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Summary of Current Knowledge of Harbour Porpoises in US and Canadian Atlantic Waters

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ABSTRACT

This paper summarises current knowledge of the three populations of harbour porpoises in US and Canadian Atlantic waters. During the summer, the populations are centred in the Gulf of Maine/Bay of Fundy region, the Gulf of St. Lawrence and off the east coast of Newfoundland. Winter distributions of all the populations are largely unknown. These populations are thought to be reasonably discrete, as shown by studies of mitochondrial DNA, reproductive schedules, contaminants and radio tagging. From the Gulf of Maine/Bay of Fundy population, the average abundance was 47,200 (95% CI = 39,500 to 70,600) for 1991 and 1992. Based on observer programs, in 1993 the bycatch in the groundfish sink gillnet fishery from the US Gulf of Maine was 1,400 (95% CI = 1,000 to 2,000) and 200 to 400 animals from the Canadian Bay of Fundy. Currently, time-area closures and acoustic devices are being used to reduce the bycatch in the Gulf of Maine and Bay of Fundy. From the Gulf of St. Lawrence, no abundance estimates are available, and based on mail surveys conducted in 1989 to 1991, approximately 2,800 harbour porpoises were caught annually in fishing gear. Reliable abundance and bycatch estimates are not available from the Newfoundland population, although it is thought that more that 1,000 animals annually were caught in the 1980's. Known life history parameters include: a mean age at sexual maturation for females of about three years; females reach larger asymptotic lengths (155cm) than males (144cm); reproduction is annual; gestation lasts approximately 10.6 months; and lactation lasts 8 to 12 months. Conception probably occurs later for the Newfoundland population than for the Gulf of Maine/Bay of Fundy population. During the summer, harbour porpoises primarily feed on Atlantic herring. The Gulf of Maine/Bay of Fundy population also feeds on silver hake, while the Gulf of St. Lawrence population feeds on capelin and redfish. Organochlorine contaminants were lowest in harbour porpoises from Newfoundland and highest in animals from the Gulf of Maine/Bay of Fundy, though these levels are lower than those measured a decade ago. Mean concentrations of cadmium and zinc contaminants were significantly higher in harbour porpoises from Newfoundland, perhaps reflecting the higher cadmium levels found in many Arctic cetaceans.

KEYWORDS: HARBOUR PORPOISE; NORTH ATLANTIC; REVIEW; DISTRIBUTION; ASSESSMENT; BIOLOGICAL PARAMETERS; FEEDING; POLLUTANTS; INCIDENTAL CAPTURE

DISTRIBUTION, SEASONAL AND SPATIAL

Gaskin (1984; 1992) suggested that there are three, more or less, separate populations of harbour porpoises (*Phocoena phocoena*) in the US and Canadian Atlantic Ocean. These populations are located in (1) eastern Newfoundland; (2) the Gulf of St. Lawrence; and (3) the Gulf of Maine/Bay of Fundy. Knowledge is most complete for the Gulf of Maine/Bay of Fundy population, and least complete for the Newfoundland population.

The Gulf of Maine/Bay of Fundy animals migrate into the northern Gulf of Maine and lower Bay of Fundy region during July and begins migrating out during September, at which time they go to unknown wintering grounds. During September to December and April to June, harbour porpoises are seen in the lower Gulf of Maine and off the Atlantic coast of Nova Scotia near Halifax, although not in the numbers observed in the Bay of Fundy region. During December to March, some of the population is presumed to be in offshore waters of the US mid-Atlantic, from North Carolina to Massachusetts, as indicated by beach strandings (Haley and Read, 1993) and several sighting surveys (CeTAP, 1982; Northridge, 1995; Palka, 1995c). Two beach strandings of harbour porpoises in Florida during March 1984 and 1985 (Smithsonian Marine Mammal Database 1994) delimit the extreme southerly extent of the population. However, the typical southerly boundary is Cape Hatteras, North Carolina.

Although the above describes general movement patterns, individual harbour porpoises exhibit a high degree of variability in both habitat utilisation and movement patterns. During August of both 1994 and 1995, nine harbour porpoises were equipped with satellite-linked transmitters before they were released from herring weirs located near Grand Manan, New Brunswick, Canada (A.J. Read and A.J. Westgate, unpubl. data). Contact durations ranged from 2 to 135 days. Three of the tagged harbour porpoises remained in the western Bay of Fundy during August, four male harbour porpoises travelled into the Gulf of Maine during August and September and one porpoise moved as far south as northern Georges Bank during November. These movement patterns are consistent with the hypothesis that the Bay of Fundy and Gulf of Maine animals represent a single population. These movements also underscore the trans-boundary nature of this population.

Throughout the summer (June to October), harbour porpoises are widely distributed in the Gulf of St. Lawrence. They are seen as far upstream as the mouth of the Saguenay River, along the northeastern shore of Quebec, to the eastern end of the Gaspé Peninsula, off Miscou Island and to a lesser extent, they are seen off Prince Edward Island and around the Magdalene Islands. During winter, when the Gulf of St. Lawrence is partially covered by ice, most harbour porpoises leave the Gulf. Their wintering grounds are unknown but the limited evidence available suggests that some harbour porpoises migrate offshore to the Grand Banks and to offshore waters north of Halifax.

During spring, the Newfoundland population is distributed in coastal shelf waters of Labrador and along the eastern and southeastern coast of Newfoundland. During summer, harbour porpoises occur in Baffin Bay and in deeper waters of the Labrador Sea. The most northerly report

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is from Cape Aston, Canada at about 70°N. The offshore boundaries of the spring and summer distributions are unknown, as are the wintering grounds.

POPULATION STRUCTURE

The eastern Newfoundland, Gulf of St. Lawrence and Gulf of Maine/Bay of Fundy populations are thought to be reasonably discrete. The division between the Newfoundland population and the other two is the most discrete. These divisions, suggested by Gaskin (1984; 1992), were based on coincident summer distribution patterns, and assumes that harbour porpoises are confined largely to continental shelf areas and rarely cross broad expanses of open ocean. These population relationships are currently being re-evaluated using genetic and pollutant analyses.

Sequences of mitochondrial DNA (Rosel *et al.*, 1995) revealed that Atlantic harbour porpoises shared no haplotypes with Pacific and Black Sea harbour porpoises, while only one of ten mtDNA haplotypes were shared between Northeast and Northwest Atlantic harbour porpoises. Amano and Miyazaki (1992) found no significant differences in cranial characteristics between Northeast and Northwest Atlantic harbour porpoises. Yurick and Gaskin (1987) however found significant differences, but inconclusive differences between characteristics of harbour porpoises from the different regions within the Northwest Atlantic.

Re-analysis of frequency distributions of mtDNA haplotypes from harbour porpoises collected from the Gulf of Maine, Bay of Fundy, Gulf of St. Lawrence and Newfoundland suggested that females were philopatric while males may disperse between sites (Wang, 1993; J. Wang, pers. comm.). Bay of Fundy females could not be distinguished from those from the Gulf of Maine, although both were different from the females from the Gulf of St. Lawrence and Newfoundland, whose haplotypes were indistinguishable from one another.

Individuals from the Gulf of Maine and Bay of Fundy appear to comprise a single population. This is based on evidence from: (1) mtDNA studies (above); (2) life history parameters which indicate these two areas share a unified, highly synchronised reproductive schedule (Read *et al.*, 1994); (3) the relatively rapid movements of four of nine satellite tagged individuals from the Bay of Fundy into the Gulf of Maine (A.J. Read and A.J. Westgate, unpubl. data); and (4) the consistent similarity in organochlorine profiles recorded in porpoises from the Bay of Fundy and Gulf of Maine (Westgate, 1995).

A recent analysis of regional differences in organochlorine (Westgate, 1995) and heavy metal (Johnston, 1995) contaminants (see later section) revealed significant differences among Newfoundland, Gulf of St. Lawrence and Gulf of Maine/Bay of Fundy harbour porpoise populations. Regional differences were more pronounced in organochlorine groups than individual heavy metals. Generally, levels of organochlorine compounds were significantly lower in Newfoundland porpoises, intermediate in St. Lawrence animals and consistently highest in Gulf of Maine/Bay of Fundy animals. Although all heavy metals showed some degree of regional variation, only cadmium and zinc were consistently different among areas, where these compounds were significantly higher in Newfoundland harbour porpoises. Overall, patterns of contaminant data support Gaskin's (1984) original population structure hypothesis. Microsatellite analyses are currently being conducted to more fully investigate the relationships between these three groups of animals (P. Rosel, pers. comm.).

ABUNDANCE

Abundance estimates of US and Canadian Atlantic harbour porpoises are available only for the Gulf of Maine/Bay of Fundy population. In the summers of 1991, 1992 and 1995, line transect surveys were conducted in the region north of Portland, Maine, south of St. John's, New Brunswick and west and south of Port Joli, Nova Scotia. The survey methodology was described in Palka (1995a). Abundance estimates including $g(0)$, for 1991 was 37,500 (%CV = 28.8%; 95% CI 26,700–86,400) and 67,500 in 1992 (%CV = 23.1%; 95% CI 32,900–104,600). The 1995 data have not been analysed yet. The weighted average of the 1991 and 1992 estimates was 47,200 (%CV = 19.0; 95% CI 39,500–70,600), where each estimate was weighted by the inverse of its variance (Smith *et al.*, 1993). Although the 1991 and 1992 estimates were not statistically different, the differences could be due to inter-annual changes in migration and small-scale spatial distribution patterns, which were shown to be correlated to inter-annual changes in sea surface temperature and prey density (Palka, 1995b).

No abundance estimates currently exist for the Gulf of St. Lawrence or Newfoundland populations. An estimate for the Gulf of St. Lawrence population may result from an aerial line transect sighting survey conducted in the summer of 1995 (M. Kingsley, pers. comm.).

LIFE HISTORY PARAMETERS

Life history of harbour porpoises from the Bay of Fundy and Gulf of Maine has been studied for several decades (e.g. Fisher and Harrison, 1970; Gaskin *et al.*, 1984; Read, 1990a; b; Read and Hohn, 1995). Here we only present the most recent estimates of life history parameters.

Read and Hohn (1995) examined 239 harbour porpoises killed between 1989 and 1993 in demersal gillnets from the Bay of Fundy and Gulf of Maine. Most specimens were taken in the Bay of Fundy during summer or in the southern Gulf of Maine during autumn; few samples were available from winter or spring. In this sample, there was no evidence of any widespread segregation by reproductive status. The oldest specimen was 17 years old, but most harbour porpoises (94%) were younger than ten. Mean age at sexual maturation in females was 3.4 years (SE = 0.01, n = 99). Asymptotic lengths were 155cm for females and 144cm for males (Read and Gaskin, 1990). The timing of reproduction was seasonal with ovulation and conception occurring in late June and early July followed by parturition in May. Sexually mature males also demonstrated seasonality, and maximum testis size and spermatogenic activity occurred during summer months (Gaskin *et al.*, 1984). Most females (93%) collected during late summer and early autumn were pregnant, indicating an annual reproduction cycle. Many adult females (59%) were also lactating. Gestation was estimated to last for 10.6 months, followed by a lactation period of 8 to 12 months (Read, 1990b).

Richardson (1992) examined 94 harbour porpoises (59 male and 35 female) killed during June to August in demersal gillnets off eastern Newfoundland. In most respects, the life history of these animals was similar to that of harbour porpoises in the Gulf of Maine/Bay of Fundy. The majority of the Newfoundland sample (56%) were younger than five years; the oldest individual was 12 years old. Mean age at sexual maturation of females was 3.1 years (SE = 0.07, $n = 32$). Females reached larger asymptotic lengths (156cm) than males (143cm). Reproduction was seasonal; most sexually mature females (76%) were in the early stages of pregnancy and many (59%) were also lactating. Ovulation and conception occurred during July, slightly later than the females in the Gulf of Maine/Bay of Fundy.

There are no published descriptions of the life history of harbour porpoises from the Gulf of St. Lawrence.

No data exist to empirically estimate the rate of increase of any harbour porpoise population. This lack of data is due to limitations in our ability to estimate natural mortality or to obtain a time series of abundance estimates from an expanding population. However, using model populations, several investigators estimated the potential rate of increase of harbour porpoises. Barlow and Boveng (1991), using a re-scaled human mortality schedule, estimated the maximum potential rate of increase to be 9.4%. Woodley and Read (1991) estimated a 4% rate of increase by combining empirical estimates of harbour porpoise fecundity with a scaled survival schedule from the Himalayan thar. To quantify the uncertainty inherent in these estimates, Caswell *et al.* (1995) used a series of re-scaled mortality schedules and a Monte Carlo sampling procedure to produce a distribution of potential rates of increase. This procedure indicated that it is highly unlikely that the rate of increase exceeded 10% per year. The median of the distribution was 4%, similar to the value of Woodley and Read (1991). It is not known, however, whether the median of this distribution represents the best estimate of the potential rate of increase (Palka, 1994).

FEEDING ECOLOGY

The diet of Bay of Fundy and Gulf of Maine harbour porpoises has been studied for over 25 years (Smith and Gaskin, 1974; Recchia and Read, 1989; Smith and Read, 1992; Read *et al.*, 1994). Most harbour porpoises were obtained from incidental catches in demersal gillnets, primarily from the Bay of Fundy during the summer. Only recently have samples been available from other areas and other seasons. During the summer, harbour porpoises in the Gulf of Maine/Bay of Fundy primarily feed on Atlantic herring (*Clupea harengus*), with smaller proportions of silver hake (*Merluccius bilinearis*) and other small demersal fishes. Cephalopods and hagfish (*Myxine glutinosa*) are also eaten but in small amounts. Herring was present in over 87% of 51 stomachs taken during summer (Read *et al.*, 1994). Calves showed a gradual progression from complete dependence on milk to nutritional independence, and often started to take solid food items such as euphuasiids in late summer (Smith and Read, 1992).

There are indications of significant seasonal changes in the diet of harbour porpoises from this area. In the fall, herring, silver hake and pearlsides (*Maurolicus weitzmani*) were important prey items for older harbour porpoises, as evident from the 39 stomachs examined by Read *et al.* (1994). Prey diversity increased in winter, although only 15 stomachs were examined. Prey diversity was lowest in the summer with a mean of 2.2 prey species present in each stomach (SD = 1.2, $n = 51$).

The stomach from a single harbour porpoise taken in a pelagic driftnet off Cape Hatteras, North Carolina in February 1993 contained a different prey assemblage (Nicolas *et al.*, 1996). The majority of prey comprised the digested remains of a lanternfish (*Ceratoscopelus maderensis*). Several other myctophids and other mid-water fishes were also present in this stomach, but absent from stomachs from the Gulf of Maine or Bay of Fundy. In general, the winter diet is poorly understood.

Fontaine *et al.* (1994b) examined the stomachs of 138 harbour porpoises taken incidentally between May and August 1989 in commercial fisheries in the Gulf of St. Lawrence. Atlantic herring, capelin (*Mallotus villosus*) and redfish (*Sebastes marinus*) were the primary prey species. Together, herring and capelin contributed more than 88% of the estimated caloric intake. Significant differences in diet existed between collection areas. Harbour porpoises taken in the northern Gulf of St. Lawrence consumed more capelin, while those in the southern Gulf ate more herring. In general, prey diversity was low, 66% of the stomachs contained only a single prey species. As with harbour porpoises from the Bay of Fundy, most prey items were small; the mean length of the principal prey items consumed was 28cm (SD = 9).

No published descriptions of the feeding ecology of harbour porpoises from Newfoundland exist.

BYCATCH

Gulf of Maine/Bay of Fundy

Gillnets

From the Gulf of Maine sink gillnet fishery, estimates of annual harbour porpoise bycatch taken during 1990 to 1993 were 2,900 (95% CI 1,500–5,500), 2,000 (1,000–3,800), 1,200 (800–1,700) and 1,400 (1,000–2,000), respectively (Bravington and Bisack, 1996). These bycatch estimates were based on prorating to the effort from the entire sink gillnet fishery, bycatch per haul from fishing trips in which an onboard observer monitored catches. Approximately 1%, 6%, 7.5% and 5% of the US Gulf of Maine sink gillnet fishery was monitored during the years 1990 to 1993, respectively.

Read and Gaskin (1988) estimated that about 100 harbour porpoises were killed annually in the Canadian Bay of Fundy gillnet fishery. In 1993 an observer program was initiated and observers collected data from 62 trips made by 13 gillnet fishers from five ports in the Bay of Fundy. A total of 25 harbour porpoises were caught, all from waters around Campobello and Grand Manan Islands, New Brunswick. From these efforts, a preliminary total of harbour porpoise bycatch was estimated to be in the range of 200 to 400 animals (Department of Fisheries and Oceans, 1995). During 1994 the observer program expanded to collect information from 171 fishing trips made by 16 gillnet vessels from Campobello and Grand Manan Islands. The 1994 program sampled approximately 57% of the lower Bay of Fundy fishing fleet and 84% of the Campobello and Grand Manan fleets. For 1994, the total bycatch from the lower Bay of Fundy was estimated to be between 80 and 120 animals (Department of Fisheries and Oceans, 1995). The majority (86%) of these animals were from two areas, Swallowtail (off North Head, Grand Manan Island) and the Wolves.

Herring weirs

Smith *et al.* (1983) estimated that about 27 harbour porpoises died annually in herring weirs. Since 1992, a co-operative program has developed in which fishermen and biologists work to release harbour porpoises that become trapped in herring weirs around Grand Manan, New Brunswick, Canada (Neimanis *et al.*, 1995). Since 1992, 369 harbour porpoises have been recorded in herring weirs in this area, of which 260 were released alive, 61 died and 48 were not accounted for. The annual mortality rate varied from a high of 22.9% in 1993 to a low of 5.9% in 1995. These mortality rates are lower than the 39% previously reported by Smith *et al.* (1983). The body condition and sex ratio of the weir sample were not significantly different from harbour porpoises incidentally caught in groundfish gillnets set in the waters around Grand Manan during the same time interval. However, there were differences in the mean length and age between the two samples, thought to be due to the disproportionate number of yearlings represented in the weir sample. These differences might reflect age-specific differences in habitat utilisation by harbour porpoises in the Bay of Fundy.

Mid-Atlantic US states

No bycatch estimates exist for harbour porpoises caught along the mid-Atlantic states, although it is known that some bycatch occurs (Palka, 1994). Between 23 February and 15 May 1993 (coinciding with coastal gillnet fishing), 50 harbour porpoise carcasses were recovered from beaches between New York and North Carolina, some of which exhibited signs of entanglement (Haley and Read, 1993). Between November 1993 and May 1994, 66 carcasses were collected from the same region of which 35 were in sufficient condition to determine the cause of death; 21 had died as a result of entanglement in fishing gear (A.J. Read, unpubl. data). No harbour porpoises were caught during the 91 fishing trips observed in the mid-Atlantic waters during July 1993 and April 1994 (D.L. Palka, unpubl. data).

Gulf of St. Lawrence

In 1989 and 1990, questionnaires were sent to all fixed gear permit holders in the northern Gulf, western Gulf and St. Lawrence estuary regions. Each permit holder was asked to report the number of harbour porpoises caught in the previous fishing season. A total annual bycatch of approximately 1,900 harbour porpoises was estimated by scaling the reported catch by the proportion of permit holders who responded (Fontaine *et al.*, 1994a). Peak catches were found to occur during July and August. More than 90% of the catches were in groundfish gillnets, while the remaining occurred in pelagic gillnets. Eastern Gaspé, Honguedo Channel and the Lower North Shore were identified as areas of relatively high catches. In 1991, a similar questionnaire was sent to permit holders in the southern and eastern Gulf of St. Lawrence. Based on this survey, 876 to 949 harbour porpoises were estimated to have been caught (NEFSC, 1992).

From May to August 1992, a study was carried out in parts of the Gulf of St. Lawrence to determine patterns of fishing habits that correlated with harbour porpoise bycatch rates, in co-operation with 22 volunteer fishermen. A total of 401 harbour porpoises were taken in 2,492 gillnet hauls (0.16 harbour porpoises per haul). The highest bycatch rates were from the Miscou Banks and northeastern Gulf regions (4 to 5 harbour porpoises per ton of fish landed). The absence of a measure of total fishing effort precluded estimation of the total bycatch (Larrivée and Kingsley, 1994).

Newfoundland

Lien *et al.* (1994) review attempts to estimate harbour porpoise bycatches in Newfoundland in 1990 by a number of methods including a telephone survey. A total of 235 fisherman from various villages were interviewed. Information on gear types used, fishing effort and total bycatch were requested. The majority of small cetaceans were caught in groundfish gillnets, while some were in salmon gillnets, occasionally in lumpfish gillnets and rarely in cod traps and trawls. High levels of small cetacean bycatch were reported in the Fogo/Twillingate, Fortune and St. Mary's Bay areas. Although the majority of respondents reported no bycatch, a few reported catches up to 30 animals per fishing season. In total, from 100 fisherman, 243 harbour porpoises were caught during one fishing season. Although an estimate of total bycatch could be made by scaling the reported catch rates by the total number of licensed fishermen, this resulting estimate would be problematic for a number of reasons (NEFSC, 1992; Lien *et al.*, 1994). However, annual bycatch estimates of more than 1,000 harbour porpoises from Newfoundland waters, and an estimate in the low hundreds from the Labrador coast are believed to be reasonable (Lien, 1989).

METHODS TO REDUCE BYCATCH

Two measures to reduce bycatches of harbour porpoises in the Gulf of Maine are being investigated: (1) time-area closures (initiated in 1994); and (2) experiments with net alarms. The location and timing of the closed areas correspond to areas and periods when harbour porpoise bycatch was thought to most likely occur, as predicted from data collected during 1990 to 1993 (NEFMC, 1994). From 1–30 March parts of Massachusetts Bay were closed; from 15 August-13 September an area off the coast of northern Maine was closed; and from 1–30 November an area off New Hampshire and southern Maine was closed. The effectiveness of these closures has not yet been evaluated. For 1996, it was proposed to increase the time and/or area of these closures (D. Palka, pers. comm.)

Following two preliminary experiments conducted in 1992 and 1993, a comprehensive study of the effects of acoustic deterrent devices on the Gulf of Maine sink gillnet fishery was conducted during October and November of 1994 (Kraus *et al.*, 1995). Active acoustic 'pingers' were attached to 421 strings of sink gillnets from 15 commercial fishing vessels operating on Jeffery's Ledge (off the New Hampshire coast). Each string comprised 12 nets, with a pinger located at the points where nets were joined and at each end of the string. Catches from these strings were compared to 423 strings on which control (non-functional) pingers were placed. The active pingers were activated by a salt water switch; thus, fishermen were unaware of which strings had active or control pingers until the strings were hauled in. In total, 25 harbour porpoises were entangled in the control strings and two were entangled in the active strings. This difference in harbour porpoise bycatch rate was highly significant, indicating that the acoustic devices were effective in reducing the entanglement of harbour porpoises in sink gillnets located on Jeffery's Ledge during the fall of 1994 (Kraus *et al.*, 1995).

Two measures to reduce bycatches in the Bay of Fundy are being taken: (1) release of porpoises caught in herring weirs (Neimanis *et al.*, 1995); (2) investigations of active acoustic pingers (Department of Fisheries and Oceans, 1995). Time-area closures have also occurred in the groundfish sink gillnet fishery (26 July-31 August) but this was because the groundfish quota had been reached and is not related to harbour porpoise bycatch.

In order to try to examine at what point during the fishing operation harbour porpoises become entangled, a study was initiated to determine cooling rates of dead harbour porpoises left in approximately 13°C sea water (McLellan *et al.*, 1995). Preliminary results from one female harbour porpoise (35.5kg, 125.5cm) indicated that the core body temperature dropped off sharply within minutes after death; after 8.3 hours the internal temperature had reached an asymptote that tracked the ambient water temperature.

OTHER ANTHROPOGENIC INFLUENCES

Organochlorines

Concentrations of organochlorine contaminants in 201 samples of blubber from US and Canadian Atlantic harbour porpoises collected from 1989 to 1991 have recently been analysed (Westgate, 1995) and the results are summarised below. Levels of 99 individual contaminants were recorded, including 68 PCB congeners, DDT and its metabolites, 14 chlordane related compounds, toxaphene, chlorobenzenes, hexachlorocyclohexanes, dieldrin and mirex.

Organochlorine contaminants in harbour porpoises from Newfoundland ($n = 29$) were significantly lower than those in animals from other regions, with males having a mean total PCB concentration (wet weight) of 5.2 ±2.5 μg/g and females 5.5 ±4.4 μg/g. Mean levels of major contaminants (in order of importance: toxaphenes, PCBs, DDTs and chloranes) were similar to those reported for pilot whales (*Globicephala melas*), but were approximately four times lower than those of white-beaked dolphins (*Lagenorhynchus albirostris*) from the same area (Muir *et al.*, 1988).

Gulf of St. Lawrence harbour porpoises ($n = 62$) had levels intermediate between those from Newfoundland and the Gulf of Maine/Bay of Fundy. Mean concentrations of total PCBs were 10.6 ±5.4 μg/g and 7.2 ±3.9 μg/g for males and females, respectively. The major contaminant groups, in order of decreasing concentration, were toxaphene, PCBs, DDTs and chlordanes.

Concentrations of organochlorine contaminants from the Gulf of Maine/Bay of Fundy (1989 to 1991, $n = 110$) were higher than those found in animals in the other regions; mean levels of total PCBs were 17.3 ±11.2 μg/g in males and 11.4 ±4.8 μg/g in females. PCBs were the most prominent contaminants but were much lower than the average levels (males: 78.6 μg/g; females: 45.0 μg/g) reported earlier by Gaskin *et al.* (1983). Similar trends were found for DDTs; average levels from animals caught during 1989 to 1991 (males: 8.0 μg/g; females: 5.7 μg/g) were down two orders of magnitude from those reported for harbour porpoises taken much earlier in the same region (Gaskin *et al.*, 1982).

In males, organochlorine contaminant levels generally increased with age, while in females levels decreased with age due to losses incurred through gestation and lactation. It is difficult to assess the impact of contaminants on harbour porpoises, both proximately and ultimately, because of the limited knowledge of the effects and physiological responses of harbour porpoises to xenobiotics. However, during hundreds of detailed necropsies, none of the pathological symptoms commonly associated with elevated levels of PCBs and organic contaminants in other marine mammals (Martineau *et al.*, 1988) were detected (A.J. Read, unpubl. data).

Trace metals

Trace metal contaminants in the US and Canadian Atlantic harbour porpoises that have recently been studied (Johnston, 1995) include cadmium (Cd), copper (Cu), zinc (Zn) and mercury (Hg). Trace metal contaminant concentrations (mg/g wet weight) were measured from 133 samples of liver, kidney and muscle tissues. Metal concentrations followed patterns previously reported for cetaceans:

Cu, Zn and Hg concentrations: liver > kidney > muscle
Cd concentrations: kidney > liver > muscle.

Mean concentrations of both Cu and Zn in harbour porpoises from the Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence and western Newfoundland were similar to values previously reported for harbour porpoises from other locations (Falconer *et al.*, 1983) and for other cetaceans in Canadian waters (Wagemann *et al.*, 1990). Mean Hg concentrations for these three harbour porpoise populations were similar to those found in harbour porpoises from other locations (Joiris *et al.*, 1991; Teigen *et al.*, 1993), but somewhat lower than previously reported for Bay of Fundy animals (Gaskin *et al.*, 1979). Mean Cd concentrations were higher in these three harbour porpoise populations as compared to harbour porpoises found in British waters (Law *et al.*, 1992).

Both Cu and Hg in male and female harbour porpoises showed little regional variation. The most significant regional differences were found in Cd and Zn concentrations. Levels of Cd in liver, kidney and muscle of male harbour porpoises and liver and muscle in female harbour porpoises were all significantly higher in Newfoundland animals than in animals from the other two regions. This may reflect the higher Cd levels commonly found in many Arctic cetaceans (Wagemann *et al.*, 1983; 1990). Zn levels in liver and kidney tissues from male and female Newfoundland porpoises were also higher than the other two regions, and may be related to the elevated Cd levels found in Newfoundland porpoises (Donovan, 1985; Henningsen and Würsig, 1992).

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