Status of Harbour Seals, *Phoca vitulina*, in Canada*

ROBIN W. BAIRD

Biology Department, Dalhousie University, Halifax, Nova Scotia B3H 4J1 Canada
Current address: National Marine Fisheries Service, NOAA, 101 Pivers Island Road, Beaufort, North Carolina 28516 USA

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The Harbour Seal (*Phoca vitulina*) inhabits all three of Canada's coastlines, as well as a number of fresh-water systems. Three subspecies are recognized from Canadian waters, *Phoca vitulina richardsi* from the Pacific coast, *Phoca vitulina concolor* from the Atlantic and Arctic coasts, and *Phoca vitulina mellonae* from several freshwater lakes on the Ungava Peninsula, Quebec. This report reviews the status and management of *Phoca vitulina richardsi* and *Phoca vitulina concolor* in Canadian waters, discussing distribution, movements, population discrimination, population size and trends, and threats to this species in Canada. The Harbour Seal population in western Canada is large and has been increasing in size. While there are a number of actual or potential anthropogenic threats, including: overfishing, immunosuppresion due to accumulation of toxins, and illegal killing associated with aquaculture operations, the western Canadian population should probably be listed as not at risk. Little recent research has been undertaken on Harbour Seals in the Canadian Arctic or for most areas off eastern Canada, and insufficient information is available to assess the status of these populations.

Key Words: Harbour Seal, Phoque Commun, Loups Marin, Kasigiak, *Phoca vitulina richardsi, Phoca vitulina concolor*, Pacific, Atlantic, Arctic, Phocid, status, pinniped.

The Harbour Seal (*Phoca vitulina* Linnaeus, 1758, Figure 1), known in Quebec as Phoque Commun or Loups Marin, in parts of northern Canada as the Ranger Seal or Kasigiak, and in Europe as the Common Seal, is a small coastal Phocid, and is one of the most widely distributed pinnipeds in the northern hemisphere. On both the east and west coasts of Canada Harbour Seals average about 80 cm at birth (McLaren 1993). The average adult length is about 1.5 m, and they have been recorded to reach a maximum length of about 1.9 m (Boulva 1971; Bigg 1981; McLaren 1993). Males are usually slightly larger than females (5% off Nova Scotia, 13% off British Columbia; McLaren 1993). Harbour Seals have been described as "large-headed, short-bodied and short-limbed" (Figures 1 and 2), and have an extremely variable pelage pattern with spots, rings and blotches which range in color from light grey to dark brown or black on either a light or dark background (Stutz 1967; Bigg 1981). Harbour Seals usually lose their lanugo (white) coat in utero, though Boulva (1971) and Oftedal et al. (1991) noted 16% and 6% (respectively) of the pups born at Sable Island have a lanugo coat. Individuals with rust-coloured coats, particularly on the head and upper body, have also been observed (Jefferson et al. 1993). The eyes are large and set close together, and the nostrils form a distinct "V" shape. Harbour Seals are usually very difficult to approach on shore. They are gregarious on land, but usually solitary or in very small groups when seen in the water. Most of time Harbour Seals spend on shore they just lay on the substrate with periodic checks of their surroundings, but often also lie with their head and hind flippers elevated in a characteristic crescent position (Katona et al. 1993; Figure 2).

Considerable taxonomic uncertainty has existed regarding Harbour Seals, both at the sub-specific and specific levels (e.g., McLaren 1966; Shaughnessy and Fay 1977; Bigg 1981; Smith et al. 1994; O'Corry-Crowe and Westlake 1997). Until recently, Harbour Seals and Largha Seals (*Phoca largha*) were frequently lumped as one species, *Phoca vitulina*, resulting in some confusion as to, for example, geographic range (O'Corry-Crowe and Westlake 1997). Three subspecies of the Harbour Seal are currently recognized from Canadian waters, with *Phoca vitulina richardsi* in the Pacific, *Phoca vitulina concolor* in the Atlantic and Arctic, and *Phoca vitulina mellonae*, the Lacs des Loups Marins Harbour Seal, found exclusively in freshwater lakes in Quebec's Ungava Peninsula (Smith et al. 1994). The status of this latter population has been recently reviewed (Smith 1997) and classified by COSEWIC (the Committee on the Status of Endangered Wildlife in Canada) as "Vulnerable".

The purpose of this report is to review available information and assess the status of the other two subspecies of Harbour Seal found in Canadian waters, on behalf of COSEWIC. While they are one of the most well-studied pinnipeds (Cottrell 1995), surprisingly little recent information is available regarding population size, trends, and sources and

*Reviewed and approved by COSEWIC, April 1999, status assigned — Atlantic and Arctic coastal waters Indeterminate, North Pacific coastal waters Not At Risk.

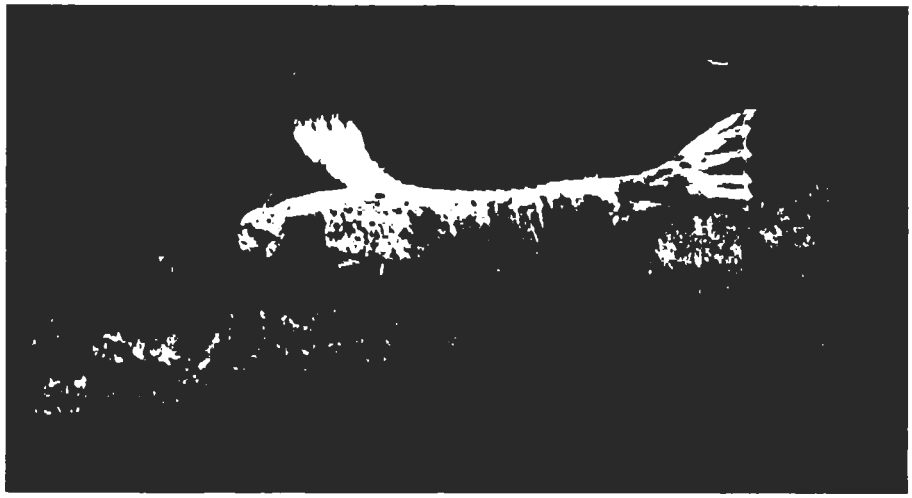

FIGURE 1. Harbour Seal hauled out on rocky substrate off southern Vancouver Island. Photo by the author.

levels of anthropogenic mortality in Canadian waters.

Distribution

Harbour Seals have a coastal distribution in temperate, sub-Arctic and some Arctic waters throughout the northern hemisphere, with some populations also occurring in fresh-water systems. In the Pacific, they are found from northern Japan (Hokkaido), through the Aleutians and the Gulf of Alaska, and south along the coast of North America as far as western central Baja California, Mexico. Records reported from Alaskan waters of the Beaufort Sea (e.g., Mansfield 1967) are of Largha Seals. In the Atlantic, Harbour Seals have been documented as far south as Florida (Reeves et al. 1992), and occur regularly from New York and New England north to Greenland, Iceland, the UK, Norway and Svalbard (Wiig 1989), and south as far as Brittany, France.

In Canada, Harbour Seals are found in coastal waters in the Pacific and Atlantic oceans, as well as in parts of Hudson Strait, Ungava Bay, Hudson Bay and around Baffin Island (Figure 3; Mansfield 1967; Beck et al. 1970; Bigg 1981). While sightings in Canadian waters have been reported as far north as Ellesmere Island (79°N), no recent information is available on their distribution in the Canadian Arctic, and there is some evidence to suggest that their distribution in the Arctic may have changed. Mansfield (1967) noted that Harbour Seals had been eliminated from some areas in the Canadian Arctic by native hunting.

As mentioned above, Harbour Seals can also be found in fresh water, including not only the population which resides year-round in the Seal Lakes (Lacs des Loups Marin) in northern Quebec, but also rivers and lakes on other coastlines. In western and northwestern Hudson Bay Harbour Seals have been recorded as far as 240 km inland in several rivers and lakes (Mansfield 1967; Beck et al. 1970), and on the Pacific coast, Harbour Seals also enter small rivers and lakes, occasionally as far as 300 km inland (Fisher 1952). In eastern Canada, Harbour Seals were once found in a number of fresh water systems, including Lake Champlain and Lake Ontario (Allen 1880). It appears their use of fresh water systems in eastern Canada has declined; Boulva and McLaren (1979) noted that Harbour Seals seldom reach Montreal in the St. Lawrence River. Similarly, Lesage et al. (1995b) report relatively few in the Saguenay River in 1994, while Boulva and McLaren (1979) reported a population of approximately 100 individuals in that river in 1973 (it should be noted however that the methods of these two studies differ greatly, and numbers in each are not comparable).

Movements and Population Discrimination

On land, Harbour Seals exhibit fairly poor mobility, with movements typically restricted to tens of meters. However, Renouf and James (1975) state that pregnant females have been known to travel more than a kilometer overland on Sable Island, to give birth on the shores of inland lakes.

Harbour Seals are generally considered to be non-migratory (Bigg 1981), being present in most areas year-round, and showing considerable site fidelity (e.g., Olesiuk et al. 1995). However, extensive movements do occur. Based on seasonal decreases in counts at haul-outs in the Bay of Fundy, and corresponding increases in numbers hauled out in Maine, Rosenfeld et al. (1988) suggested that there is a seasonal movement of Harbour Seals between these two

FIGURE 2. Harbour Seals hauled out on dock, Victoria Harbour. Note the individual on the left is lying with head and tail raised, a typical posture for Harbour Seals. Photo by the author.

areas. Using satellite tags on individuals in the St. Lawrence estuary, Lesage et al. (1995a) documented a migration of one individual which moved 520 km to overwinter, and returned to the same summering area the next year. In terms of dispersal from breeding areas, Beck (1983) noted that juveniles tagged at Sable Island, off Nova Scotia, moved to various mainland sites, and included one individual which moved to New Jersey, a straight line distance of 1475 km.

Despite such long-ranging movements, there is a variety of evidence that suggest Harbour Seals on the west coast of Canada may be subdivided into two or more populations (Stutz 1967; Temte et al. 1991; Burg 1996; Lamont et al. 1996). Stutz (1967) noted geographic variation in pigmentation patterns for several areas on the coast of British Columbia and southeast Alaska and suggested these reflect subdivision of the population. Yochem et al. (1990) documented geographic variation in pigmentation patterns off California which suggest limited movements between areas. Differences in pupping seasonality between various areas on the west coast (Bigg 1969b) also imply more than one population (Temte et al. 1991). Burg (1996) recently examined mitochondrial and microsatellite data from animals throughout British Columbia and in southeast Alaska, and concluded that evidence suggests population segregation. Based on pigmentation patterns and dentition, suggestions of population discreteness have been made for Harbour Seals on Sable Island (Boulva and McLaren 1979), though recent microsatellite data from Sable Island (Coltman, Bowen and Wright, unpublished, cited in Whitehead et al. 1998) suggest mixing with mainland populations.

Protection

International

Harbour Seals are not listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), thus international trade is not monitored or regulated.

National

Canada: Two factors are important in the protection of a species, the legal system in place which prohibits or regulates hunts or kills, and the system of monitoring and enforcement of the regulations or rules which exist. In Canada, management authority for Harbour Seals lies with the federal Department of Fisheries and Oceans through the Marine Mammal Regulations of 1993 (promulgated under the Fisheries Act of Canada, 1867). These regulations theoretically control the hunting of this species in Canadian waters. All individuals except aboriginals are required to obtain a "Fishing Licence" to hunt seals, and fees for such a licence are low ($5). Issuance of licences is at the discretion of the Minister of Fisheries and Oceans, but for Harbour Seals, all areas are currently closed for hunting (Marine Mammal Regulations; J. Conway, personal communication). D. Petrachenko (in litt.) notes that Fisheries and Oceans has issued licences to aboriginals in British Columbia for a small scale harvest. In Arctic regions all hunting is likely to be by aboriginals (who do not require licences), thus no protection appears to be in place. In British Columbia, aquaculture operators are permitted to kill nuisance animals around their net pens (D. Petrachenko, in litt.). Some nuisance animals were killed at aquaculture operations in New Brunswick as part of a pilot licencing

system, but such killing is currently prohibited (J. Conway, personal communication). "Disturbance" is also prohibited through these regulations, except when hunting under licence. The operation of aircraft within 600 m of any live seal on land is also prohibited. Smith (1997) notes that freshwater seals north of the 55th parallel are listed as protected under the James Bay and Northern Quebec agreement, but that this protection does not have the force of law. Some haul-out and breeding sites are protected from development by both provincial and federal governments through provincial parks and/or ecological reserves as well as federal parks (such designations also provide limited protection from land-based disturbance).

In terms of monitoring or enforcement of regulations, little information is available. Disturbance of animals regularly occurs at haulout sites by boats, planes, and people on land (Baird, personal observations), and no monitoring or enforcement action is taken. As well, there have been numerous reports of illegal shooting of animals around aquaculture operations on the west and east coasts, as well as shooting by fishermen, though no prosecutorial action has been taken (H. Breen, J. Conway, D. Tobin, personal communication). Such a lack of monitoring or enforcement of these regulations leaves their effectiveness in question.

United States: Killing or disturbance of Harbour Seals in the United States is prohibited under the Marine Mammal Protection Act.

Greenland: Since 1960, hunting of adult Harbour Seals in Greenland has been prohibited from May through September. Some specific regions have more restrictive regulations, with hunting of adults completely forbidden. Restrictions have been recently reviewed by Teilmann and Dietz (1994).

Population Numbers, Sizes and Trends

Populations on both the Pacific and Atlantic coasts of Canada were substantially reduced due to long-term bounty or culling programs and/or commercial hunts (Bigg 1969a; Boulva and McLaren 1979; Olesiuk et al. 1990a), which ended in the late 1960s and early 1970s (1969 in British Columbia, 1976 in the Atlantic). On the Pacific coast of Canada, the Harbour Seal is the most abundant marine mammal in the province, and the population has been increasing since the end of culling and may be near original levels (Olesiuk et al. 1990a). The most recent published data from British Columbia (from 1988) suggests the population was between 75 000 and 88 000 animals. The trend in population growth at that time suggested a continued increase (Olesiuk et al. 1990a), though Smith (1994) noted that there is some indication from recent surveys that the increase is beginning to level off. Between 1973 and 1988, the British Columbia population was estimated to increase at about 12.5% per year (Olesiuk et al. 1990a).

Populations which border British Columbia appear to be increasing or stable. From 1978 through 1993, counts of Harbour Seals in the neighboring waters to the south, in Washington state, increased at an average rate of almost 8% (Huber 1995); surveys from neighboring waters to the north, in southeast Alaska, have generally shown increases or stable populations (Hill et al. 1997).

Off Canada's east coast, information on population sizes or trends is less complete. Numbers from eastern Canadian waters south of Labrador in 1973 were estimated by Boulva and McLaren (1979) using questionnaire surveys, interviews and distribution of bounty kills. The total population off eastern Canada at that time was estimated to be 12 700 individuals, with some local areas showing decreasing numbers and other areas having stable numbers. Stobo and Fowler (1994) present data from aerial surveys in the Bay of Fundy and off southwest Nova Scotia from 1985–1987 and from 1991–1992, and suggest that Harbour Seal abundance has increased between those periods. However, the rate of growth and current population size for that area is unknown (Stobo and Fowler 1994). In the late 1980s, the Sable Island population was the largest in eastern Canada. However, numbers of animals on Sable Island have decreased drastically in recent years (D. Bowen, W. Stobo, personal communication; Ellis 1998). Trends in the number of pups born on Sable Island between 1978 and 1996 have been presented by Ellis (1998). The number of pups born annually have shown a steady decline since 1989, when about 600 pups were born, through to 1997, when only 30 pups were born (Ellis 1998; D. Bowen, personal communication), and the number of adults of both sexes has also dramatically declined (Ellis 1998). Causes of this decline are unknown, but could include predation by sharks, competition with Grey Seals, and/or movements of individuals away from Sable Island (D. Bowen, W. Stobo, personal communication; Ellis 1998). Recent (1994) information on Harbour Seals in the St. Lawrence Estuary has been provided by Lesage et al. (1995b). A total of 389 Harbour Seals were counted, but it is unclear what proportion of the population this count represents. While this number is substantially lower than the 710 seals estimated to live in the area in 1973 (Boulva and McLaren 1979), Lesage et al. (1995b) note that differences in methods between the two studies make any direct comparison impossible. Some distributional data, from a mail-out survey to fishermen, was recently collected for Prince Edward Island (D. Cairns, Department of Fisheries and Oceans, PEI, personal communication). No recent information on Harbour Seals in Newfoundland, Labrador or the outer Gulf of St. Lawrence has been

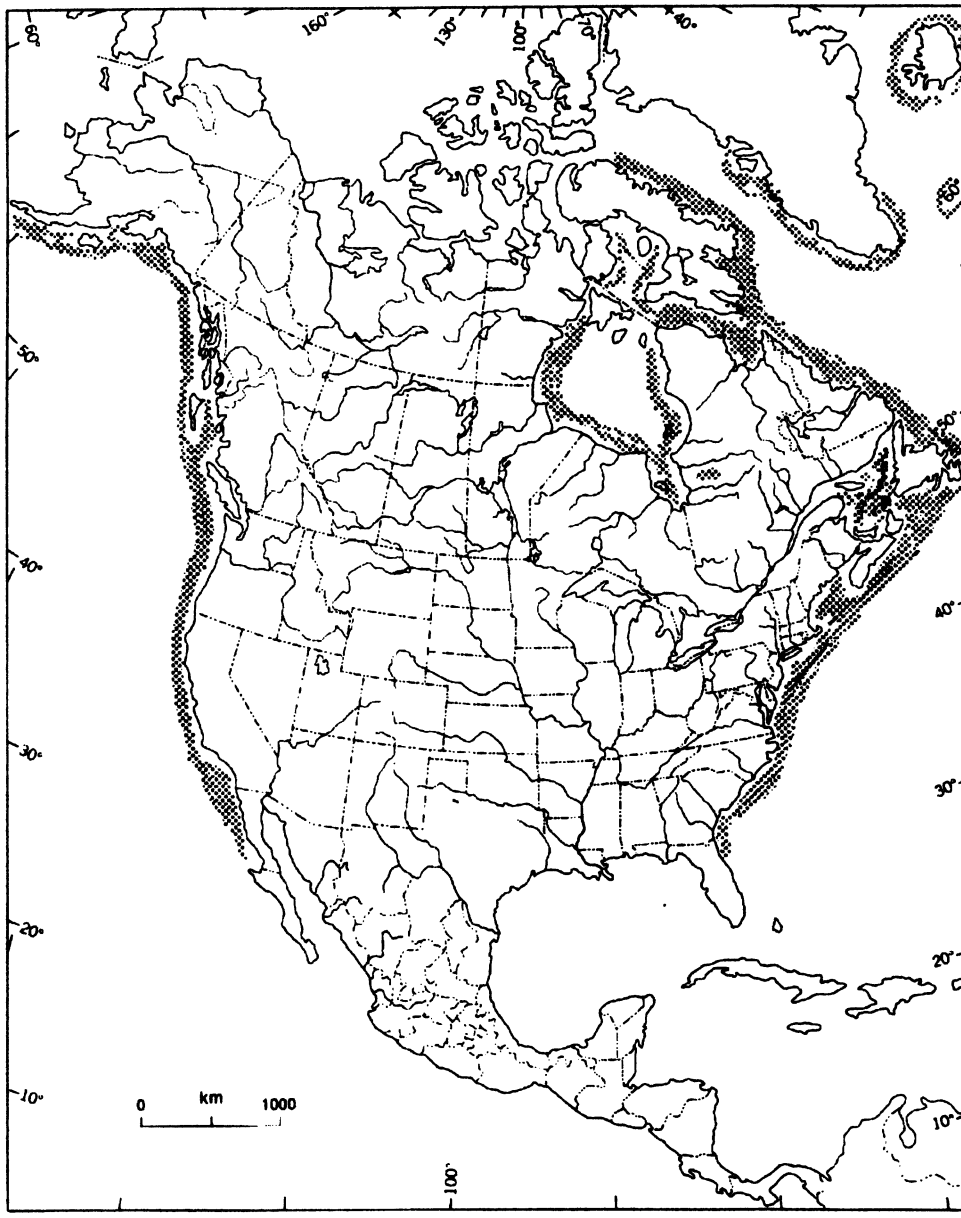

FIGURE 3. Distribution of Harbour Seals in Canadian waters.

collected (J. Lawson, J. Lien, G. Stenson, personal communication).

No substantive information is available regarding population size or trends of Harbour Seals in the Canadian Arctic (though see Remnant 1997 for a recent assessment of numbers in the Lower Churchill River).

On the east coast there are three countries/territories which likely exchange Harbour Seals with Canadian populations: the United States, Greenland, and the French islands of St. Pierre and Miquelon. The Harbour Seal population in adjoining U.S. waters appears to be increasing, with an 8.7% annual rate of increase in Maine coastal waters based on counts between 1981 and 1993 (Kenney and Gilbert 1994; Waring et al. 1997). In Greenland, Teilmann and Dietz (1994) report an apparent decline in Harbour Seals numbers over the last 100 years, and

suggest that hunting may have been the primary cause for this decline. Harbour Seal numbers at the French islands of St. Pierre and Miquelon, off the south coast of Newfoundland, appeared to increase between 1970 and 1982 (Ling et al. 1974; Davis and Renouf 1987), but no recent information is available.

Habitat

Like all pinnipeds, Harbour Seals utilize both aquatic and terrestrial habitats. In terms of aquatic habitats, Harbour Seals are generally a near-shore, coastal species, though movements in pelagic waters have been documented (Beck 1983). As noted above, Harbour Seals also inhabit fresh-water systems and may spend considerable time in river estuaries. Use of the aquatic environment, i.e., which areas of the water column Harbour Seals tend to use most, may differ depending on time of year (breeding versus non-breeding, or in response to local concentrations of prey), sex (since males during the breeding season may remain closer to breeding sites; e.g., Coltman et al. 1997; Van Parijs et al. 1997), and location, due to bathymetry, or since predation pressure may differ between east and west coasts of Canada, thus affecting diving behaviour (cf. Le Boeuf and Crocker 1996). In the Arctic, Mansfield (1967) noted that Harbour Seals are largely restricted to areas of high current flow where the surface is kept clear of ice.

In terms of terrestrial habitats used, Harbour Seals haul out on both sand and rock substrates, usually on isolated rocks or islets (without land-based predators), on sand bars, and occasionally in small sea caves, including some on large islands with terrestrial predators, e.g., Vancouver Island. Harbour Seals also make use of man-made structures such as log booms and recreational floats for pupping and hauling out (e.g., Cottrell 1995; Figure 2). In some areas (e.g., southeast Alaska) Harbour Seals will also pup on ice calved off tidal glaciers (e.g., Matthews 1995). Areas used for pupping are also used during the non-breeding season as haul-out sites. Age- and sex-based segregation occurs at some haul-out sites, and may vary according to season (e.g., Allen et al. 1988; Kovacs et al. 1990; Whitman and Payne 1990). Understanding which factors influence hauling out behaviour is important both for calibrating surveys (e.g., Olesiuk et al. 1990), as well as for understanding how disease transfer at haulout sites might be influenced by environmental fluctuations (Lavigne and Schmitz 1990; Grellier et al. 1996). A number of factors seem to influence hauling out behaviour, including haul-out substrate, tide height, time of year (relative to breeding and moulting periods), time of day, temperature, wind speed, precipitation, cloud cover, the occurrence of storms, disturbance, El Niño events, and location (Boulva and McLaren 1979; Pauli and Terhune 1987a, 1987b; Yochem et al. 1987; Watts 1992, 1993; Grellier et al. 1996; Hanan 1996), thus it seems that location-specific studies are needed for developing survey calibration factors. Use of land-based sites is typically restricted to a few tens of meters from shore (though see exception above in Distribution and Movements).

General Biology

Harbour Seals can be quite gregarious on land (Figure 4). Olesiuk et al. (1990) note a mean haul-out size in the Strait of Georgia of about 22 individuals, but groups of several thousand have been recorded (Bigg 1981). While in groups Harbour Seals typically maintain some distance between individuals (Sullivan 1982).

Harbour Seals give birth to a single pup, and have a clearly defined pupping season that typically lasts one to two months in any particular area (Bigg 1981). Timing of pupping varies geographically (Bigg 1969b; Temte et al. 1991), but generally occurs between May and July. Unlike most other phocids, Harbour Seal pups follow their mothers into the water within hours of birth (Lawson and Renouf 1985). Pups on Sable Island are weaned at 24 days of age (Muelbert and Bowen 1993), and females come into estrous within two weeks after weaning (Bigg 1969a). Females mature at between 3 and 6 years of age, with most maturing by 5 years (Bigg 1969a). Mortality rates have recently been summarized by Heide-Jorgensen and Harkonen (1988). Mortality of animals in the first year can be quite high, ranging from 0.20 to 0.60. For individuals older than one year, annual mortality ranges betwen 0.05 and 0.20, and males older than five years show higher mortality than females (e.g., Pitcher 1990). Maximum recorded longevity is 32 years of age (Pitcher and Calkins 1979).

While numerous studies have been undertaken on the diet of Harbour Seals in Canadian and adjoining waters, characterization of the diet is exacerbated by biases in techniques to study diet (Harvey 1989; Cottrell et al. 1996), as well as strong seasonal, geographical, age and habitat-based variation (Bigg 1973; Bigg et al. 1990; Olesiuk 1993; Cottrell 1995; Bowen and Harrison 1996; Iverson et al. 1997; Tollit et al. 1998). In general, Harbour Seals have an extremely diverse diet (Bigg 1981), usually taking advantage of locally abundant prey. In the Strait of Georgia, Pacific Hake (*Merluccius productus*) and Pacific Herring (*Clupea pallasi*) account for 75% of the diet both in terms of energy and biomass, while Salmon (*Oncorhynchus* spp.), Plainfin Midshipman (*Porichthys notatus*), Lingcod (*Ophiodon elongatus*) and others comprise the remaining prey (Olesiuk et al. 1990b; Olesiuk 1993). Their tendency to move into river mouths following salmon runs (Fisher 1952; Bigg et al. 1990; Cottrell 1995) has caused considerable conflict with fishermen. Off eastern Canada, recent work by Bowen and Harrison (1996)

FIGURE 4. Group of Harbour Seals on sandy beach at Smith Island, Washington State. Photo by the author.

in two areas off Nova Scotia and New Brunswick suggest that Atlantic Herring (*Clupea harengus*), Atlantic Cod (*Gadus morhua*), Polluck (*Pollachius virens*), and Short-finned Squid (e.g., *Illex illecebrosus*) appear to comprise the majority of prey. Bowen and Harrison (1996) document geographic and interannual variability in prey taken in their study, and other evidence also suggests strong geographic or temporal variation. For example, Payne and Selzer (1989) note that American Sandlance (*Ammodytes americanus*) dominated the diet of Harbour Seals off Cape Cod, and a small sample of stomach contents from Sable Island examined by Walker and Bowen (1993) contained only Sandlance. Little has been reported on their diet in Arctic waters, though Beck et al. (1970) report stomach contents of one individual taken in fresh water, which contained Lake Trout (*Salvelinus namaycush*) and Whitefish (*Coregonus clupeaformis*).

Sources of Mortality and Potentially Limiting Factors

Potentially limiting factors can be from either anthropogenic or natural sources. Such factors could either directly or indirectly cause the death of animals, or result in decreased reproductive rates. Anthropogenic factors which may contribute to population declines or limits include: incidental mortality in fisheries, direct killing (illegal or permitted culling associated with aquaculture operations and fisheries, as well as small-scale harvesting by natives), oil spills, accumulation of persistent toxins, disturbance at breeding colonies by tourism, coastal development, vessel traffic or researchers, displacement from feeding or breeding areas by acoustic harassment (e.g., high amplitude seal "scarers" at aquaculture operations), and depleted food sources from competition with human fisheries.

Historically Harbour Seal populations in both eastern and western Canada were drastically reduced from direct kills in both control or bounty programs and/or for harvesting of pelts (Bigg 1969a; Boulva and McLaren 1979). Re-initiation of such bounty or culling programs have frequently been suggested by fishing groups, in response to perceived or actual conflicts with fisheries. In British Columbia, direct takes occur from a number of sources. In terms of harvesting by natives, Fisheries and Oceans Canada has issued licences for a coast-wide harvest totaling less than 100 individuals (D. Petrachenko, in litt.). Aquaculture operations in both eastern Canada and British Columbia are licenced to shoot nuisance seals. In British Columbia a total of about 500 Harbour Seals are reported to be killed annually under these permits (D. Petrachenko, in litt.). However, reports of substantial illegal kills at aquaculture operations suggest that the number killed may be much greater (H. Breen, personal communication). In 1997 Fisheries and Oceans Canada undertook a small cull (approximately 25 seals) in one

area on the British Columbia coast. Levels of direct takes in Arctic and eastern Canadian waters are unknown. Remnant (1997) notes that some hunting of seals occurrs in the freshwater portion of the Churchill River, and that Manitoba Natural Resources annually harvests some seals in the same area for bait for live-trapping Polar Bears (*Ursus maritimus*). I. McLaren (personal communication) noted that pelts of Harbour Seals are prized by Arctic hunters, and Mansfield (1967) stated that given the extremely localized distribution of Harbour Seals in Arctic waters, this species is an easy target for native hunters, and their "future [is] somewhat precarious".

Harbour Seal bycatch in gillnet fisheries has been well-documented in California, Washington and Alaska (Barlow et al. 1994; Read 1994), but little information is available from Canadian waters, probably due to the lack of observer programs on fishing vessels. Reports have been made of Harbour Seals being taken on longlines in eastern Canada, and such seals drown, since the lines are weighted to the bottom (W. Stobo, personal communication). Harbour Seal mortality in the Smelt cage fishery off Prince Edward Island have also been reported (P.-Y. Daoust, personal communication). Off Norway, Bekkby and Bjorge (1998) suggest that mortality in fishing gear may control population growth, thus some effort in assessing mortality in fishing gear in Canadian waters is probably warranted. Hooking of Harbour Seals on sports fishing lines also occurs (R. Bates, personal communication). While it seems unlikely these animals are directly killed as a result, retention of hooks and trailing lines in the digestive tract of Harbour Seals could cause problems associated with feeding or infection.

In heavily-populated areas, pups are occasionally "kidnapped" by well-meaning people who assume they have been abandoned, while a mother is out foraging or when she is disturbed into the water by approaching humans. Such pups are often raised at rehabilitation facilities and released back into the wild, but little information is available on survival rates. Vessel collisions with Harbour Seals do occur in Canadian waters (K. Langelier, personal communication), though there is no information to assess how frequently such collisions occur or whether they always result in death. A. Morton (personal communication) has noted an increase in the frequency of vessel collisions in one area on the British Columbia coast, which has corresponded with the initiation and use of high-intensity acoustic harassment devices at nearby aquaculture operations (suggesting that Harbour Seals might be deafened by such devices). Disturbance of Harbour Seals at pupping or haul out sites, resulting in sudden movement of all hauled-out animals into water, occurs regularly in some areas (e.g., Kovacs et al. 1990). Such disturbance may potentially result in separation of mothers and pups, as well as injury of individuals, or increased vulnerability to predation by sharks or killer whales, due to increased time in the water. There are numerous sources of such disturbance, including close approaches by private or commercial vessels engaged in fishing, wildlife viewing, or transiting through an area, overflights by aircraft (military and private), and approaches by dogs or people on land (including researchers). In one area, Race Rocks, at the southern tip of Vancouver Island, military activity at a site used for explosive testing regularly results in disturbance of hauled out seals. No information is available to estimate the magnitude of the impacts of disturbance on Harbour Seals in Canada, but its effects may not be trivial. For example, Johnson (1977) estimated that overflights by aircraft may have been responsible for the deaths of 10% of approximately 2000 Harbour Seal pups born on an island in Alaska in 1976. A review of Harbour Seal reactions to aircraft and other sources of disturbance is presented in Richardson et al. (1995).

The role of contaminants in immunosuppression of Harbour Seals and other marine mammals has received considerable attention in recent years (e.g., Ross et al. 1995, 1996, 1997; see also Schandorff 1997a, 1997b). As a result of captive studies which demonstrated that ambient contaminant levels in Baltic Sea herring were immunotoxic when fed to Harbour Seals, it is now thought that the 1988 Morbilivirus-associated mass mortality among northern European Harbour Seals may have been exacerbated by contaminants (Ross et al, 1996, 1997; de Swart et al. 1996). From the British Columbia coast, Ross et al. (1998) report on levels of a number of contaminants (PCBs, PCDDs and PCDFs) in Harbour Seals, and note that 2 of 24 recently weaned pups sampled had levels higher than those found to produce immunotoxicity in captive Harbour Seals. Ross (personal communication) also notes that male Harbour Seals above about seven years of age in the Strait of Georgia also have levels above the point which produces immunotoxity. Given the exponential rate of increase of the Harbour Seal population on much of the British Columbia coast (Olesiuk et al. 1990), it is clear that such toxins do not have a substantial impact on reproduction or longevity, although their potential role in mass mortalities (and the huge impacts such mortalities may have on population size, see below) does warrant concern.

The wide-spread distribution of Harbour Seals along Canada's coasts make them less likely to be seriously impacted on a population level by an oil spill than species whose distributions are more limited. However, their habit of hauling out in inter-tidal areas would bring them into direct contact with spilled oil, and spills (and related spill cleanup activities) occurring during pupping periods could have the potential to result in separations of mothers and offspring. Frost

et al. (1994) discuss a variety of impacts on Harbour Seals from a major oil spill in Prince William Sound, Alaska, and conclude that seals became coated with oil, oil was incorporated into tissues, seals behaved abnormally, and pathological damage occurred. Comparisons of counts within Prince William Sound before and after the spill showed a significant decline in numbers at oiled sites compared to non-oiled sites (Frost et al. 1994).

Indirect effects including competition with human fisheries may be important, though little information is available to assess such threats (see Baird et al. 1992; Lavigne 1995; Trites 1997). Thompson et al. (1997) note that in times of shortages of preferred prey, switches to alternate prey items may result in haematological changes leading to anemia.

A number of natural sources of mortality have been identified, including predation, separation of dependent pups from their mothers, injury during storms, and diseases. Predation by Killer Whales (*Orcinus orca*) and sharks has long been known as a source of mortality (Scheffer and Slipp 1944). Mortality due to predation may be quite high in some areas. Harbour Seals appear to be the primary prey taken by "transient" Killer Whales around southern Vancouver Island (Baird and Dill 1996), and Watts (1996) noted that an individual seal may face a 50-80% chance of being eaten by a Killer Whale before reaching reproductive age. Off Sable Island, Nova Scotia, sharks are thought to be a major source of mortality (Beck 1983; Ellis 1998; W. Stobo personal communication). Some predation by Northern Sea Lions, *Eumetopias jubatus* (Pitcher and Fay 1982) as well as Coyotes (Steiger et al. 1989) has been documented, and aggression by Northern Elephant Seals (*Mirounga angustirostris*) towards Harbour Seals has been seen at one site in California (Mortenson and Follis 1997). Interspecific competition with other rapidly increasing pinniped populations may also influence population growth (Hanan 1996). Injury during storms has been reported as a source of injury (Wilke 1943), and separations of mothers and pups during storms can be quite frequent (Boness et al. 1992). Pup mortality may also increase during El Niño events (Koons 1998). Disease outbreaks, including phocine distemper virus and influenza (Geraci et al. 1982; Hinshaw et al. 1984; Osterhaus and Vedder 1988; Duignan 1995), have been responsible for large-scale die-offs in some areas (e.g., North Sea and New England). The die-off in the North Sea in 1988 resulted in a population reduction of over 50%. Such die-offs are clearly unpredictable, but given their magnitude and apparently increasing frequency of occurrence, they must be taken into account in conservation planning and population viability analyses (Young 1994; Simmonds and Mayer 1997).

Special Significance

In some areas of Canada (e.g., British Columbia and the Bay of Fundy) Harbour Seals are important components of commercial wildlife viewing excursions, and thus contribute economically to tourism, although the level of economic input from such tourism has not been quantified. Since Harbour Seals co-inhabit many developed coastal regions in Canada, they are often frequently viewed by residents and may be given considerable aesthetic value as an important component of the natural environment. Conversely, due to actual or perceived conflicts with fisheries in many parts of country, Harbour Seals (and other pinnipeds) are viewed primarily as a pest. As a species which appears to show considerable site-fidelity, feeds relatively high on the food web, and lives for relatively long periods, they may also be viewed as a potential indicator species in the marine environment (Calambokidis et al. 1991). One population in Canada, at Sable Island, is unique, being the only truly offshore breeding population of this species in the world (Whitehead et al. 1998).

Evaluation

Based on the large population and evidence of increasing trends in numbers (Olesiuk et al. 1990a), the Pacific coast population of Harbour Seals should probably be classified as Not at Risk (NAR) by COSEWIC. However, recent evidence of contaminant levels high enough to cause immunosuppression (Ross et al. 1998), and reports of high levels of illegal kills (H. Breen personal communication) both warrant further study, as does the potential impact of overfishing or natural fluctuations in prey populations on Harbour Seal population dynamics. No one is doing research to establish the pesent status of Harbour Seals in the Canadian Arctic, including Hudson Bay and James Bay, because they have little economic importance (P. Richard, personal communication). Yet, they are more vulnerable to overexploitation than other species because they live in small sedentary pockets of population (P. Richard, personal communication).

For the same reason (ie., lack of economic importance), little is known about the status of Harbour Seals off Labrador, Newfoundland, the outer Gulf of St. Lawrence, or off mainland Nova Scotia. The population which has received the most research attention off eastern Canada, at Sable Island, has drastically declined in recent years, although the causes are unknown. Insufficient information is available to assess the status of eastern Canadian or Arctic populations, and these populations should be classified as Indeterminate by COSEWIC.

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Literature Cited

Allen, J. A. 1880. History of North American pinnipeds. U.S. Geological and Geographical Survey Territorial Miscellaneous Publication 12. 785 pages. [Not seen, cited in Boulva and McLaren 1979]

Allen, S. G., C. A. Ribic, and **J. E. Kjelmyr.** 1988. Herd segregation in harbor seals at Point Reyes, California. California Fish and Game 71: 55–59.

Baird, R. W., and **L. M. Dill.** 1996. Ecological and social determinants of group size in *transient* killer whales. Behavioral Ecology 7: 408–416.

Baird, R.W., P. A. Abrams, and **L. M. Dill.** 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89: 125–132.

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, L. F. Lowry, D. Hanan, J. Sease, and **V. N. Burkanov.** 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation. Reports of the International Whaling Commission Special Issue 15: 405–426.

Beck, B. 1983. The harbour seal in Canada. Underwater World, Fisheries and Oceans, Canada.

Beck, B., T. G. Smith, and **A.W. Mansfield.** 1970. Occurrence of the harbour seal, *Phoca vitulina*, Linnaeus in the Thlewiaza River, N.W.T. Canadian Field-Naturalist 84: 297–300.

Bekkby, T., and **A. Bjorge.** 1998. *Abstract.* Behaviour of pups and adult female harbour seals *Phoca vitulina* during late lactation and first post weaning period. Page 12 *in* Abstracts of the World Marine Mammal Science Conference, Monaco.

Bigg, M. A. 1969a. The harbour seal in British Columbia. Fisheries Research Board of Canada Bulletin 172.

Bigg, M. A. 1969b. Clines in the pupping season of the harbour seal, *Phoca vitulina*. Journal of the Fisheries Research Board of Canada 26: 449–455.

Bigg, M. A. 1973. Adaptations in the breeding of the harbour seal, *Phoca vitulina*. Journal of Reproduction and Fertility Supplement 19: 131–142.

Bigg, M. A. 1981. Harbour seal *Phoca vitulina* Linnaeus, 1758 and *Phoca largha* Pallas, 1811. Pages 1–27 *in* Handbook of Marine Mammals Volume 2 Seals. *Edited by* S. H. Ridgway and R. J. Harrison. Academic Press.

Bigg, M. A., G. M. Ellis, P. Cottrell, and **L. Milette.** 1990. Predation by harbour seals and sea lions on adult salmon in Comox Harbour and Cowichan Bay, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 1769.

Boness, D. J., D. Bowen, S. J. Iverson, and **O. T. Oftedal.** 1992. Influence of storms and maternal size on mother — pup separations and fostering in the harbor seal, *Phoca vitulina*. Canadian Journal of Zoology 70: 1640–1644.

Boulva, J. 1971. Observations on a colony of whelping harbour seals, *Phoca vitulina concolor*, on Sable Island, Nova Scotia. Journal of the Fisheries Research Board of Canada 28: 755–759.

Boulva, J., and **I. A. McLaren.** 1979. Biology of the harbour seal, *Phoca vitulina*, in eastern Canada. Fisheries Research Board of Canada Bulletin 200.

Bowen, W. D., and **G. D. Harrison.** 1996. Comparison of harbour seal diets in two inshore habitats of Atlantic Canada. Canadian Journal of Zoology 74: 125–135.

Burg, T. M. 1996. Genetic analysis of eastern Pacific harbour seals (*Phoca vitulina richardsi*) from British Columbia and parts of Alaska using mitochondrial DNA and microsatellites. M.Sc. thesis, University of British Columbia, Vancouver. 77 pages.

Calambokidis, J., G. H. Steiger, L. J. Lowenstine, and **D. S. Becker.** 1991. Chemical contamination of harbor seal pups in Puget Sound. Report prepared for the U.S. Environmental Protection Agency under Contract Number 68-D8-0085.

Coltman, D. W., W. D. Bowen, D. J. Boness, and **S. J. Iverson.** 1997. Balancing foraging and reproduction in the male harbour seal, an aquatically mating pinniped. Animal Behaviour 54: 663–678.

Cottrell, P. E. 1995. Diet, activity budgets, and movement patterns of harbour seals (*Phoca vitulina*) in Cowichan Bay and adjacent areas. M.Sc. thesis, University of Victoria. 118 pages.

Cottrell, P. E., A. W. Trites, and **E. H. Miller.** 1996. Assessing the use of hard parts in faeces to identify harbour seal prey: results of captive-feeding trials. Canadian Journal of Zoology 74: 875–880.

Davis, M. B., and **D. Renouf.** 1987. Social behaviour of harbour seals, *Phoca vitulina*, on haulout grounds at Miquelon. Canadian Field-Naturalist 101: 1–5.

Duignan, P. J. 1995. Morbillivirus infection in pinnipeds in the western Atlantic. Pages 21–24 *in* Pinniped populations in the Gulf of Maine – status, issues and management. *Edited by* M. L. Mooney-Seus and G. S. Stone. New England Aquarium Aquatic Forum Series Report 95-1. Boston.

Ellis, S. L. 1998. Maternal effects on offspring traits from birth to weaning in the harbour seal (*Phoca vitulina*) Ph.D. thesis, Dalhousie University, Halifax.

Fisher, H. D. 1952. The status of the harbour seal in British Columbia, with particular reference to the Skeena River. Fisheries Research Board of Canada Bulletin 93.

Frost, K. J., L. F. Lowry, E. H. Sinclair, J. V. Hoef, and **D. C. McAllister.** 1994. Impacts on distribution, abundance, and productivity of harbor seals. Pages 97–118 *in* Marine Mammals and the Exxon Valdez. *Edited by* T. R. Loughlin. Academic Press, San Diego. 395 pages.

Geraci, J. R., D. J. St. Aubin, I. K. Barker, R. G. Webster, V. S. Hinshaw, W. J. Bean, H. L. Ruhnke, J. H. Prescott, G. Early, A. S. Baker, S. Madoff, and **R. T. Schooley.** 1982. Mass mortality of harbor seals: pneumonia associated with influenza A virus. Science 215: 1129–1131.

Grellier, K., P. M. Thompson, and **H. M. Corpe.** 1996.

The effect of weather conditions on harbour seal (*Phoca vitulina*) haulout behaviour in the Moray Firth, northeast Scotland. Canadian Journal of Zoology 74: 1806–1811.

Hanan, D. A. 1996. Dynamics of abundance and distribution for Pacific harbor seal, *Phoca vitulina richardsi*, on the coast of California. Ph.D. dissertation, University of California, Los Angeles. 158 pages.

Harvey, J. T. 1989. Assessment of errors associated with harbour seal (*Phoca vitulina*) faecal sampling. Journal of Zoology, London 219: 101–111.

Heide-Jorgensen, M.-P., and **T. J. Harkonen.** 1988. Rebuilding seal stocks in the Kattegat-Skagerrak. Marine Mammal Science 4(3): 231–246.

Hill, P. S., D. P. DeMaster, and **R. J. Small.** 1997. Alaska marine mammal stock assessments, 1996. NOAA Technical Memorandum NMFS-AFSC-78.

Hinshaw, V. S., W. J. Bean, R. G. Webster, J. E. Rehg, P. Fiorelli, G. Early, J. R. Geraci, and **D. J. St. Aubin.** 1984. Are seals frequently infected with avian influenza viruses? Journal of Virology 51: 863–865.

Huber, H. 1995. The abundance of harbor seals (*Phoca vitulina richardsi*) in Washington, 1991–1993. M.S. thesis, University of Washington, Seattle. 56 pages. [Not seen, cited in J. Barlow, K. A. Forney, P. S. Hill, R. L. Brownell, J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessments: 1996. NOAA Technical Memorandum SWFSC-248.]

Iverson, S. J., K. J. Frost, and **L. F. Lowry.** 1997. Fatty acid signatures reveal fine scale structure of foraging distribution of harbor seals and their prey in Prince William Sound, Alaska. Marine Ecology Progress Series 151: 255–271.

Jefferson, T. A., S. Leatherwood, and **M. A. Webber.** 1993. Marine mammals of the world. FAO Species Identification Guide, UNEP, Rome.

Johnson, B. W. 1977. The effects of human disturbance on a population of harbor seals. Environmental Assessment, Alaskan Continental Shelf, Annual Report Principal Investigator NOAA, Boulder, Colorado, 1977(1): 422–432. [Not seen, cited in Richardson et al. 1995]

Katona, S. K., V. Rough, and **D. T. Richardson.** 1993. A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland. Fourth Edition. Smithsonian Institution Press, Washington.

Kenney, M. K., and **J. R. Gilbert.** 1994. Increase in harbor and gray seal populations in Maine. Department of Commerce NOAA-NMFS Contract Report 50-EANF-2-00064. 19 pages [Note seen, cited *in* G. T. Waring, D. L. Palka, K. D. Mullin, J. H. W. Hain, L. J. Hansen, and K. D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments — 1996. NOAA Technical Memorandum NMFS-NE-114.]

Koons, R. N. 1998. *Abstract.* Correlation of El Niño SSTs with strandings of harbor seal pups, (*Phoca vitulina richardsi*). Page 74 *in* Abstracts of the World Marine Mammal Science Conference, Monaco.

Kovacs, K. M., K. M. Jonas, and **S. E. Welke.** 1990. Sex and age segregation by *Phoca vitulina concolor* at haulout sites during the breeding season in the Passamaquoddy Bay region, New Brunswick. Marine Mammal Science 6: 204–214.

Lamont, M. M., J. T. Vida, J. T. Harvey, S. Jeffries, R. Brown, H. H. Huber, R. DeLong, and **W. K. Thomas.** 1996. Genetic substructure of the Pacific harbor seal (*Phoca vitulina richardsi*) off Washington, Oregon, and California. Marine Mammal Science 12: 402–413.

Lavigne, D. M. 1995. Ecological interactions between marine mammals, commercial fisheries, and their prey: unravelling the tangled web. Pages 59–71 *in* Studies of high-latitude seabirds. 4. Trophic relationships and energetics of endotherms in cold ocean systems. *Edited by* W. A. Montevecchi. Canadian Wildlife Service Occasional Paper Number 91.

Lavigne, D. M., and **O. J. Schmitz.** 1990. Global warming and increasing population densities: a prescription for seal plagues. Marine Pollution Bulletin 21: 280–284.

Lawson, J. W., and **D. Renouf.** 1985. Parturition in the Atlantic harbor seal, *Phoca vitulina concolor*. Journal of Mammalogy 66: 395–398.

Le Boeuf, B. J., and **D. E. Crocker.** 1996. Diving behavior of elephant seals: implications for predator avoidance. Pages 193–205 *in* Great white sharks: the biology of *Carcharodon carcharias*. *Edited by* A. P. Klimley and D. G. Ainley. Academic Press, San Diego. 517 pages.

Lesage, V., M. O. Hammill, and **K. M. Kovacs.** 1995a. *Abstract.* Comparison of dive behaviour and movements of harbour and grey seals from the St. Lawrence estuary, Quebec, Canada. Page 68 *in* Abstracts of the 11th Biennial Conference on the Biology of Marine Mammals, December 14–18, 1995, Orlando, Florida.

Lesage, V., M. O. Hammill, and **K. M. Kovacs.** 1995b. Harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) abundance in the St Lawrence Estuary. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2307.

Ling, J. K., C. E. Button, and **B. A. Ebsary.** 1974. A preliminary account of gray seals and harbour seals at Saint-Pierre and Miquelon. Canadian Field-Naturalist 88: 461–468.

Mansfield, A. W. 1967. Distribution of the harbor seal, *Phoca vitulina* Linnaeus, in Canadian Arctic waters. Journal of Mammalogy 48: 249–257.

Matthews, E. A. 1995. Long-term trends in abundance of harbor seals (*Phoca vitulina richardsi*) and development of monitoring methods in Glacier Bay National Park, southeast Alaska. Pages 254–253 *in* Proceedings of the Third Glacier Bay Science Symposium, 1993. *Edited by* D. R. Engstrom. National Park Service, Anchorage, Alaska.

McLaren, I. A. 1966. Taxonomy of harbour seals of the western North Pacific and evolution of certain other hair seals. Journal of Mammalogy 47: 466–473.

McLaren, I. A. 1993. Growth in pinnipeds. Biological Review 68: 1–79.

Mortenson, J., and **M. Follis.** 1997. Northern elephant seal (*Mirounga angustirostris*) aggression on harbor seal (*Phoca vitulina*) pups. Marine Mammal Science 13: 526–530.

Muelbert, M. M. C., and **W. D. Bowen.** 1993. Duration of lactation and postweaning changes in mass and body composition of harbour seal, *Phoca vitulina*, pups. Canadian Journal of Zoology 71: 1405–1414.

O'Corry-Crowe, G. M., and **R. L. Westlake.** 1997. Molecular investigations of spotted seals (*Phoca largha*) and harbor seals (*P. vitulina*), and their relationship in areas of sympatry. Society for Marine Mammalogy Special Publication 3: 291–304.

Oftedal, O. T., W. D. Bowen, E. M. Widdowson, and **D. J. Boness.** 1991. The prenatal molt and its ecological significance in hooded and harbor seals. Canadian Journal of Zoology 69: 2489–2493.

Olesiuk, P. F. 1993. Annual prey consumption by harbor seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia. Fishery Bulletin 91: 491–515.

Olesiuk, P. F., M. A. Bigg, and **G. M. Ellis.** 1990a. Recent trends in the abundance of harbour seals, *Phoca vitulina*, in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 47: 992–1003.

Olesiuk, P. F., M. A. Bigg, G. M. Ellis, S. J. Crockford, and **R. J. Wigen.** 1990b. An assessment of the feeding habits of harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis. Canadian Technical Report of Fisheries and Aquatic Sciences 1730.

Olesiuk, P. F., T. G. Smith, G. Horonowitsch, and **G. M. Ellis.** 1995. *Abstract.* Translocation of harbour seals (*Phoca vitulina*): a demonstration of homing ability and site fidelity. Page 84 *in* Abstracts of the 11th Biennial Conference on the Biology of Marine Mammals, December 14–18, 1995, Orlando, Florida.

Osterhaus, A. D. M. E., and **E. J. Vedder.** 1988. Identification of virus causing recent seal deaths. Nature 335: 20.

Pauli, B. D., and **J. M. Terhune.** 1987a. Tidal and temporal interaction on Harbour seal haul-out patterns. Aquatic Mammals 13: 93–95.

Pauli, B. D., and **J. M. Terhune.** 1987b. Meteorological influences on Harbour seal haul-out. Aquatic Mammals 13: 114–118.

Payne, P. M., and **L. A. Selzer.** 1989. The distribution, abundance and selected prey of the harbor seal, *Phoca vitulina concolor*, in southern New England. Marine Mammal Science 5: 173–192.

Pitcher, K. W. 1990. Major decline in number of harbor seals, *Phoca vitulina richardsi*, on Tugidak Island, Gulf of Alaska. Marine Mammal Science 6(2): 121–134.

Pitcher, K. W., and **D. Calkins.** 1979. Biology of the harbor seal (*Phoca vitulina richardsi*) in the Gulf of Alaska. U.S Department of Commerce, NOAA, OCSEAP Final Report 19(1983): 231–310.

Pitcher, K. W., and **F. H. Fay.** 1982. Feeding by Steller sea lions on harbor seals. Murrelet 63: 70–71.

Read, A. J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. Reports of the International Whaling Commission Special Issue 15: 133–147.

Reeves, R. R., B. S. Stewart, and **S. Leatherwood.** 1992. The Sierra Club handbook of seals and sirenians. Sierra Club Books, San Francisco.

Remnant, R. A. 1997. Abundance of seals in the Lower Churchill River, 1996 and 1997. A report prepared for Manitoba Hydro, North/South Consultants Inc., Winnipeg, Manitoba.

Renouf, D., and **H. James.** 1975. Navigation in harbour seals. Pages 247–253 *in* Biology of the seal. *Edited by* K. Ronald and A. Mansfield. Rapports de Proces-verbaux de Reunions. Conseil International Permanent pour l'Exploration de la Mer 169. [Not seen, cited in Davis and Renouf 1987]

Richardson, W. J., C. R. Greene, C. I. Malme, and **D. H. Thomson.** 1995. Marine mammals and noise. Academic Press, San Diego.

Rosenfeld, M., M. George, and **J. M. Terhune.** 1988. Evidence of autumnal harbour seal, *Phoca vitulina*, movement from Canada to the United States. Canadian Field-Naturalist 102: 527–529.

Ross, P. S., R. L. De Swart, P. J. H. Reijnders, H. Van Loveren, J. G. Vos, and **A. D. M. E. Osterhaus.** 1995. Contaminant-related suppression of delayed-type hypersensitivity and antibody response in harbor seals fed herring from the Baltic Sea. Environmental Health Perspectives 103: 162–167.

Ross, P., R. De Swart, R. Addison, H. Van Loveren, J. Vos, and **A. Osterhaus.** 1996. Contaminant-induced immunotoxicity in harbour seals: wildlife at risk? Toxicology 112: 158–169.

Ross, P. S., R. L. De Swart, H. Van Loveren, A. D. M. E. Osterhaus, and **J. G. Vos.** 1997. The immunotoxicity of environmental contaminants to marine wildlife: a review. Annual Review of Fish Diseases 6: 151–165.

Ross, P. S., M. G. Ikonomou, G. M. Ellis, L. G. Barrett-Lennard, and **R. F. Addison.** 1998. *Abstract.* Elevated levels of PCBs, PCDDs and PCDFs in harbour seals (*Phoca vitulina* and killer whales (*Orcinus orca*) inhabiting the Strait of Georgia, British Columbia, Canada. Page 117 *in* Abstracts of the World Marine Mammal Science Conference, January 1998, Monaco.

Schandorff, S. 1997a. Developmental stability and skull lesions in the harbour seal (*Phoca vitulina*) in the 19th and 20th centuries. Annals Zoologica Fennici 34: 151–166.

Schandorff, S. 1997b. Developmental stability and the harbour seal epizootic in 1988. Annals Zoologica Fennici 34: 167–175.

Scheffer, V. B., and **J. W. Slipp.** 1944. The harbor seal in Washington State. American Midland Naturalist 32: 373–416.

Shaughnessy, P. D., and **F. H. Fay.** 1977. A review of the taxonomy and nomenclature of North Pacific harbour seals. Journal of Zoology, London 182: 385–419.

Simmonds, M. P., and **S. J. Mayer.** 1997. An evaluation of environmental and other factors in some recent marine mammal mortalities in Europe: implications for conservation and management. Environmental Review 5: 89–98.

Smith, R. J. 1997. Status of the Lacs des Loups Marins harbour seal, *Phoca vitulina mellonae*, in Canada. Canadian Field-Naturalist 111: 270–276.

Smith, R. J., D. M. Lavigne, and **W. R. Leonard.** 1994. Subspecific status of the freshwater harbor seal (*Phoca vitulina mellonae*): a re-assessment. Marine Mammal Science 10: 105–110.

Smith, T. G. 1994. Changes in marine mammal abundance. Page 121 *in* Proceedings of the First Annual Pacific Ecozone Workshop, Sidney, B.C., February 1–3, 1994. Canadian Wildlife Service Pacific and Yukon Region Technical Report Series Number 222.

Steiger, G. H., J. Calambokidis, J. C. Cubbage, D. E. Skilling, A. W. Smith, and **D. H. Gribble.** 1989. Mortality of harbor seal pups at different sites in the inland waters of Washington. Journal of Wildlife Diseases 25: 319–328.

Stobo, W. T., and **G. M. Fowler.** 1994. Aerial surveys of seals in the Bay of Fundy and off southwest Nova Scotia. Canadian Technical Report of Fisheries and Aquatic Sciences 1943.

Stutz, S. S. 1967. Pelage patterns and population distributions in the Pacific harbour seal (*Phoca vitulina richardsi*). Journal of the Fisheries Research Board of Canada 24: 451–455.

Sullivan, R. M. 1982. Agonistic behavior and dominance

relationships in the harbor seal, *Phoca vitulina*. Journal of Mammalogy 63: 554–569.

de Swart, R. L., P. S. Ross, J. G. Vos, and **A. D. M. E. Osterhaus.** 1996. Impaired immunity in harbour seals (*Phoca vitulina*) exposed to bioaccumulated environmental contaminants: review of a long-term feeding study. Environmental Health Perspectives 104: supplement 4.

Temte, J. L., M. A. Bigg, and **O. Wiig.** 1991. Clines revisited: the timing of pupping in the harbour seal (*Phoca vitulina*). Journal of Zoology, London 224: 616–632.

Teilmann, J., and **R. Dietz.** 1994. Status of the harbour seal, *Phoca vitulina*, in Greenland. Canadian Field-Naturalist 108: 139–155.

Thompson, P. M., D. J. Tollit, H. M. Corpe, R. J. Reid, and **H. M. Ross.** 1997. Changes in haematological parameters in relation to prey switching in a wild population of harbour seals. Functional Ecology 11: 743–750.

Tollit, D. J., A. D. Black, P. M. Thompson, A. Mackay, H. M. Corpe, B. Wilson, S. M. Van Parijs, K. Grellier, and **S. Parlane.** 1998. Variation in harbour seal *Phoca vitulina* diet and dive-depths in relation to foraging habitat. Journal of Zoology, London 244: 209–222.

Trites, A. W. 1997. The role of pinnipeds in the ecosystem. Pages 31–39 *in* Pinniped populations, eastern North Pacific: status, trends and issues. *Edited by* G. Stone, J. Goebel, and S. Webster. New England Aquarium Report.

Van Parijs, S. M., P. M. Thompson, D. J. Tollit, and **A. Mackay.** 1997. Distribution and activity of male harbour seals during the breeding season. Animal Behaviour 54: 35–43.

Walker, B. G., and **W. D. Bowen.** 1993. Changes in body mass and feeding behaviour in male harbour seals, *Phoca vitulina*, in relation to female reproductive status. Journal of Zoology, London 231: 423–436.

Waring, G. T., D. L. Palka, K. D. Mullin, J. H. W. Hain, L. J. Hansen, and **K. D. Bisack.** 1997. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments — 1996. NOAA Technical Memorandum NMFS-NE-114.

Watts, P. 1992. Thermal constraints on hauling out by harbour seals (*Phoca vitulina*). Canadian Journal of Zoology 70: 553–560.

Watts, P. 1993. Possible lunar influence on hauling-out behavior by the Pacific harbor seal (*Phoca vitulina richardsi*). Marine Mammal Science 9: 68–76.

Whitehead, H., W. D. Bowen, S. K. Hooker, and **S. Gowans.** 1998. Marine mammals of the Gully. *In* The Gully science review. *Edited by* G. Harrison and D. Fenton. Fisheries and Oceans Canada, Maritimes Region.

Whitman, A. A., and **P. M. Payne.** 1990. Age of harbour seals, *Phoca vitulina concolor*, wintering in southern New England. Canadian Field-Naturalist 104: 579–582.

Wiig, O. 1989. A description of common seals, *Phoca vitulina* L. 1758, from Svalbard. Marine Mammal Science 5: 149–158.

Wilke, F. 1943. Unusual injury to a young harbour seal. Journal of Mammalogy 24: 401–402.

Yochem, P. K., B. S. Stewart, R. L. DeLong, and **D. P. DeMaster.** 1987. Diel haul-out patterns and site fidelity of harbor seals (*Phocavitulina richardsi*) on San Miguel Island, California, in autumn. Marine Mammal Science 3: 323–332.

Yochem, P. K., B. S. Stewart, M. Mina, A. Zorin, V. Sadovov, and **A. Yablokov.** 1990. Non-metrical analyses of pelage patterns in demographic studies of harbor seals. Reports of the International Whaling Commission Special Issue 12: 87–90.

Young, T. P. 1994. Natural die-offs of large mammals: implications for conservation. Conservation Biology 8: 410–418.

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