Photo-identification of the Minke Whale (*Balaenoptera acutorostrata*) around the Isle of Mull, Scotland.

Report to the Hebridean Whale and Dolphin Trust 2000

Alison Gill, Brennen Fairbairns, Richard Fairbairns

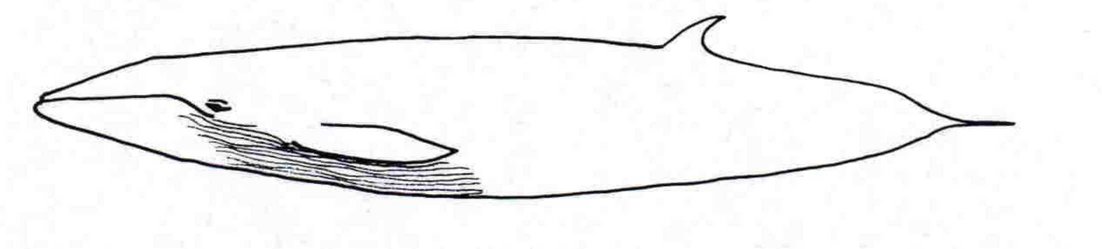
1. Introduction

1.1. Morphology

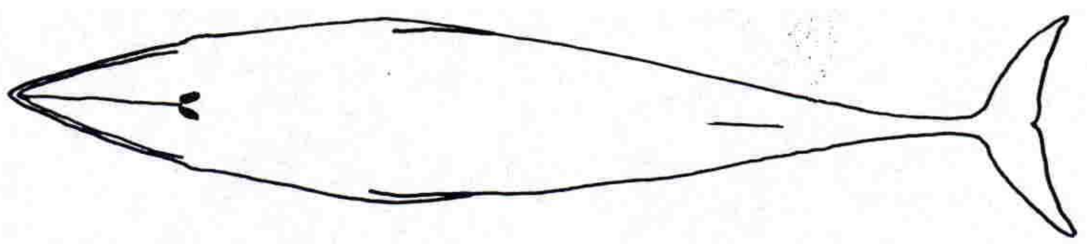
The minke whale *Balaenoptera acutorostrata* (Lacepede, 1804) is the smallest member of the family *Balaenopteridae* or rorqual whales, a family of whales that have many throat grooves which distend when feeding and includes the blue *(Balaenopteridae musculus)*, fin *(Balaenoptera physalus),* sei *(Balaenoptera borealis)*, humpback *(Megaptera novaeangliae),* and Bryde's *(Balaenoptera edeni)* whales. The shape of the minke whale is fusiform with a very distinctive narrow, pointed rostrum and a single prominent head ridge (Figure 1.1.). There are 50 to 70 throat grooves which end anterior to the navel just behind the pectoral fins. The pectoral fins are slim and very pointed and the dorsal fin is sickle-shaped, positioned approximately two-thirds along the body length (Leatherwood, 1983). The minke whale has 230-360 baleen plates, measuring about 20cm in length and 12cm in width at their base, positioned on each side of the upper jaw.

Figure 1.1. General shape of the minke whale.

(a) Dorsal view.



(b) Lateral view.



1.2. Taxonomy

The taxonomy of the species is still in question but generally three subspecies are recognized (Omura, 1975; Rice, 1977). In the Northern Hemisphere two subspecies are recognized, the North Atlantic form *Balaenoptera acutorostrata* and the North Pacific form *Balaenoptera acutorostrata davidsoni.* These two forms are morphologically similar with adults reaching lengths of 511-826cm (mean 737cm) for the North Atlantic form (Sergeant, 1963) and 480-914cm (mean 715cm) for the North Pacific form (Jonsgard, 1951). However, they are distinguished mainly by their skull morphology with the North Atlantic form having a longer rostrum (Tomilin, 1967). Omura (1975) studied the colour patterns on the pectoral fins of the two forms and found that with the North Pacific form, the white stripe on the fin runs across the fin parallel to the body, but with a small central projection of white into the black of the fin (Figure 1.2.a). The fin in the North Atlantic form differs in that the white area is more angled and the projection has not been noted (Figure 1.2.b).

Figure 1.2. Pectoral fin coloration of Northern Hemisphere minke whales.

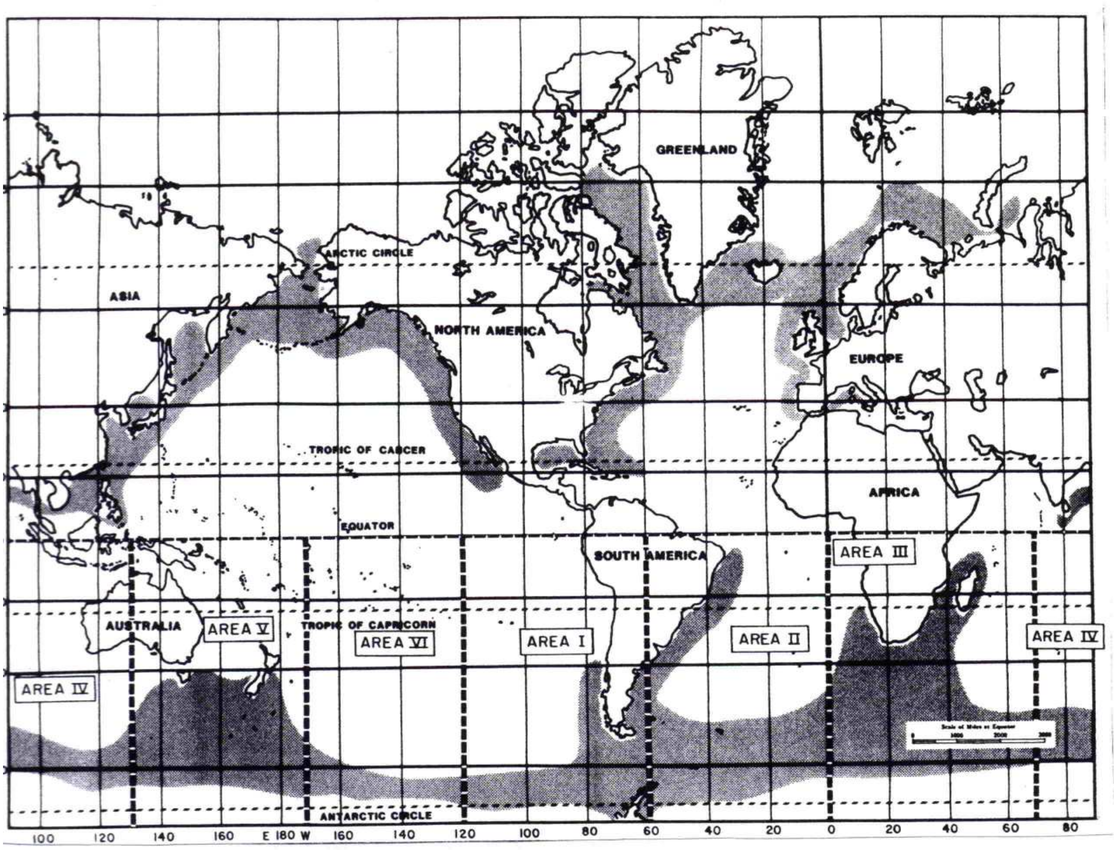
(a) North Pacific. (b) North Atlantic.

Minke whales in the Southern Hemisphere are morphologically distinct from those in the Northern Hemisphere and a third subspecies *Balaenoptera acutorostrata bonaerensis* is described, based on its greater length of 710-930cm (mean 814cm) (Ohsumi *et al.,* 1970) and the presence of a 5cm black border on the posterior baleen plates as opposed to the all creamy-white baleen found in the Northern Hemisphere minke whales (Burmeister, 1897; Williamson, 1959, 1961, 1975; Ohsumi *et al.,* 1970; Bushuev, 1986; Singarajah, 1984; Best, 1985). The pectoral fin of the Southern Hemisphere form is coloured various tones of grey and lacks the striking white band seen in the Northern Hemisphere forms. Significant differences in the skull morphology (Omura, 1975) and biochemical differences (Wada, 1983, 1984a) have been demonstrated between the Northern and Southern Hemisphere forms. The existence of a fourth form, the dwarf minke whale or the diminutive form has been described in the Southern Hemisphere (Best, 1985; Arnold *et al.,* 1987) although this form constituted only 0.1% of the Antarctic catch and 3-4% of the South African catch (Wada *et al*., 1979). The low catch figures may be due to its small size and solitary behaviour. This dwarf form has all white baleen and has a vivid white blaze on its pectoral fins, with the white coloration extending onto the shoulder. Best (1985) reports that this form appears to be born at a smaller size than other forms and attains sexual maturity at a smaller size. There has not been a determination of the taxonomic nomenclature on this dwarf form. For a more detailed description of the morphological and genetic differences of the subspecies consult Horwood (1990).

1.3. Distribution and Migration

Minke whales are cosmopolitan in their distribution (Figure 1.3.) but are generally seasonal in occurrence due to their migration from their calving and breeding grounds in the tropics to their feeding grounds towards the polar regions.

Figure 1.3. General distribution of the minke whale (From Stewart and Leatherwood, 1985).



North Atlantic

The International Whaling Commission (IWC) recognises four stocks in the North Atlantic: Canadian east coast, west Greenland, central North Atlantic, and northeast Atlantic (IWC, 1980).

In the northwest Atlantic minke whales have been reported to migrate north past Nova Scotia in May, reaching the northern Labrador coast by August (Katona *et al.,* 1977). The presence of minke whales in the Gulf of St. Lawrence, the Newfoundland coast and off southwest Greenland during the summer has been reported with some whales moving further north as far as Davis Strait and Baffin Bay later in the summer (Sergeant, 1963; Jonsgard, 1966; Kapel, 1980). It appears that there is an offshore southward migration in the winter (Jonsgard, 1951; Fraser, 1953; Mitchell, 1975) however, Sergeant (1963) reports the presence of minke whales off northern Labrador until the ice develops and off west Newfoundland in November and December. Kapel (1980) reports that off southwest and central Greenland whales were caught in the winter months. Catch data of whaling along the coasts of Greenland and eastern Canada reveals that there was a predominance of mature females in these areas early in the summer but as the season progressed relatively more young whales of both sexes were caught (Mitchell and Kozicki, 1975; Solvik, 1976; Kapel, 1980; Christensen, 1982; Anon, 1984, 1985, 1986). On the east coast of Greenland and around Iceland minke whales appear along the coast in June to September and then migrate south (Oien and Christensen, 1985). The sex ratio of Icelandic catches showed a predominance of females in early and late summer with males predominating in midsummer (Sigurjonsson, 1982). Larsen and Oien (1987) suggest that there exists a similar pattern of segregation by sex off both east and west Greenland with females arriving earlier in the season and migrating farther north.

Data from Norwegian pelagic whaling and coastal whaling in the northern northeast Atlantic show that, in the summer months, the whales can be found in coastal bays and inlets along the northern coastlines but are also present in large numbers offshore in the Barents Sea and central northern North Atlantic (Solvik, 1976). Minke whales are common in inshore northern and western coastal waters of the British Isles, at 47-67 degrees north, from July to October (Harmer, 1927; Fraser 1934, 1946; Stephenson, 1951; Evans, 1980). In the autumn these whales appear to migrate south to temperate waters (Jonsgard, 1966; Fraser, 1979). Yet again the predominance of mature females in catches is reported in the early summer in the more northern seas and that immature whales are located further south (Jonsgard, 1962). Jonsgard (1962) suggested that the mature males were encountered less frequently on their northward migration because they migrated in open seas away from the coast.

In the southern North Atlantic minke whales have been reported south of Bermuda from December to May (Winn et al, 1976) and strandings have been reported on the coast of Florida and the Gulf of Mexico from December to February (Mead, 1989). Several authors report minke whales in the Mediterranean and most of these are reported in the summer months (Lens *et al*., 1987; Casinos *et al*., 1976; Scattergood, 1949; Viale, 1985; Di Natale, 1983).

The evidence thus suggests that during the summer in the North Atlantic, sexual and age segregation occurs with the females predominating in the early summer months in the coastal regions and also in the most northern regions during most of the season whilst the males migrate north in open seas. The immature whales are believed to migrate slightly later and remain further south.

North Pacific

The IWC recognises two stocks in the northwest Pacific : Okhotsk Sea/ West Pacific; and the Sea of Japan, including the Sea of Japan, the Yellow Sea, and the East China Sea (IWC, 1980).

Minke whales are found all year-round in the Bering Sea but have not been seen further north than the Bering Strait (Kasamatsu and Hata, 1985; Ivashin and Votrogov, 1981). Soviet fleets have caught minke whales off the Kamchatka Peninsula from May to October (Ivashin and Votrogov, 1981). Also catches off the Aleutian Islands and the Kuril Islands and northern Okhotsk Sea have been reported (Kasamatsu et al., 1985). Gong (1987) reports that minke whales are caught off the coast of Korea in the Yellow Sea and the Sea of Japan throughout the year. Catches of whales taken further north and west of these Korean catches in the Yellow Sea reveal a seasonal abundance of minke whales in the summer (Wang, 1985a). Apart from Gong's (1987) report, very little is known about the winter distribution of minke whales in the western North Pacific.

There exists very little information on minke whales caught off the eastern coasts of the North Pacific. However sightings information has revealed that minke whales are common in the Bering Sea, coastal Gulf of Alaska, Puget Sound, San Juan Islands and the Strait of Juan de Fuca in spring and summer (Scheffer, 1973; Rice, 1974; Boran and Osborne, 1978; Braham *et al*., 1979; Everitt *et al*., 1980). Studies on the minke whale seen in the San Juan Islands and from the northern Puget Sound suggest that minke whales may reside all-year round in these areas (Everitt *et al*., 1980; Dorsey, 1983; Angell and Balcomb, 1982). Dorsey *et al.* (1990) studied free-ranging minke whales in three study sites along the west coast of North America; Monterey Bay in central California (1984-1987): San Juan Islands in Northern Washington (1980-1984) and the Johnstone Strait area of northern Vancouver Island, British Columbia (1981-1987). By identifying individuals from photographic techniques they provided evidence that a small population of minke whales is present in each site within and between years, probably returning each summer from winter grounds. In the San Juan Islands and the Monterey Bay sites individual minke whales were seen exclusively or almost exclusively in one of three subregions or ranges in the San Juan Islands and in one of two subregions in Monterey Bay. This small-scale spatial segregation persisted over many years with individual whales showing fidelity to a subregion in successive years.

There appears to be a northward migration along the coasts on both the east and west Pacific in the spring and summer followed by a southward migration in the autumn and winter apparently further offshore (Matsuura, 1936; Scattergood, 1949; Tomilin, 1967; Ohsumi, 1975; Rice, 1974; Mitchell, 1978). As in the North Atlantic, the whales in the North Pacific appear to show sex and age segregation in that during the summer months, immature animals remain in more southern waters while the mature whales travel to the more northern feeding grounds with females and males segregated geographically (Omura and Sakiura, 1956).

Southern Hemisphere

The IWC recognises six arbitrarily assigned baleen whale areas in the Southern Hemisphere for the management of minke whales stocks (IWC, 1978).

Minke whales in the Southern Hemisphere appear to be circumpolar and occur in great abundance. During the austral summer (December-May) the whales are abundant off Antarctica around the pack ice and coastal waters (Lillie, 1915; Williamson, 1959; Doroshenko, 1979; Lockyer, 1981). There appears to be geographical and temporal segregation in this area with males arriving earlier in the summer, the females arriving about a month later but continuing to higher latitudes near to the ice edge (Kato, 1982; Kasamatsu and Ohsumi, 1981). Kato *et al.* (1988) report that immature minke whales are found away from the ice edge. Japanese sightings data reveal the latitudinal and seasonal movement of the whales with a southward migration at the beginning of the austral summer from near the equator and a northward return beginning around February of the next year (Best and Ohsumi, 1980; Horwood *et al*., 1981; Joyce *et al*., 1988). This migration has also been shown by markings data with whales marked in the Antarctic in January and February being caught off the Brazilian coast in July and September (Horwood, 1990).

In the lower latitudes of the Southern Hemisphere, catch data revealed the presence of minke whales around the northeast tip of Brazil (Williamson, 1975) and that the catch was more productive from September to November (Paiva and Grangeiro, 1970). The earliest that a minke whale was caught was mid-June and the latest was in the last week of December. Data reveal that mature males are arriving in these areas later than the mature females in September and October (Singarajah, 1984).

Minke whales have been reported off the coast of western Africa and Angola but are generally uncommon (Williamson, 1975). Off Durban in southeast Africa it appears that minke whales are present all year round with abundance greatest during June to September (Burmeister, 1867; Lahille, 1908; Williamson, 1975; Best, 1967, 1974, 1977, 1982) when the population consists mainly of mature males (Best 1982). Sightings have also been made off both east and west coasts of Madagascar and off the coast of Mauritius (Gambell *et al*., 1975). Cruises in the southern Indian Ocean revealed that minke whales are widely distributed from November to February (Gambell *et al*., 1975) and that minke whales are reported in the Red Sea, Gulf of Aden, Persian Gulf, off Sri Lanka and off Indonesia, which are north of the equator, and that these whales are present in all months (Slijper et al, 1964). The relationship of these whales to those of the Southern Hemisphere is unknown.

1.4. Reproduction

The breeding cycle in baleen whales is usually biannual with mating and calving occurring approximately a year apart in warm, low latitude waters. Suckling is usually for seven months after which the calf is weaned. However, in the minke whale it appears that the breeding cycle is annual (Lockyer, 1979). Gestation has been estimated at 10 months (Best, 1982; Sergeant, 1963; Omura and Sakiura, 1956; Stephenson, 1951; Wang, 1985b; Ivashin and Mikhalev, 1978) and lactation is thought to last six months (Best, 1982; Jonsgard, 1951,1962). In the North Atlantic conception takes place from December to May with a peak month of February (Jonsgard, 1951; Sergeant, 1963; Stephenson, 1951; Mitchell, 1975a) with parturition taking place from October to March with a peak in December. In the North Pacific off Japan there appear to be two phases of conception, the majority of which occurs from February to March but also from August to September (Omura and Sakiura, 1956; Matsuura, 1936), with births occurring from December to January and June to July. In the Yellow Sea stock these two phases have not been noted with conception occurring from July to September and parturition peaking from May to June (Wang, 1985b). In the Southern Hemisphere conception takes place from June to December with a peak in August and September (Best, 1982). Peak birth time occurs from July to August.

In the North Atlantic sexual maturity has been estimated at 7.1 years in females and 6 years in males. Mean lengths at sexual maturity are 7.2m for females and 6.75m for males (Christensen, 1980, 1981). In the North Pacific, age at sexual maturity is unknown but is considered to be approximately 6-8 years. However, mean lengths at sexual maturity are estimated to be 7.3m for females and 6.7-7.0m for males (Mitchell, 1975b, 1978). In the Southern Hemisphere age and length at sexual maturity is approximately 6-8 years and 7.9m for females and 5-

8 years old and 7.3m for males respectively (Ohsumi *et al*., 1970; Ohsumi and Masaki, 1975; Masaki, 1979; Lockyer, 1981).

The reproductive cycle for minke whales is therefore a ten-month gestation period followed by a lactation period of four to six months. Conception thus occurs when the whale is lactating in the warmer waters at low latitudes before migration occurs. Birth occurs after the whale has returned from its feeding grounds to the warmer waters once again.

1.5. Feeding Ecology

Baleen whales are generally grouped into three types on the basis of feeding behaviour: swallowers, skimmers, and swallowers and skimmers (Nemoto 1959, 1970). Horwood (1987) classified minke whales as swallowers and skimmers on the basis of observations of feeding on Antarctic krill. In addition to swallowing, minke whales skim the surface of the water in 50m stretches, supposedly feeding on weak concentrations of krill. Dorsey (1983) observed minke whales lunging and swallowing shoals of fish in the waters off Washington State, and both swallowing and skimming behaviours have been described for minke whales by Gaskin (1982). Balaenopterids feed by engulfing large volumes of prey-laden water that extends the throat region. The mouth is then closed expelling the engulfed water through the baleen plates and the trapped prey is swallowed (Gaskin, 1976; Jurasz and Jurasz, 1979; Leatherwood *et al*., 1981; Lambertson, 1983). Minke whales have been observed feeding at the surface, pursuing small pelagic fish which they have driven up from deeper waters and this attracts many seabirds that also feed on these fish. Seabirds seen in association with minke whales include Fulmars, Sooty and Manx Shearwaters, Storm Petrels, Kittiwakes, Great Black-backed Gulls, Puffins, Arctic Terns, and Arctic and Great Skuas (Evans, 1982).

Hoelzel *et al*. (1989) studied the feeding techniques of 23 individually identified minke whales in the inland waters of Washington State and reported that each whale tended to specialize in one of two feeding techniques, lunge feeding or bird-associated feeding. An attempt at identifying the prey species was made by collecting dead fish or scales at the site of observed feeding. Juvenile Pacific herring *Clupea harengus* were found where lunge feeding had taken place and juvenile Pacific herring and juvenile sandlance *Ammodytes hexapterus* were found on separate occasions after bird-associated feeding had taken place. Bird associated feeding involved the whale exploiting the concentrations of fish fry below flocks of feeding birds. Alcids (auks) have been observed to pursue fish from below (Hoffman *et al*., 1981). The fish may also be concentrated and driven up from below by other predatory fish such as dogfish. Minke whales are then seen surfacing at the site where the birds are feeding. Lunge feeding is described as the whale actively concentrating the prey against the air/water interface with no birds involved and then lunging through the fish with its mouth open. The individual whales tended to feed in specific areas and return to these areas throughout the season and from year to year. The techniques also tended to be specific to a certain site implying that the whales specialised on a technique depending on the area that they return to annually. The areas where lunge feeding mainly occurred consisted of open basins bounded at one side by a shallow bay and by a steep slope at the other. The area where most bird-associated feeding occurs consisted of shallow banks bounded by deep water with direct oceanic influence through the Strait of Juan de Fuca. Hoelzel *et al*. (1989) suggest that minke whale feeding strategies depend upon variations in the distribution of prey in a complex and patchy environment. They suggest that bird-associated feeding occurs when the prey is concentrated and transitory in its occurrence usually along the edge of banks and in areas of upwelling. Whereas lunge feeding occurs when the prey is patchy but predictable in locality, i.e. spawning grounds of fish, and is abundant every year. Thus it is suggested that topography, and the hydrographic influences that this creates, affects the distribution of fish fry or their planktonic prey and that this in turn determines the feeding techniques most appropriate to exploit the prey.

In the North Atlantic minke whales feed on sand eel, euphausiids (mainly *Thysanoessa inermis*), copepods (mainly *Calanus finmarchicus*), salmon, capelin, mackerel, cod, coal fish, whiting, sprat, wolf-fish, dogfish, pollack, haddock, and herring (Henking, 1901; Collett, 1912; Hentschal, 1937; Ruud, 1937; Jonsgard, 1951, 1982; Sergeant, 1963; Christensen, 1971, 1974; Mitchell, 1975b, 1975c; Larsen and Kapel, 1981). In the more northern waters of the North Atlantic crustaceans, predominantly *T.inermis*, are the most important component of the diet whereas at east Greenland and Lofoten, fish are more important (Jonsgard, 1951, 1982). Minke whales caught off the coast of England and eastern Scotland were found to eat fish, consisting mainly of herring but also mackerel and sand eels. The distribution and timing of these whales suggested that they were following the migrating herring (Stephensen, 1951).

In the western North Pacific minke whales are reported to feed on euphausiids, copepods and sand lance and those in the Okhotsk Sea take krill and less commonly fish, including sand eels, sardine or anchovy (Omura and Sakiura, 1956). A more extensive study was carried out by Kasamatsu and Hata (1985) in the North Pacific in which the samples tended to show one main prey species in each region with herring predominating in the north Okhotsk Sea, Alaskan pollack in eastern Sakhalin, mackerel to the east of the Kuril Islands and krill from the western Bering Sea. Their results also show a temporal change in food preference from two locations in the northwest Pacific, in the Okhotsk Sea and off northeast Honshu, showing a switch from predominantly selecting krill and sandeels early in the summer to favouring sardines later in the season. Stern (1990) suggests that this switching is due to prey abundance and that the minke whales are feeding on the most abundant and concentrated prey in the area at the time. Krill and sandeels are diatom feeders and so increases in primary productivity in spring and early summer would increase the abundance of these species. Sardines become more abundant later in the year in response to the increase in herbivorous zooplankton.

From the eastern North Pacific little is known about the prey species consumed by minke whales. However, minke whales have been observed feeding on shoals of herring (Dorsey, 1983; Scattergood, 1949; Stewart and Leatherwood, 1985) and on sand lance (Hoelzel *et al.*, 1989).

In the Southern Hemisphere the most important prey species in the Antarctic is krill, mainly *Euphausia superba* but also *E. spinifera* and *E. crystallorphias* (Ohsumi *et al*., 1970; Kawamura, 1980; Bushuev, 1986). Minke whales have also been reported to consume various species of myctophid fishes (Nemoto, 1959; Ohsumi *et al.*, 1970; Laws, 1977; Ohsumi, 1979, Best, 1982). Only 15% of minke whales landed at Durban in August and September had samples of food in their stomachs and these consisted mainly of euphausiids (Best, 1985). Similarly only 3% of whales killed off Brazil from June to November had small amounts of krill in their stomachs (Williamson, 1975).

1.6. Introduction to the study.

Twenty-six of the 82 known species of cetacean are known to inhabit the waters around Britain (Evans, 1990). However, while there exists a sightings network (Sea Watch Foundation and The Hebridean Whale and Dolphin Trust), very little behavioural and ecological research is being conducted in this country to determine whether these cetaceans are transient, travelling to feeding grounds further north, or whether indigenous or seasonally resident populations exist.

The waters to the north and west of Mull contain an ecologically diverse marine life. Regularly sighted cetaceans include minke whale *(Balaenoptera acutorostrata)*, harbour porpoise *(Phocoena phocoena)*, Risso's Dolphin *(Grampus griseus)*, common dolphin *(Delphinus delphis)*, and killer whale *(Orcinus orca)* (Fairbairns, Sea Life Surveys, pers. comm.). The regular sightings of minke whale in this area provides an excellent opportunity for the behavioural and ecological study of this species, the behaviour of which is virtually unknown in the Eastern North Atlantic. The results of such a study could have important implications for the management of minke whales if commercial hunting were to resume in the eastern North Atlantic. Behavioural and ecological studies are greatly enhanced by the ability to identify individuals in the population being studied. Initially individual recognition was mainly achieved by tagging and marking animals however, it was realised that some animals could be identified by their natural markings and that this benign technique was appropriate for behavioural studies. Photo-identification has proved successful for the individual recognition of cetaceans and comprehensive catalogues have been established for a number of species, for example, killer, humpback and right whales. Photo-identification has been shown to be a feasible technique for the individual recognition of minke whales in the eastern North Pacific (Dorsey, 1983; Dorsey *et al.*, 1990), western North Atlantic (Sears *et al.*, 1987) and the Antarctic (Joyce and Dorsey, 1990). However it is not known if this technique could be applied to the minke whales in the Eastern North Atlantic.

"Sea Life Surveys" was set up in 1990 by Richard Fairbairns conducting research and whalewatching trips covering the waters between Mull, the Scottish mainland (Ardnamurchan Point), Coll, Tiree, Eigg, Muck, Rum and the Treshnish Isles. Since 1997 Sea Life Surveys has been operated by Richard's son Brennen. The main focus of this research is the minke whale and data collected on these trips includes details of locations, photographs, behaviourial observations and details of environmental conditions. This research is conducted under the supervision of The Hebridean Whale and Dolphin Trust.

1.7. The Aims of this Study

The aim of this study is to evaluate the potential for identifying individual minke whales using photographic techniques and to use this photo-identification as a tool to answer various questions about the ecology of the minke whale in the coastal waters around Mull.

The aims are:

1. To examine an existing database of photographic records, collected by Sea Life Surveys, in order to assess the technique of photo-identification of the minke whale and the feasibility of its use for ecological studies.

2. To investigate whether individual minke whales are returning to the study area in successive years.

3. To investigate whether individual minke whales are seasonally resident or transient.

4. To investigate the ranges of individual minke whales in the survey area around Mull.

5. To monitor the acquisition of scars and how persistent they are.

2. Materials and Methods

2.1. The Survey Area

The survey area covered by Sea Life Surveys is shown in Figure 2.1. and is approximately 300 square miles. The survey trips are conducted aboard a 10.5 metre M.V., *Alpha Beta*, equipped with a flying bridge (the whale viewing deck) and a Global Positioning Satellite (GPS) navigation system.

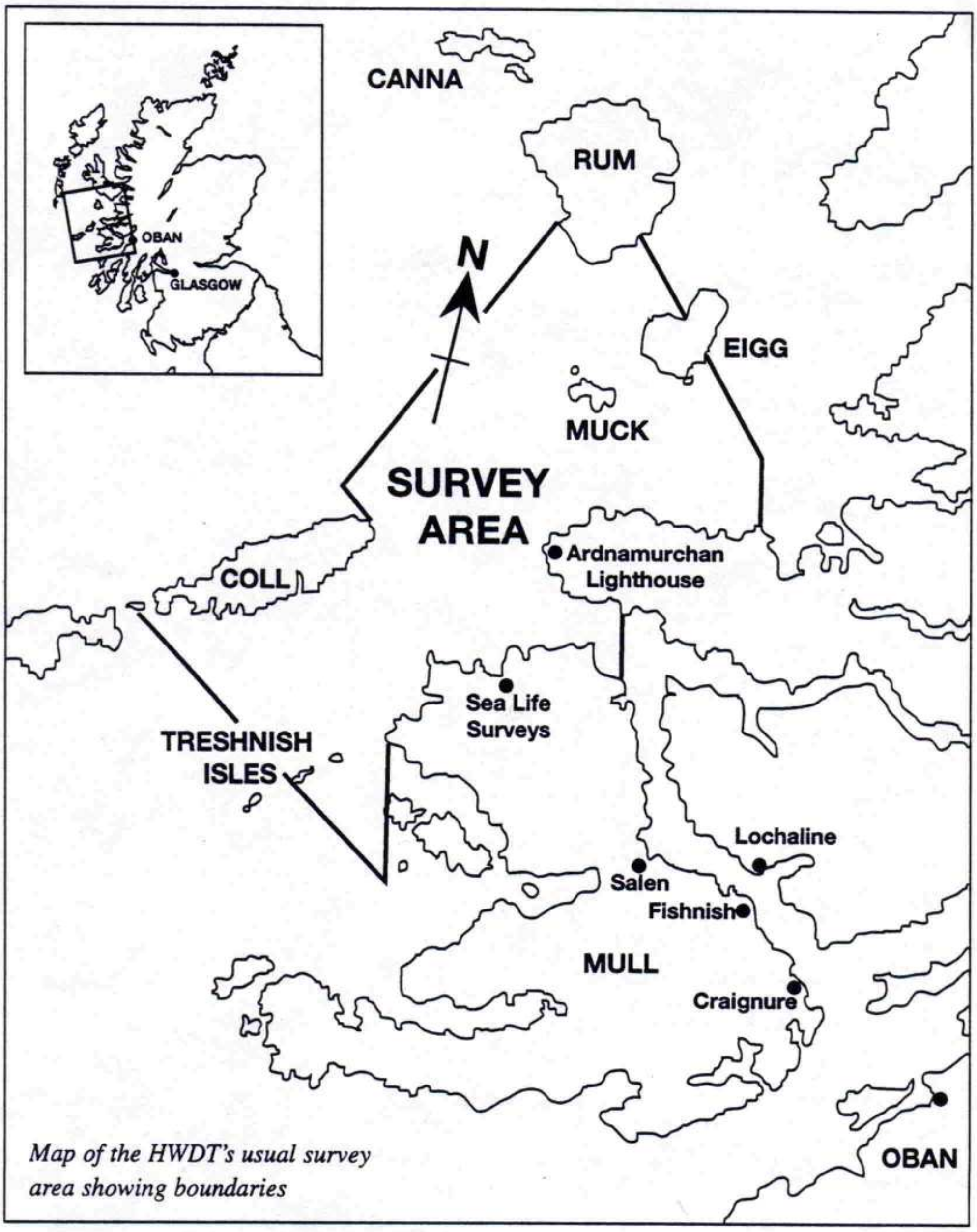
Whale-watches were either 4-hour trips, 6-hour trips or package trips which lasted between 8-12 hours depending on the weather and light conditions. Observations were generally made from the flying bridge which at eye level is approximately 4m above sea level, or from the lower deck with eye level at approximately 2m above the sea level. Twelve paying passengers are usually on board with six people at a time on the flying bridge who are actively on effort. They are positioned so that a 360° coverage of the surrounding sea is achieved. One crew member and the skipper are also present and are on effort for most of the trip.

2.2. Sighting cues

Various sighting cues have been described for minke whales. Best and Butterworth (1980, 1982) report that the major sighting cue for Antarctic minke whales is the visible blow. However for Northern Hemisphere minke whales, blows are rarely visible and the major sighting cue reported is the body surfacing (Ivashin *et al* 1981, Joyce *et al* 1989, Dorsey *et al* 1990, Oien 1990, Oien *et al* 1990 , Stern, 1990).

A variety of sighting cues are recorded for sighting minke whales around Mull. The major cue is the body surfacing but other important cues are aggregations of feeding birds, the smell of the breath of minke whales and the sound of the blow.

Figure 2.1. The Survey Area covered by Sea Life Surveys on the West Coast of Scotland.



A sighting in this study is defined as an encounter with a whale or a school of whales until such time that the whale or school is no longer in view of the observers. Every new encounter is allocated a new sighting number despite the possibility of the same whale or school being encountered.

2.3. LOGGER

"LOGGER" is a computer program written by Lex Hiby and Phil Lovell (Conservation Research Ltd.) for the collection of data in real time on a portable IBM PC on the boat. "Logger" operates whenever the boat is in motion. The use of LOGGER was initiated in June 1992. It provides a means of collecting detailed data on sightings, such as species, number of animals, date, time, distance from the boat, bearing and the initial cue; sightings effort such as number of observers, the type of search being executed and the type of voyage being run; positional data which is directly input into the PC via the serial port from the GPS navigation system; environmental data relating to sea and weather conditions and surfacing data. Environmental and effort data is usually updated every 15 minutes.

2.4. Measuring effort

It is important to take into account, when expressing the number and location of sightings, the amount of time spent at sea, the distance travelled and the type of trip conducted, as changes in the number of sightings may be due to changes in sighting effort. Therefore sightings should be expressed as the number of sightings per unit effort. Effort data has been recorded since July of 1992 in the LOGGER program recording the time spent at sea, whether the effort was directed towards actively searching for whales or otherwise and the number of observers present. Stern (1990) defined **Sightings Per Unit Effort** as the number of schools of whales seen per unit effort of search. In this study SPUE was calculated using two different units of effort for comparison. One effort unit used was given by the one hour of search time. Search time is defined as the time in which the boat is operating with observers actively searching for whales. The other unit of effort used was distance travelled defined as distance travelled by the boat with observers actively searching for whales.

2.5. Photographic data collection

The photographic catalogue consists of photographs taken during whale-watching seasons from May to October 1990-1999 and were taken by Richard Fairbairns and Brennen Fairbairns. Photographs were taken with a Canon EOS10 35mm single lens reflex camera equipped with a 300mm f2.8 lens and a motor drive. Shutter speed was set at 1/1000s. The film used was Fuji Superia 200 ISO print film and in 1999 Fujichrome Sensia II 200 ISO slide film was used for the first time. The camera has a data back facility for printing the date and time on the photograph. Photographs were processed at a commercial photographic laboratory. The photographs were labelled with date, sighting number, film number and frame number and stored in envelopes, one for each sighting.

Black and white prints were sometimes produced from the colour negatives to highlight certain features to aid individual identification; for example, by varying the contrast of the prints, scars and pigmentation of the whale can be enhanced.

2.6. Photographic Analysis

All the photographs were examined and initially sorted by selecting those photographs which were of sufficient quality for identification purposes. A photograph is considered to be of good quality if the major axis of the whale in the photograph is perpendicular to the photographer and the image is large enough to show various distinguishing features such as fin shape, pigmentation and body scars. These were stored in A4 plastic photograph holders in a file, in order of sighting number. These were then studied for various features in order to distinguish between individuals whales and to match re-sightings.

2.6.1. Features used for Photo-identification

The photographs were analysed to document the scars found on the whales and to investigate the most useful markings for the purpose of photo-identification.

In this study the initial sorting of the selected photographs involved firstly looking for any nicks on the dorsal fin. The position of the nick on the fin and the general fin shape was also noted to reduce the likelihood that two different whales were identified as one. When no nicks were obvious, the next step involved looking for any unusual fin shapes.

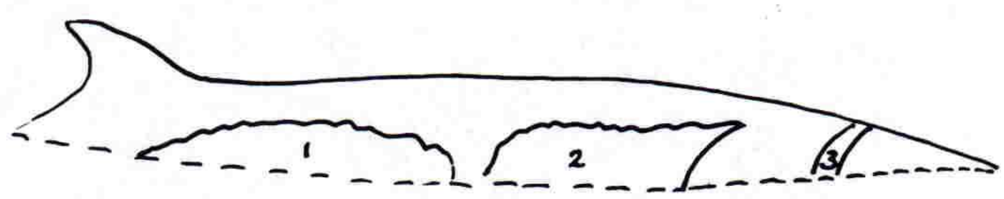
<u>Body Scars</u>

Dorsey (1983) and Dorsey *et al*. (1990) described oval scars seen on the minke whales photographed in the eastern North Pacific and the photographs were analysed for the presence of these scars. Other body scars were looked for and were used to identify individual whales. Only those scars which were considered to be permanent were used for identification purposes when the scar is the main identifying feature. Permanent scars are those resulting from healed wounds. Fresh body wounds tend to appear white and will fade upon healing and may disappear. However small white scars can be useful to aid identification especially if re-sightings occur within one year.

Lateral body pigmentation

The three distinct swaths of lighter pigmentation on each side of the minke whale's body described by Best (1985) and Dorsey (1983), consisting of the flank patch, thorax patch and the crescent-shaped grey streak, could be used as distinguishing features for photo-identification (Figure 2.6.) This lateral body pigmentation is stable over time (Dorsey *et al*., 1990) and its configuration is useful for individual identification as well as providing reference points for the position of scars. The pattern of this pigmentation is unique for each whale.

Figure 2.6. Lateral body pigmentation.



1. Flank Patch
2. Thorax Patch
3. Grey Streak

2.7. Identified Individuals

The strictness of the criteria for identification of an individual varies amongst photo-identification studies and usually depends on the purpose of the study. For population estimates the criteria are very strict as misidentifications will cause errors in the abundance estimate and usually photographs of both sides of the whale are required. Thus it is important to define in any study the criteria used to classify a whale as identified. In this study the aim was to establish a catalogue of individuals so that re-sightings of an individual could be recorded and this information would then be used to study the behaviour and ecology of the minke whale.

In this study I have set the following criteria:

1. Whales that have very distinctive nicks or notches in their dorsal fins are classified as identified. Therefore as long as a good perpendicular photograph of the dorsal fin is obtained, in future re-sightings a match should be achieved. The possibility that a whale could obtain a new nick or notch should always be considered in which case the position of notches and the shape of the fin becomes important.

2. Whales with very unusual fin shapes are classified as identified so that as long as a good perpendicular photograph of the dorsal fin is obtained, in future re-sightings a match should be achieved.

3. Whales with unusual pronounced scars on their bodies along with a dorsal fin shape tracing are classified as identified. However in this case a match can only be obtained if in future re-sightings the same side of the body is photographed. The purpose of this study is to achieve as many re-sightings as possible for ecological and behavioural studies and so if the whale is potentially identifiable from one side only, it is included in the catalogue. It is hoped that in future re-sightings both sides of the whale can be photographed. It is important to add here that when a whale is included in the catalogue on the basis of only one side of its body being photographed, there is a chance that it is already in the catalogue as a whale photographed from the opposing side. Fin shape tracings should eliminate the possibility of this occurring.

4. Whales are also identified on the basis of their lateral body pigmentation and fin shape, and the position of any body scars in relation to this pigmentation. Again the problem of only photographing one side of the body is the same as above.

A catalogue of identified whales was established containing all the photographs from the identified sighting and any subsequent re-sightings. Each identified whale was given a number and the best photographs highlighting its distinguishing feature were catalogued. A database was established for the identified whales containing information collected by the LOGGER program and also its identifying features. The locations of all the sightings for each identified whale were plotted to investigate intra-seasonal movements.

3. Results

3.1 Analysis of the LOGGER data for minke whales

LOGGER data regarding the number of sightings and group size of minke whales has been analysed and is tabulated in Appendix 1. Effort data in terms of search time and distance travelled in nautical miles is tabulated in Appendix 2.

3.1.1. Sightings

Table 3.1.1. Sightings of minke whales by month for each year

A sighting in this study is defined as an encounter with a whale or a school of whales until such time that the whale or school is no longer in view of the observers. Every new encounter is allocated a new sighting number despite the possibility of the same whale or school being encountered.

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	1	-	2	1	-	-	-
May	18	31	29	36	18	15	15	18	13	21
June	21	10	26	31	23	45	24	32	24	43
July	8	18	30	36	41	32	22	45	26	40
Aug	9	21	24	38	55	68	38	71	18	38
Sept	7	15	13	44	43	32	8	11	25	17
Oct	-	1	4	9	10	-	-	-	-	2
Total	**63**	**96**	**126**	**195**	**190**	**194**	**108**	**177**	**106**	**161**

Sightings per unit effort (SPUE) has been calculated for both hours spent searching for whales and distance travelled in nautical miles. SPUE for each year by month are shown in Figures 3.1.1. (a) and 3.1.1. (b) respectively. The graphs do not show any relationship between SPUE and month. It should be noted that differing relative values for SPUE were calculated depending on the unit of effort used (i.e. hours searching or distance travelled). This raises the question of which unit of effort is the most accurate when calculating SPUE. LOGGER data has been previously analysed to assess the relative abundance and distribution of the minke whales around Mull and in this analysis the unit of effort used was distance travelled in searching mode (Leaper *et al*, 1997).

Figure 3.1.1 (a). Sightings of minke whales per unit of effort (hours searching)

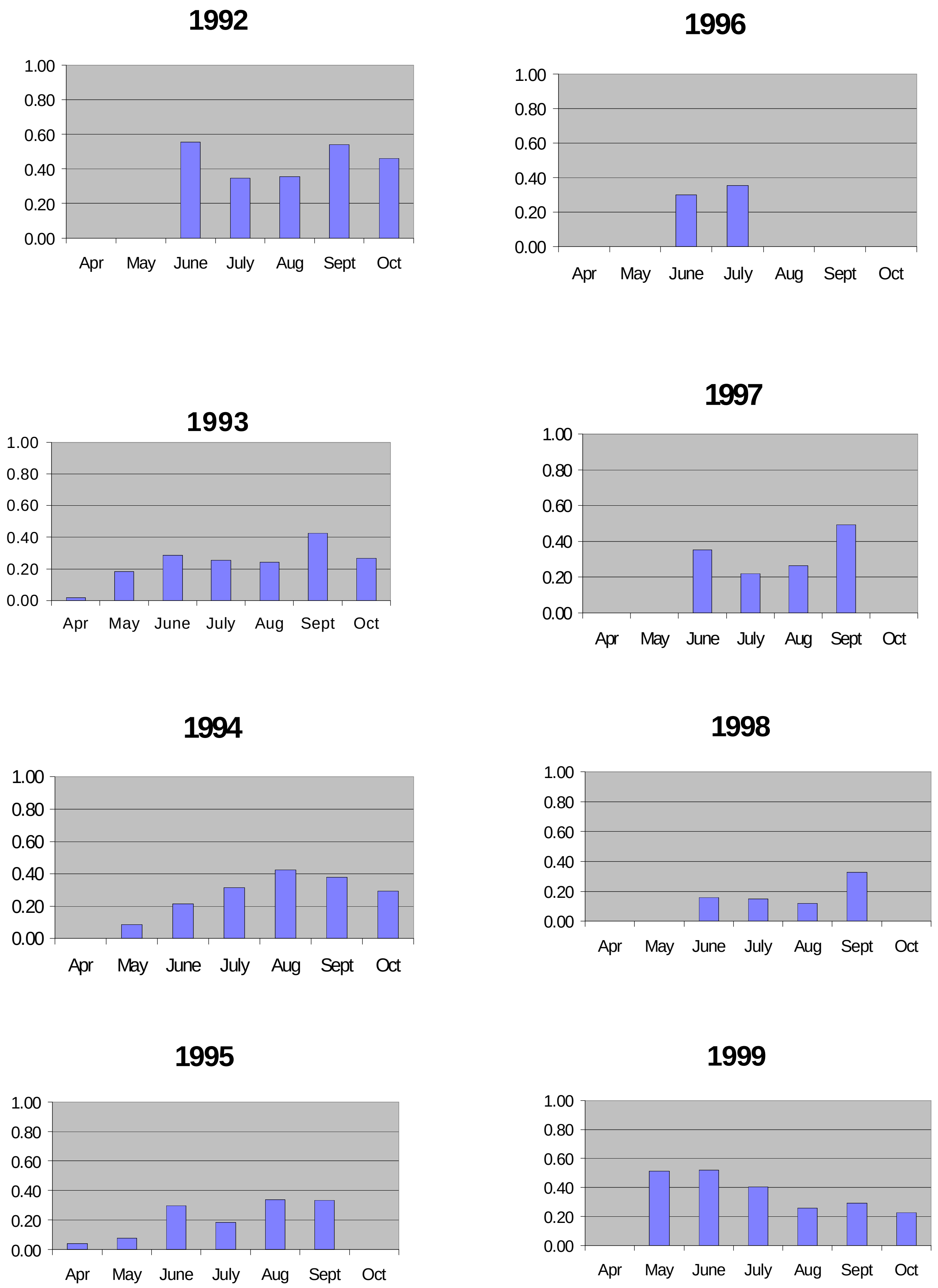
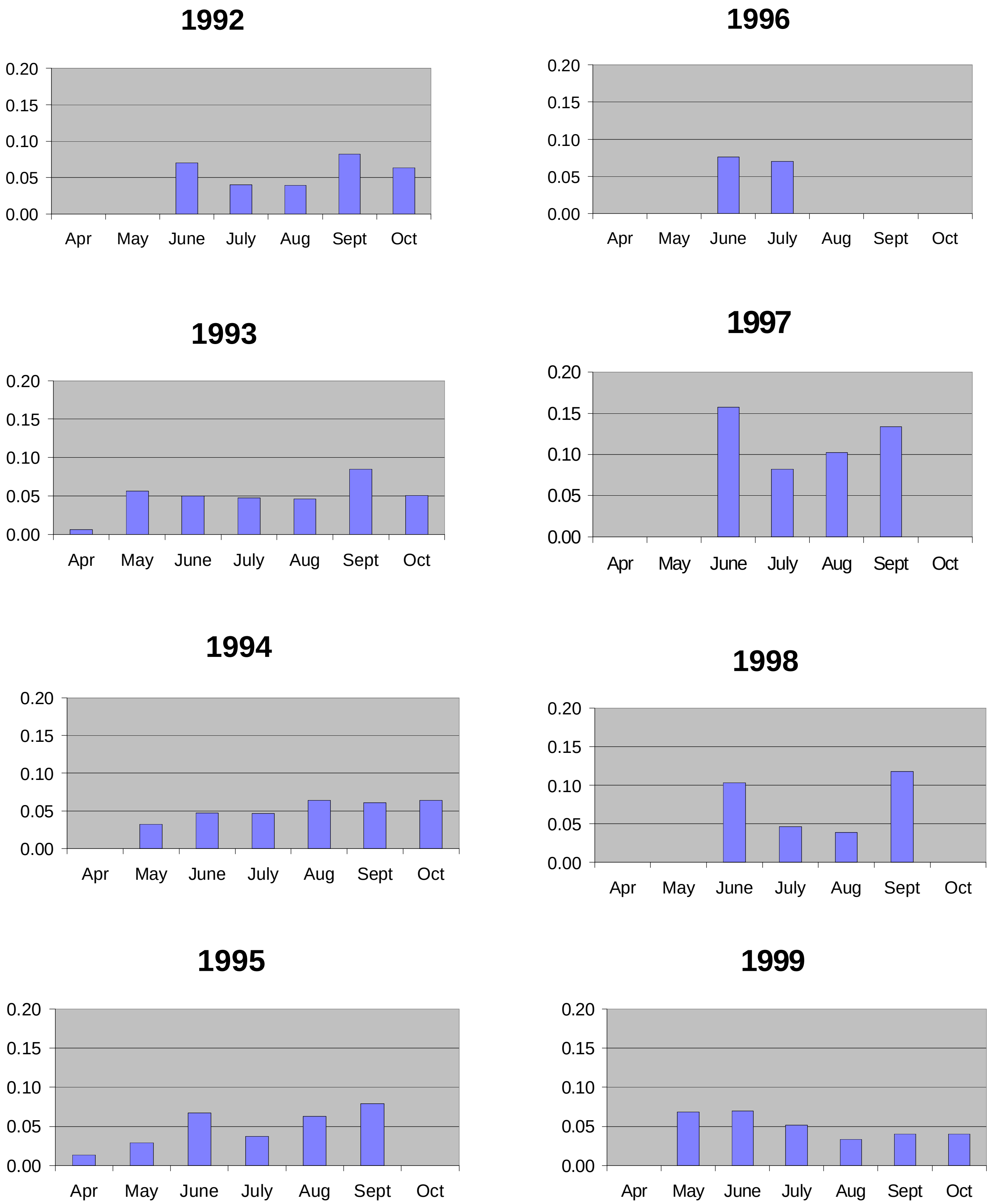


Figure 3.1.1. (b). Sightings of minke whales per unit of effort (distance in nautical miles travelled while searching)

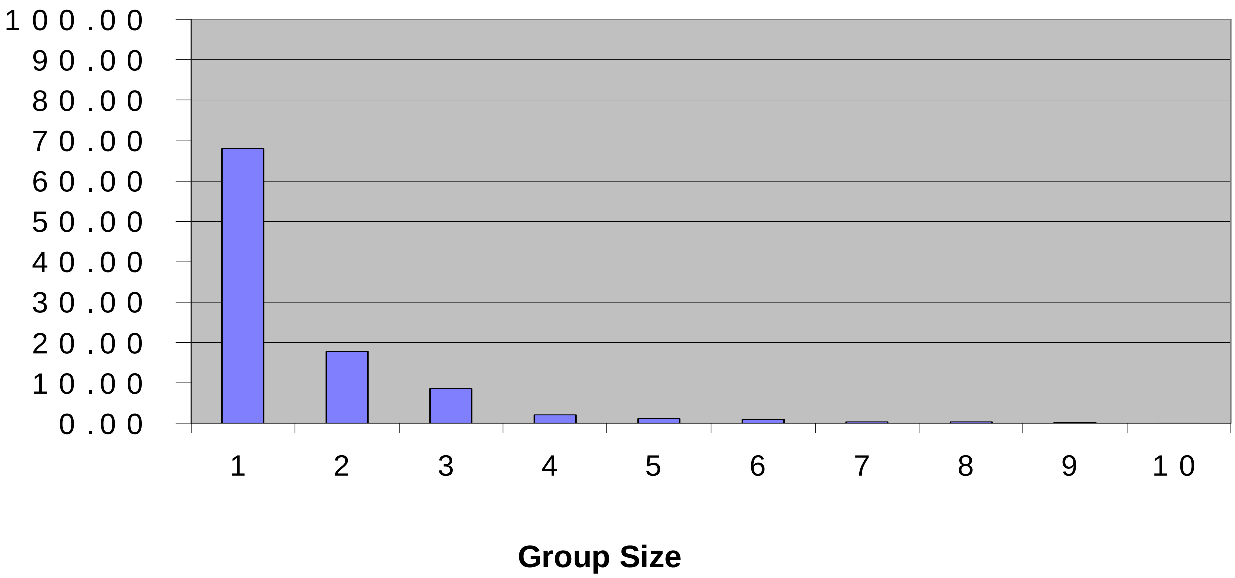


3.1.2. Group Sizes

The data was analysed to investigate the group sizes of the whales encountered and to investigate any patterns in seasonality of each group size.

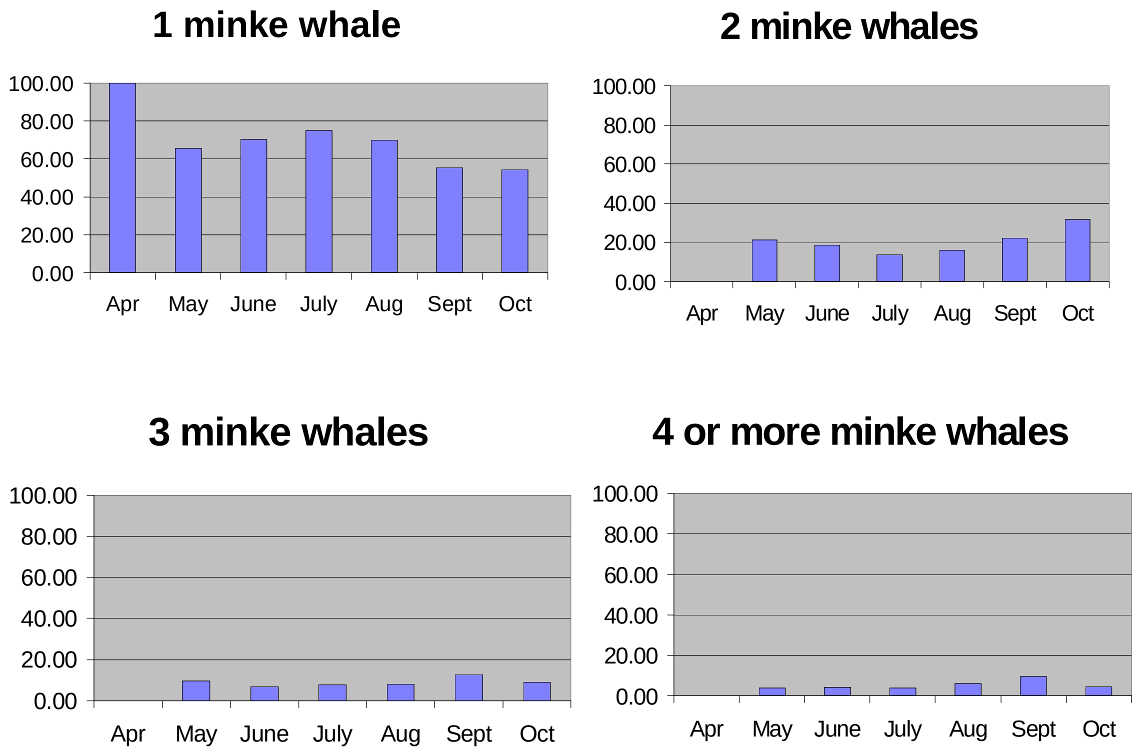
The percentage frequency distribution of the group size of whales encountered from 1990-1999 is shown in Figure 3.1.2.(a). The largest group encountered consisted of 10 whales. 68.1% of sightings were of solitary whales, 26.5% of sightings consisted of 2-3 whales and the remaining 5.4% of sightings consisted of groups varying from 4 to 10 whales. It is interesting to note that one whale in 1992 was sighted with a very young calf swimming by her side. This is the only sighting of a mother calf pair although small whales are often seen in the vicinity of larger whales.

Figure 3.1.2 (a) Percentage frequency of group size for minke whales for 1990-1999



The percentage frequencies were plotted for group sizes of 1, 2, 3 and 4 or more minke whales by month for all years to investigate if there are any patterns in seasonality of differing group sizes. These graphs are shown in Figure 3.1.2. (b). These graphs show that relatively fewer sightings of solitary whales are seen during September and October.

Figure 3.1.2 (b). Percentage frequencies of group sizes for all years 1990-1999



3.2. Analysis of Photographic Data

3.2.1. Scars on the whales

On analysis of the photographs the type of scarring on the whales have been noted.

Notches in the dorsal fins

The notches in the dorsal fin vary in shape, size, and position and very distinctive fins are shown in figures 3.2.1.(a). Some whales have smaller notches in their fins, which are less obvious and these are shown in Figure 3.2.1.(b). The cause of these scars is unknown. Dorsey *et al* (1990) found that the notches in the dorsal fins of the 55 minke whales they photographed over 11 years did not change over time, except for one identified whale which acquired an additional notch. They state that they do not know the cause of the notches.

Thin white lines

Thin white scars of varying length are apparent on the whales and are shown in Figures 3.2.1.(c). One photograph reveals the possible cause of these scars to be the parasitic copepod *Pennella sp.* Other whales have been photographed with *Pennella sp.* attached.

White oval scars

Many of the whales have oval scars although they were not present in the numbers described by Dorsey et al. (1990). These scars vary in their whiteness due to the degree of healing and are shown in Figure 3.2.1.(d). Dorsey et al (1990) estimate that these oval scars are 5cm by 3cm, indented by no more than 5mm and that the long axis of the oval scar is almost always parallel to the longitudinal axis of the whale.

Dorsey et al (1990) often photographed parasitic copepod Pennella sp. hanging from these oval scars but they do not think that these cause these scars. They suggest that the Pennella sp. attach themselves at the site of the existing wounds. As shown above Pennella sp. is thought to cause thin white scars. Circular scars have been attributed to lampreys (Pike, 1951: Nemoto, 1955) and to cookie-cutter sharks (Jones, 1971: Shevchenko, 1971) (see Figure 3.2.1. (e)).

Lampreys feed by attaching themselves to the skin of fish or mammals, rasping through the skin and sucking out the blood. Shevchenko (1971) states that lampreys can only cause circular wounds and scars not oval ones, however, Lythgoe and Lythgoe (1991) state that lamprey mouths are oval when in use and so it is feasible that they will cause oval scars. The cookie-cutter shark attaches itself to its prey with its suctorial lips, and then spins to cut out a cookie-shaped plug of flesh from the larger animal.

Lampreys are found along the north-west European and African coasts as well as around Iceland (Lythgoe & Lythgoe, 1991) and cookie-cutter sharks are found in the southern areas of the Northeast Atlantic, primarily from about the Cape Verdes southwards and usually far offshore over deep oceanic waters (The Shark Trust's Website).

White scars on the mouth

White scars are often apparent on the mouths of the whales and examples are shown in Figure 3.2.1. (f). The cause of these scars is unknown.

Notches in the rostrum

Some whale have notches in the ridges of their rostrums thought to be caused by some foreign material such as ropes being wrapped around their rostrums and examples are shown in Figure 3.2.1. (g).

Miscellaneous scars caused by entanglement in marine debris

One whale has evidence of rope entanglement as it has a scar around its head behind the blowholes. The twist of the twine is visible in the skin. Two of the whales have plastic strapping still wrapped around their rostrums caught in the baleen plates. Other whales have white scars that are probably due to plastic strapping or fishing line. Examples of these are shown in Figure 3.2.1. (h).

Other Miscellaneous scars

Other scars are apparent on the whales and are shown in Figure 3.2.1. (i). The cause of these scars is unknown.

Diatoms and Parasites

A couple of the whales had rust coloured areas on their rostrums (see Figure 3.2.1. (j)). Sears *et al* (1990) report that blue whales found in cold waters are often covered with accumulations of diatoms which appear as rust-coloured blotches. The vast majority of diatoms found on whales belong to one species, *Cocconeis ceticola* (Hart, 1935). Other parasites are sometimes seen, mainly *Pennella sp.* These appear as dark lines on the whales and can be seen in Figure 3.2.1 (j). *Xenobalanus globicipitis* has also been identified as the parasite on the dorsal fin shown in the middle photograph of Figure 3.2.1 (j).

Figure 3.2.1 (a). Dorsal fins that have distinctive notches

Whale no. F/D1

Whale no. F/D 2

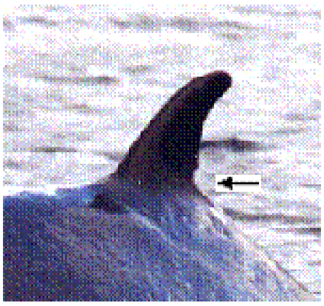
Whale no. F/D 3

Whale no. F/D 4

Whale no. F/D 5

Whale no. F/D 6

Whale no. F/D 7

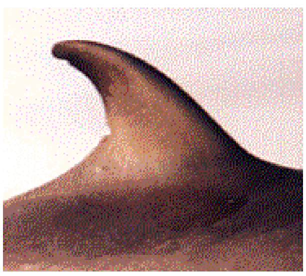


Whale no. F/D 8

Whale no. F/D 9

Whale no. F/D 10

Whale no. F/D 11

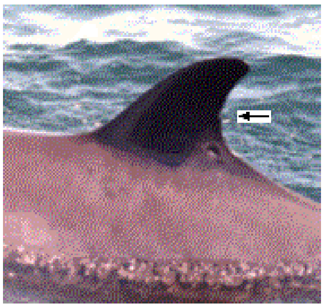


Whale no. F/D 12

Figure 3.2.1 (a) Dorsal fins that have distinctive notches

Whale no. F/D 13

Whale no. F/D 14



Whale no. F/D 15

Whale no. F/D 16

Whale no. F/D 17

Whale no. F/D 18

Whale no. F/D 19

Whale no. F/D 20

Whale no. F/D 21

Whale no. F/D 22

Whale no. F/D 23

Whale no. F/D 24

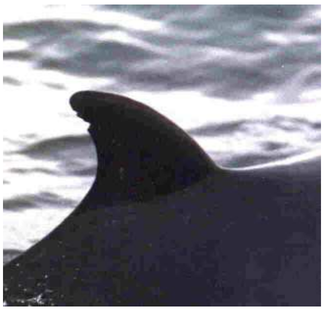
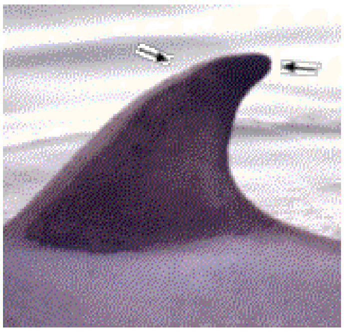


Figure 3.2.1. (b) Dorsal fins that have small notches

Whale no. F/S 1

Whale no. F/S 2



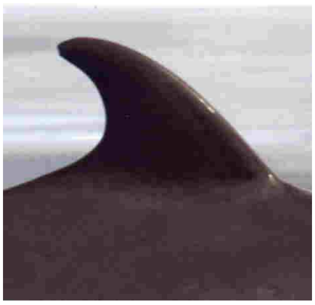
Whale no. F/S 3

Whale no. F/S 4

Whale no. F/S 5

Whale no. F/S 6

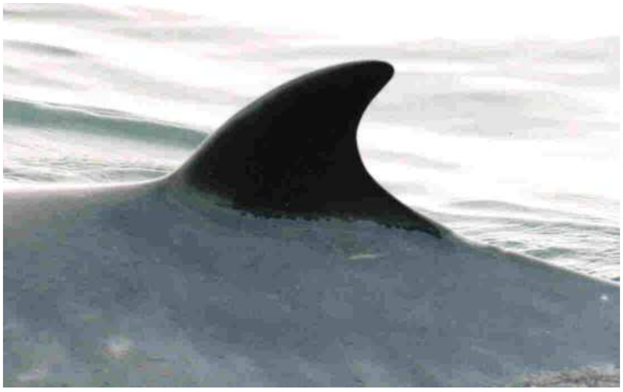
Whale no. F/S 7



Whale no. F/S 8

Whale no. F/S 9

Figure 3.2.1 (c). Thin white scars



A parasite copepod *Pennella sp*. attached to the whale, the probable cause of the white line.

Figure 3.2.1 (d). Oval scars

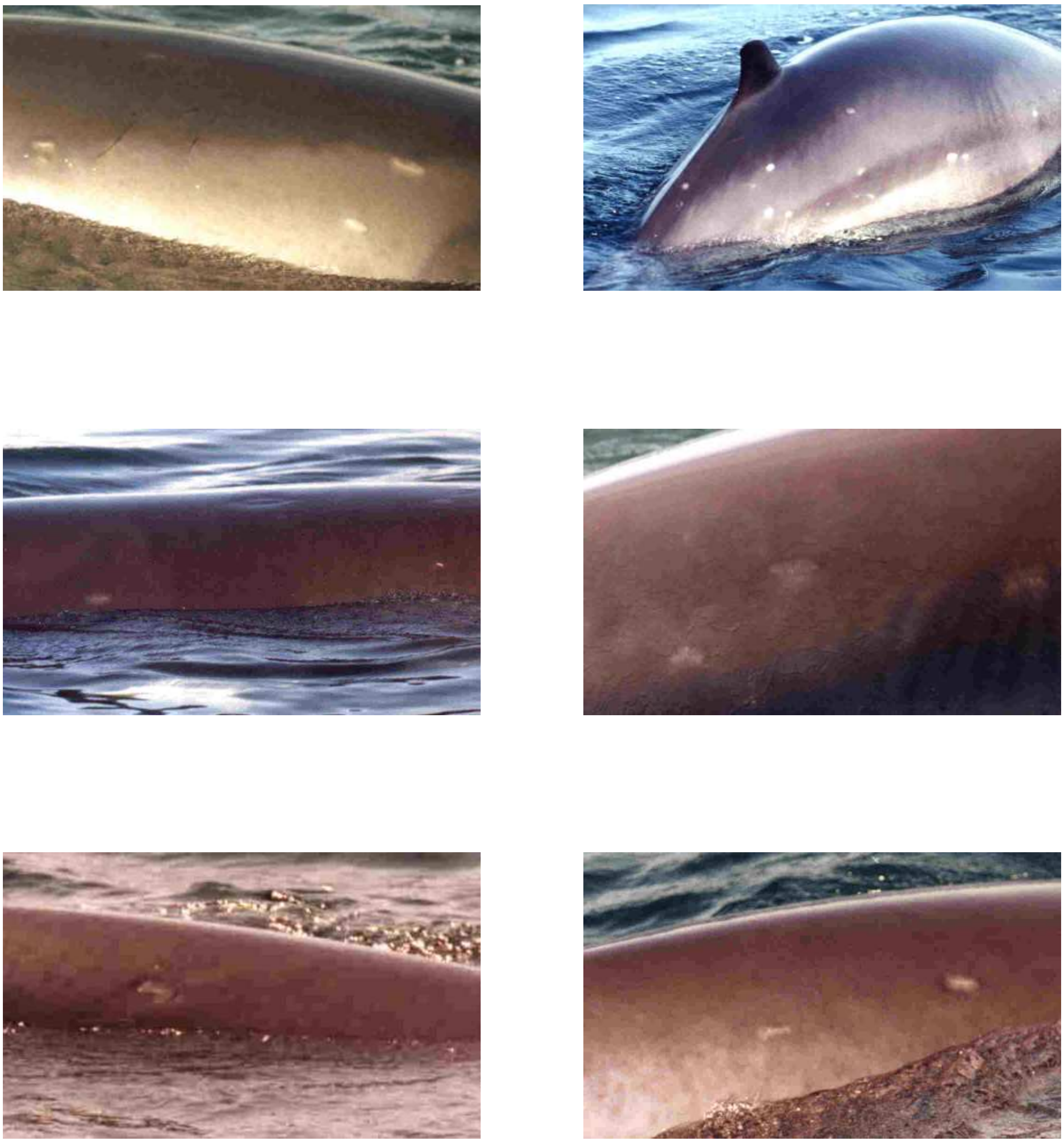


Figure 3.2.1. (e). Lamprey and Cookie-cutter sharks - the possible cause of circular and oval scars on minke whales

Lamprey **Lamprey's mouth**

Cookie-cutter shark

Scars caused by cookie-cutter scars

Figure 3.2.1. (f). White marks on the mouth

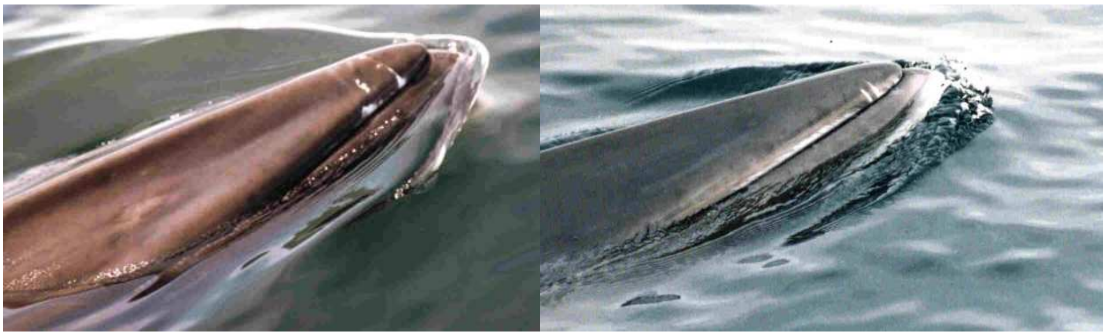


Figure 3.2.1. (g). Notches in the rostrums

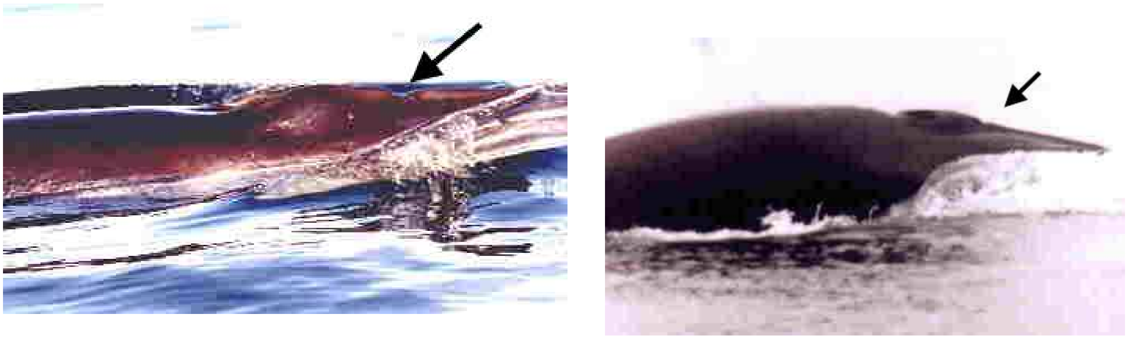


Figure 3.2.1. (h). Scars caused by entanglement in marine debris

Scar caused by a rope. See the twist of the twine in the above right hand photograph.

Figure 3.2.1. (h). continued. Scars caused by entanglement in marine debris

Looks to be caused by debris wrapped around the flank

Whales that have plastic strapping around their rostrums

Whale that has had plastic strapping or similar object cutting into its skin

3.3. Photo-identification Catalogue

Photographs collected for the period of 1990 -1999 were analysed. Whales were identified and catalogued by using one or a combination of the scars described above. Many of the whales photographed do not have scars on them and so remain unidentified.

It was recognised early in this study that the photographic ‘catchability’ of each identified whale is not equal. Those whales with very large notches in their dorsal fins are easier to re-matched on future encounters compared to those whales with very subtle marks that only show up in good quality, close up photographs. Some whales are also included in the catalogue based on their white scars which are known to fade over time. These scars are useful for re-sightings within a season but they are probably not sufficient for between-year matches. As the photo-identification project has developed it has become apparent that many whales are not being re-sighted and it is important to look at the reliability of some of the identifications and the scars used for these identifications.

Sixty-six whales have been catalogued from a total of 1416 sightings, based on the above set criteria for this study.

Of the 66 identified whales, 24 were identified by very distinctive notches in their dorsal fins; 9 were identified by smaller less distinct notches; 2 with marks on their dorsal fins; 3 from their fin shape; 16 were identified by pronounced body scars; and 12 from white oval scars and other white marks. Lateral body pigmentation proved ineffective as a means of identifying whales, probably due to the lack of appropriate lighting and the height above sea level from which the photographer operates the camera. However it was useful to look at the position of body scars in relation to the pigmentation of the whale to help with re-sightings.

3.4 Re-sightings of Identified Whales

The identified whales and their re-sightings are listed in Table 3.4. They have been numbered according to their distinguishing feature. F/D = distinctive notches in the dorsal fin, F/S = small notches in the dorsal fin, F/SH = unusual dorsal fin shapes, F/M = marks on the dorsal fin, B/S = distinctive scars on the body and B/W = white oval or circular scars on the body.

Table 3.4. Identified Whales and Sightings (Sighting number and date listed)

Distinctive notches in the dorsal fin (F/D)

F/D 1. Nick 1

94	14/8/90
217	24/5/91
283	4/7/91
371	27/8/91
783	14/8/92
825	20/9/92
847	20/9/92
1060	13/7/93
1329	5/9/93
1381	17/9/93
1395	26/9/93
1538	2/6/94
2328	30/5/95
2553	1/8/95
2560	1/8/95
2561	2/8/95
2563	2/8/95
2593	6/8/95
3622	10/6/97
3809	20/7/97
3926	5/8/97
4061	18/8/97
4180	28/5/98
4228	29/6/98
4393	9/9/98
4449	17/5/99
4490	1/6/99

F/D 2. Nick 2

523	22/5/92
542	29/5/92
763	9/8/92
926	20/5/93
1185	16/8/93
1472	24/5/94
1829	14/8/94
1844	17/8/94
1915	25/8/94
2836	14/9/95
2841	15/9/95
3531	3/9/96
3830	22/7/97
4018	13/8/97
4020	13/8/97
4155	23/9/97
4161	26/9/97
4166	13/5/98
4168	13/5/98
4172	15/5/98
4177	22/5/98
4796	25/8/99
4802	26/8/99
4825	13/9/99

F/D 3 . Hook

715	21/7/92

F/D 4. Cubix

556	7/6/92

F/D 5. Holey

565	9/6/92
751	7/8/92
1849	18/8/94
2011	1/9/94
2096	11/9/94
2677	18/8/95

F/D 6. Notch

238	28/5/91
322	7/8/91
378	30/8/91
514	22/5/92
932	23/5/93
4172	15/5/98

F/D 7. Chunky

76	28/7/90
257	23/6/91
718	22/7/92

F/D. 8 Hi-Nick

1259	30/8/93
2159	19/9/94
3459	13/8/96
3430	14/8/96
4110	24/8/97

F/D 9. Slash

1624	3/7/94
4827	14/9/99

F/D 10. Face

1641	5/7/94
2096	11/9/94
3504	23/8/96
3509	26/8/96

F/D 11. Double Nick

674	7/7/92
1031	28/6/93
1651	5/7/94
2617	8/8/95

F/D 12. Ratchett

1928	25/8/94
2871	19/9/95
4253	10/7/98

F/D 13. Gnocchi

1177 15/8/93
2236 10/10/94
2624 9/8/95
2843 17/9/95

F/D 14. Bullet

2403 22/6/95

F/D 15. Triangle

3430 14/8/96

F/D 16. Munch

3127 8/7/96

F/D 17. Peck

3523 30/8/96

F/D 18. Snip

3622 10/6/97
3647 19/6/97
3857 25/7/97

F/D 19. Tipsy

4286 27/7/98

F/D 20. Groover

3641 17/6/97
4418 22/9/98
4435 27/9/98

F/D 21. No Fin

4624 6/7/99

F/D 22. Cogs

4791 24/8/99
4799 25/8/99

F/D 23. Beak

4722 3/8/99

F/D 24. Rags

4829 16/9/99

Small Notches in the dorsal fin (F/S)

F/S 1. Top Notch

240 28/5/91
944 28/5/93
954 28/5/93
1002 11/6/93
3811 20/7/97

F/S 2. Gnasher

1286 1/9/93

F/S 3. Weenick

288 7/7/91

F/S 4. Lownick

718 22/7/92
2025 2/9/94

F/S 5. Nibble

283 4/7/91
324 7/8/91
2824 12/9/95
4245 7/7/98
4581 27/6/99

F/S 6. Nipper

2556 1/8/95

F/S 7. Bite

692 10/7/92
2383 13/6/95
2630 10/8/95

F/S 8. Knock

3647 19/7/97
4193 5/6/98

F/S 9. Clipper

3588 29/5/97
3592 30/5/97

Unusual Fin shapes (F/SH)

F/SH 1. Spikey

931 23/5/93

F/SH 2. Flat Top

298 21/7/91
1132 27/7/93
1734 20/7/94
3487 21/8/96

F/SH 3. Bump

4286 27/7/98

Marks on the dorsal fin (F/M)

F/M 1. Finmark

2159 19/9/94

F/M 2. Snowy

1558 10/6/94
2427 26/6/95

Body Scars (B/S)

B/S 1. Denty

1615 30/6/94

B/S 2. Lumpy

2208 25/9/94

B/S 3. Scribble

278 2/7/91
348 22/8/91

B/S 4. Blow

214 22/5/91

B/S 5. Socket

2288 17/5/95

B/S 6. Scratch

2858 18/9/95

B/S 7. Polka

2752 31/8/95

B/S 8. Bolt

1353 10/9/93
2870 19/9/95
3207 18/7/96

B/S 9. Eye

2946 6/6/96

B/S 10. Whirl

3636 17/6/97

B/S 11. Twig

3596 30/5/97

B/S 12. Catty

4211 9/6/98

B/S 13. Patches

4426 25/9/98

B/S 14. Ropey

4435 27/9/98

B/S 15. Nose

2880 21/9/95
4435 27/9/98

B/S 16. Tape

4460 20/5/99

White circular or oval body scars (B/W)

B/W 1. Betty

514 22/5/92

B/W 2. Blotch

553 7/6/92
573 12/6/92
718 22/7/92

B/W 3. Spotter

1802 8/8/94

B/W 4. Double dot

2457 10/7/95

B/W 5. Trio

2960 13/6/96
3072 26/6/96

B/W 6. Blobs

3617 5/6/97

B/W 7. Two-pin

4067 19/8/97

B/W 8. Sweep

4172 15/5/98
4174 18/5/98
4194 5/6/98

B/W 9. Moley

4166 13/5/98
4173 17/5/98

B/W 10. Pox

4210 9/6/98

B/W 11. Oval

4640 10/7/99
4647 11/7/99

B/W 12. Dotty

4587 1/7/99

Of the 66 identified whales 30 have been sighted at least twice, the greatest number of re-sightings for one whale is 27 spanning 10 years. 21 of these whales have been sighted in more than one year and this illustrates that whales are returning to the same area in successive years showing temporal site fidelity.

20 of the identified whales have been sighted at least twice within one or more years, of which 13 whales were sighted in at least two different months in any one year. This suggests that these whales may be resident at least seasonally in the waters surrounding Mull.

The most useful feature used for re-sightings has proved to be notches in the dorsal fins, especially for re-sightings spanning many years. Of the 30 re-sighted whales identified by notches in the dorsal fin, no changes or additional notches have been noted. No re-sightings between years have been achieved with whales identified by white circular or oval scars. However re-sightings within a season have been achieved. This suggests that these scars fade over time and so are not suitable for re-sighting whales between years.

3.5 Location of re-sightings

The locations of all the sightings for each identified whale, that have been sighted at least twice, were plotted and are shown in Appendix 3. The positions for 27 whales were plotted. Some of the positional data is missing due to errors in data collection and so not all the sightings have been plotted for some of the whales. The different months in which the whales were sighted are coloured coded: May = green, June = red, July = black, August = yellow and September = blue, Oct = brown.

It is interesting to note from these plots that whales do favour certain areas in the survey area and at different times of the year. Whales that are re-sighted within a few days tend to stay in the same location. During May and June whales tended to be sighted in the southern part of the survey area in particular around the Isle of Coll. Later on in the season the whales are located progressively northwards towards the Small Isles and around the Ardnamurchan Peninsula. These plots could reflect the fact that more effort is concentrated in the southern area of the survey in the earlier months and more in the north in the latter part of the season. The boat does not operate by conducting strict transects but goes to areas where whales are more likely to be seen and these “hunches” reflect that whales do shift in their locality throughout the season.

3.6 Marine Debris

Nine of the identified whales show evidence of accumulating marine debris. Two whales, photographed in May 1997 and May 1999, have plastic packing strips wrapped around their rostrums. These plastic strips have become trapped in the baleen in the upper jaws and appear to be cutting into the whale's skin. Another whale, photographed in September 1999, has a white scar thought to be caused by a packing strip or twine. Three minke whales appear to have evidence of creel ropes wrapped around their heads. Two of the whales, photographed in August 1994 and September 1998, have large circular notches in their rostrums along the ridge. These notches look to be caused by ropes wrapped around their rostrums and the size of the notch would suggest that it is a thick rope such as those used for creels. One whale, photographed in September 1998, has obviously had a thick rope wrapped around its head and the twist of the twine can be seen in the scar. Two other whales in the catalogue have marks on the tips of their mouths which look to be caused by a physical abrasion of some sort and one whale has scars around its flank. Again these are probably caused by marine debris.

4. Discussion

This study has shown that photo-identification is a feasible technique for the individual recognition of minke whales in the coastal waters around Mull. The most useful feature for the identification of individuals in the survey area has proved to be notches in the dorsal fin. Dorsey *et al.* (1990) studying minke whales in the eastern North Pacific identified 40% of these whales, from dorsal fin features compared to 50% of identified individuals in this study.

Lateral body pigmentation and white oval and circular scars have proved to be ineffective for identifying whales. Dorsey *et al (*1990) used these features to identify individual whales. The lack of re-sightings in this study is probably due to the opportunistic way that the photo-identification project is conducted and the fact that the oval scars fade on healing. Minke whales are not easy to photograph and are very unpredictable in their surfacings. Researchers in the eastern North Pacific photographed minke whales from small boats equipped with outboard motors which were very manoeuvrable. They were almost always able to photograph both sides of a whale and position themselves to the best angle relative to the whale, to optimise lighting conditions (Jonathan Stern, pers. comm.). The boat used in this study was a 10.5 metre motor vessel, which lacked the manoeuvrability of the smaller boats. When a whale is encountered the boat engines are switched off and an approach at the whale is never attempted. Therefore it is difficult in many cases to photograph both sides of the whale and also to be in the right position relative to the sun to obtain photographs which highlight the lateral body pigmentation and scars. A feasibility study for the identification of Southern Hemisphere minke whales by Joyce and Dorsey (1990) using large boats also reported a lack of manoeuvrability which resulted in 75% of the whales only being photographed from one side of the body

There appears to be very little scarring of any type on the minke whales around Mull compared to that reported by Dorsey *et al* (1990). Many of the whales photographed are completely unmarked and so remain unidentified despite good quality photographs. Many juveniles are sighted throughout the season and have not yet acquired scars. Those whales that have distinctive body scars have mainly only been photographed on one side of their body which may result in the same whale appearing as two different whales in the catalogue.

It is interesting to note that some very distinctive whales have not been re-sighted whereas other similarly marked whales are repeatedly re-sighted. This might suggest that some whales range further than others. It could also suggest sex differences as it has been shown that males and females do occupy different areas and ranges on their feeding grounds (Jonsgard, 1962). Another factor that plays a part in the fact that re-sightings of individuals are low is that sampling size is small and of an opportunistic nature. If the population of minke whales is large then the probability of re-sightings are small.

It is not feasible to use the results of this study for estimates of population abundance. This is due to the possibility of duplicates in the catalogue, the small sampling size and the opportunistic nature of this project in that no directed effort is aimed at the photo-identification. Whales that tend to be identified are those that choose to come over to the boat rather than the equal sampling of the whales that is attempted in other photo-identification studies. Another reason for not attempting population estimates is that the whales are not equally likely to be re-sighted as some features such as distinctive notches are easier to recapture.

Despite these difficulties photo-identification has been shown in this study to be a feasible technique as a tool to study the ecology and behaviour of the minke whales around the coast of Mull. It has highlighted the fact that whales return to the survey area year after year thus showing site fidelity. Also apparent is the seasonal residency of some of the whales.

The possibility that minke whales show site fidelity may have important implications for the identification of stocks and for the setting of catch quotas because if whaling is resumed it could have a severe impact on local populations. Management models assume that minke whales are evenly distributed throughout the North Atlantic. Dorsey's (1990) data from the eastern North Pacific suggests otherwise implying that some whales show a seasonal residency and site fidelity to particular areas. Clapham and Seipt (1991) report that of 16 fin whale calves identified on summer feeding grounds in Massachusetts Bay, four were observed to return to the same feeding grounds in subsequent years. This suggests that for these whales, fidelity to a summer feeding ground is determined matrilineally. They suggest that the young fin whales may learn migratory routes from their mothers and that the separation of the mother and the calf occurs by or at the end of the calf's natal year. This was also demonstrated for humpback whales with many individuals observed returning year after year to maternal ranges in several areas of the western North Atlantic Ocean (Clapham and Mayo 1987; Katona, 1986).

Some whales may show a considerable temporal specificity such as returning to the same location at the same time of the year. This could bias the estimation of population parameters. Different sex and age classes often show differences in site specificity and in temporal patterns and indeed this has been reported for minke whales in the eastern North Atlantic with females migrating earlier to northern feeding grounds while immature whales are located further south (Jonsgard, 1962). Because of this, it is necessary to estimate population parameters separately for particular age and/or sex classes of a population. However, whereas it was considered by Jonsgard (1962) that, while the mature whales migrate to northern feeding grounds, the immature whales remain around Britain, there is some evidence of year round sightings off Britain and Norway. Year round residents will have different foraging strategies from that of migratory whales, and studying whale energetics and prey distribution may provide some insights to life history parameters of these residents. Residency of such a large mobile predator could have important implications in terms of energy and material flow and material cycling in the local ecosystem.

The data does imply that the minke whales around Mull show a progressive movement northwards throughout the season. The distribution of minke whales is likely to be in relation to their prey species. Dorsey *et al.* (1990) report the absence of minke whales during the summer of 1984 from one feeding ground in the San Juan Islands where a local decrease in baitfish occurred. Therefore this movement northwards could be in response to the shift in the abundance of the prey species or to the whales switching from one species to another. Temporal changes in food preference or switching throughout the season has been reported for minke whales in the North Pacific (Kasamatsu and Hata , 1985). Other factors could be affecting the distribution of prey such as strong tidal exchanges, which create strong currents. The sporadic appearance and disappearance of minke whales may suggest that the minke whales have several feeding sites.

The evidence of marine debris on the whales is cause for concern. It is believed that most of this debris comes from shipping or from fishing activities. The evidence suggests that some whales are able to free themselves eventually of this debris but the extent of the scars suggests that they have carried this debris for quite some time. Strandings information has shown that marine debris and entanglement causes the death of minke whales. Therefore the problem of marine debris is an issue for animal welfare concern.

Future Work

It is important to continue the photo-identification work to obtain re-sightings of the identified individuals and this, together with additional sightings data, will provide the foundation for ecological and behavioural studies. It is also important to continue to monitor the problem of marine debris. If other organisations throughout the Hebrides could obtain photographs of minke whales the data here could be used to investigate how far some of these whales are ranging.

The photo-identification work could be greatly enhanced if a small boat was available so that the photographer could be placed in a position optimal for achieving the right lighting conditions and angle to the whale. Obtaining underwater footage of the minke whales could reveal the sex of some individuals which will be important for investigating the spatial and temporal segregation of the sexes. The recognition of individuals will enhance the study of feeding behaviour which can then be related to other factors such as oceanographic features and conditions. Improving our knowledge of the behaviour and ecology of the minke whale would also help to ensure its conservation and welfare.

Acknowledgements

This work is conducted and funded by Sea Life Surveys and The Hebridean Whale and Dolphin Trust. Support costs have been provided by World Wide Fund for Nature and The International Fund for Animal Welfare. Additional information has been provided by The Scottish Agricultural College.
The data collection has been enhanced by the hard work of many enthusiastic volunteers.

References

Angell, T., Balcomb, K.C. (1982). Marine birds and Mammals of Puget Sound. Univ of Washington State.

Anon., (1984). Norwegian Progress reports on Cetacean Research, Rep. Int. Whaling Comm., 34, 217.

Anon., (1985). Norwegian Progress reports on Cetacean Research, Rep. Int. Whaling Comm., 35, 173.

Anon., (1986). Norwegian Progress reports on Cetacean Research, Rep. Int. Whaling Comm., 36, 166.

Arnold, P., Marsh, H., Heinsohn, G. (1987). The occurrence of two forms of minke whales in east Australian waters with a description of external characters and skeleton of the diminutive or dwarf form. Sci. Rep. Whales Res. Inst. 38, 1.

Best, P.B., (1967). Distribution and feeding habits of baleen whales off the Cape Province, Invest. Rep. Div. Sea Fish. S. Afr. 57, 1-44.

Best, P.B., (1974). Status of the whale populations off the West coast of South Africa and current research. In The Whale Problem: A status report (Ed. W.E.Schevill) 53-81. Harvard Univ. Press, Cambridge, Massachusetts.

Best, P.B., (1977). Status of whale stocks off South Africa, 1975. Rep. Int. Whal. Commn. 27 116-121.

Best, P.B., (1982). Seasonal Abundance, feeding, reproduction, age and growth in minke whales off Durban. Rep. Int. Whal. Commn 30 , 257-283.

Best, P.B., (1985). External characters of southern minke whales and the existence of a diminutive form, Sci. Rep. Whales Res., 36, 1.

Best, P.B., Ohsumi, S., (1980). International Whaling Commission, International Decade of Cetacean research (IWC/IDCR) southern minke whale assessment cruise 1978/79, Polar Rec., 20, 52.

Boran, R.J., Osborne, R.W., (1978). Orca survey: whale hotline cetacean sightings report. Unpublished report to Marine Mammal Div., Natl. Mar. Fish. Serv., Seattle, Washington.

Braham, H., Krogman, B., Marquette, W., Rugh, D., Johnson, J., Nerini, M., Leatherwood, S., Dahlheim, M., Sonntag, R., Carrol, G., Bray, T., Savage, S., Cubbage, J., (1979). Bowhead whale preliminary research results, June-December 1978. Paper SC31/Doc 15 presented to the Int. Whal. Commn Scientific Committee, June 1979.

Burmeister, H., (1867). Preliminary description of a new species of finner whale *(Balaenoptera bonaerensis)*, Proc. Zool. Soc. London, 707.

Bushuev, S.G., Feeding of minke whales, *Balaenoptera acutorostrata,* in the Antarctic, Rep. Int. Whaling Commn., 36, 241.

Casinos, A., Vericad, J.R., (1976). The cetaceans of the Spanish coasts: a survey, Mammalia 40 (2) 267.

Christensen, I., (1971). Minke whale investigations in the area Spitsbergen-Barents Sea in May-June 1972. Fisk. Gang 48, 961-965.

Christensen, I., (1974). Minke whale investigations in the Barents Sea and off east and west Greenland 1973. Fisk. Gang 60, 278-286.

Christensen, I., (1980). Catch and effort in the Norwegian minke whale fishery in the 1978 whaling season. Rep. Int. Whaling Commn 30, 209-212.

Christensen, I., (1981). Age determination of minke whales, *Balaenoptera acutorostrata,* from laminated structures in tympanic bullae. Rep. Int. Whal. Commn. 31, 245-253.

Christensen, I., (1982). Catch and effort and the sex composition in the Norwegian minke whale fishery, 1976-1980. Rep. Int. Whaling Comm., 32, 255.

Clapham, P.J., Mayo, C.A., (1987). Reproduction and recruitment of individually identified humpback whales, *Megaptera novaeangliae,* observed in Massachusetts Bay, 1979-1985. Canadian Journal of Zoology, 65: 2853-2863.

Clapham, P.J., Seipt, I.E., (1991). Re-sightings of independent fin whales *Balaenoptera physalus,* on maternal summer ranges.

Collett, R., (1912). Norges Pattedyr (Norges Hvirveldyr I.) H. Aschehoug, W. Nygaard, Kristiania (Oslo).

Di Natale, A., (1983). The minke whale *(Balaenoptera acutorostrata,* Lacepede) in the Italian Seas, Rapp. Comm. Int. Mer Medit., 28 (5), 205.

Doroshenko, N.V., (1979). Populations of minke whales in the Southern Hemisphere. Rep. Int. Whal. Commn. 29, 361-365.
Dorsey, E.M., (1983). Exclusive adjoining ranges in individually identified minke whales *(Balaenoptera acutorostrata)* in Washington State. Can. J. Zool. 61, 174-181.

Dorsey. E.M., Stern, S.J., Hoelzel, A.R., Jacobsen, J., (1990). Minke whales *(Balaenoptera acutorostrata)* from the West Coast of North America: Individual Recognition and Small-Scale Site Fidelity. Rep. Int Whal. Commn (Special Issue 12). SC/A88/ID21. 357-368.

Evans, P.G.H. (1980). Cetaceans in British Waters. Mammal. Rev. 10, 1-46.

Evans, P.G.H. (1982). Associations between seabirds and cetaceans: A review. Mammal. Rev. 12, 187-206.

Everitt, R.D., Fiscus, C.H., DeLong, R.L. (1980). Northern Puget Sound Marine Mammals. U.S. Govt. Printing Office, Washington, D.C.

Fraser, F.C. (1934). Report on Cetacea stranded on the British coasts from 1927-1932. Br. Mus. (Nat. Hist.) 11, 1-41.

Fraser, F.C. (1946). Report on Cetacea stranded on the British coasts from 1933 to 1937. Br. Mus. (Nat. Hist.) 12, 1-56.

Fraser, F.C. (1979). Royal fishes: the importance of the dolphin. Functional Anatomy of Marine Mammals. Ed. R.J. Harrison. Vol III 1-44. Academic Press, London.

Gambell, R., Best, P.B., Rice, D.W., (1975). Report on the International Indian Ocean whale marking cruise. Rep. Int. Whal. Commn 26, 240-252.

Gaskin, D.E., (1976). The evolution, zoogeography and ecology of Cetacea Oceanogr. Mar. Biol. 14, 247-346.

Gong, Y., (1987). A note on the distribution of minke whales in Korean waters, Rep. Int. Whaling Comm, 37, 281.

Harmer, S.F. (1927). Report on Cetacea stranded on the British coasts from 1913 to 1926. Br. Mus. (Nat. Hist.) 10, 1-91.

Hart, T.J. (1935). On the diatoms of the skin film of whales and their possible bearing on problems of whale movements. Discovery Rep., 10: 249-82, 1pl.

Henking, H. (1901). Norwegen's Walfang. Abh. Dtsch Seefisch. Ver. 6, 119-171.

Hentschel, E. (1937). Naturgeschichte der nordatlantischen Wale and Robben. In Handbuch der Seefischerei Nordeuropas. Eds H. Lubbert and E. Ehrenbaum. Vol 3, 1-54, Stuttgart.

Hoelzel, A.R., Dorsey, E.M., Stern, J., (1989). The foraging specializations of individual minke whales. Anim. Behav., 38, 786-794.

Horwood, J. (1987). The Sei Whale: Population Biology, Ecology and Management, Croom Helm, London, 375.

Horwood, J. (1990). Biology and exploitation of the minke whale. CRC Press, Inc. Boca Raton, Florida.

Horwood, J.W., Best, P.B., Ohsumi, S., (1981). IWC/IDCR southern hemisphere minke whale assessment cruise 1979/80, Polar Rec., 20, 565.

Ivashin, M.V., Mikhalev, Yu. A., (1978). To the problem of the prenatal growth of minke whales *Balaenoptera acutorostrata* of the southern hemisphere and of the biology of their reproduction, Rep. Int. Whaling Commn. 28, 201.

Ivashin, M.V., Votrogov, L.M., (1981). Minke Whales, *Balaenoptera acutorostrata davidsoni,* inhabiting inshore waters of the Chukotka coast, Rep. Int. Whaling Comm., 31, 231.

IWC, (1978). Report of the special meeting on Southern Hemisphere minke whales. SC/30/Rep 4.

IWC, (1980). Draft Report of the minke whale sub-committee, IWC/32/4/Annex E.

Jonsgard, A., (1951). Studies on the little piked whale or minke whale *(Balaenoptera acutorostrata* Lacepede), Nor Hvalfangst Tid., 5, 209.

Jonsgard, A., (1962). Population studies on the minke whale *Balaenoptera acutorostrata* Lacepede. The exploitation of Natural Animal Populations, Le Cren, E.D. and Holdgate, M.W., Eds., Blackwell Scientific, Oxford. 160.

Jonsgard, A., (1966). The distribution of Balaenopteridae in the North Atlantic Ocean. Whales, Dolphins and Porpoises. Ed K.S Norris. University of California Press, Berkeley. 114-124.

Jonsgard, A., (1982). The food of minke whales *(Balaenoptera acutorostrata)* in northern North Atlantic Waters. Rep. Int. Whal. Commn 32, 259-269.

Joyce, G.G., Dorsey, E.M., (1990). A feasibility study on the use of photo-identification techniques for Southern Hemisphere minke whale assessment (SC/A88/ID43) 419.

Joyce, G.G., Kasamatsu, F., Rowlett, R., Tsunoda, L., (1988). The IWC/IDCR southern hemisphere minke whale assessment cruises: the first ten years, IWC Doc. Sc/40/O16, International Whaling Commission, Cambridge, England.

Jurasz, C.M., Jurasz, V.P., (1979). Feeding modes of the humpback whale, *Megaptera novaeangliae,* in southeast Alaska. Sci. Rep. Whales Inst. 31, 69-83.

Kapel, F.O. (1980). Sex ratio and seasonal distribution of catches of minke whales in West Greenland. Rep. Int. Whal. Commn. 30. 195-200.

Kasamatsu, F., Ohsumi, S., (1981). Distribution pattern of minke whales in the Antarctic with special reference to the sex ratio in the catch. Rep. Int. Whaling Commn. 31, 345.

Kasamatsu, F., Hata, T., (1985). Notes on minke whales in the Okhotsk Sea West Pacific Area. Rep. Int. Whal. Commn. 35, 299.

Kato, H., (1982). Some biological parameters for the Antarctic minke whale. Rep. Int. Whaling. Commn. 32, 935.

Kato, H., Hiroyama, H., Fujise, Y., Ono, K., (1988). Preliminary report of the feasibility study on southern minke whale under the Japanese proposal to the special permit, IWC Doc. SC/40/Mi 18, International Whaling Commission, Cambridge, England.

Katona, S.K., (1986). Biogeography of the humpback whale, *Megaptera novaeangliae,* in the North Atlantic Pp. 166-171, in Pelagic biogeography (A.C. Pierrot-Balts, S. van der Spoel, B.J. Zahuranec, and R.K. Johnson eds.) United Nations Educational, Scientific and Cultural Organisation, Technical Papers in Marine Science, 49: 1-372.

Katona, S., Richardson, D., Hazard, R., (1977). A field guide to the whales and seals of the Gulf of Maine, College of the Atlantic, Bar Harbor, Maine.

Kawamura, A., (1980). A review of food of Balaenopterid whales, Sci. Rep. Whales Res. Inst., 32, 155.

Lahille, F. (1908). Notas sobre un ballenato de 2.10 metros de largo. An. Mus. Nac. Buenos Aires. 16, 375-401.

Lambertsen, R.H., (1983). Internal mechanism of rorqual feeding. J. Mammal. 64, 76-88.

Larsen, S., Kapel, F.O., (1981). Collection of biological material of minke whales off west Greenland 1979. Rep. Int. Whal. Commn 31, 279-287.

Larsen, S., Oien, N., (1987). Do East and West Greenland minke whales belong to different stocks?, IWC Doc. SC/39/Mi 1, International Whaling Commission, Cambridge, England.

Laws, R.M., (1977). The significance of vertebrates in the Antarctic marine ecosystem. In Adaptation within Antarctic Ecosystems. Ed. G.A. Llano 411-438. Smithsonian Institution, Washington, D.C.

Leaper, R., Fairbairns, R., Gordon, J., Hiby, A., Lovell, P., Papastavrou, V. (1997). Analysis of data collected from a whale-watching operation to assess relative abundance and distribution of the minke whale *(Balaenoptera acutorostrata)* around the Isle of Mull, Scotland. Rep. Int. Whal. Commn 47:505-11.

Leatherwood, S., Thomas, J.A., Awbrey, F.T., (1981). Minke whales off north-western Ross Island. Antarct. J. 16, 154-156.

Leatherwood, S., Reeves, R., Foster, L., (1983). Sierra Club Handbook of Whales and Dolphins, Sierra Club Books, San Francisco, Calif.

Lens, S., Rey, J.M., (1987). The minke whale about the Iberian Peninsula, IWC Doc. SC/39/Mi 19, International Whaling Commission, Cambridge, England.

Lillie, D.G. (1915). Cetacea. Br. Antarct. (Terra Nova) Exped. Nat. Hist. Rep., Zool. 1. 85-124.

Lockyer, C.L. (1979). Review (in minke whales) of the weight/length relationship and the Antarctic catch biomass and a discussion of the implications of imposing a body length limitation of the catch. Rep. Int. Whal. Commn. 29: 369-374.

Lockyer, C. (1981). Estimation of the energy costs of growth, maintenance, and reproduction in the female minke whale *(Balaenoptera acutorostrata)* from the Southern Hemisphere. Rep. Int. Whal. Commn 29, 369-374.

Lythgoe, J., Lythgoe, G. (1991). Fishes of the Sea. The North Atlantic and Mediterranean. Blandford Press, London.

Masaki, Y., (1979). Yearly changes of biological parameters for the Antarctic minke whale. Rep. Int. Whaling Commn. 29, 375-395.

Matsuura, Y., (1936). On the lesser rorqual found in the adjacent waters of Japan. Bull. Jpn. Soc. Sci. Fish. 4 325-395.

Mead, J.G., (1989). Data provided by JGM from the Marine Mammal Program of Smithsonian Institution, Washington, D.C.

Mitchell, E.D., (1975a). Report of the meeting on smaller cetaceans Montreal, April 1-11, 1974, J. Fish. Res. Bd. Can., 32, 263.

Mitchell, E.D., (1975b). Porpoise, dolphin and small whale fisheries of the world: status and problems. IUCN Monogr. 3, 31-42.

Mitchell, E.D., (1975c). Review of biology and fisheries for smaller cetaceans. J. Fish. Res. Board Can. 32 891-895.

Mitchell, E.D., (1978). Finner whales. Marine mammals of Eastern North Pacific and Arctic waters. Ed. D. Haley. 37-53. Pacific Search Press, Seattle.

Mitchell, E.D., Kozicki, M.V., (1975). Supplementary information on minke whale (*Balaenoptera acutorostrata)* from Newfoundland fishery, J. Fish. Res. Bd. Can., 32 (7), 985.

Nemoto, T., (1959). Food of baleen whales with reference to whale movements, Sci. Rep. Whales Res. Inst. 14, 149.

Nemoto, T., (1970). Feeding patterns of baleen whales in the ocean in Marine Food Chains, Ed. Steele, J.H., Oliver & Boyd, Edinburgh, 1970, 241.

Ohsumi, S., (1975). Review of Japanese small-type whaling. J. Fish. Res. Board Can. 32, 1111-1121.

Ohsumi, S., (1979). Feeding habits of the minke whale in the Antarctic. Rep. Int. Whal Commn. 29, 473-476.

Ohsumi, S., Masaki, Y., (1975). Biological parameters of the Antarctic minke whale at the virginal population level. J. Fish. Res. Board Can. 32 , 995-1004.

Ohsumi, S., Masaki, Y., Kawamura, A., (1970). Stock of the Antarctic minke whale, Sci. Rep. Whales Res. Inst., 22, 75.

Oien, N., Christensen, I., (1985). Catch per unit effort in Norwegian minke whaling at west and east Greenland, Rep.Int. Whaling Comm., 35, 331.

Omura, H. (1975). Osteological study of the minke whale from the Antarctic. Sci. Rep. Whales Res. Inst. 27, 1-36.

Omura, H., Sakiura, H. (1956). Studies on the little piked whales from the coast of Japan. Sci. Rep. Whales Res. Inst. 30, 25-37.

Paiva, M.P., Grangeiro, B.F., (1970). Investigations on the whaling season 1964-1967, off the northeastern coast of Brazil, Arq. Cienc. Mar, 10 (2), 111.

Rice, D.W. (1974). Whales and whale research in the eastern North Pacific. The Whale Problem: A status report. Ed. W.E. Schevill. 170-195. Harvard Univ. Press, Cambridge, Massachusetts.

Rice, D.W. (1977). A list of the marine mammals of the World. NOAA Tech. Rep. Commn 30, 379-384.

Ruud, J.T. (1937). Vaagehvalen, *Balaenoptera acutorostrata* Lacepede. Nor. Hvalfangst-Tid., 193-194.

Scattergood, L.W., (1949). Notes on the little piked whale (with bibliography), Murrelet, 30 (1), 3.

Scheffer, V.B., (1973). Marine mammals in the Gulf of Alaska. In a review of the Oceanography and Renewable Resources of the Northern Gulf of Alaska. Ed. D.H. Rosenburg. 175-207. Inst, Marine Science, Univ. of Alaska, Fairbanks.

Sears, R., Wenzel, F.W., Williamson, J.M., (1987). The Blue Whale: A catalogue of individuals from the Western North Atlantic (Gulf of St. Lawerence). Mingan Island Cetacean Study. Saint-Lambert (QC).

Sears, R., Williamson M., Wenzel, F.W., Berube, M., Gendron, D., Jones, P. (1990). Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St Lawrence, Canada. Rep. Int Whal. Commn (Special Issue 12). SC/A88/ID23. 335-342.

Sergeant, D.E., (1963). Minke whales, *Balaenoptera acutorostrata* Lacepede, of the Western Atlantic, J. Fish. Res. Bd. Can., 20, 1489-1504.

Sigurjonsson, J., (1982). Icelandic minke whaling, 1914-1980, Rep. Int. Whaling Comm., 32, 287.

Singarajah, K.V.,(1984). Observations on the occurrence and behaviour of minke whales off the coast of Brazil, Sci. Rep. Whales Res. Inst.,35, 17.

Slijper, E.J., van Utrecht, W.L., Naaktgeboren, C., (1964). Remarks on the distribution and migration of whales, based on observations from Netherlands ships, Bijdr. Dierkd., 34, 1.

Solvik, O.V., (1976). The Minke Whale, *Balaenoptera acutorostrata* (Lacepede), in the North Atlantic, IWC Doc. NA76/10, International Whaling Commission, Cambridge.

Stephenson, W. (1951). The lesser rorqual in British waters. Dover Mar. Lab. Rep. 3, 7-48

Stern, J., (1990). Minke whales *(Balaenoptera acutorostrata)* of the Monterey Area. Masters of Arts thesis, San Francisco State University. December 1990.

Stewart, B.S., Leatherwood, S., (1985). Minke whale *Balaenoptera acutorostrata* Lacepede 1804, in handbook of Marine Mammals, Vol 3, Ridgway, S. and Harrison, R. Eds. Academic Press, London, chap. 4.

Tomilin, A.G., (1967). Mammals of the USSR and Adjacent Countries, Cetacea, Vol.9, Israel Prog. Sci. Transl, Jerusalem,
717.

Viale, D., (1985). Cetaceans in the northwestern Mediterranean: their place in the ecosystem, Oceanogr. Mar. Biol. Annu. Rev., 23, 491.

Wada, S., (1983). Genetic structure and taxonomic status of minke whales in the coastal waters of Japan, Rep. Int . Whaling Comm., 33, 361.

Wada, S., (1984a). A note on the gene frequency differences between minke whales from Korean and Japanese coastal waters, Rep. Int. Whaling Comm., 29, 421.

Wada, S., (1984b). Movements of marked whales in the Antarctic. Rep. Int. Whal. Commn. 34: 349-55.

Wada, S., Numachi, K., (1979). External and biochemical characters as an approach to stock identification for the Antarctic minke whale, Rep. Int. Whaling Comm., 29, 421

Wang, P. (1985a). Distribution of Cetaceans in Chinese Waters, translated by Perrin, C.H., Southwest Fisheries Center Rep. LJ-85-24, Perrin, W.F., original citation in Chin. J. Zool., 6, 52, 1984.

Wang, P. (1985b). Studies on the breeding habits of the minke whale *(Balaenoptera acutorostrata)* in the Yellow Sea, Chin. J. Oceanol. Limnol., 3 37.

Williamson, G.R., (1959). Three unusual rorqual whales from Antarctic, Proc. Zool. Soc. London, 133, 135-144.

Williamson, G.R., (1961). Two kinds of minke whales in the Antarctic. Nor. Hvalfangst Tid., 50, 133.

Williamson, G.R., (1975). Minke whales off Brazil, Sci. Rep. Whales Res. Inst., 27, 37.

Winn, H.E., Perkins, P.J. (1976). Distributions and sounds of the minke, with a review of mysticete sounds, Cetology, 19, 1.

Appendix 1. LOGGER Data for Minke Whale Sightings

Hyphens in the table means that there are no sightings of minke whales during this month or in the case of effort tables where no effort was made to find whales. A * means that data is missing due to errors in the data collection.

Table 1. Sightings of minke whales by month for each year

A sighting in this study is defined as an encounter with a whale or a school of whales until such time that the whale or school is no longer in view of the observers. Every new encounter is allocated a new sighting number despite the possibility of the same whale or school being encountered.

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	1	-	2	1	-	-	-
May	18	31	29	36	18	15	15	18	13	21
June	21	10	26	31	23	45	24	32	24	43
July	8	18	30	36	41	32	22	45	26	40
Aug	9	21	24	38	55	68	38	71	18	38
Sept	7	15	13	44	43	32	8	11	25	17
Oct	-	1	4	9	10	-	-	-	-	2
Total	**63**	**96**	**126**	**195**	**190**	**194**	**108**	**177**	**106**	**161**

Table 2. The total number of minke whales encountered for each month and year.

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	1	-	2	1	-	-	-
May	33	47	47	47	24	18	23	25	21	39
June	38	15	38	33	26	80	33	39	36	54
July	15	33	48	46	45	52	40	46	27	59
Aug	13	31	32	76	110	96	76	73	19	44
Sept	16	19	17	88	81	61	27	1	46	24
Oct	-	1	5	15	18	-	-	-	-	2
Total	**115**	**146**	**187**	**306**	**304**	**309**	**200**	**184**	**149**	**222**

Table 3. The mean group sizes of minke whales encountered by month

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	1.00	-	1.00	1.00	-	-	-
May	1.83	1.57	1.62	1.38	1.41	1.29	1.64	1.39	1.62	1.86
June	1.84	1.67	1.73	1.10	1.18	1.91	1.57	1.22	1.50	1.39
July	1.88	1.83	1.60	1.39	1.25	1.68	1.91	1.02	1.08	1.51
Aug	1.44	1.82	1.52	2.11	2.08	1.52	2.05	1.04	1.06	1.19
Sept	2.29	1.58	1.31	2.15	1.88	2.03	3.86	-	1.92	1.41
Oct	-	1.00	1.67	1.88	2.00	-	-	-	-	1.00

Table 4a. Sightings per unit of effort by month (effort is measured as hours searching)

Month	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	0.02	-	0.04	*	-	-	-
May	*	0.18	0.09	0.08	*	*	*	0.51
June	0.56	0.29	0.22	0.30	0.30	0.35	0.16	0.52
July	0.35	0.25	0.32	0.18	0.35	0.22	0.15	0.40
Aug	0.36	0.24	0.42	0.34	*	0.27	0.12	0.26
Sept	0.54	0.43	0.38	0.33	*	0.49	0.33	0.29
Oct	0.46	0.27	0.29	-	-	-	-	0.23

*** = missing effort data**

Table 4b. Sightings per unit of effort by month (effort is measured as distance travelled in nautical miles while searching)

Month	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	0.01	-	0.01	*	-	-	-
May	*	0.06	0.03	0.03	*	*	*	0.07
June	0.07	0.05	0.05	0.07	0.08	0.16	0.10	0.07
July	0.04	0.05	0.05	0.04	0.07	0.08	0.05	0.05
Aug	0.04	0.05	0.06	0.06	*	0.10	0.04	0.03
Sept	0.08	0.09	0.06	0.08	*	0.13	0.12	0.04
Oct	0.06	0.05	0.06	-	-	-	-	0.04

*** = missing effort data**

Table 5. Number of sightings that had the number of minke whales present entered

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Apr	-	-	-	1	-	2	1	-	-	-	**4**
May	18	30	29	34	17	14	14	18	13	21	**208**
June	21	9	22	30	22	42	21	32	24	39	**262**
July	8	18	30	33	36	31	21	45	25	39	**286**
Aug	9	17	21	36	53	63	37	70	18	37	**361**
Sept	7	12	13	41	43	30	7	1	24	17	**195**
Oct	-	1	2	8	9	-	-	-	-	2	**22**
Total	**63**	**87**	**117**	**183**	**180**	**182**	**101**	**166**	**104**	**155**	**1338**

Table 6a. Number of sightings that consist of a single minke whale

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	1	-	2	1	-	-	-
May	9	19	17	23	13	11	10	11	9	14
June	10	6	12	27	18	23	14	26	16	32
July	3	12	21	22	29	22	13	44	23	25
Aug	6	9	13	15	30	45	17	69	17	32
Sept	2	6	10	19	23	16	2	1	16	13
Oct	-	1	-	3	6	-	-	-	-	2
Total	**30**	**53**	**73**	**110**	**119**	**119**	**57**	**151**	**81**	**118**

Table 6b. Number of sightings that consist of two minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0	-	0	0	-	-	-
May	6	7	6	9	2	2	2	7	2	1
June	7	1	6	3	4	12	4	5	5	2
July	3	1	4	9	5	4	1	1	2	9
Aug	2	3	6	12	12	8	9	1	1	3
Sept	2	5	2	12	10	4	2	-	3	3
Oct	-	0	2	3	2	-	-	-	-	0
Total	**20**	**17**	**26**	**48**	**35**	**30**	**18**	**14**	**13**	**18**

Table 6c. Number of sightings that consist of three minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0	-	0	0	-	-	-
May	2	3	6	2	1	1	1	0	1	3
June	3	1	2	0	0	4	2	1	2	3
July	2	2	3	2	2	2	5	0	0	4
Aug	1	4	1	4	4	7	6	0	0	2
Sept	2	1	1	6	7	6	0	0	2	0
Oct	-	0	0	2	0	-	-	-	-	0
Total	**10**	**11**	**13**	**16**	**14**	**20**	**14**	**1**	**5**	**12**

Table 6d. Number of sightings that consist of four or more minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0	-	0	0	-	-	-
May	1	1	0	0	1	0	1	0	1	3
June	1	1	2	0	0	3	1	0	1	2
July	0	3	2	0	0	3	2	0	0	1
Aug	0	1	1	5	7	3	5	0	0	0
Sept	1	0	0	4	3	4	3	0	3	1
Oct	-	0	0	0	1	-	-	-	-	0
Total	**3**	**6**	**5**	**9**	**12**	**13**	**12**	**0**	**5**	**7**

Table 7a. Percentage frequency of sightings that have a single minke whale

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	100	-	100	100	-	-	-
May	50	63.33	58.62	67.65	76.47	78.57	71.43	61.11	69.23	66.67
June	47.62	66.67	54.55	90.00	81.82	54.76	66.67	81.25	66.67	82.05
July	37.50	66.67	70	66.67	80.56	70.97	61.90	97.78	92.00	64.10
Aug	66.67	52.94	61.90	41.67	56.60	71.43	45.95	98.57	94.44	86.49
Sept	28.57	50	76.92	46.34	53.49	53.33	28.57	100.00	66.67	76.47
Oct	-	100	0.00	37.50	66.67	-	-	-	-	100

Table 7b. Percentage frequency of sightings that have two minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0.00	-	0.00	0.00	-	-	-
May	33.33	23.33	20.69	26.47	11.76	14.29	14.29	38.89	15.38	4.76
June	33.33	11.11	27.27	10.00	18.18	28.57	19.05	15.63	20.83	5.13
July	37.50	5.56	13.33	27.27	13.89	12.90	4.76	2.22	8.00	23.08
Aug	22.22	17.65	28.57	33.33	22.64	12.70	24.32	1.43	5.56	8.11
Sept	28.57	41.67	15.38	29.27	23.26	13.33	28.57	0.00	12.50	17.65
Oct	-	0.00	100	37.50	22.22	-	-	-	-	0.00

Table 7c. Percentage frequency of sightings that have three minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0.00	-	0.00	0.00	-	-	-
May	11.11	10.00	20.69	5.88	5.88	7.14	7.14	0.00	7.69	14.29
June	14.29	11.11	9.09	0.00	0.00	9.52	9.52	3.13	8.33	7.69
July	25.00	11.11	10.00	6.06	5.56	6.45	23.81	0.00	0.00	10.26
Aug	11.11	23.53	4.76	11.11	7.55	11.11	16.22	0.00	0.00	5.41
Sept	28.57	8.33	7.69	14.63	16.28	20.00	0.00	0.00	8.33	0.00
Oct	-	0.00	0.00	25.00	0.00	-	-	-	-	0.00

Table 7d. Percentage frequency of sightings that have four or more minke whales

Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	-	-	0.00	-	0.00	0.00	-	-	-
May	5.56	3.33	0.00	0.00	5.88	0.00	7.14	0.00	7.69	14.29
June	4.76	11.11	9.09	0.00	0.00	7.14	4.76	0.00	4.17	5.13
July	0.00	16.67	6.67	0.00	0.00	9.68	9.52	0.00	0.00	2.56
Aug	0.00	5.88	4.76	13.89	13.21	4.76	13.51	0.00	0.00	0.00
Sept	14.29	0.00	0.00	9.76	6.98	13.33	42.86	0.00	12.50	5.88
Oct	-	0.00	0.00	0.00	11.11	-	-	-	-	0.00

Table 8a. Number of sightings of minke whales for each group size.

group size	1	2	3	4	5	6	7	8	9	10
1990	30	20	10	1	1	1				
1991	53	17	11	4	2					
1992	73	26	13	3	2					
1993	110	48	16	4	1	1	1	1		1
1994	119	35	14	3	2	1	3	3		
1995	119	30	20	4	2	6			1	
1996	57	18	14	4	3	3	1		1	
1997	151	14	1							
1998	81	13	5	2	1	1		1		
1999	118	18	12	4	2	1				
all years	911	239	116	29	16	14	5	5	2	1

Table 8b. Percentage frequency for each group size for all years

group size	1	2	3	4	5	6	7	8	9	10
1990	47.62	31.75	15.87	1.59	1.59	1.59	0.00	0.00	0.00	0.00
1991	60.92	19.54	12.64	4.60	2.30	0.00	0.00	0.00	0.00	0.00
1992	62.39	22.22	11.11	2.56	1.71	0.00	0.00	0.00	0.00	0.00
1993	60.11	26.23	8.74	2.19	0.55	0.55	0.55	0.55	0.00	0.55
1994	66.11	19.44	7.78	1.67	1.11	0.56	1.67	1.67	0.00	0.00
1995	65.38	16.48	10.99	2.20	1.10	3.30	0.00	0.00	0.55	0.00
1996	56.44	17.82	13.86	3.96	2.97	2.97	0.99	0.00	0.99	0.00
1997	90.96	8.43	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	77.88	12.50	4.81	1.92	0.96	0.96	0.00	0.96	0.00	0.00
1999	76.13	11.61	7.74	2.58	1.29	0.65	0.00	0.00	0.00	0.00
All years	**68.09**	**17.86**	**8.67**	**2.17**	**1.20**	**1.05**	**0.37**	**0.37**	**0.15**	0.07

Table 9. Percentage frequency of group sizes for all years by month

	Apr	May	June	July	Aug	Sept	Oct
1	100.00	65.38	70.23	74.83	70.08	55.38	54.55
2	0.00	21.15	18.70	13.64	15.79	22.05	31.82
3	0.00	9.62	6.87	7.69	8.03	12.82	9.09
4 or >	0.00	3.85	4.20	3.85	6.09	9.74	4.55

Appendix 2. LOGGER Effort Data

Effort data is only available from June 1992. Some effort data has been lost and is marked by a *

Table 1. Effort as number of seconds spent searching for whales

Month	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	211674	110243	172972	*	-	-	11483
May	-	703971	750364	683359	*	*	*	147473
June	168237	390249	384769	542104	289846	327613	537909	298589
July	311955	508817	466410	623138	223793	732998	624888	356062
Aug	242260	564253	467105	723254	*	962557	537474	530591
Sept	86652	372251	408242	344901	*	80331	273891	210035
Oct	31315	120752	122626	-	-	-	-	31738

Table 2. Effort as number of hours spent searching for whales

Month	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	58.80	30.62	48.05	*	-	-	3.19
May	-	195.55	208.43	189.82	*	*	*	40.96
June	46.73	108.40	106.88	150.58	80.51	91.00	149.42	82.94
July	86.65	141.34	129.56	173.09	62.16	203.61	173.58	98.91
Aug	67.29	156.74	129.75	200.90	*	267.38	149.30	147.39
Sept	24.07	103.40	113.40	95.81	*	22.31	76.08	58.34
Oct	8.70	33.54	34.06	-	-	-	-	8.82

Table 3. Effort as the distance travelled in nautical miles while searching for whales

Month	1992	1993	1994	1995	1996	1997	1998	1999
Apr	-	162.75	92.28	147.89	*	-	-	25.52
May	-	637.97	551.99	516.09	*	*	*	307.51
June	368.50	620.44	485.22	671.43	313.71	202.90	232.92	617.33
July	749.90	756.51	879.65	861.00	312.53	548.50	559.82	771.10
Aug	610.99	820.59	856.87	1085.09	*	694.54	461.65	1132.37
Sept	158.30	516.73	710.52	405.71	*	82.07	212.56	419.34
Oct	62.94	178.30	156.12	-	-	-	-	49.37

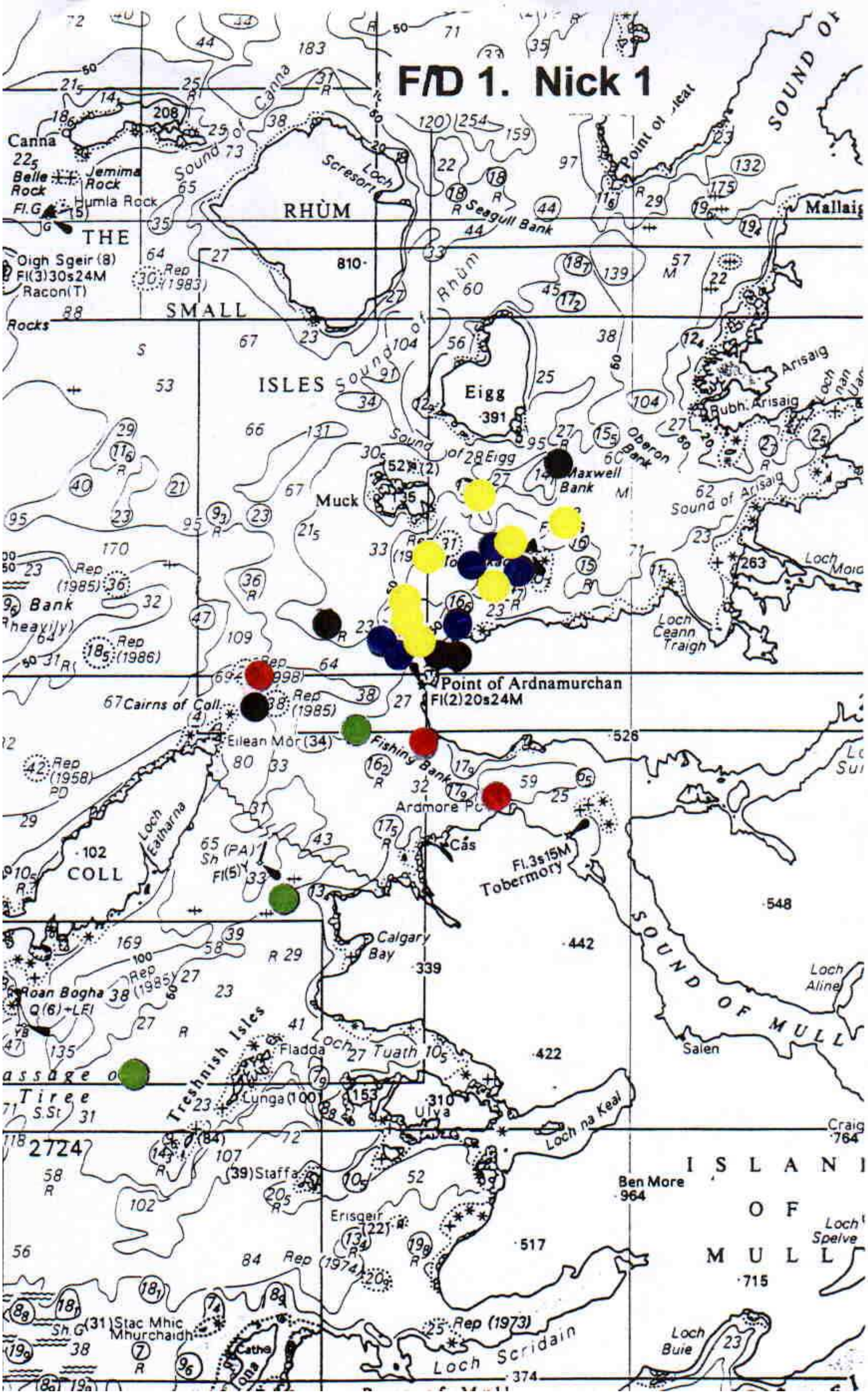
Appendix 3.

Maps to show the location of re-sightings for each identified whale seen at least twice.

The months are coloured coded:

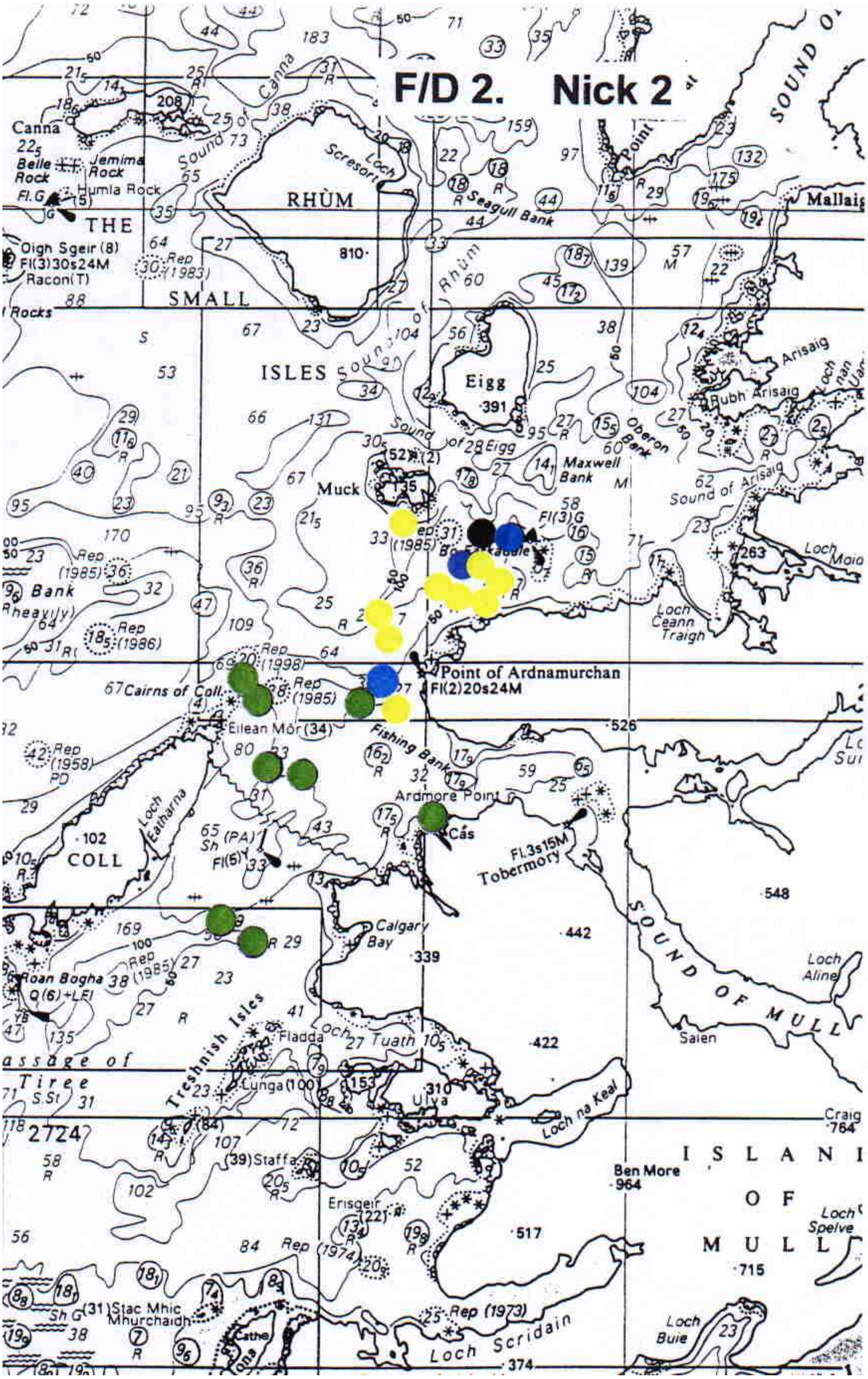
May = green
June = red
July = black
August = yellow
September = blue
October = brown

F/D 1. Nick 1

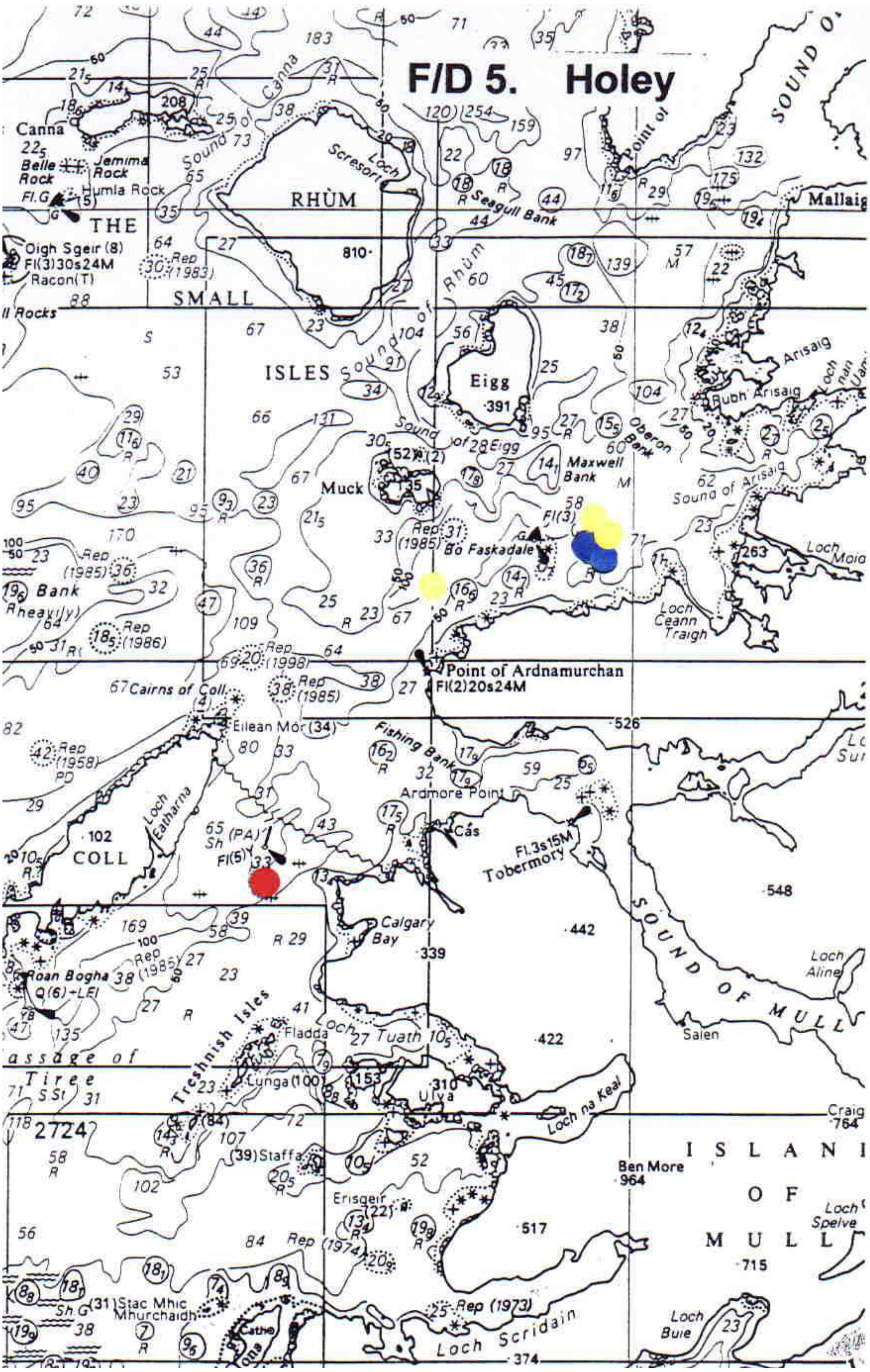


Canna
RHÙM
THE
SMALL
ISLES
Eigg
Muck
Sound of Canna
Sound of Rhùm
Sound of Eigg
Seagull Bank
Maxwell Bank
Oberon Bank
Sound of Arisaig
Arisaig
Mallaig
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Pt
Càs
Tobermory
COLL
Loch Eatharna
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Lunga (100)
Loch Tuath
Ulva
Loch na Keal
Staffa
Erisgeir
Ben More 964
ISLAND OF MULL
Loch Spelve
Loch Scridain
Loch Buie
Stac Mhic Mhurchaidh
Passage of Tiree
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Humla Rock
Jemima Rock
Belle Rock
Loch Scresort
Loch Ceann Traigh
Roan Bogha
2724

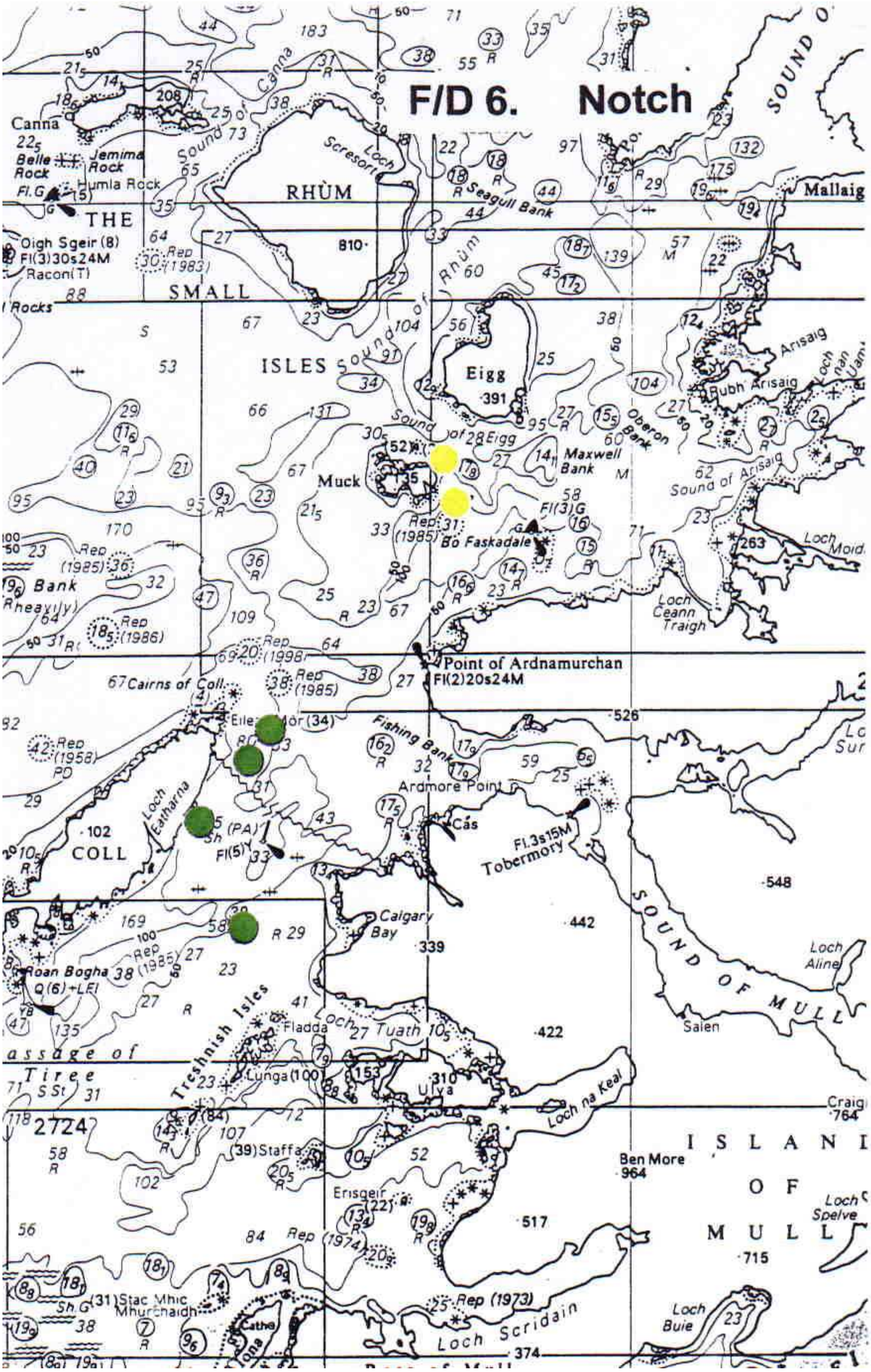
F/D 2. Nick 2


Canna
RHÙM
THE SMALL ISLES
Eigg
Muck
Point of Ardnamurchan
Cairns of Coll
COLL
Tobermory
SOUND OF MULL
ISLAND OF MULL
Mallaig
Arisaig
Treshnish Isles
Staffa
Ulva
Loch Scridain
Ben More
Calgary Bay
Fishing Bank
Ardmore Point
Seagull Bank
Maxwell Bank
Oberon Bank

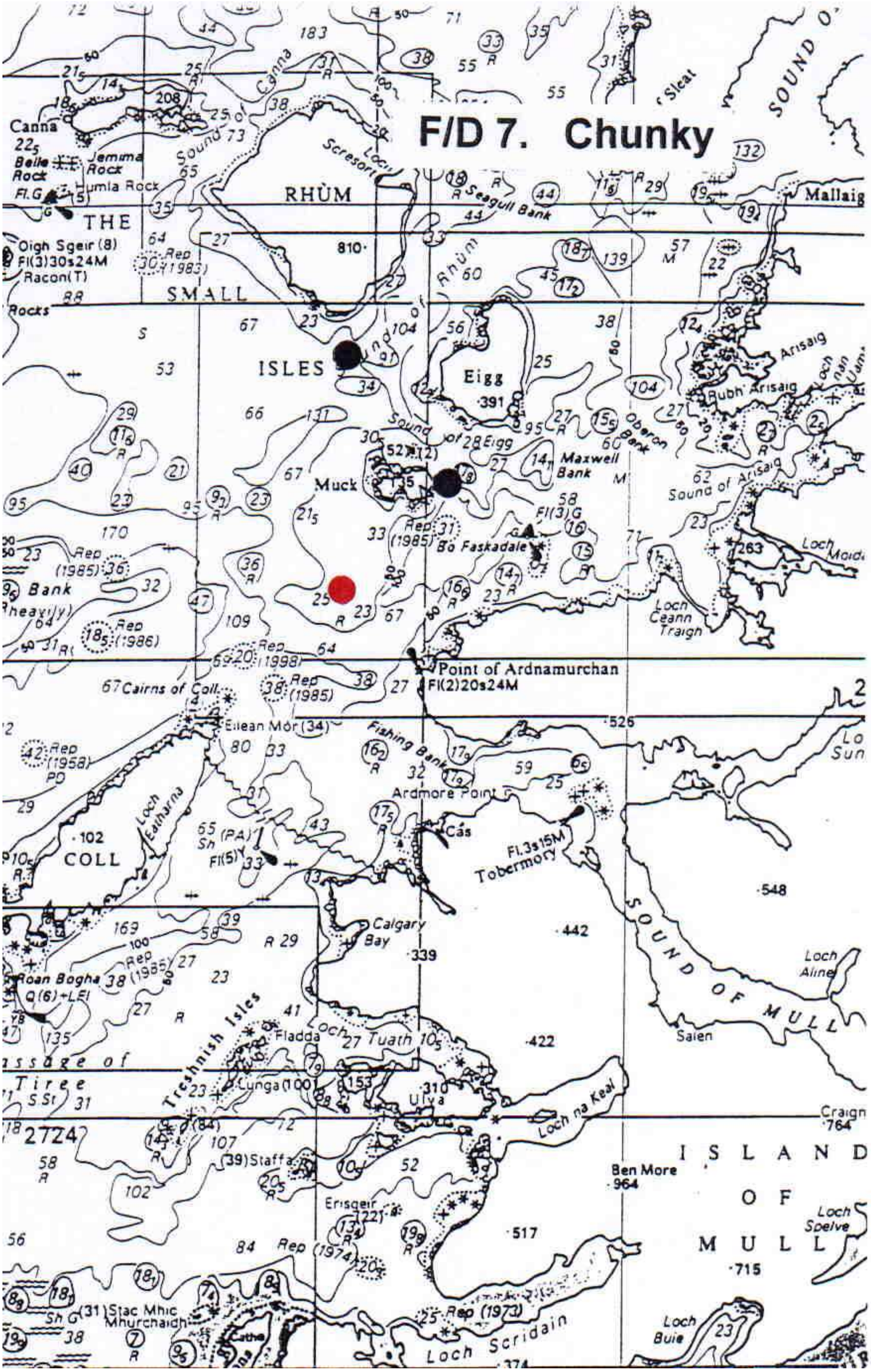
F/D 5. Holey



Canna
Belle Rock
Jemima Rock
Humla Rock
Sound of Canna
Scresort
Loch
RHÙM
Seagull Bank
Mallaig
THE SMALL ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Rep (1983)
Sound of Rhùm
Eigg
391
Arisaig
Rubh' Arisaig
Oberon Bank
Maxwell Bank
Sound of Arisaig
Sound of Eigg
Muck
Rep (1985)
Bo Faskadale
Loch Moidart
Loch Ceann Traigh
Bank
Rep (1986)
Rep (1998)
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Rep (1985)
Eilean Mor (34)
Fishing Bank
Rep (1958)
Loch Eatharna
Ardmore Point
Cás
Fl.3s15M
Tobermory
COLL
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Roan Bogha
Q(6)+LFl
Rep (1985)
Treshnish Isles
Fladda
Loch Tuath
Passage of Tiree
Lunga (100)
Ulva
Loch na Keal
Craig 764
2724
Staffa
Ben More 964
ISLAND OF MULL
Erisgeir
Rep (1974)
Loch Spelve
715
Stac Mhic Mhurchaidh
Rep (1973)
Loch Scridain
Loch Buie
374

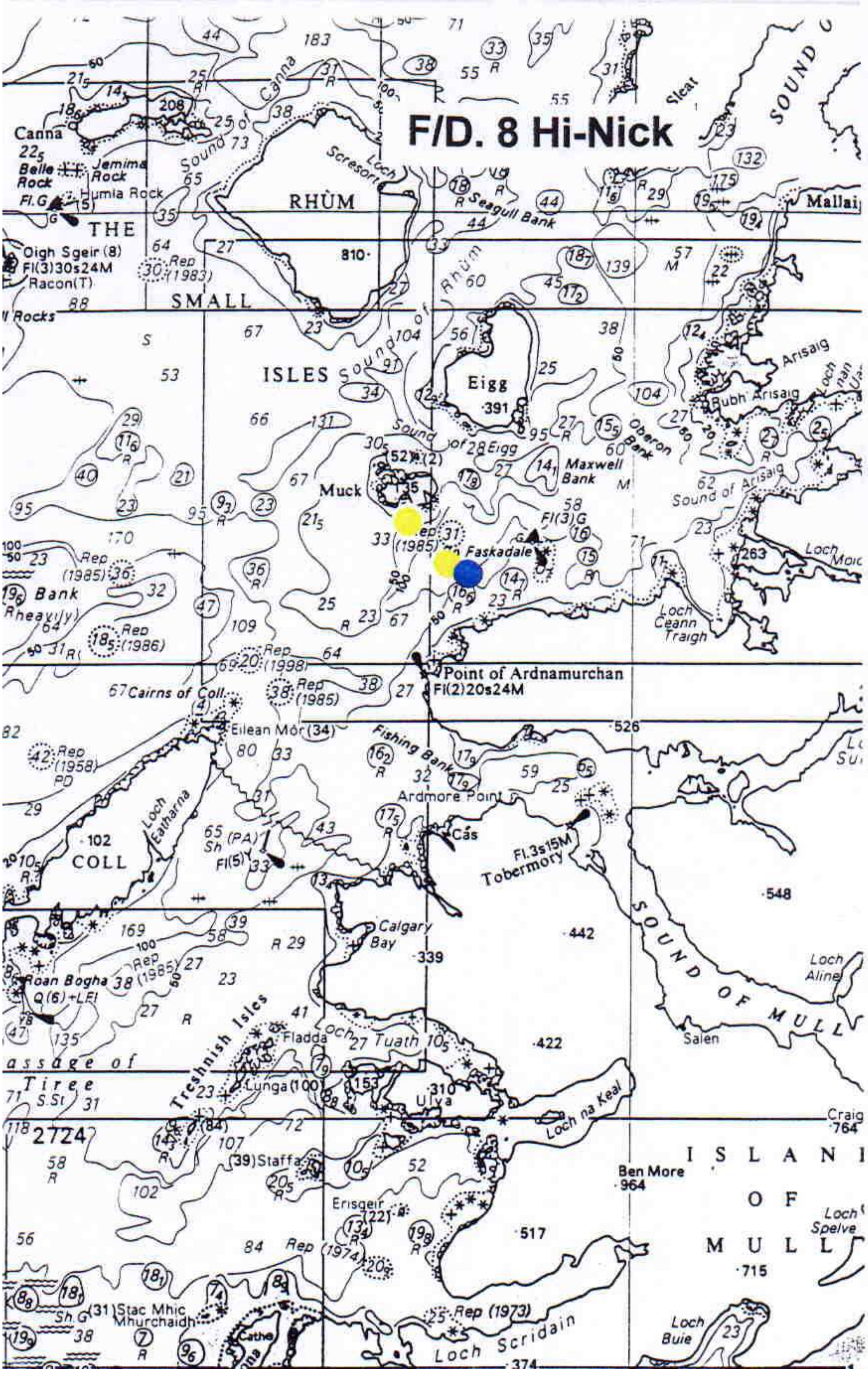

F/D 6. Notch
Canna
RHÙM
Mallaig
THE
SMALL
ISLES
Eigg
Muck
Sound of Canna
Sound of Rhùm
Sound of Eigg
Seagull Bank
Maxwell Bank
Oberon Bank
Bo Faskadale
Sound of Arisaig
Arisaig
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Fishing Bank
Ardmore Point
Càs
Fl.3s15M
Tobermory
COLL
Loch Eatharna
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Loch na Keal
Staffa
Erisgeir
ISLAND OF MULL
Ben More 964
Loch Spelve
Loch Scridain
Loch Buie
Passage of Tiree
Roan Bogha
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Humla Rock
Belle Rock
Jemima Rock
Craig 764

F/D 7. Chunky

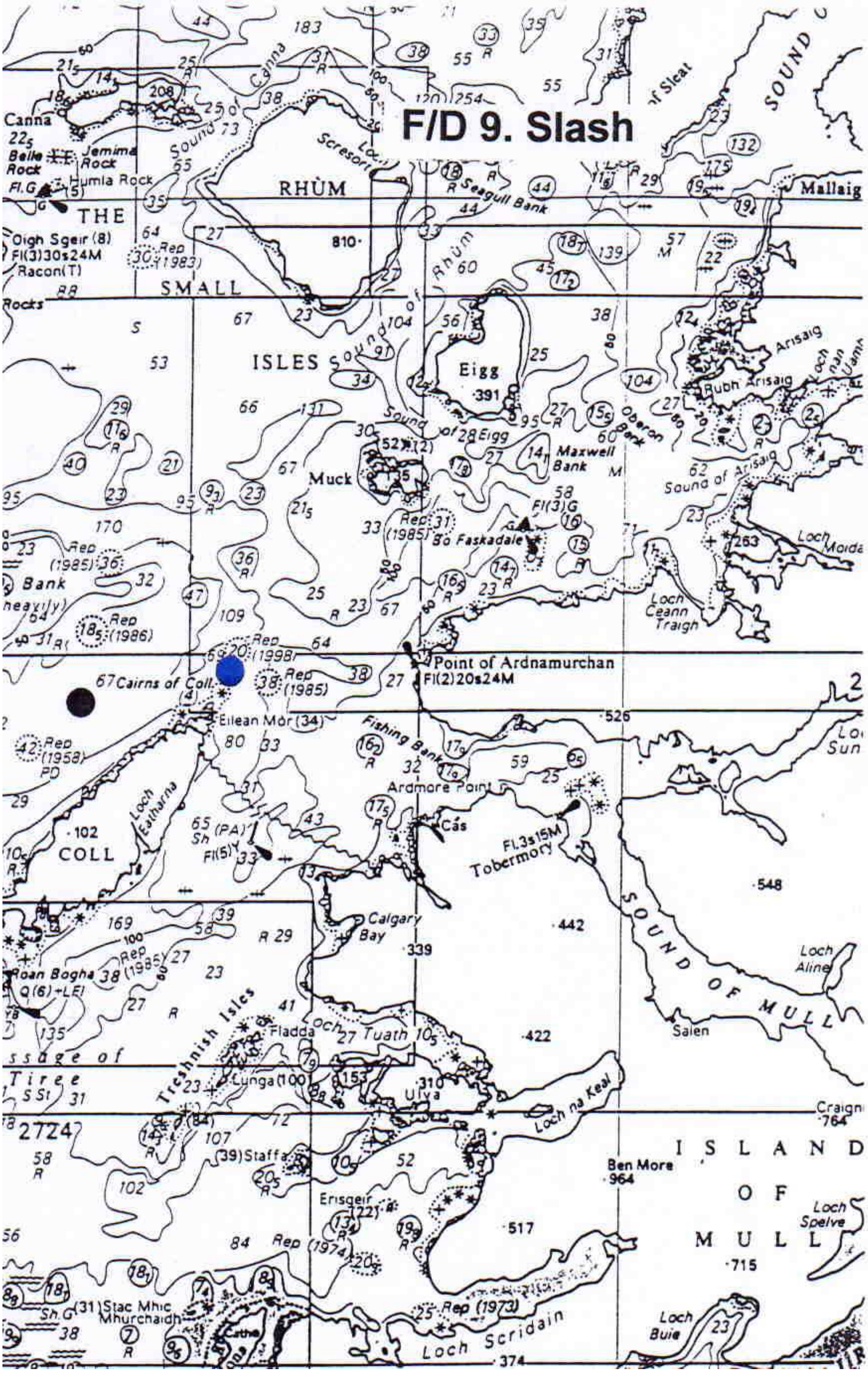


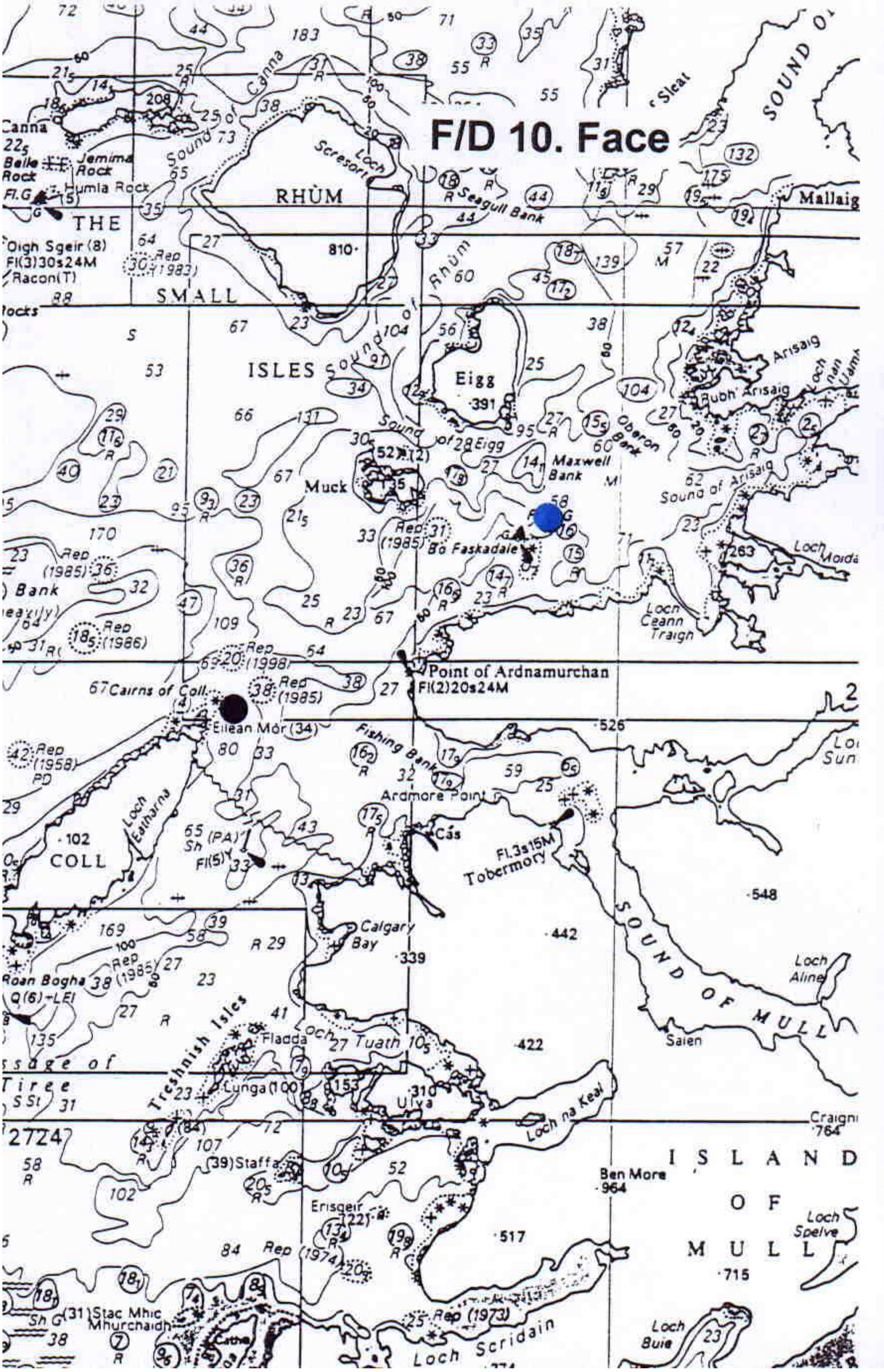
Canna
Belle Rock
Jemima Rock
Humla Rock
THE
SMALL
ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Rocks
Sound of Canna
RHÙM
Loch Scresort
Seagull Bank
Mallaig
Sound of Rhùm
Eigg
Sound of Eigg
Muck
Oberon Bank
Maxwell Bank
Sound of Arisaig
Arisaig
Rubh' Arisaig
Bo Faskadale
Loch Ceann Traigh
Bank
Cairns of Coll
Point of Ardnamurchan
Fl(2)20s24M
Eilean Mór
Fishing Bank
Ardmore Point
Cás
Fl.3s15M
Tobermory
Loch Eatharna
COLL
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Roan Bogha
Q(6)+LFl
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Loch na Keal
Passage of Tiree
Staffa
Erisgeir
Ben More
ISLAND OF MULL
Loch Spelve
Loch Buie
Loch Scridain
Stac Mhic Mhurchaidh

F/D. 8 Hi-Nick

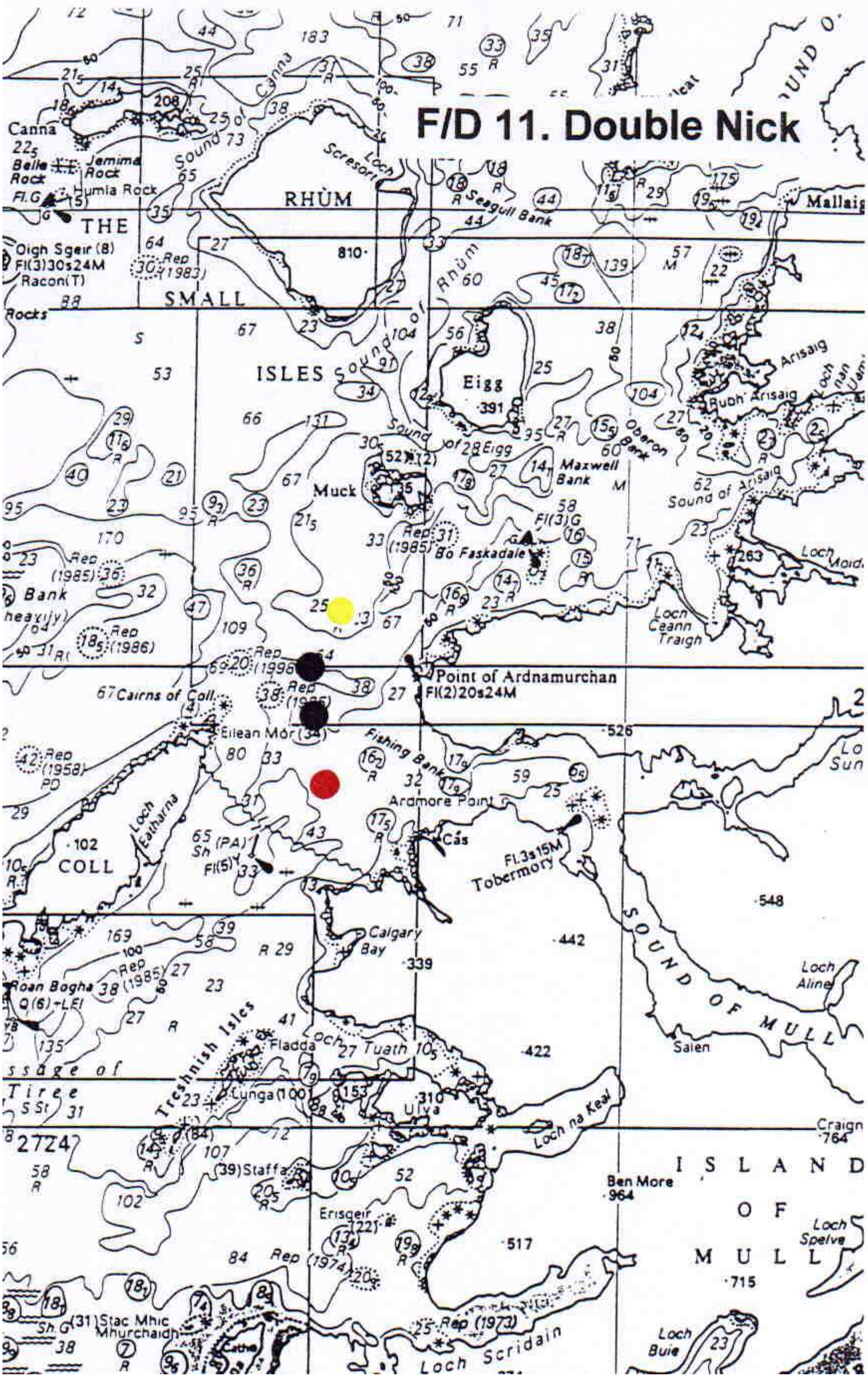


Canna
Belle Rock
Jemima Rock
Humla Rock
THE
SMALL
ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Sound of Canna
RHÙM
Loch Scresort
Seagull Bank
Sound of Rhùm
Sleat
SOUND OF
Mallaig
Eigg
Sound of Eigg
Muck
Oberon Bank
Maxwell Bank
Sound of Arisaig
Rubh' Arisaig
Arisaig
Faskadale
Loch Ceann Traigh
Loch Moidart
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Cás
Fl.3s15M
Tobermory
COLL
Loch Eatharna
Calgary Bay
Roan Bogha
Q(6)+LFl
Passage of Tiree
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
Staffa
Erisgeir
Stac Mhic Mhurchaidh
Loch Scridain
Rep (1973)
Ben More
964
ISLAND OF MULL
Loch Buie
Loch Spelve
SOUND OF MULL
Salen
Loch Aline
Craig
764
2724

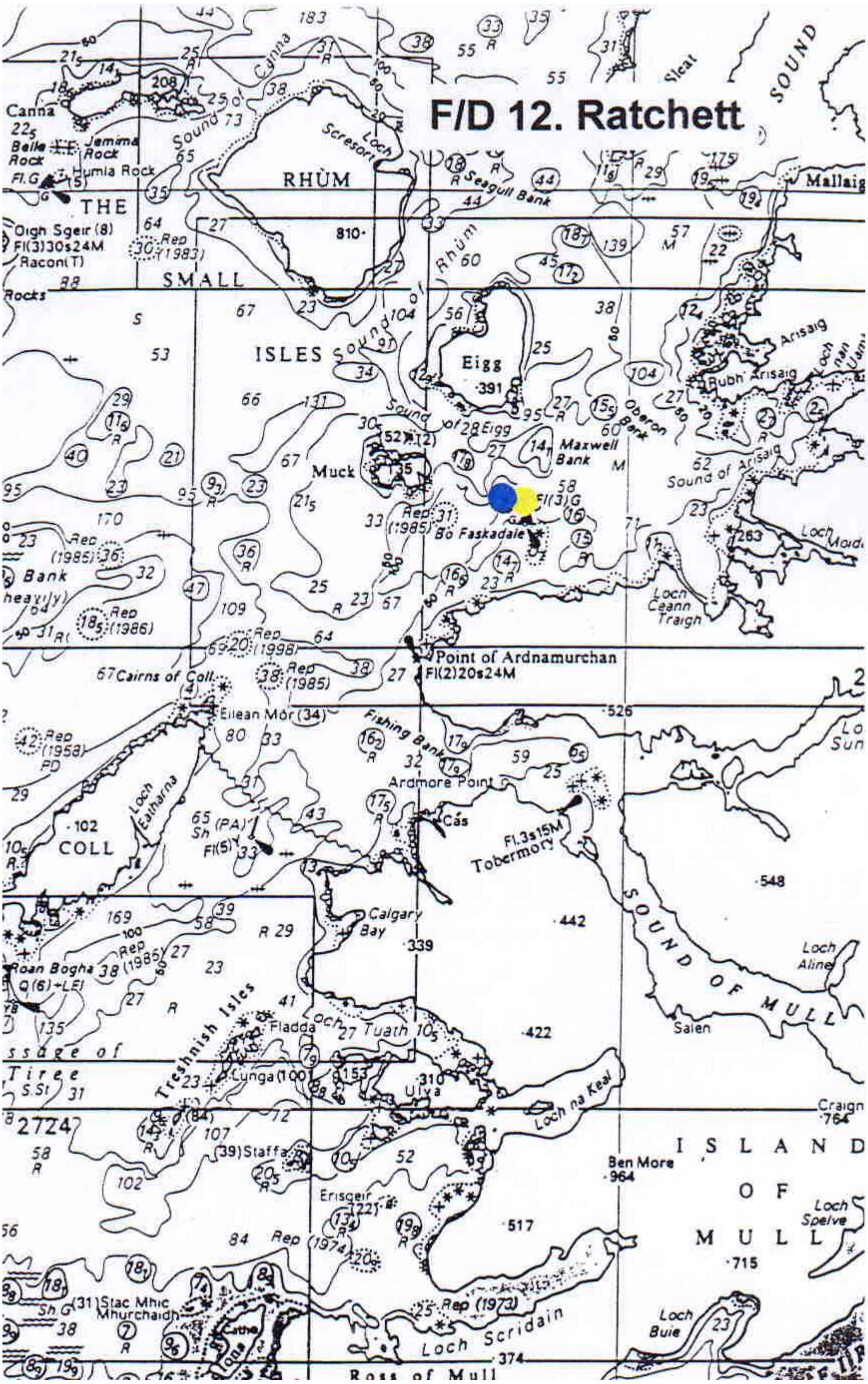

F/D 9. Slash
Canna
Jemima Rock
Belle Rock
Humla Rock
THE SMALL ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
RHÙM
Sound of Canna
Sound of Rhùm
Sound of Eigg
Seagull Bank
Mallaig
Eigg
Muck
Arisaig
Rubh' Arisaig
Sound of Arisaig
Maxwell Bank
Oberon Bank
Bo Faskadale
Loch Ceann Traigh
Loch Moidart
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mor (34)
Fishing Bank
Ardmore Point
Càs
Fl.3s15M
Tobermory
COLL
Loch Eatharna
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
Staffa
Erisgeir
ISLAND OF MULL
Ben More
964
Loch Spelve
Craignure
Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie
Passage of Tiree


F/D 10. Face
Canna
Jemima Rock
Humla Rock
THE
SMALL
ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Sound of Canna
RHÙM
Loch Scresort
Seagull Bank
Sound of Rhùm
Sleat
SOUND OF
Mallaig
Eigg
Sound of Eigg
Muck
Maxwell Bank
Oberon Bank
Bo Faskadale
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Cås
Fl.3s15M
Tobermory
Loch Eatharna
COLL
Calgary Bay
Roan Bogha
Q(6)+LFl
Passage of Tiree
Treshnish Isles
Fladda
Lunga (100)
Loch Tuath
Ulva
Loch na Keal
SOUND OF MULL
Loch Aline
Salen
Staffa
Erisgeir
Ben More
ISLAND OF MULL
Craignure
Loch Spelve
Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie
Rep (1973)

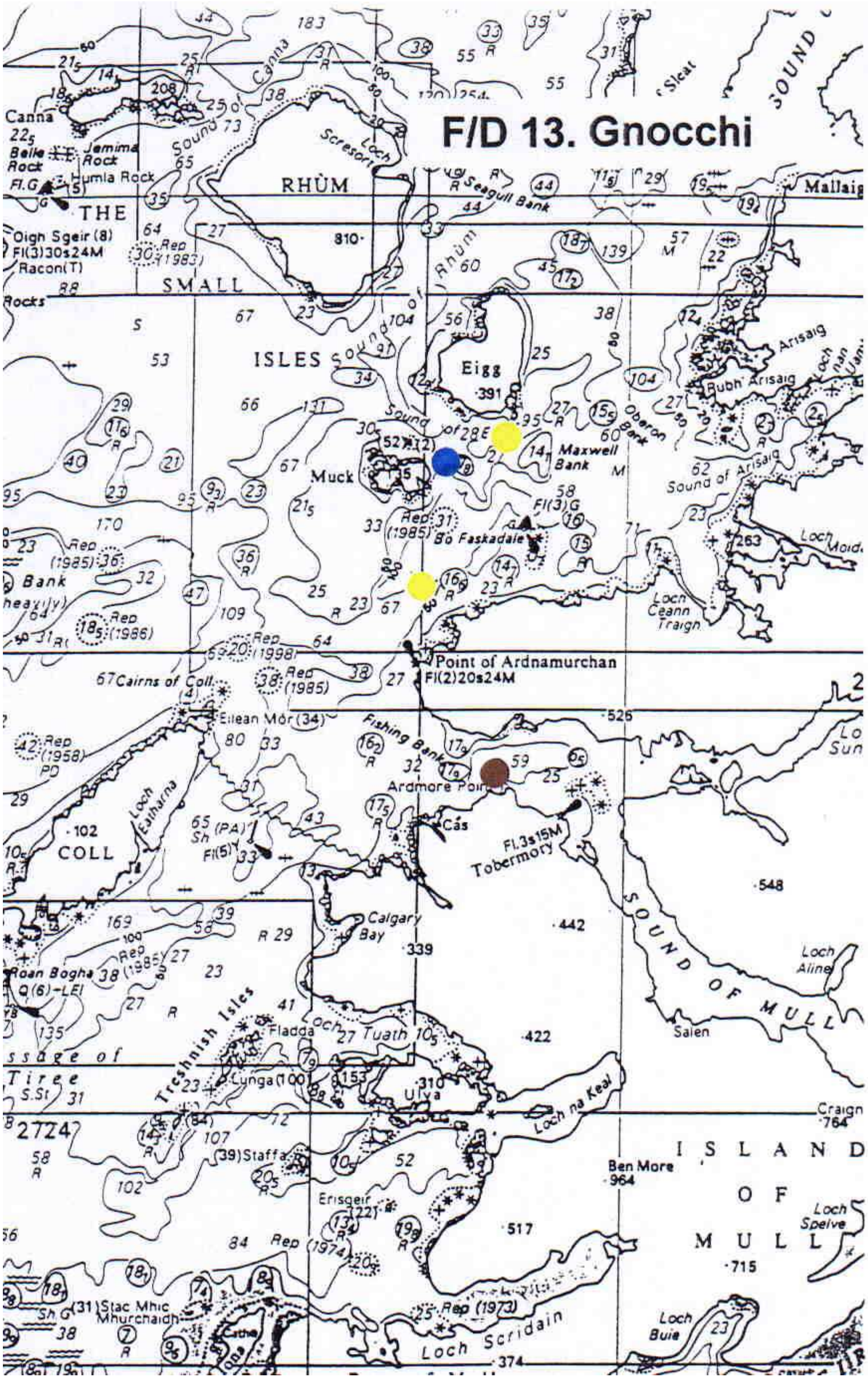
F/D 11. Double Nick



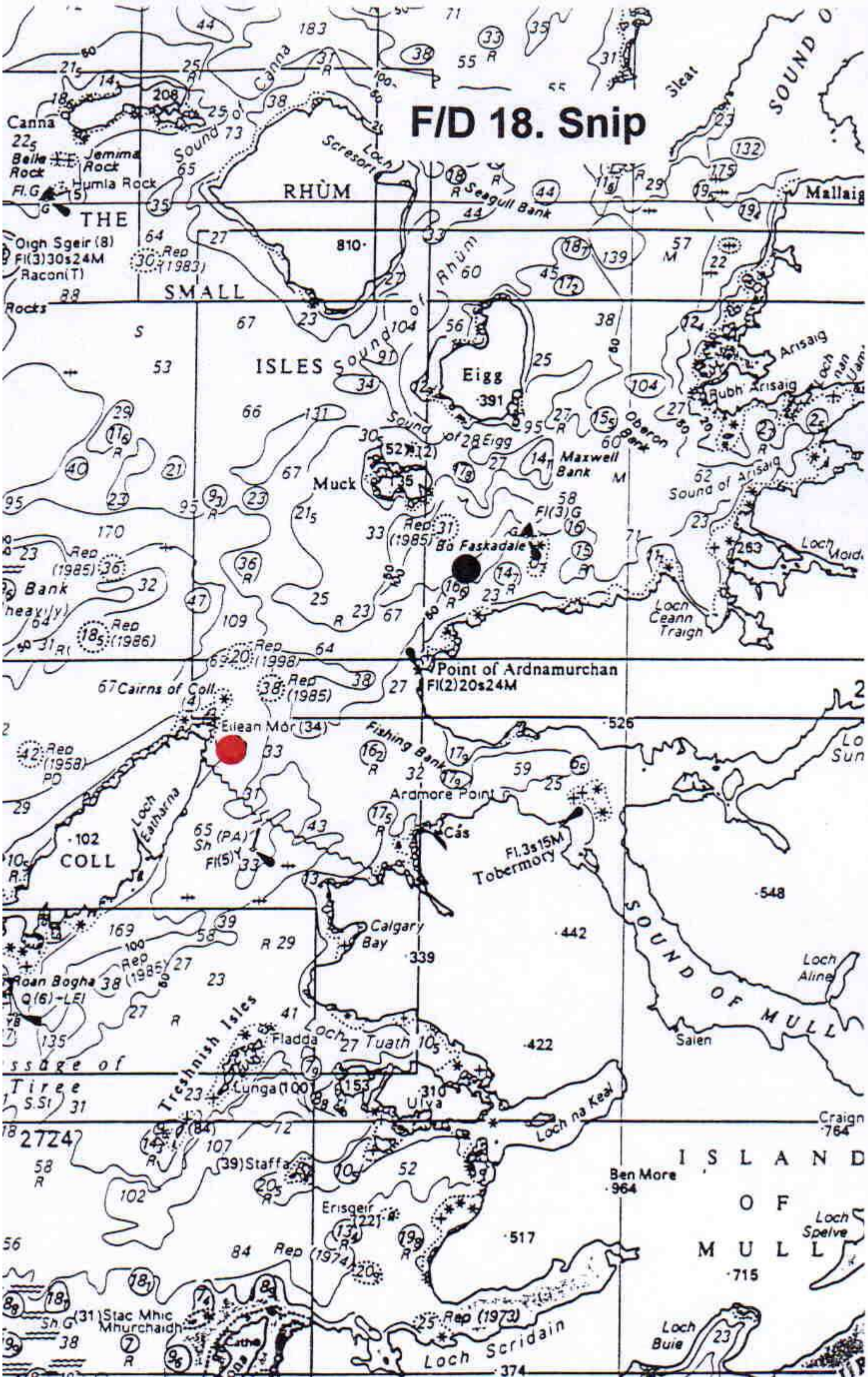
F/D 12. Ratchett



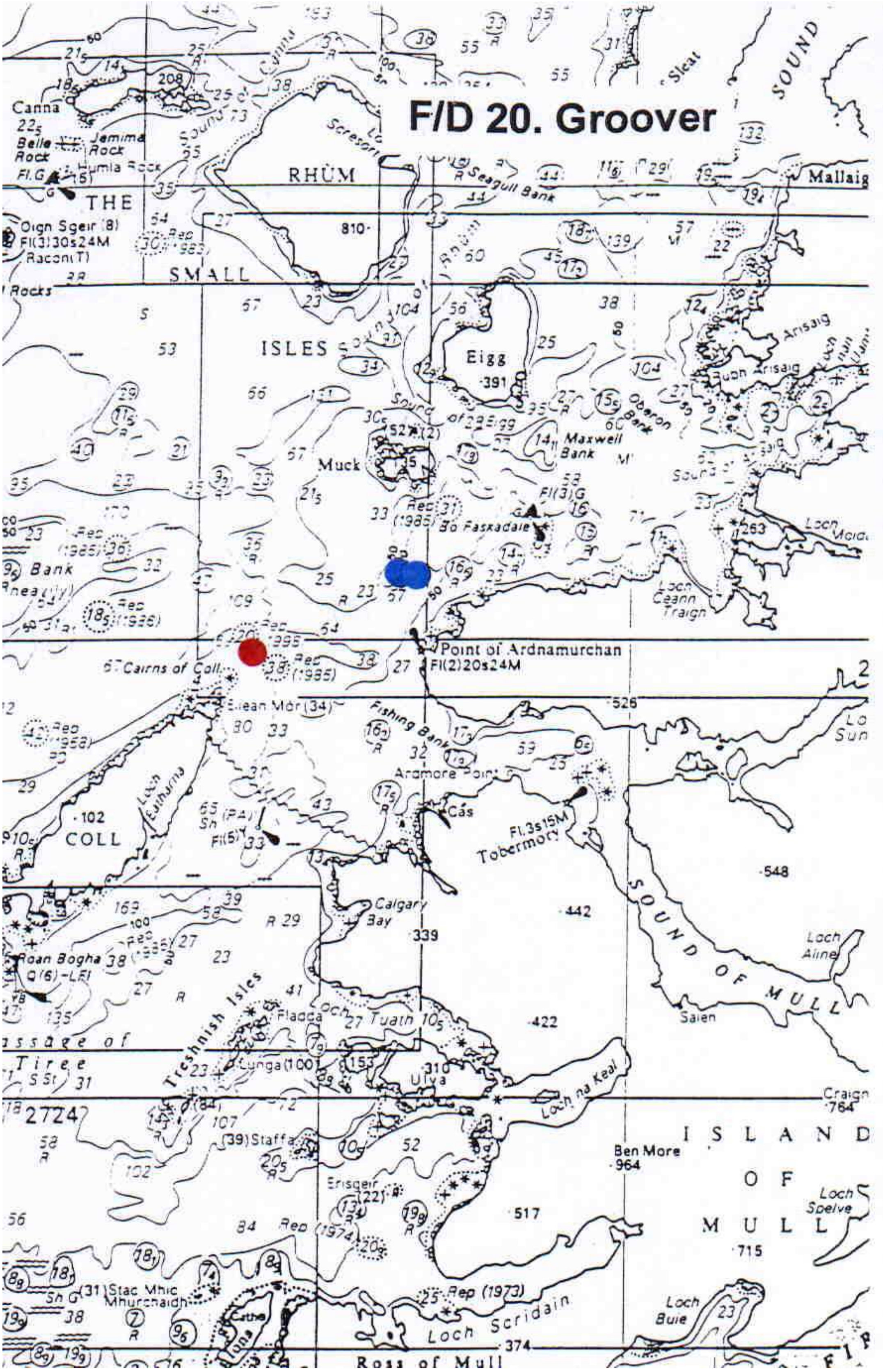
F/D 13. Gnocchi



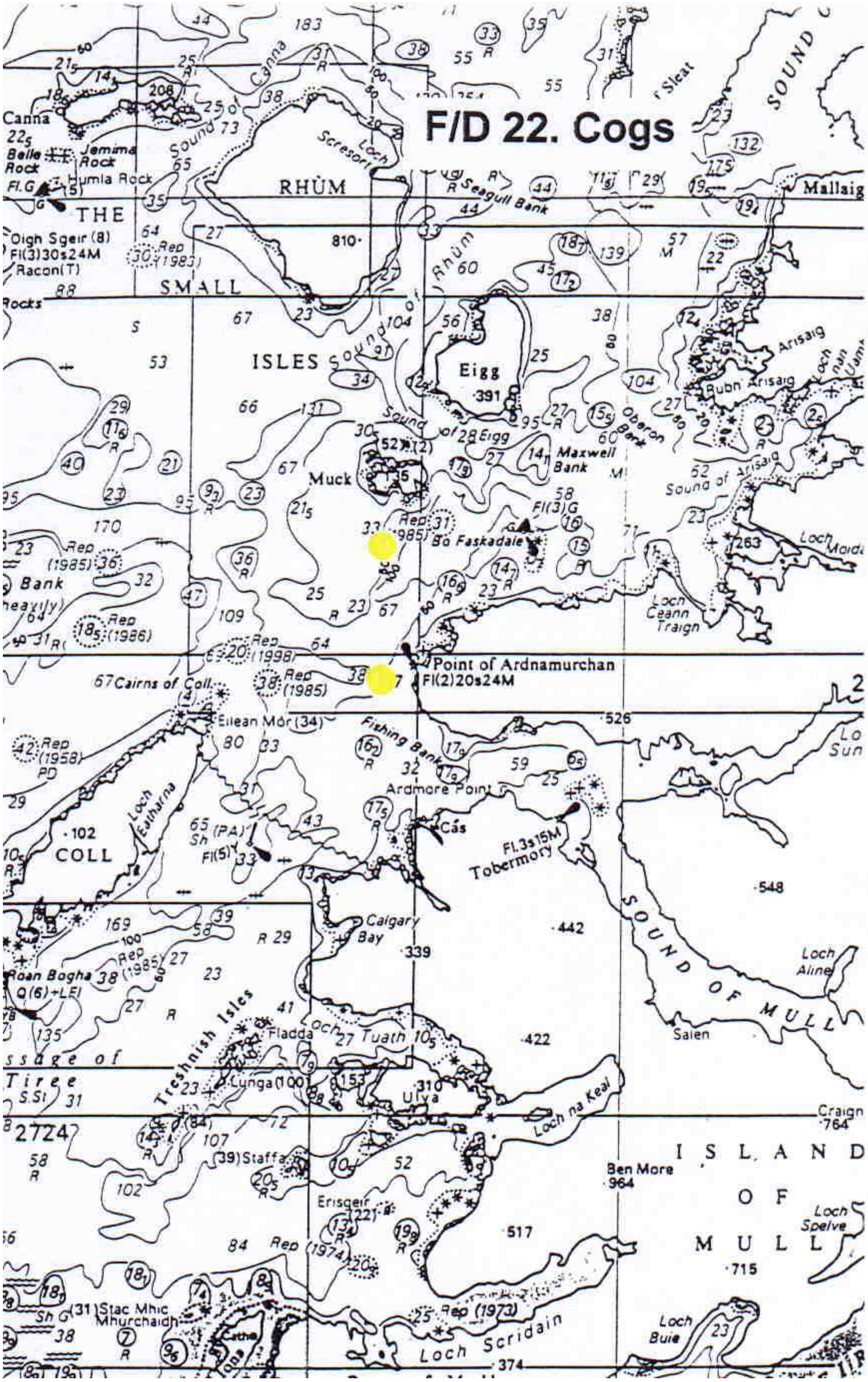
F/D 18. Snip



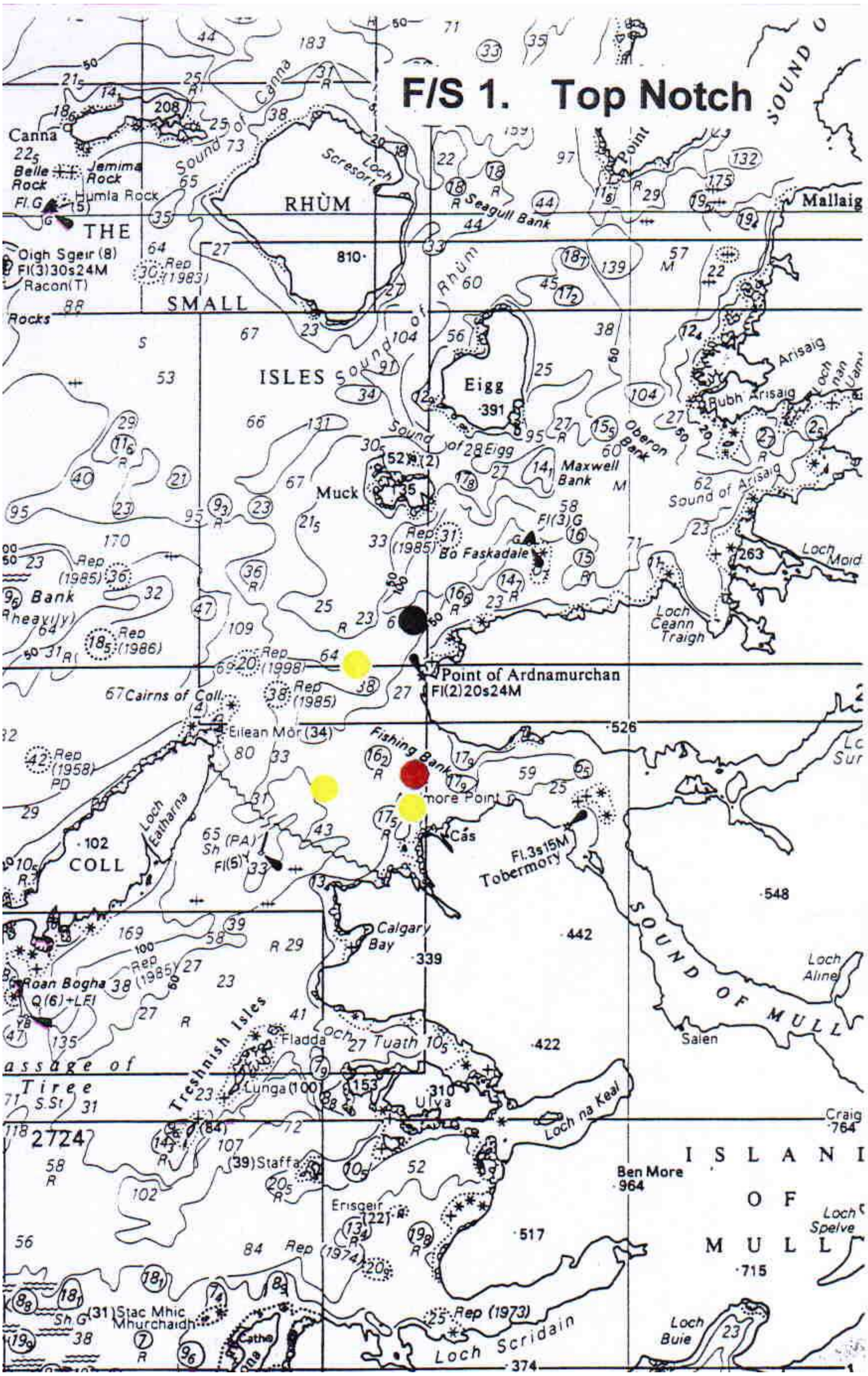
Canna
Belle Rock
Jemima Rock
Humla Rock
Sound of Canna
RHÙM
Loch Scresort
Seagull Bank
Mallaig
Sleat
SOUND OF
THE
SMALL
ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Rocks
Sound of Rhùm
Eigg
Sound of Eigg
Muck
Maxwell Bank
Oberon Bank
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch nan Uamh
Bo Faskadale
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Càs
Fl.3s15M
Tobermory
Loch Eatharna
COLL
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Loch na Keal
Staffa
Erisgeir
Ben More
964
ISLAND OF MULL
Loch Spelve
Craign
Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie
Tiree



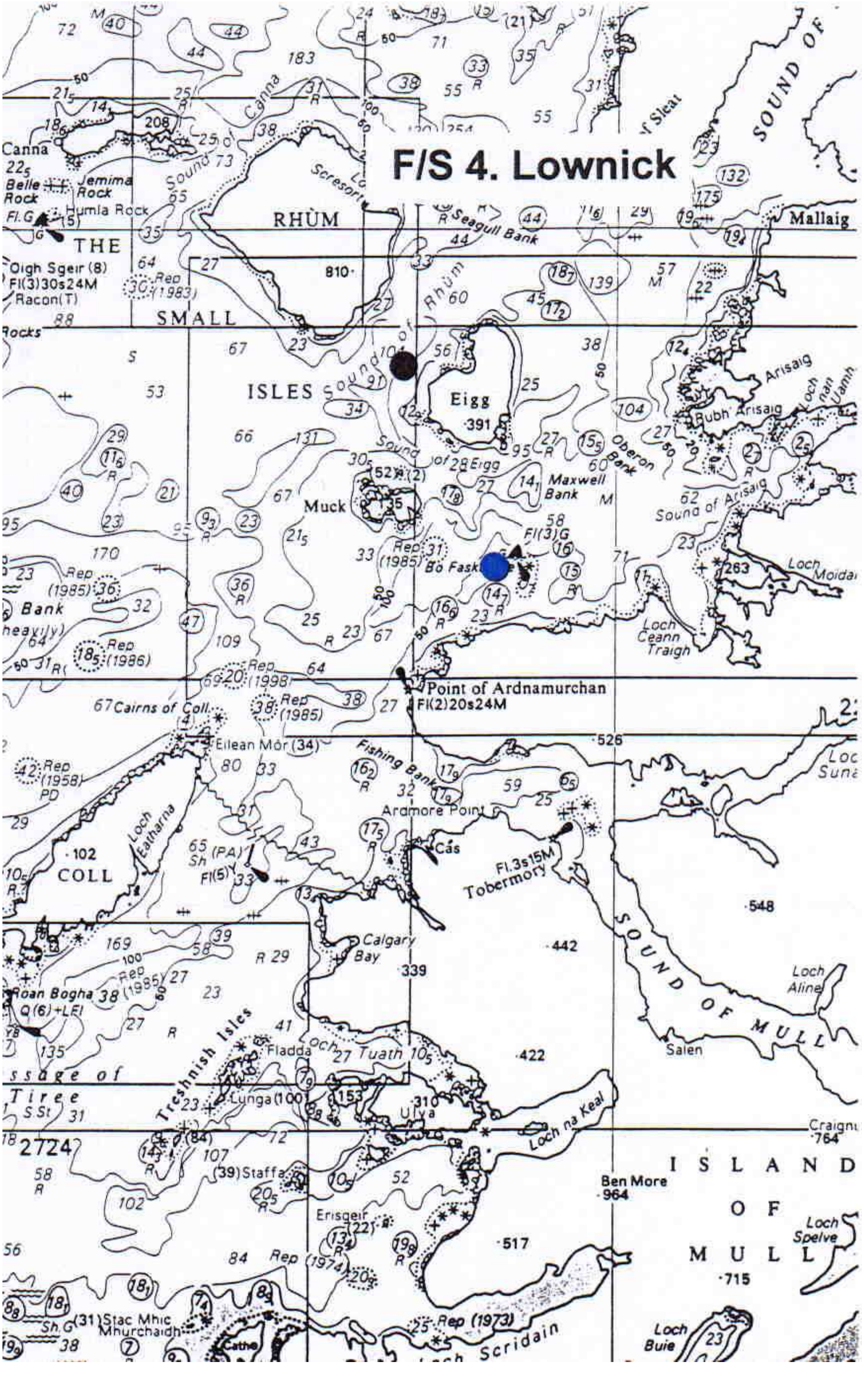
F/D 20. Groover
Canna
RHUM
THE
SMALL
ISLES
Eigg
Muck
Mallaig
Arisaig
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
COLL
Tobermory
SOUND OF MULL
Treshnish Isles
Staffa
Ulva
Loch na Keal
ISLAND OF MULL
Ben More
Loch Scridain
Ross of Mull
Calgary Bay
Sound of Rhum
Sound of Eigg
Seagull Bank
Maxwell Bank
Oberon Bank
Bo Faskadale
Fishing Bank
Ardmore Point
Loch Ceann Traigh
Loch Buie
Tuath
Craign


F/D 22. Cogs
Canna
RHÙM
THE SMALL ISLES
Sound of Rhum
Eigg
Muck
Sound of Eigg
Maxwell Bank
Oberon Bank
Bo Faskadale
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Cás
Tobermory
COLL
Loch Eatharna
Calgary Bay
Treshnish Isles
Fladda
Lunga
Loch Tuath
Ulva
Loch na Keal
Staffa
Erisgeir
Loch Scridain
Stac Mhic Mhurchaidh
Ben More
ISLAND OF MULL
SOUND OF MULL
Loch Aline
Salen
Loch Spelve
Loch Buie
Mallaig
Arisaig
Sound of Arisaig
Loch Ceann Traigh
Loch Moidart
Seagull Bank
Sound of Sleat
Humla Rock
Jemima Rock
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Loch Scresort
Sound of Canna

F/S 1. Top Notch

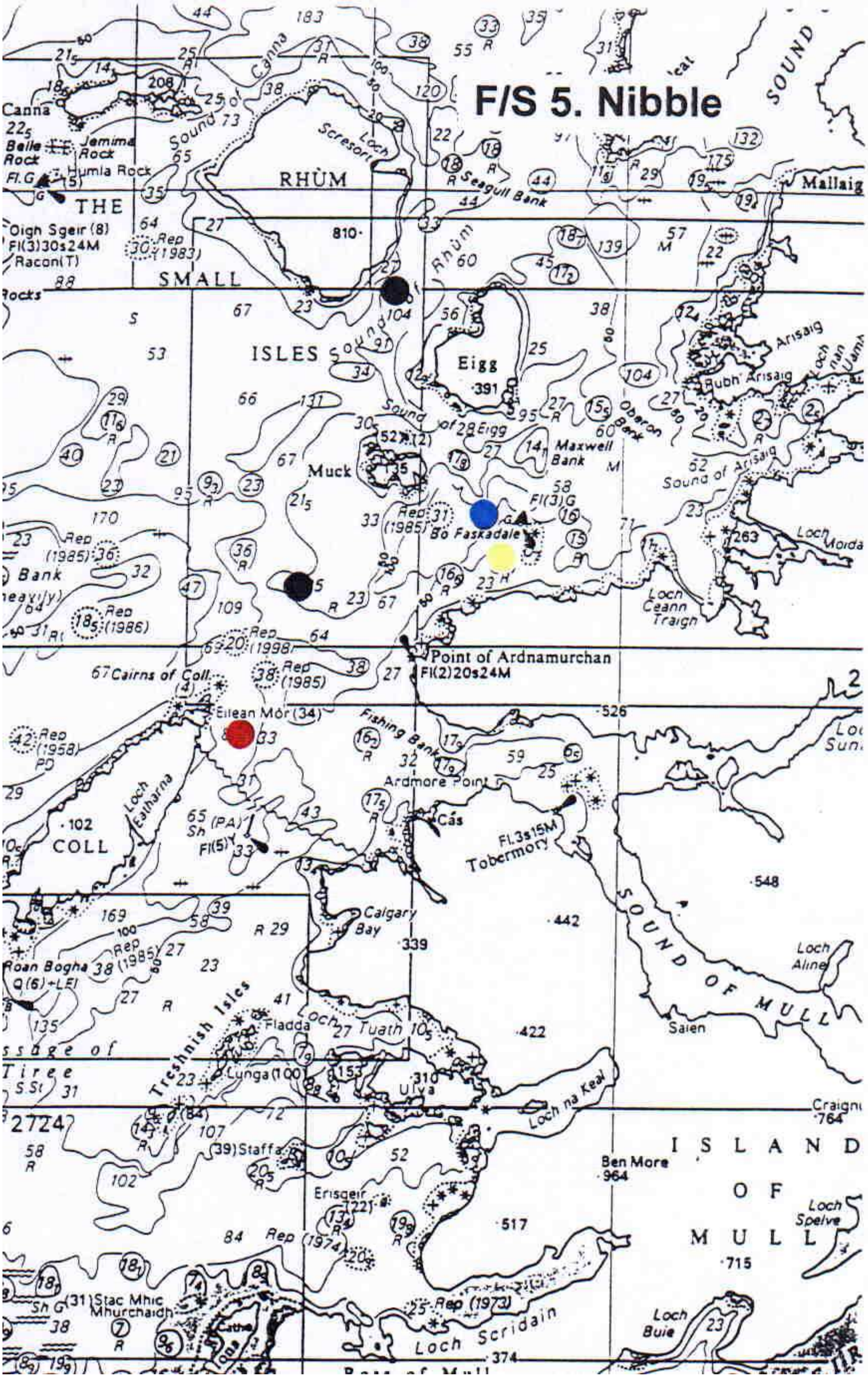


F/S 4. Lownick



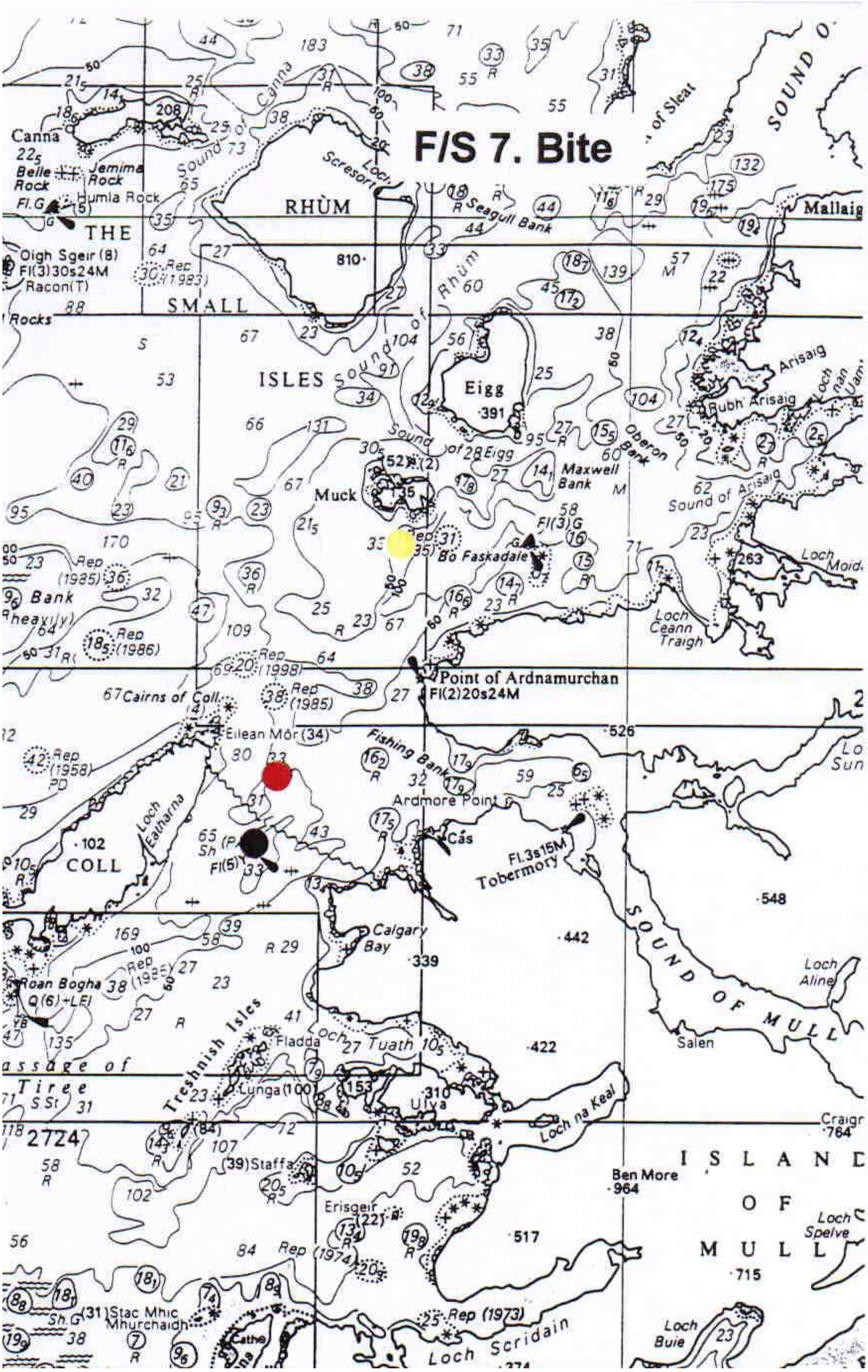
Canna
Belle Rock
Jemima Rock
Humla Rock
RHÙM
THE SMALL ISLES
Oigh Sgeir (8) Fl(3)30s24M Racon(T)
Sound of Canna
Sound of Rhùm
Seagull Bank
Sound of Sleat
Mallaig
Eigg
Sound of Eigg
Muck
Oberon Bank
Maxwell Bank
Arisaig
Rubh' Arisaig
Loch nan Uamh
Sound of Arisaig
Bo Faskadale
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Càs
Tobermory Fl.3s15M
Loch Sunart
Loch Eatharna
COLL
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Roan Bogha Q(6)+LFl
Passage of Tiree
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
ISLAND OF MULL
Ben More 964
Craignure 764
Staffa
Erisgeir
Loch Spelve
Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie
Rep (1973)

F/S 5. Nibble

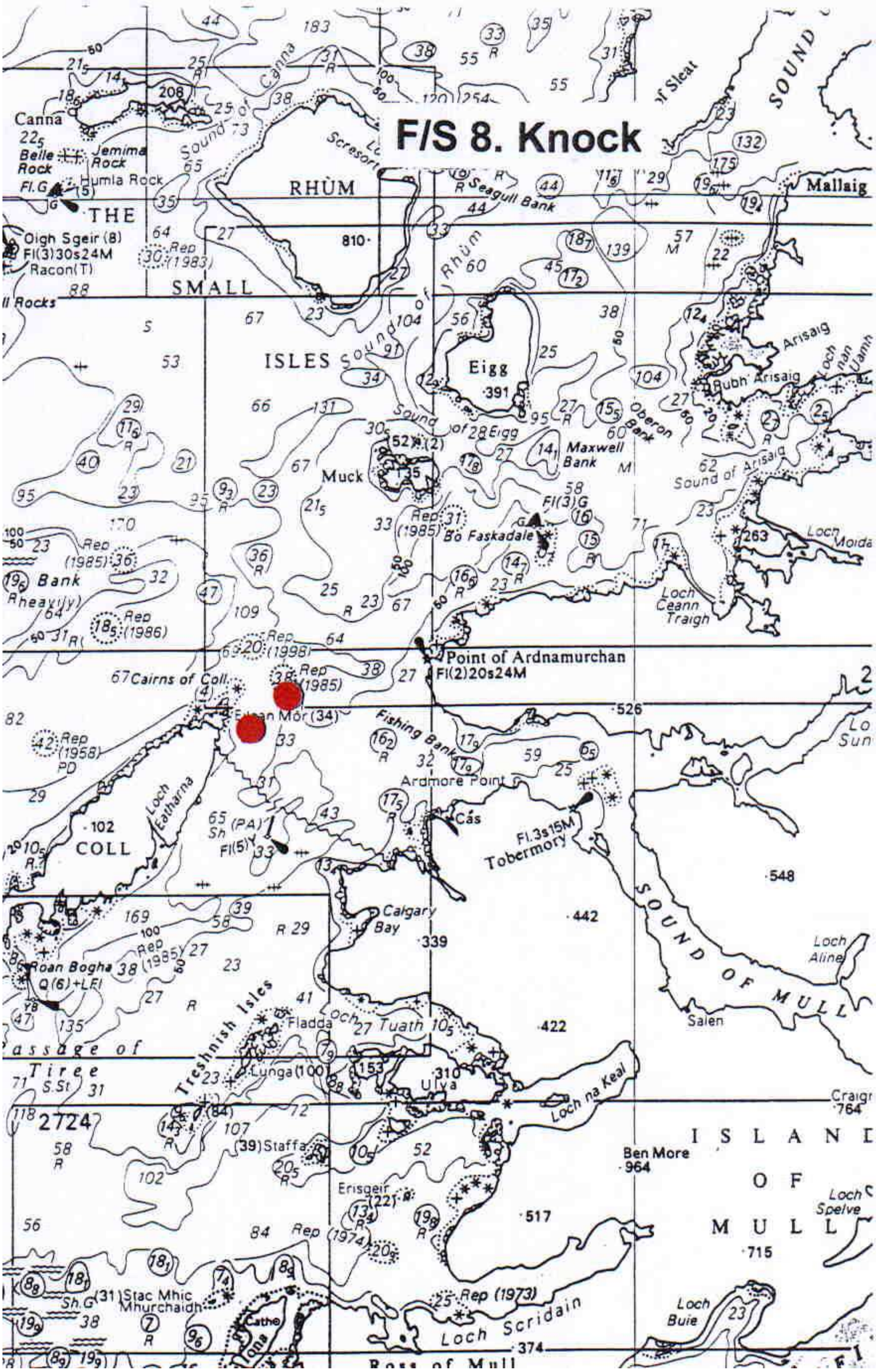


Canna
Jemima Rock
Humla Rock
Sound of Canna
RHÙM
THE SMALL ISLES
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Rep (1983)
Scresort Loch
Seagull Bank
Mallaig
810
Rhùm Sound
Sound of Rhùm
Eigg
391
Sound of Eigg
Muck
Maxwell Bank
Oberon Bank
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch Moidart
Bo Faskadale
Fl(3)G
Rep (1985)
263
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Rep (1998)
Rep (1985)
Rep (1958)
Rep (1986)
Fishing Bank
Ardmore Point
Cås
Fl.3s15M
Tobermory
Loch Eatharna
COLL
102
Fl(5)Y
526
548
442
339
Calgary Bay
SOUND OF MULL
Loch Aline
Saien
Roan Bogha
Q(6)+LFl
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
422
310
Staffa
Erisgeir
Rep (1974)
Ben More 964
ISLAND OF MULL
517
715
Loch Spelve
Craignure
Stac Mhic Mhurchaidh
Rep (1973)
Loch Scridain
Loch Buie
374

F/S 7. Bite

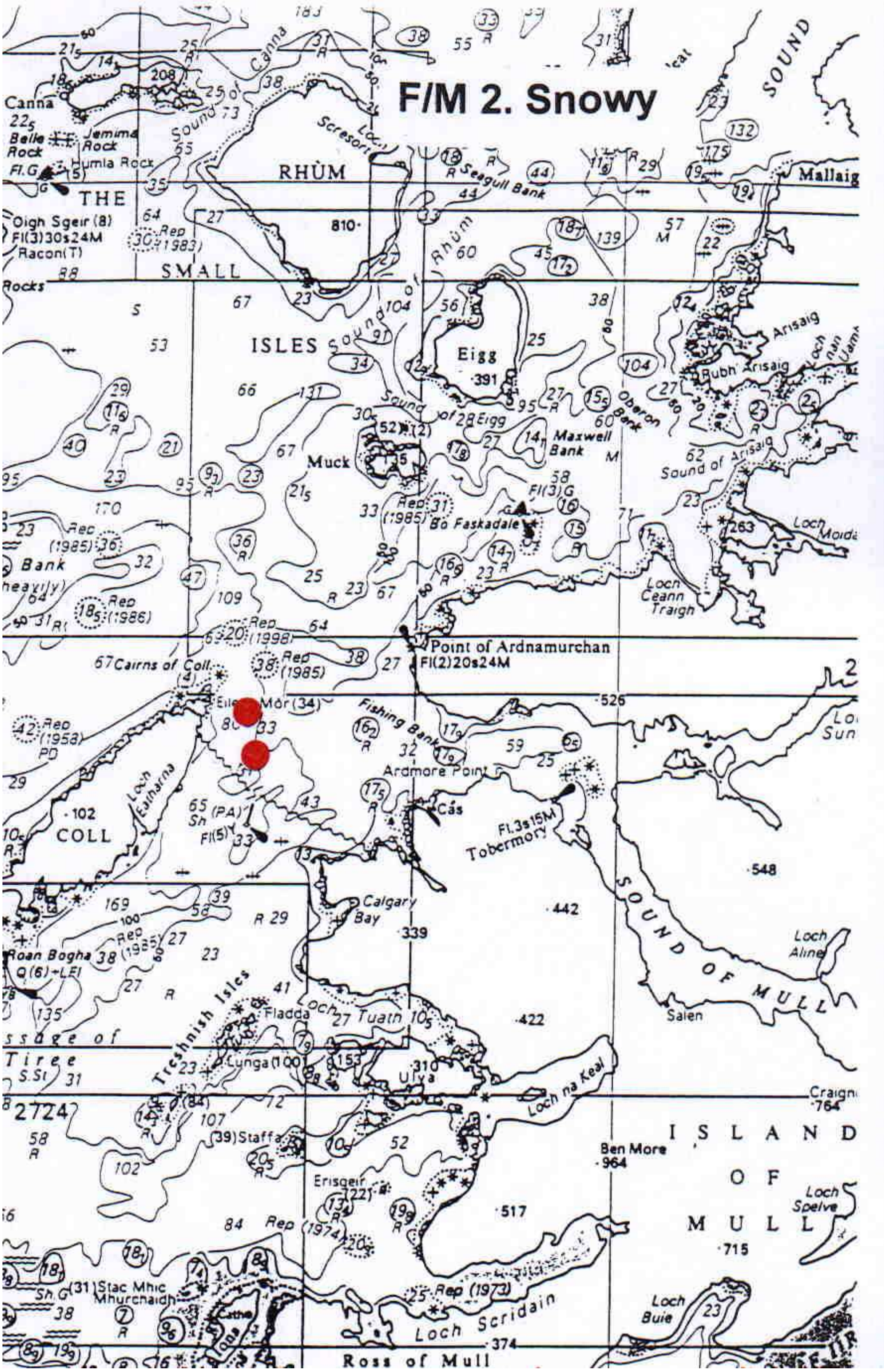

Canna
Belle Rock
Jemima Rock
Humla Rock
THE
SMALL
ISLES
RHÙM
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
Sound of Canna
Sound of Rhùm
Seagull Bank
Sound of Sleat
SOUND OF
Mallaig
Eigg
Sound of Eigg
Muck
Oberon Bank
Maxwell Bank
Bo Faskadale
Sound of Arisaig
Arisaig
Rubh Arisaig
Loch nan Uamh
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mòr (34)
Fishing Bank
Ardmore Point
Càs
Fl.3s15M
Tobermory
COLL
Loch Eatharna
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Roan Bogha
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
Staffa
Erisgeir
ISLAND OF MULL
Ben More
Loch Spelve
Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie

F/S 8. Knock

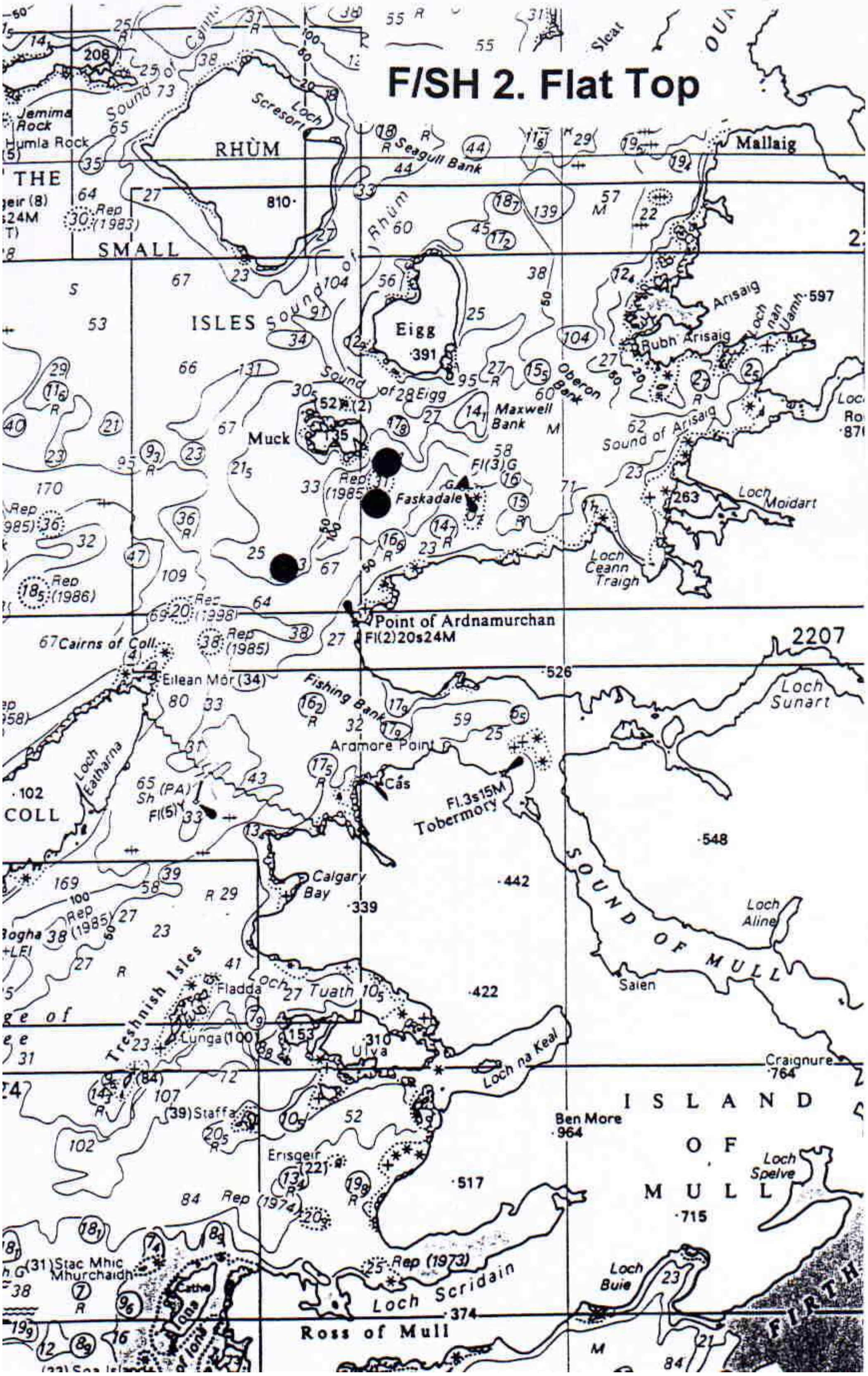


Canna
Belle Rock
Jemima Rock
Humla Rock
Oigh Sgeir (8)
Fl(3)30s24M
Racon(T)
THE SMALL ISLES
Sound of Canna
RHÙM
Sound of Rhùm
Seagull Bank
Mallaig
Eigg
Muck
Sound of Eigg
Maxwell Bank
Oberon Bank
Arisaig
Sound of Arisaig
Bo Faskadale
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Cás
Tobermory
Fl.3s15M
Loch Eatharna
COLL
SOUND OF MULL
Calgary Bay
Roan Bogha
Treshnish Isles
Fladda
Lunga(100)
Loch Tuath
Ulva
Loch na Keal
Passage of Tiree
Staffa
Erisgeir
ISLAND OF MULL
Ben More
·964
Loch Aline
Salen
Loch Spelve
Loch Buie
Loch Scridain
Stac Mhic Mhurchaidh
Iona
Ross of Mull

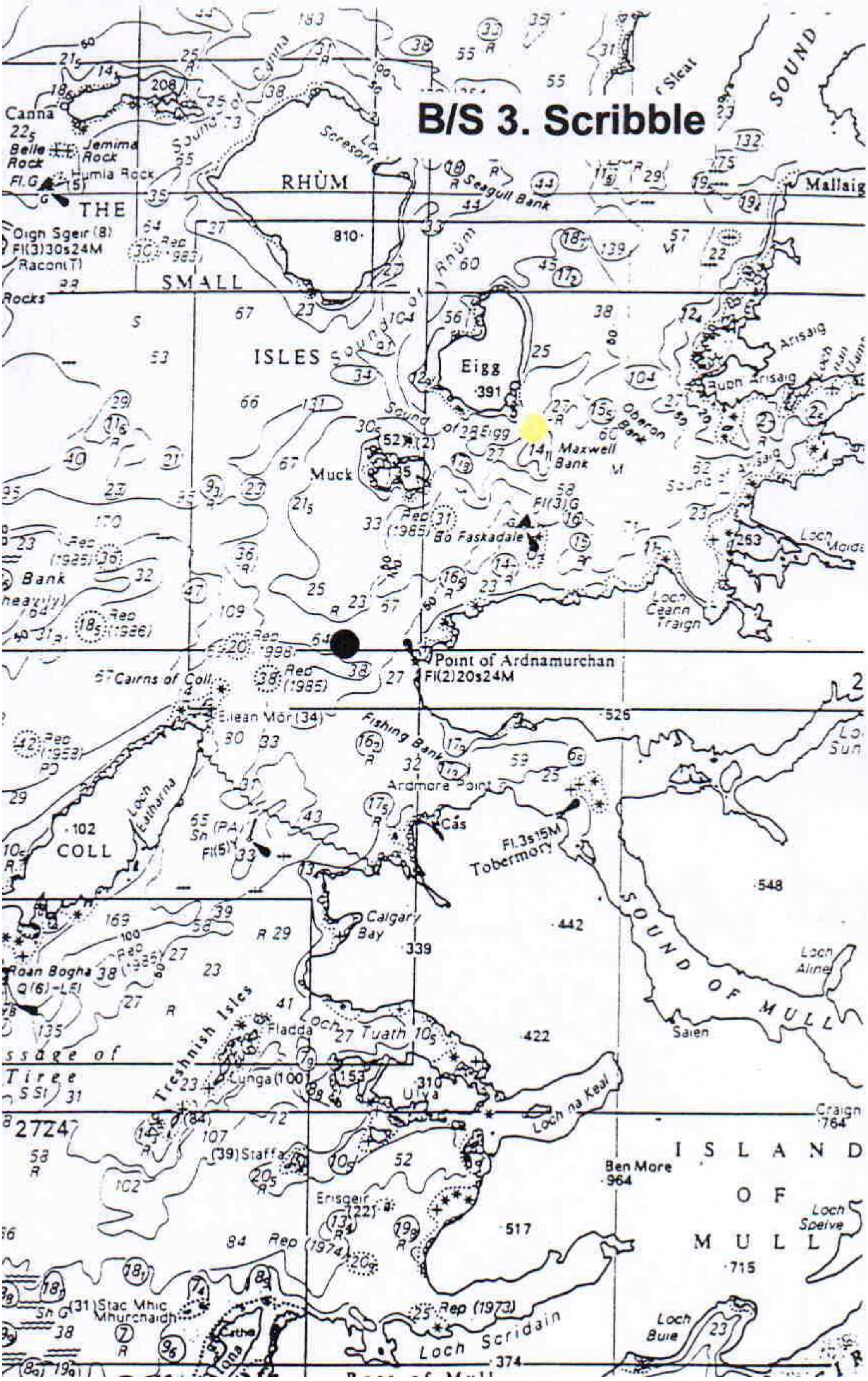
F/M 2. Snowy

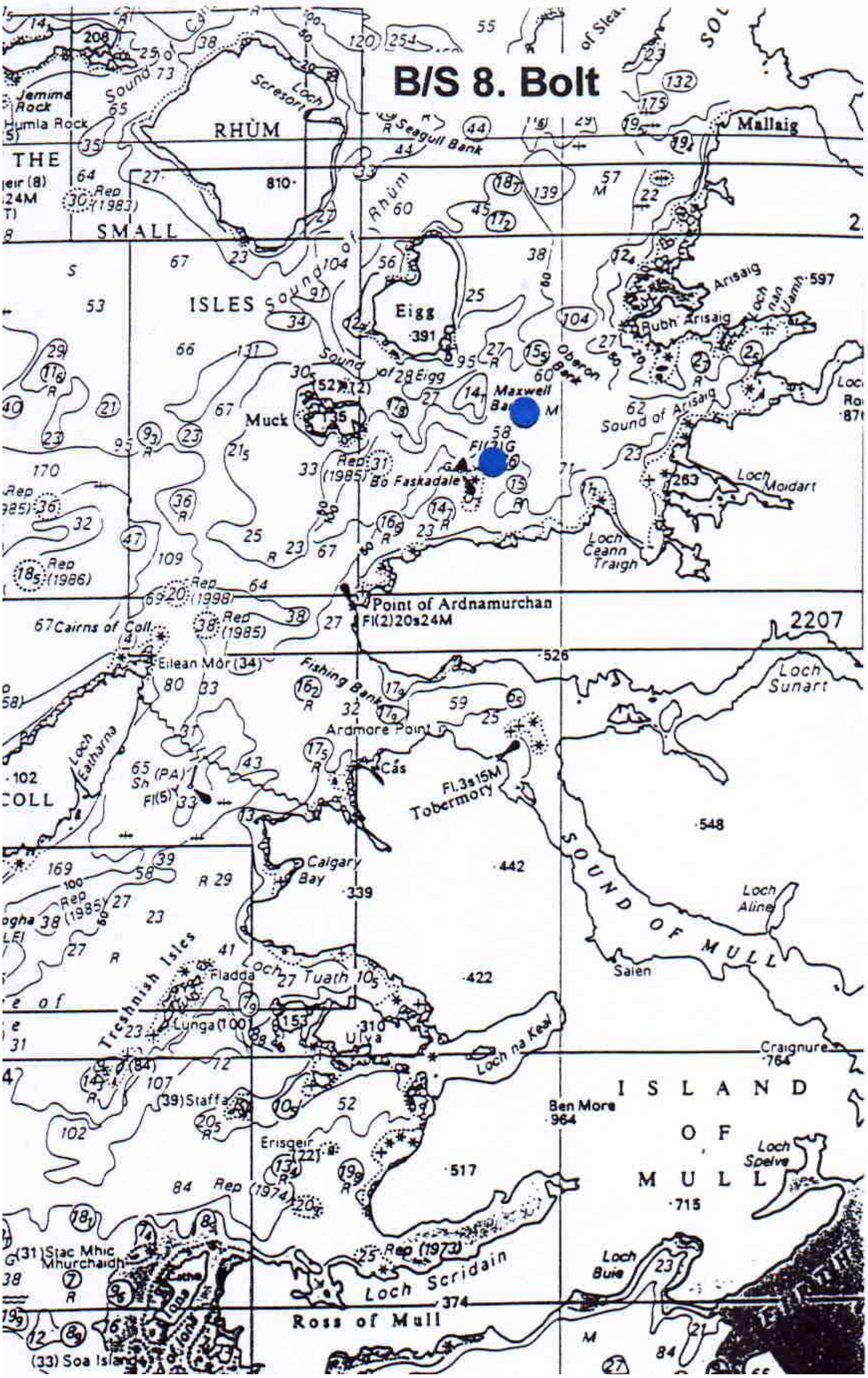

Canna
RHÙM
THE
SMALL
ISLES
Sound of Rhùm
Eigg
Muck
Maxwell Bank
Oberon Bank
Seagull Bank
Mallaig
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch Moidart
Loch Ceann Traigh
Bo Faskadale
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Fishing Bank
Ardmore Point
Càs
Fl.3s15M
Tobermory
COLL
Loch Eatharna
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Staffa
Loch na Keal
ISLAND OF MULL
Ben More
Erisgeir
Loch Spelve
Loch Buie
Loch Scridain
Ross of Mull
Stac Mhic Mhurchaidh
Tiree
Roan Bogha
Oigh Sgeir
Fl(3)30s24M
Racon(T)
Jemima Rock
Humla Rock
Belle Rock
Rocks
Craignure

F/SH 2. Flat Top

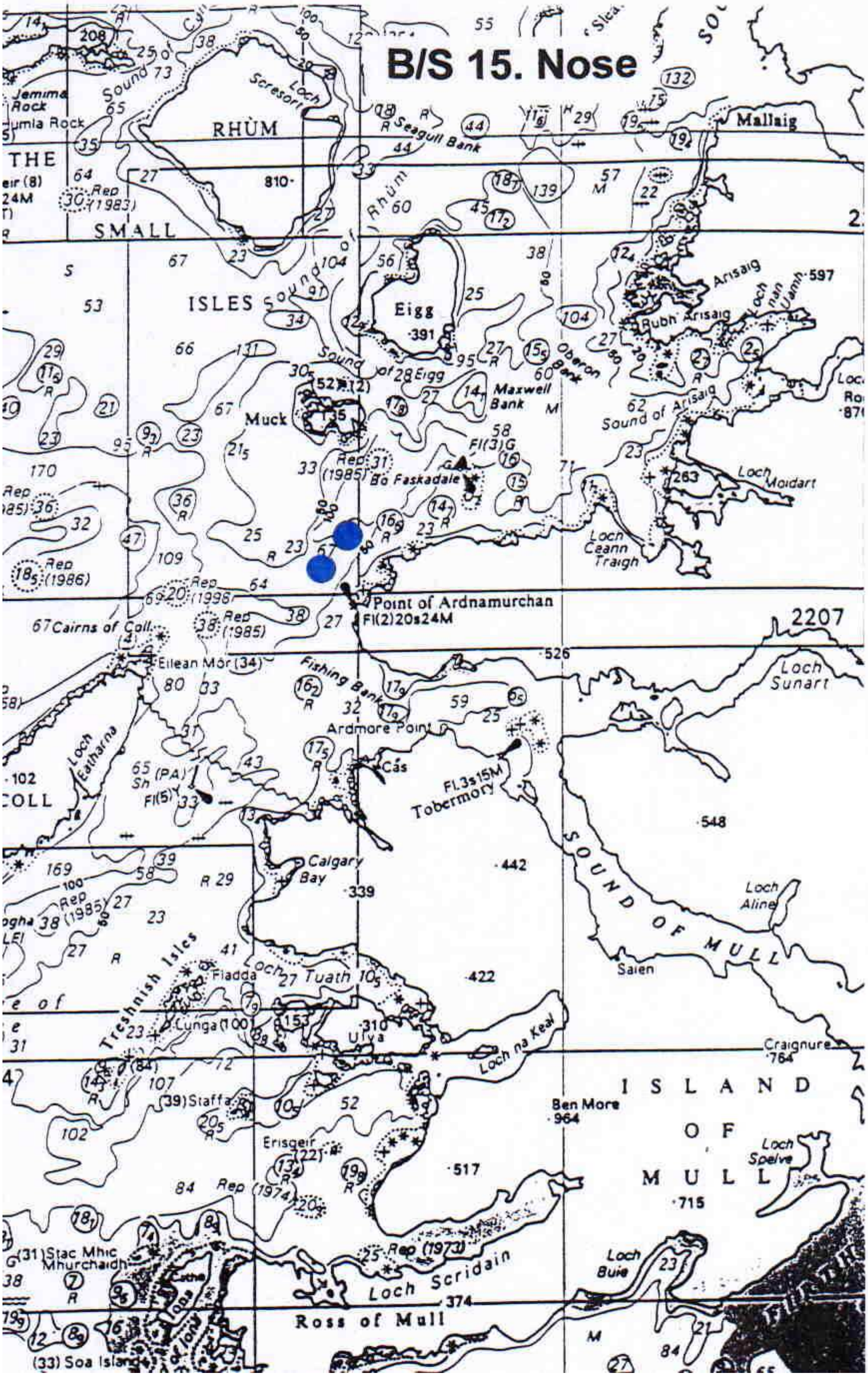


B/S 3. Scribble

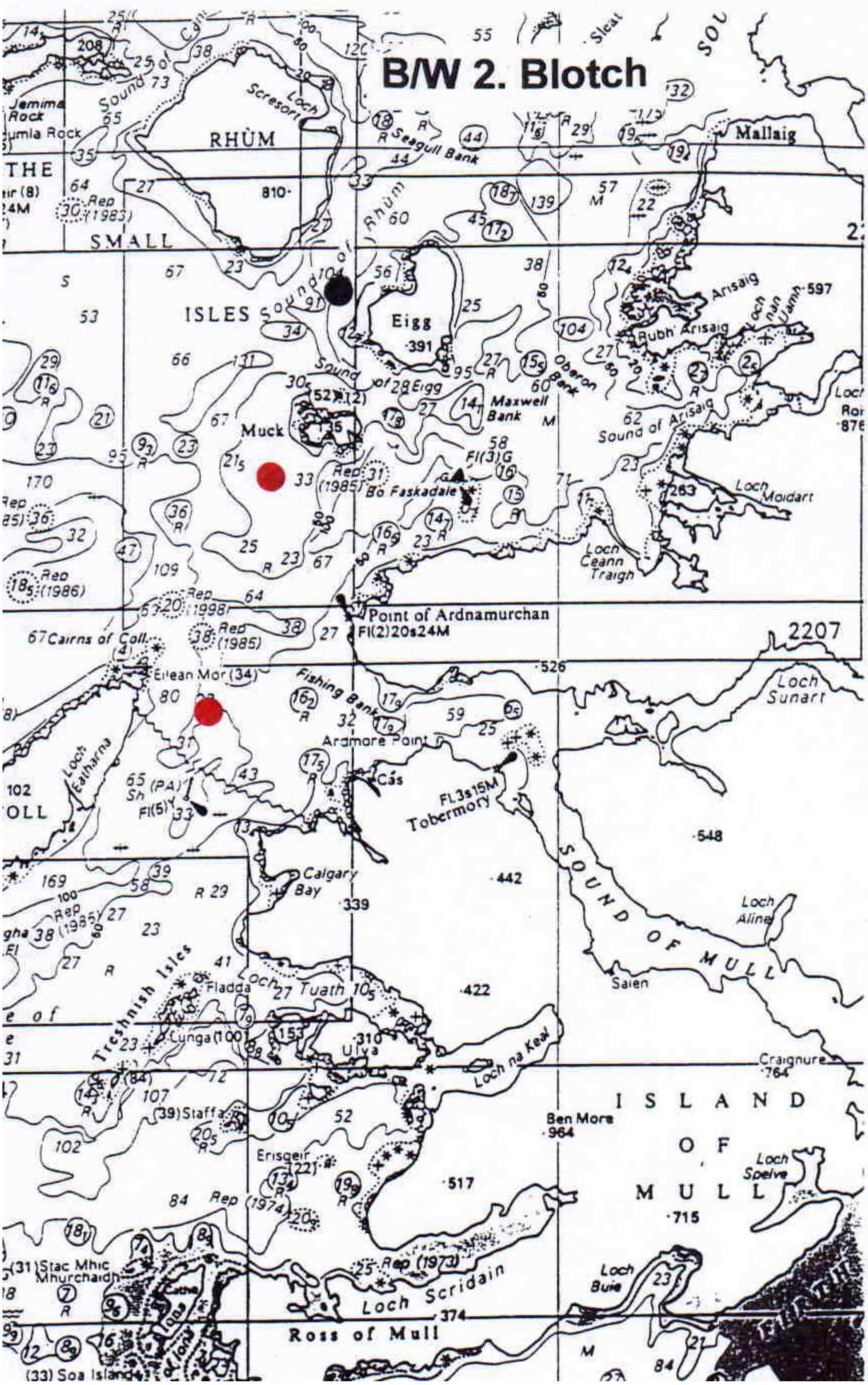



B/S 8. Bolt
RHÙM
SMALL
ISLES
Eigg
Muck
Maxwell Bank
Bo Faskadale
Oberon Bank
Seagull Bank
Mallaig
Arisaig
Sound of Arisaig
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Loch Sunart
Tobermory
Fl.3s15M
Calgary Bay
SOUND OF MULL
Loch Aline
Saien
Treshnish Isles
Fladda
Lunga
Loch Tuath
Ulva
Loch na Keal
Staffa
Erisgeir
Ben More
ISLAND OF MULL
Craignure
Loch Spelve
Loch Buie
Loch Scridain
Ross of Mull
Stac Mhic Mhurchaidh
Soa Island
COLL
2207

B/S 15. Nose

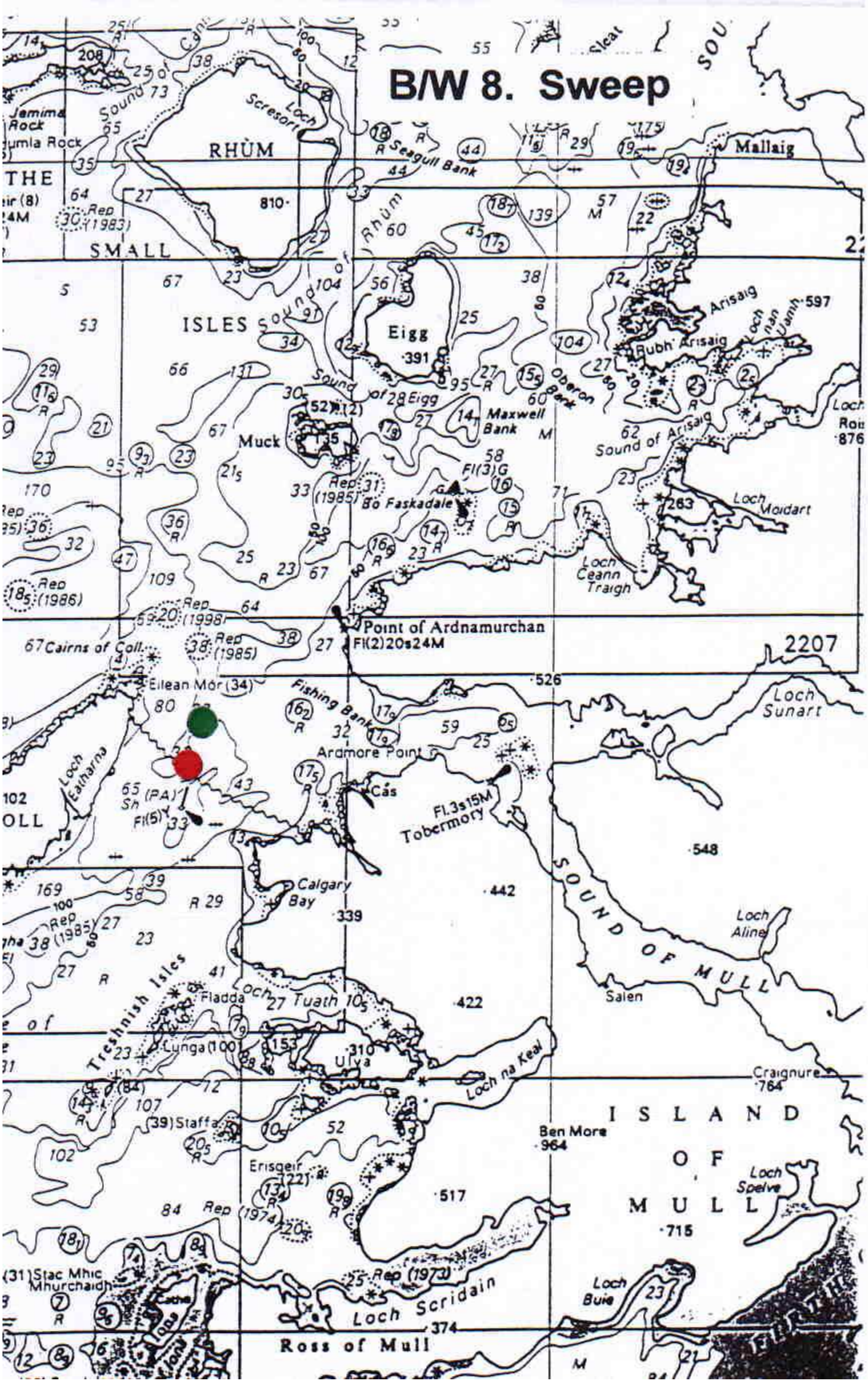

RHÙM
Sound of Canna
Loch Scresort
Seagull Bank
Mallaig
THE
SMALL
ISLES
Sound of Rhùm
Eigg
Sound of Eigg
Arisaig
Rubh' Arisaig
Sound of Arisaig
Oberon Bank
Maxwell Bank
Muck
Bo Faskadale
Loch Moidart
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
Cairns of Coll
Eilean Mór
Fishing Bank
Ardmore Point
Càs
Loch Sunart
Loch Eatharna
COLL
Tobermory
Fl.3s15M
SOUND OF MULL
Calgary Bay
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Cunga
Ulva
Loch na Keal
Craignure
Staffa
ISLAND OF MULL
Ben More
Erisgeir
Loch Spelve
Loch Buie
Stac Mhic Mhurchaidh
Loch Scridain
Ross of Mull
Soa Island

B/W 2. Blotch

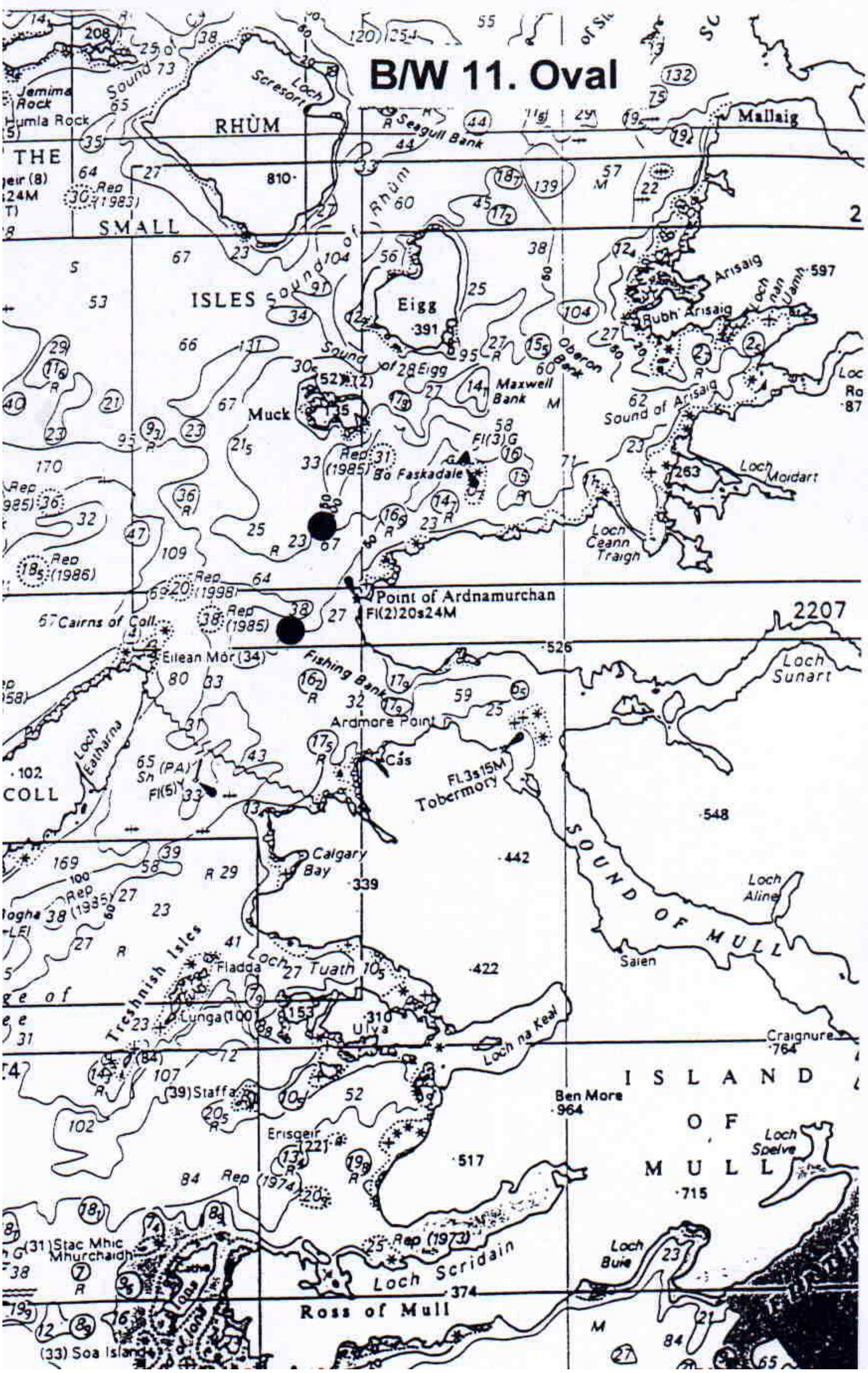


RHÙM
Sound of Canna
Loch Scresort
Seagull Bank
Mallaig
SMALL ISLES
Sound of Rhùm
Eigg
Sound of Eigg
Muck
Maxwell Bank
Oberon Bank
Arisaig
Rubh' Arisaig
Loch nan Uamh
Sound of Arisaig
Loch Moidart
Bo Faskadale
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
2207
Cairns of Coll
Eilean Mor (34)
Fishing Bank
Ardmore Point
Loch Sunart
Loch Eatharna
Càs
Tobermory
FL3s15M
SOUND OF MULL
Calgary Bay
Loch Aline
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Loch na Keal
Salen
Craignure
Staffa
Ben More
ISLAND OF MULL
Erisgeir
Loch Spelve
Stac Mhic Mhurchaidh
Loch Buie
Loch Scridain
Ross of Mull
Soa Island
Jemima Rock

B/W 8. Sweep



RHÙM
Mallaig
SMALL
ISLES
Sound of Rhùm
Seagull Bank
Eigg
Muck
Sound of Eigg
Maxwell Bank
Oberon Bank
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch Moidart
Bo Faskadale
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
2207
Cairns of Coll
Eilean Mór
Fishing Bank
Ardmore Point
Loch Sunart
Loch Eatharna
Tobermory
Fl.3s15M
Calgary Bay
SOUND OF MULL
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga
Ulva
Loch na Keal
Craignure
Staffa
ISLAND OF MULL
Ben More
Erisgeir
Loch Spelve
Loch Buie
Loch Scridain
Ross of Mull
Stac Mhic Mhurchaidh
Jemima Rock


B/W 11. Oval
RHÙM
Mallaig
Seagull Bank
THE
SMALL
ISLES
Sound of Rhum
Eigg
Sound of Eigg
Muck
Maxwell Bank
Oberon Bank
Arisaig
Rubh' Arisaig
Sound of Arisaig
Loch Moidart
Bo Faskadale
Loch Ceann Traigh
Point of Ardnamurchan
Fl(2)20s24M
2207
Cairns of Coll
Eilean Mór (34)
Fishing Bank
Ardmore Point
Cás
Loch Sunart
Loch Eatharna
COLL
FL3s15M
Tobermory
SOUND OF MULL
Calgary Bay
Loch Aline
Salen
Treshnish Isles
Fladda
Loch Tuath
Lunga (100)
Ulva
Loch na Keal
Craignure
ISLAND OF MULL
(39) Staffa
Ben More
Erisgeir
Loch Spelve
Rep (1974)
(31) Stac Mhic Mhurchaidh
Loch Scridain
Loch Buie
Ross of Mull
(33) Soa Island
Jemima Rock
Humla Rock
Rep (1983)
Rep (1985)
Rep (1986)
Rep (1998)
Rep (1973)