	Wickaninnish Bay
August 8	Chestermans Beach	Sept. 18	Ahous Bay
August 11	Wickaninnish Bay	Sept. 19	Ahous Bay

Between April 8 and 17 Two Dot Star moved from Wickaninnish Bay to Chestermans Beach and by May 15 had returned to Wickaninnish Bay. Next sighting was on May 31 near Cox Point, between Chestermans Beach and Wickaninnish Bay; the whale was with two others, all apparently feeding. By the next day, June 1, it had returned to Wickaninnish Bay. By June 12 Two Dot Star had moved to the tidal rip off Tonquin Beach, near Tofino, with two other whales, Saddle and Streak and was last seen with these two on the outside of Wickaninnish Island, having left the tidal rip area and moved between Echachis and Tonquin Island. Two Dot Star was not seen again until 40 days later, July 22, in Wickaninnish Bay (Wickaninnish Bay had been checked 6 times during that period; Ahous Bay once.) By August 8 Two Dot Star had moved

to Chestermans Beach and when sighted was accompanied by Saddle. The period August 8-14 is the longest uninterrupted sequence of any whale's movements (Fig. 24). From Chestermans Beach on August 8 they (Two Dot Star and Saddle) had moved to Wickaninnish Bay by August 11, on August 12 they were sighted in Schooner Cove, by August 13 both were in Ahous Bay, on August 14 back in Wickaninnish Bay and they remained there for August 15. By August 19 Saddle was absent but Two Dot Star was discovered moving northwest off Cox Point with another whale (Stranger) and was followed outside Lennard and Wickaninnish Islands and the Vargas reefs (La Croix Group) as far as the gap between Cleland and Blunden Island and appeared to be continuing northwest. Two Dot Star was back in Ahous Bay and the study area by September 8, had moved to Wickaninnish Bay by September 11, was absent from Wickaninnish Bay the next day, and seen in Ahous Bay again on September 18 and 19.

1976 Sightings

May 15	Wickaninnish Bay	August 4	Wickaninnish Bay
May 18	Wickaninnish Bay	August 5	Wickaninnish Bay
May 19	Wickaninnish Bay (probably absent from study area)	August 6	Wickaninnish Bay
		August 11	Wickaninnish Bay
July 18	Vargas reefs, moving north	August 12	Wickaninnish Bay (probably absent from study area)
July 27	Kanim Lake area	Sept. 9	Rafael Point
July 28	Kanim Lake area		
July 31	Wickaninnish Bay		

In 1976 Two Dot Star was first sighted in Wickaninnish Bay

on May 15, 18 and 19 then not seen until 60 days later, July 18, off the Vargas reefs (La Croix Group) moving northwest with two other whales (Wickaninnish Bay had been checked 19 times during that period; Ahous Bay, 6). It was sighted again on July 27 and 28 off the Kanim Lake area between Hot Springs Cove and Estevan Point feeding in the company of another whale not identified (Fig. 25). Three days later, by July 31, Two Dot Star had returned to Wickaninnish Bay (Fig. 25). Although not seen on August 1 it was present on August 4, 5, 6, 11 and 12, then departed again. Finally on September 9 Two Dot Star was spotted among 12 other whales off Rafael Point on Flores Island (28 days later; Wickaninnish Bay checked 7 times; Ahous Bay 7).

B) Saddle

1975 Sightings

April 16	Chestermans Beach	August 8	Chestermans Beach
April 17	Chestermans Beach	August 11	Wickaninnish Bay
April 18	Chestermans Beach (probably absent from study area)	August 12	Schooner Cove
		August 13	Ahous Bay
May 26	Wickaninnish Bay	August 14	Wickaninnish Bay
May 31	Wickaninnish Bay	August 15	Wickaninnish Bay
June 7	Chestermans Beach/ Wickaninnish Island		
June 11	Tidal rip-Wickaninnish Island (probably absent from study area)		

Saddle was first seen on April 16, 17, 18, 1975 off Chestermans Beach. Then not until 38 days later in Wickaninnish

Bay, May 26 (Wickaninnish Bay had been checked 9 times; Ahous Bay 0). Saddle was possibly (no photo taken) seen the day before, May 25, travelling south off Frank Island with another whale. On May 31 Saddle was present in Wickaninnish Bay and by June 7 had moved to Chestermans Beach. On that day Saddle, accompanied by Streak, was followed from north Chestermans past Tonquin and Echachis Islands to the outside of Wickaninnish Island and northwest as far as Farther Charles Channel (Fig. 27). By June 12 both Saddle and Streak had returned to the tidal rip off Tonquin Beach then were followed, with Two Dot Star, along the southeast shore of Wickaninnish Island to the outside of Echachis Island. Saddle was not seen again until 56 days later, August 8, off Chestermans Beach (Wickaninnish Bay had been checked 7 times; Ahous Bay 0). From August 8 to August 15 Saddle followed the same path as described for Two Dot Star, from Chestermans Beach to Wickaninnish Bay to Ahous Bay and back to Wickaninnish Bay (Fig. 24). The last sighting of Saddle that summer was on August 15 in Wickaninnish Bay (checked 9 more times; Ahous Bay 7).

1976 Sightings

May 15	Wickaninnish Bay	June 13	Wickaninnish Bay
May 19	Wickaninnish Bay	June 23	Chestermans Beach
June 9	Wickaninnish Bay	June 26	Wickaninnish Bay
June 3	Wickaninnish Bay	June 28	Cox Point, moving south
June 4	Wickaninnish Bay	June 29	Radar Beach to Wickaninnish Bay
June 5	Wickaninnish Bay		(probably absent from study area)
June 6	Wickaninnish Bay		

Saddle was first sighted in 1976 on May 15 in Wickaninnish Bay and probably remained there or close by until June 13 as it was seen 8 of 10 searches during that period. By June 23 Saddle had moved to Chestermans Beach, and was feeding with Big White and Rip. By June 26 all three had moved to Wickaninnish Bay but apparently Saddle and Rip left again soon after as Saddle was seen moving southeast off Cox Point 2 days later (June 28), heading towards Wickaninnish Bay again, accompanied by another whale not identified (Fig. 26). On June 29 Saddle and Rip were followed from Radar Beach to Wickaninnish Bay (Fig. 26). Saddle was not seen again in 1976, in 82 days until September 19 when observation was terminated (Wickaninnish Bay was checked 20 times; Ahous Bay 23).

The next three examples are of whales which have spent relatively long periods present in or absent from Wickaninnish or Ahous Bays and have not been seen elsewhere.

C) Whitepatch

1975 Sightings

April 8	Wickaninnish Bay	May 26	Wickaninnish Bay
April 19	Wickaninnish Bay	May 31	Wickaninnish Bay
April 21	Wickaninnish Bay	June 1	Wickaninnish Bay
May 6	Wickaninnish Bay		

In 1975 Whitepatch probably spent most of April and May in Wickaninnish Bay; sightings were made on April 8, 19, 21 and May 6, 26 and 31 and finally on June 1, seven of the twelve

times that the area was checked. If it can be assumed that no excursions from the area were made Whitepatch was present for 54 days and since Wickaninnish Bay was not searched again until June 22 Whitepatch's presence may have lasted up to 74 days. Consistent observation continued until September 26, 1975, 117 days later, and Whitepatch was not seen again. (Wickaninnish Bay checked 22 times; Ahous Bay 8).

1976 Sightings

May 15	Wickaninnish Bay
May 18	Wickaninnish Bay
May 19	Wickaninnish Bay (probably absent from the study area)
June 26	Wickaninnish Bay
June 29	Wickaninnish Bay (probably absent from the study area)
July 31	Wickaninnish Bay
August 1	Wickaninnish Bay
August 4	Wickaninnish Bay
August 5	Wickaninnish Bay
August 10	Wickaninnish Bay
August 11	Wickaninnish Bay
August 12	Wickaninnish Bay
August 17	Wickaninnish Bay
August 22	Wickaninnish Bay
August 28	Wickaninnish Bay
August 29	Wickaninnish Bay
Sept. 2	Wickaninnish Bay
Sept. 5	Wickaninnish Bay
Sept. 10	Wickaninnish Bay
Sept. 19	Wickaninnish Bay

In 1976 Whitepatch was first identified in Wickaninnish Bay on May 15, 18 and 19. It was not seen again until 38 days later, June 26, also in Wickaninnish Bay (Wickaninnish Bay checked 7 times; Ahous Bay 11). After June 29 Whitepatch was not seen until 31 days later, July 31 (Wickaninnish Bay checked 4 times; Ahous Bay 6). After July 31 this whale apparently remained in Wickaninnish Bay for the duration of the summer. It was sighted on August 1, 4, 5, 10, 11, 12,

17, 22, 28, 29 and September 2, 5, 10, 19 and was absent only once (August 6) out of 16 times the area was checked. If no short excursions were made elsewhere the maximum time the whale may have stayed during this period is 51 days. Since Whitepatch was still present when observation terminated for the summer, on September 19, the whale's length of stay may have been significantly longer.

D) Orange Scar

1975 Sightings

April 8	Wickaninnish Bay	Aug. 24	Wickaninnish Bay
April 12	Wickaninnish Bay (probably absent from study area)	Aug. 25	Wickaninnish Bay
		Sept. 1	Wickaninnish Bay
July 21	Wickaninnish Bay	Sept. 11	Wickaninnish Bay
July 22	Wickaninnish Bay	Sept. 12	Wickaninnish Bay
Aug. 6	Wickaninnish Bay	Sept. 19	Wickaninnish Bay
Aug. 9	Wickaninnish Bay	Oct. 12	Wickaninnish Bay
Aug. 11	Wickaninnish Bay	Oct. 24	Wickaninnish Bay
Aug. 12	Wickaninnish Bay		
Aug. 15	Wickaninnish Bay		
Aug. 19	Wickaninnish Bay		

In 1975 Orange Scar was probably first seen on April 8 and 12 but no photograph was obtained. The first positive sighting of this whale was not until July 21 after which it apparently remained in Wickaninnish Bay for the rest of the summer and fall. Orange Scar was seen on 15 of the 16 times whales were sought in this area between July 21 and October 12 plus probably once more on October 24. Orange Scar was not

present on July 12, but was sighted on July 21, 22 and August 6, 9, 11, 12, 15, 19, 24, 25, September 1, 11, 12, 19, October 12 and 24 (not seen on August 14 when Wickaninnish Bay checked and the October 24 identification was from the beach with binnoculars). Therefore, Orange Scar probably remained in Wickaninnish Bay for 84 days or 91 if the October 24 identification is included.

E) Blackjack

Sightings 1976

May 3	Ahous Bay	July 8	Ahous Bay
May 14	Ahous Bay	July 11	Ahous Bay
June 6	Ahous Bay	July 15	Ahous Bay
June 20	Ahous Bay	July 18	Ahous Bay
July 4	Ahous Bay	July 30	Ahous Bay

Each day that whales were photographed in Ahous Bay, May 3, 14, June 16, 20, July 4, 8, 11, 15, 18, 30 Blackjack was present. However, between these dates and after July 30 there were days when no whales were present in Ahous Bay. These days with no sightings were May 15, June 2, July 2, 12, 13 and August 10, 15, 17, 22, 28 and 30 and September 2, 8, 9, 18. One unidentified whale was seen in Ahous Bay August 2 and then no whales were sighted until September 12; these whales also unidentified. Blackjack has not been seen in Wickaninnish Bay nor at any other location but apparently moved in and out of Ahous Bay through summer 1976.

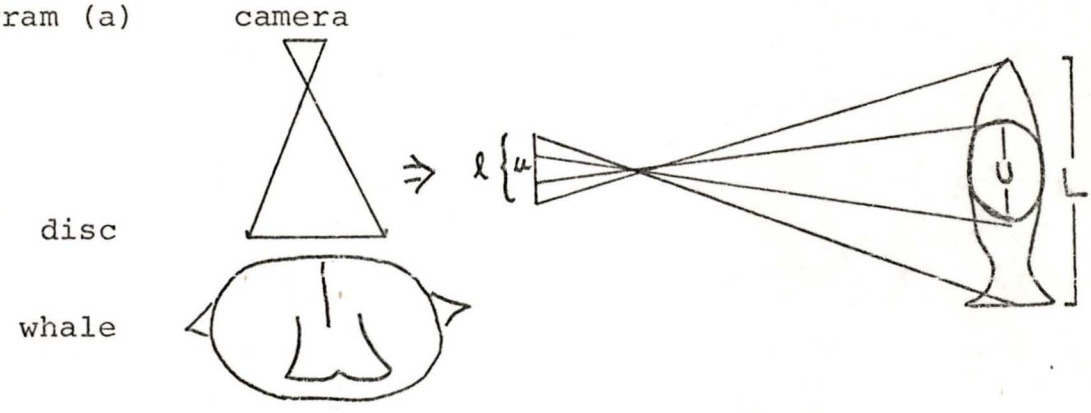
Appendix II. Measuring, (from Whitehead & Payne, 1976).

The whales length (L) in meters is determined by dividing its length (l) in mm. on the negative by the maximum diameter of the disc (u) in mm. on the negative. This would give an accurate measurement only if the disc were directly on top of the whale:

Case 1. Disc directly over whale.

a) Camera directly above disc and whale.

Diagram (a)



In this case L = length of whale (m.)
l = length of whale on negative (mm.)
U = diameter of disc = 1 m.
u = maximum diameter of disk on negative

and

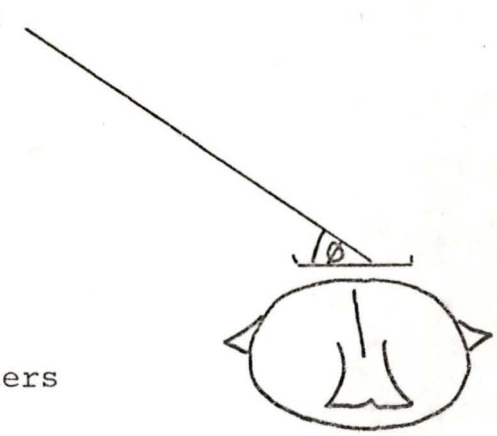
$$L/l = \frac{U}{u} \quad (U = 1 \text{ meter})$$

$$= L = l/u \; U = \frac{1mm \times 1m.}{umm} = l/u \text{ meters}$$

b) Camera at an angle ϕ to disc.

The same is true as above, i.e.:

Diagram (b)



and: L = 1/u meters

The simple L = 1/u meters is true in Case 1 (a + b above) because the factors affecting the size of the disc appearing on the negative, lens size, altitude, and camera angle (ϕ) will affect the size of the whale similarly and since the true diameter of the disc is known, the whale's measurements can be calculated.

However, in practice, the disc would rarely if ever be directly above the whale:

Case 2. When the disc is not directly above the whale (i.e. the distances camera to whale and camera to disc are different).

In these cases a correction to the formula L = 1/u is necessary. In proportion to its distance from the whale a disc would differ in size from a theoretical disc directly above the whale. If the disc is behind the whale (looking from the camera) it will be smaller and if in front, larger than the theoretical disc on top of the whale. This difference in size, actual disc to theoretical disc, as it appears on the negative, must be taken into account in deriving the length

(L) of the whale - thus the correction factor:

$$\left[1 \pm h/v\sqrt{(u/s)^2 - 1}\right]$$

hmm = measured distance from center of whale to center of disc on negative
vmm = image distance of camera lens (~300 mm. in this case) (i.e. size of camera lens)
smm = measured diameter of disc, when extended passes through the center of the whale

The + (plus) sign is used when the disc is in front of the whale (i.e. if the whale is further than the disc from the camera) and the - (minus) sign if the disc is behind the whale (i.e. the whale is closer to the camera than the disc). That is, if the disc is behind the whale it is smaller on the negative than a disc directly above the whale would be (note diagram below). Therefore, if the diameter of the disc (u) was divided directly into the length of the whale (l) a larger than true length would be calculated. Once the difference factor is determined it must be subtracted from the apparent length of the whale. The reverse is the case if the disc is in front of the whale: it is larger than it would be directly above the whale therefore a smaller than true length would be calculated and the different factor must be added to the apparent length of the whale on the negative.

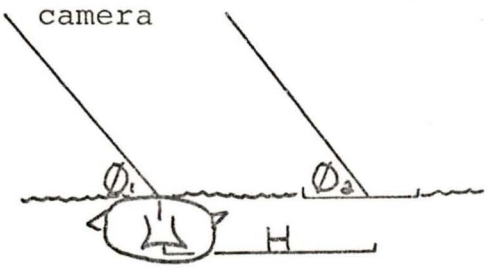
The Correction Factor

a) Limiting Factor:

A limiting factor in the use of the correction factor and in turn the use of the method is the distance the disc is away from the whale (H meters on the water or hmm. on the negative). It is assumed in the use of this correction factor

that the angle between the camera - disc axis and the disk (assumed to be parallel and on the surface of the water) and the camera - whale axis and the whale (also assumed to be parallel and on the surface of the water) are equal or negligibly different. That is, $\phi_1 \tilde{=} \phi_2$.

Diagram (c)

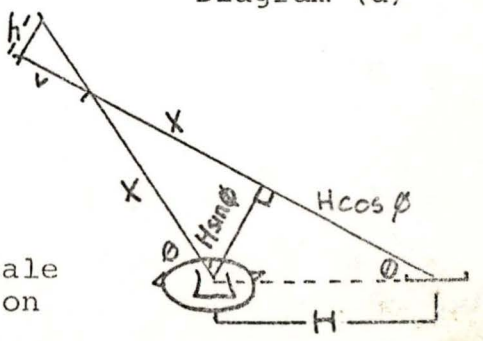


As the distance, center of whale to center of disc (Hm on the water and hmm. on the negative) increases the difference in the angles ϕ_1 and ϕ_2 increases. After a point the correction factor which relies on the use of similar angles camera to disc and camera to whale is no longer calculable. Whitehead and Payne (1976) determined that hmm. on the negative must be less than 20 mm. That is, if the whale is in one corner of a 35 mm. negative (35 x 24 mm.) and the disc is in the opposite or adjacent corner h is large enough to disallow the photograph as useable in this technique.

b) <u>How the correction factor is derived</u>.

Step 1

Diagram (d)



X = distance camera lens to whale.

$H\sin\phi$ = distance center of whale to center of disc actually seen in camera due to angle ϕ.

(H is the true distance between the whale and disc but would only appear as such on the negative if the angle ϕ was 90^{o}).

From diagram (d):

$$\frac{H\sin\phi}{h} = \frac{x}{v} \quad \frac{\text{the distance center of disc to center of whale as seen from the camera}}{\text{the distance camera lens to whale}} =$$

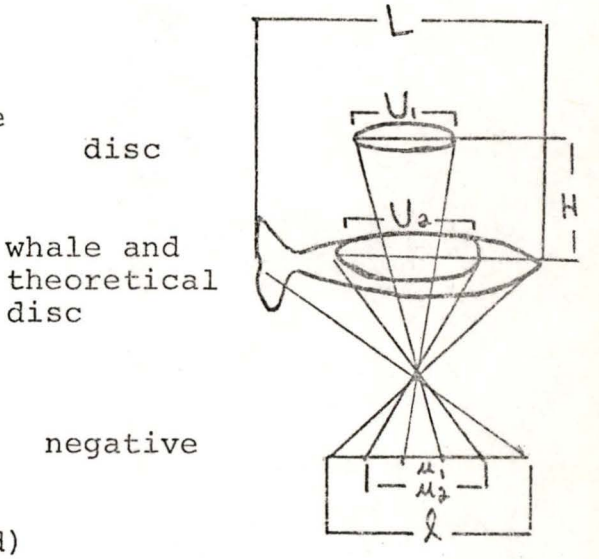
i.e.

$$= \frac{H\sin\phi}{x} = h/v \quad \frac{\text{the distance center of disc to center of whale on negative}}{\text{the image distance of the camera lens}}$$

Step 2

U_1 = max. diameter of disc
U_2 = max. diameter of disc over whale
u_1 = max. diameter of disc on negative
u_2 = max. diameter of disc over whale on negative

Diagram (e)



disc

whale and theoretical disc

negative

Therefore: From Step 1 and Diagram (d)

$$u_2/u_1 = \frac{H\cos\phi + x}{x} = \frac{H\cos\phi}{x} + \frac{x}{x}$$

$$= \frac{H\cos\phi}{x} + 1$$

$$= 1 + {}^{H}/_{x}\cos\phi$$

But from Step 1

$$H/x = h/v \sin\phi$$

$$\therefore \quad u^2/u^1 = 1 + h/v\sin\phi \cdot \cos\phi$$

$$= 1 + h/v \cot\phi$$

That is, the difference in maximum diameter of the disc when not directly above the whale (U_1) and when directly above the

whale (U_2) on the negative, i.e. $\frac{u^2}{u^1}$ is proportional to:

$$\left.\frac{\text{the distance camera lens to whale + whale to disc}}{\text{the distance camera lens to whale}}\right\} \text{ as seen from camera}$$

$$= \left.\frac{1 + \text{the distance whale to disc}}{\text{the distance camera lens to whale}}\right\} \text{ as seen from the camera}$$

And from Step 1:

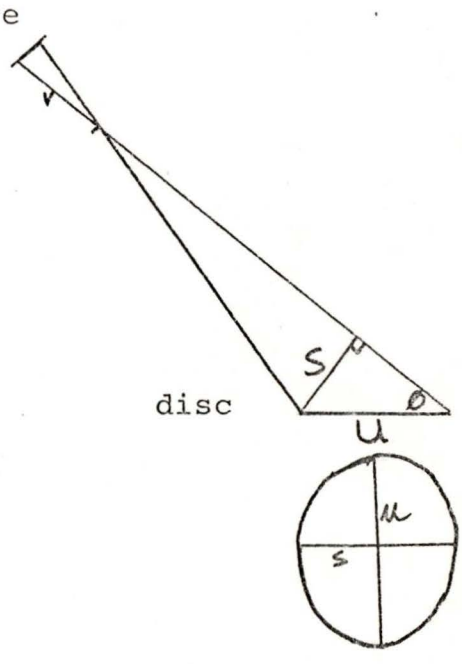
$$= \frac{1 + \text{the distance center of disc to center of whale on the negative times } \cot\phi}{\text{the image length of the camera lens}}$$

At this point the only value in the factor which cannot be obtained is the cotangent of ϕ. Therefore:

$$\text{As } L = 1/u \ (^{u_2}/_{u_1}) = 1/u \ (1 + h/v \cot\phi)$$

Step 3

smm = diameter of disc which when extended passes through center of whale



$U = \sin\phi$

$\frac{U}{S} = \csc\phi = u/s$

and $\cot\phi = \pm\sqrt{\csc^2\phi - 1}$

$= \pm\sqrt{(u/s)^2 - 1}$

Therefore: the formula

$$L = 1/u \ (1 + h/v \cot\phi)$$

$$= 1/u \left[1 \pm h/v \sqrt{(u/s)^2 - 1}\right]$$

in which all the variables can be determined.

Errors

Four sources of error in measurements made by this technique are discussed by Whitehead and Payne (1976)

They calculate a theoretical error of about 3% from:

1) Inaccuracies in the correction for the whale not being beside the disc (i.e. in the correction $1 \pm h/v\sqrt{u/s^2-1}$). These errors were principally due to the whale not lying in the plane of the disk due to waves, etc. or the whale lying beneath the surface. The authors feel these errors were less than 5% causing an error in the calculated length of less than about 3% of the true length (mathematics in Whitehead and Payne, 1976).

2) Errors due to the twist of the whale (i.e. the whale not being perpendicular to the line joining the whale and the camera). Calculations when the disc is not horizontal rely on the whale being perpendicular to the line joining the whale and camera. If the whale is not so the size of the error varies with degree the whale is off perpendicular (β^{o}) and the angle (ϕ) from which the photograph is taken. (In such a case the true length of the whale (L^1) is given by $L^1 = L\sqrt{Cos^2B+Sin^2\beta\ Sin^2\phi}$ meters, mathematics showing the twist B^{o} necessary to produce a particular % error are shown in Whitehead and Payne, 1976). The closer ϕ gets to 90% the larger the angle off perpendicular which can be tolerated without a high % error (<1%). That is,

if $\phi = 45^{o}$ the angle the whale is off perpendicular cannot be greater than 11.5^{o} if the % error is to remain below 1% , however, if $\phi = 80^{o}$ the whale can be as much as 54^{o} off perpendicular before the error in the final measurement exceeds 1% of the true length (in Whitehead and Payne, 1976). The authors, by taking into account that generally a motor drive sequence of photographs is taken as the plane flies in a semi-circle around the surfacing whale and the use of the 'best' photograph obtained by this technique, determined that the error in the final result would be less than 1% due to twist of the whale off perpendicular.

3) Errors due to inclination of the whale, i.e. errors resulting from inclination of the whale to the water surface in the verticle plane. Again the error varies with the angle (ϕ) from which the photograph is taken as well as the angle at which the whale is inclined. However, whereas in the previous error (twist of the whale) the larger the angle ϕ the greater the twist that could be tolerated, the reverse is the case in dealing with inclination. That is, if $\phi = 45^{o}$ a whale can be inclined at 11.5^{o} to the water surface without the error exceeding 1%; if $\phi = 90^{o}$ the angle at inclination cannot exceed 8.1% to maintain the same percentage error (in Whitehead and Payne, 1976). The authors' calculations indicate that the error due to inclination of the whale would be <.5% of the true length in the final result.

4) Errors due to refraction. Since often the extremities of the whale between which measurements are made are below the water surface the refractive properties of water must be taken into account. Whitehead and Payne (1976) in considering the depth at which the whale is below the surface (n meters), the height above the surface from which it is photographed (m meters), the angle from which the photograph is taken (ϕ) and the refractive index of water (μ) show that the error δL due to refraction equals

$$\delta L = \frac{Ln}{m} \left(\frac{1-\sin\phi}{\sqrt{\mu^2-\cos^2\phi}}\right) \text{ meters}$$

and percentage error

$$\simeq 100\ n/m \left(\frac{1-\sin\phi}{\sqrt{\mu 2-\cos^2\phi}}\right) \quad \%$$

In their work $\phi > 30\%$, $n < 2$ meters, and $m \simeq 100$ m giving the errors due to refraction as less than 1%. The same values of ϕ , n and m hold in our measurements.

In conclusion, Whitehead and Payne state that in their normal situation, with a circling airplane taking pictures almost continuously, the total error, if $\phi = 30^{o}$, due to the errors discussed above is less than 5.5% (3 % + 1% + .5% + 1%) and probably around 3% as these effects will rarely all produce three maximum errors in the same direction at the same time.

These authors also determined the root mean square percentage error in calculated length for the same whale measured in different photographs taken during the same year at about 9%. This included all of their data for much of which the end points of the length measurements, snout tip to fluke knotch were not clearly visible. For errors where these points were distinct the errors in calculated length approximated 4-5% (Whitehead and Payne, 1976).

Our effort in measuring has not been sufficient to calculate deviations in measurements of the same whale, one photograph to another, taken the same year, and clearly this would provide some assurance as to their accuracy.

Appendix III. Example of Lightstation Report Form.

Cape Beale

GRAY WHALE SIGHTINGS

West Coast Vancouver Island - Winter 1975/76

DATE	LOCATION	NUMBERS	DIRECTION MOVING
April 1	Passing C. Beale	21	North
" 2	" " "	12	North
" 3	" " "	7	North
" 4	in to Barkley Sound	10	North
" 5	" " "	5	North
" 6	" " "	4	North
" 7	" " "	10	North
" 8	" " "	1	North
" 9	" " " 2. Staying in Sound.	11	North
" 10	Passing C. Beale	6	North
" 11	" " "	3	North
" 12	" " "	10	North
" 13	" " "	11	North
" 14	—	0	
" 15	Poor Vis. Rough Sea	0	
" 16	Rough Sea.	0	—
" 17	—	0	—
" 18	Passing C. Beale	3	North

COMMENT

Please record any notable behavior or activity amongst the whales (eg. moving quickly past observer or staying around one particular area for some time). At the end of each month please give the number of days obervation was impossible (ie. poor visability).

20 - 2 Playing in Barkley Sound

21 - 1 " " " "

From 22 - 23 Poor Vis. Rough Seas unable to Observe.

" 24 - 30. No whales seen.

VITA

SURNAME: Darling GIVEN NAMES: James David

PLACE OF BIRTH: Toronto, Ont. DATE OF BIRTH: Sept. 25/50

EDUCATIONAL INSTITUTIONS ATTENDED, WITH DATES OF ENTERING AND LEAVING:

University of Victoria (fulltime) 1968 to 1972

University of Victoria (fulltime) 1975 to 1977

DEGREES, DIPLOMAS, ETC. AWARDED WITH DATES AND NAMES OF INSTITUTIONS:

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HONOURS AND AWARDS:

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University of Victoria, Graduate Scholarship 1976/77

PUBLICATIONS:

Hatler, D.F. and J.D. Darling. 1974. Recent observations of the gray whale in British Columbia. Canadian Field Naturalist 88: 449-459.

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TITLE OF THESIS: Aspects of the behaviour and ecology of Vancouver Island gray whales, Eschrictius glaucus Cope.

AUTHOR: [redacted]

Signature

JAMES DAVID DARLING

Name

October 12, 1977

Date