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A review of beaked whale (Ziphiidae) stranding incidents from the inshore waters of eastern Canada

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Abstract
Cetaceans of the family Ziphiidae (beaked whales) include some of the least known whale species. We review 78 ziphiid stranding incidents from the inshore waters of eastern Canada (defined as the Atlantic provinces north to central Labrador, including the Gulf coast of Quebec, from ~latitude 43.5°N to 55.0°W), with outcomes that involve 84 individual whales. This includes all eastern Canadian ziphiid stranding incidents known to us from the first report of 24 February 1934 to 31 December 2021 for the five species documented from eastern Canada: Northern Bottlenose Whale (*Hyperoodon ampullatus*), Sowerby's Beaked Whale (*Mesoplodon bidens*), Blainville's Beaked Whale (*Mesoplodon densirostris*), True's Beaked Whale (*Mesoplodon mirus*), and Cuvier's Beaked Whale (*Ziphius cavirostris*). Northern Bottlenose Whale (41.0% of incidents, 40.4% of individuals) and Sowerby's Beaked Whale (46.1% of incidents, 46.4% of individuals) have stranded most frequently, with the remaining three species stranding very rarely in the region. An average of 0.55 individual ziphiids/year were reported stranded from 1934 to 1999 in eastern Canada, but since 2000 this has increased to an average of 2.2 stranded individuals/year. Much of this increase is undoubtedly due to improved reporting, but other factors may also be involved. We emphasize the importance of the ongoing documentation of cetacean stranding incidents, but especially the need to better understand causes of ziphiid mortality, particularly for those species that reach the edge of their range in the western North Atlantic or are of conservation concern.

Key words: Cetacean strandings; eastern Canada; *Hyperoodon ampullatus*; *Mesoplodon bidens*; *Mesoplodon densirostris*; *Mesoplodon mirus*; *Ziphius cavirostris*

Introduction
Cetaceans of the family Ziphiidae (beaked whales, the second largest cetacean family) characteristically live in deep water, usually offshore, and include some of the rarest and least known species of whales (MacLeod 2018). The International Union for the Conservation of Nature considers seven of the 24 ziphiid species currently recognized as Data Deficient, three as Near Threatened, and one Endangered. The remaining 12 are considered of Least Concern (https://www.iucnredlist.org/search?taxonomies=101272&searchType=species) while a recently described species remains unassessed (Carroll *et al.* 2021).

For many of these ziphiid species, virtually everything that is known about their biology has been gleaned from dead and live-stranded animals (Ellis and Mead 2017; Li and Rosso 2021). Although encountered far from their natural habitat when stranded, beached ziphiids remain an important source of information for both natural history and conservation. For example, Einfeldt *et al.* (2019a) sequenced the complete mitochondrial genome for True's Beaked Whale (*Mesoplodon mirus*) from tissue taken from an animal stranded on Iles de la Madeleine, Quebec (QC), while Desforges *et al.* (2021) was able to undertake full-depth blubber analysis for contaminants from a Northern Bottlenose Whale (*Hyperoodon ampullatus*) stranded in Newfoundland (NF). With the exception of the Northern Bottlenose Whale population that occupies the Scotian Shelf (Whitehead and Hooker 2012), the distributions of ziphiids that occur off Canada's east coast are not well understood. While dead or live-stranded ziphiids undoubtedly provide a very biased, and possibly even distorted, reflection of true distribution, stranding location and frequency may nevertheless reflect a shift in range. Furthermore, understanding cause of mortality in these animals may well be critical for conservation management.

Nemiroff *et al.* (2010) reported cetacean strandings in the Maritimes (provinces of New Brunswick [NB], Nova Scotia [NS], and Prince Edward Island [PEI]) from 1990 to 2008. During that 18-year period there were nearly 100 cetacean strandings documented from the coastline of the southern Gulf of St. Lawrence, with only a single ziphiid whale recorded (McAlpine and Rae 1999). Likewise, Truchon *et al.* (2013) analyzed 549 cetacean strandings from the St. Lawrence Estuary and northern Gulf from 1994 to 2008, with the only ziphiids included being Northern Bottlenose Whale and Sowerby's Beaked Whale (*Mesolodon bidens*). Truchon *et al.* (2013) classified both as rare in the Gulf. We are aware of only two reports of ziphiid whale strandings (of Northern Bottlenose Whale) in the Gulf of St. Lawrence prior to 1990 (cited in Hooker 1999), and prior to 2008 there appear to be only two Sowerby's Beaked Whale strandings for the Gulf. Lucas and Hooker (2000) summarized whale strandings for Sable Island, NS, from 1970 to 1998, a site well offshore on the Atlantic coast. Among 267 cetacean strandings, a mere four were ziphiids.

Here we review 78 stranding incidents comprising 84 ziphiid whales from the inshore waters of eastern Canada (defined as the Atlantic provinces north to central Labrador (NL), including the Gulf coast of QC, from ~latitude 43.5°W to 55.0°W; Figure 1) from the first report on 24 February 1934 to 31 December 2021 for the five species of ziphiids known from the region: Northern Bottlenose Whale, Sowerby's Beaked Whale, Blainville's Beaked Whale (*Mesoplodon densirostris*), True's Beaked Whale (*Mesoplodon mirus*), and Cuvier's Beaked Whale (*Ziphius cavirostris*). Stanistreet *et al.* (2017) detected Gervais' Beaked Whale (*Mesoplodon europaeus*) acoustically on the United States portion of the continental slope of Georges Bank; however, to date this species has not been reported in Canadian waters or recorded stranded on Canadian shores (Naughton 2012). The most northerly stranding of this species in the northwest Atlantic appears to be Cape Cod Bay, Massachusetts, in September 1997 (Moore *et al.* 2004).

Methods

Through the early 1990s, multiple agencies (Canadian Coast Guard, Department of Fisheries and Oceans Canada [DFO], Grand Manan Whale and Seabird Research Station [GMWSRS], New Brunswick Museum [NBM], Nova Scotia Stranding Network [NSSN], Nova Scotia Museum, and the Whale Release and Strandings Program of Memorial University of NF's Whale Research Group) monitored cetacean stranding incidents across the Canadian Maritime provinces and the Gulf of St. Lawrence and NF and NL. With the founding of the Marine Animal Response Society in 1999 (MARS, formerly the NSSN-1990–1996) based in Halifax, NS, Whale Release and Strandings (WR&S) in St. Johns, NF, in 2001, and the Réseau québécois d'urgences pour les mammifères marins (RQUMM) in 2004, the latter coordinated by the Group for Research and Education on Marine Mammals (GREMM; founded 1985) in Tadoussac, QC, documentation of marine mammal standings in the region has become much more systematic. Each of these groups maintains a public reporting hotline (Wimmer and Maclean 2021). Opportunity to report marine mammal stranding incidents to these 24 h hotlines has substantially enhanced reporting and documentation. Databases documenting stranding incidents for the region are now maintained by the Canadian Wildlife Health Cooperative (CWHC), DFO (NF & NL), GREMM, MARS, and the NBM. Ziphiid stranding incidents documented here were mainly reported through these agencies and WR&S. It should be noted that individually none of these databases are complete, even for the regions they encompass (e.g., CWHC is restricted to whales that have undergone veterinary necropsies by affiliated staff). Earlier stranding reports (<1980) are taken from the published literature. Where information on strandings from multiple sources and data are in disagreement (usually stranding dates, but sometimes location and total length of animals), we have chosen to follow veterinary necropsy reports and peer reviewed

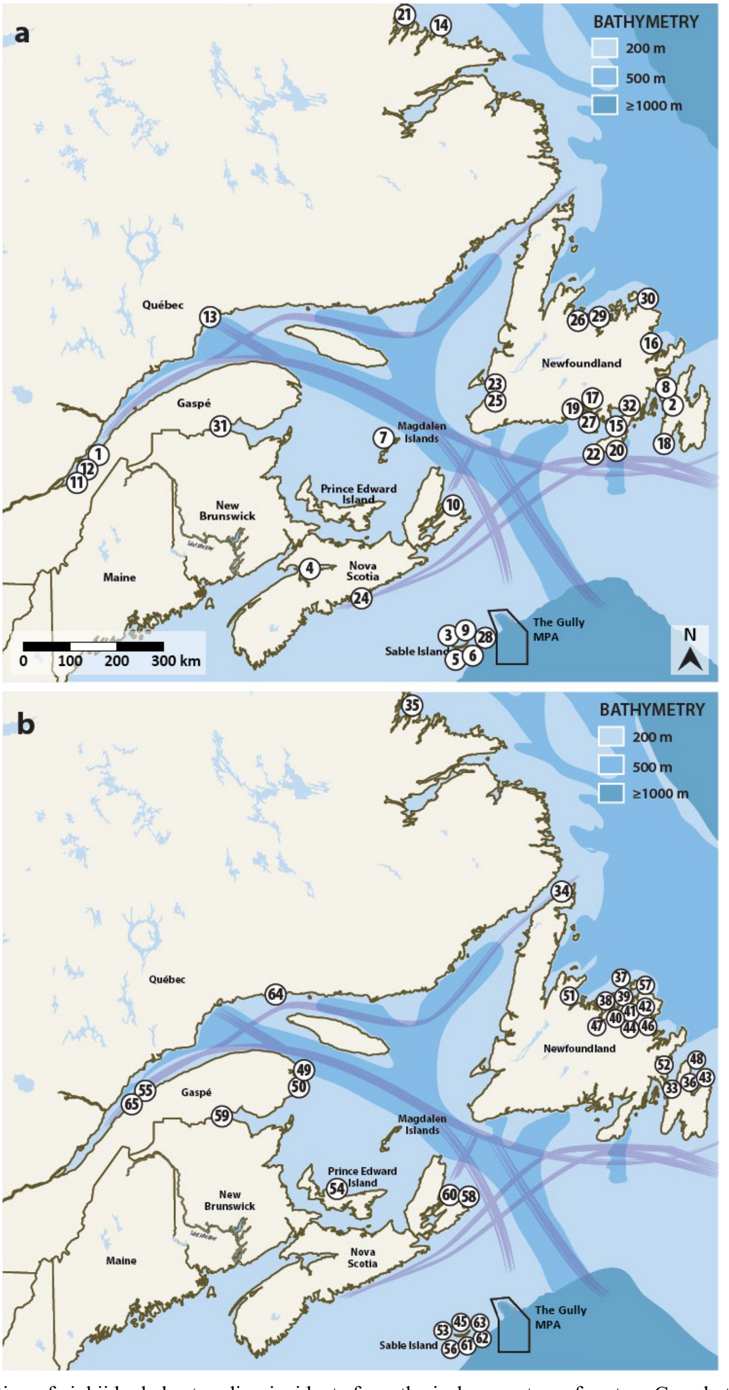

FIGURE 1. Distribution of ziphiid whale stranding incidents from the inshore waters of eastern Canada to December 2021. Each incident number represents one or more whales. Numbers correspond to incidents (not individuals) in Table 1. Major commercial shipping routes through the Gulf of St. Lawrence that might pose increased risk of cetacean–vessel strikes are also shown in purple and based on Réseau d'observation de mammifères marins (2014). The Gully Marine Protected Areas (MPA) is the marked polygon. a. Northern Bottlenose Whale (*Hyperoodon ampullatus*). b. Sowerby's Beaked Whale (*Mesoplodon bidens*). c. Blainville's Beaked Whale (*Mesoplodon densirostris*). d. True's Beaked Whale (*Mesoplodon mirus*). e. Cuvier's Beaked Whale (*Ziphius cavirostris*). Figure continued on the next page.

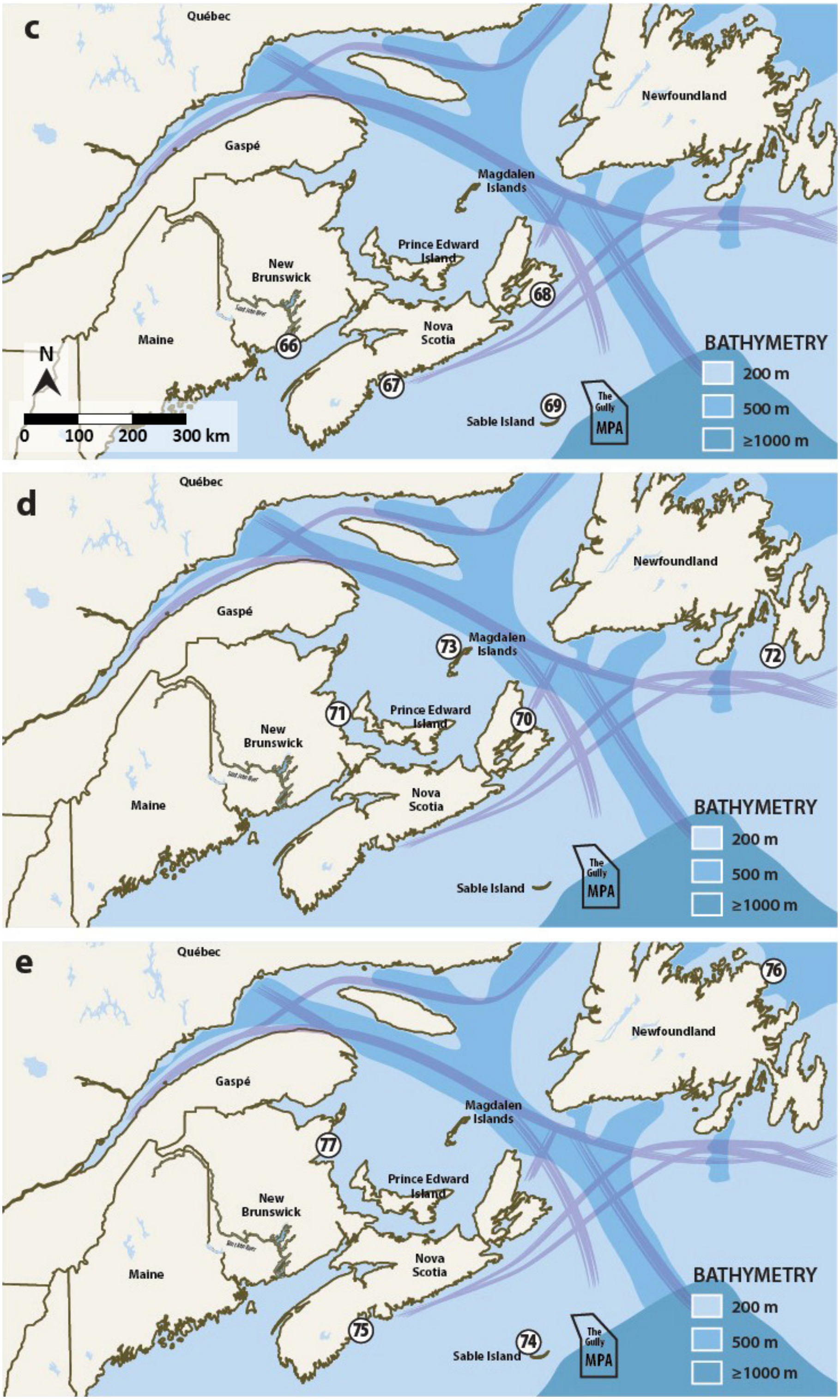

FIGURE 1. *Continued.*

sources as the most authoritative.

Ziphiid species, particularly those of the genus *Mesoplodon*, are not always easily identified. At minimum, we therefore provide confirmatory photos for stranding events, but also note the availability of museum specimens (and the nature of the material retained), necropsy reports, and published literature as confirming sources or supporting evidence for species identity. We sought to locate all ziphiid specimen material from eastern Canada deposited in public museum collections. In a few cases skeletal material has been collected from stranded ziphiids in eastern Canada but now resides in private hands or with groups or agencies that do not maintain permanent scientific collections. As this material is less accessible to the scientific community, and is likely to be even less so in the long-term, we have not included it here.

For purposes of this review we define a "stranding incident" as one or more cetaceans positioned dead or alive on the shoreline at or below high water or in water <20 m deep (atypical habitat for any ziphiid) at the same place and on the same date. Each stranding has been assigned a number consisting of 2–3 digits. Numbers have been assigned sequentially by date for each species, from the earliest to the most recent. The first 1–2 digits in the number sequence refer to the stranding incident. Because strandings may include more than a single whale, we have also assigned a fractional number to each stranded individual within an incident. The highest fractional number, paired with each whole number, records the total number of individuals comprising each stranding incident. This is usually a 1, because most strandings are single animals (e.g., 3.1 = the third stranding of a Northern Bottlenose Whale, a single male stranded 12 January 1968 on South Beach, Sable Island, NS), but some incidents include two animals. A "mass stranding incident" is defined as the (live) stranding of two or more whales (excluding female with calf pairs) at the same place and on the same date (Geraci and Lounsbury 2005). "Atypical mass stranding events", most often associated with detrimental underwater noise, include two or more whales (exclusive of female with calf pairs) found within a six-day period and spread apart along up to 74 km of coastline (D'Amico *et al.* 2009). By definition, atypical mass stranding events included multiple standing incidents. "Dead-stranded" refers to ziphiids discovered dead on the shoreline at or below high water. "Live-stranded" refers to animals that were beached alive when discovered or were observed inshore in waters <20 m deep. In several cases animals observed to live-strand were able to swim away, with their fate unknown. In other cases, these animals were discovered dead-stranded later at another location.

We also coded all stranding incidents using an incident narrative to briefly summarize the circumstances and final outcome of each stranding incident. We report some of these incidents in greater detail in the text where it contributes to a better understanding of these mortality events. We have included four incidents where ziphiids were purposely killed in inshore waters. We justify their inclusion here on the assumption there is some probability that these animals would have live or dead-stranded had they not been purposely killed. A single incident narrative may therefore include both live and dead-stranded (multiple) components, but a stranding incident includes only a single outcome (i.e., harpooned, live-stranded, shot, died on shore, dead at discovery, outcome unknown). In cases where animals are reported stranding in two provinces, this indicates either dead or live-stranding in the first province and usually a dead-stranding reported at a later date in an adjacent province. Dead-stranded animals were sometimes moved by tidal events and currents from an initial site of discovery in one province to another. Coordinates given are for the first stranding site, although information sources cited also record the final stranding site. We also emphasize that our list of eastern Canadian ziphid mortalities is not complete. Animals recorded entangled or floating dead offshore, of which there are reports (see Feyrer *et al.* [2021] and network records) are not included here.

Unfortunately, there are very limited published data available on minimum or mean total lengths at sexual maturity for ziphiids. For Northern Bottlenose Whale, males have been reported to reach maturity at 7.30 m, females at 6.00 m (Mead 1989). Age at sexual maturity is unconfirmed in Sowerby's Beaked Whale, but it appears animals may reach sexual maturity at about 4.7 m total length (MacLeod and Herman 2004). There appear to be no data on minimum or mean size at sexual maturity for True's or Blainville's Beaked Whales. Although some ziphiids display sexual size dimorphism (Pitman 2018), with females being the larger sex, sexual size dimorphism in Blainville's Beaked Whale has not been reported (MacLeod 2006). Omura *et al.* (1955) reported mean length at sexual maturity in male Cuvier's Beaked Whale as 5.5 m. For purposes of this review, a sexually mature whale (versus a sexually immature juvenile/calf) is defined based on the limited data cited above. Small whales accompanying females are considered to be calves.

When stranding incidents are attended by stranding network biologists, volunteers, or fisheries agencies, data are collected and recorded that generally include, at minimum, species identity, geographic location, date, sex, and total length, and often observations that document entanglement, other sources of injury, or aspects of natural history (i.e., reproductive state, stomach contents; Wimmer and Reid 2008). Over the past decade, stranding networks in the Atlantic region have become increasingly professionalized, with specially trained staff collecting an increasingly wide range of data and samples in support of research and facilitating the transport of carcasses to situations where they can be examined by specialists. Nonetheless, while observations recorded by stranding network staff are important, they are not a substitute for examination and necropsy by a qualified veterinary pathologist. For this review, we therefore only consider dissection by a veterinary pathologist with marine mammal experience, followed by any subsequent laboratory analysis and the filing of a formal report, to qualify as a "veterinary necropsy". This said, we also draw on information from "non-veterinary" necropsies where available (mostly reported in the annual reports of the WR&S, NL). We accessed all ziphiid veterinary necropsy reports for eastern Canada on file with the CWHC (n = 12) by searching the CWHC database under *Hyperoodon*, *Mesoplodon*, and *Ziphius*. We also received one report that was conducted prior to establishment of the CWHC partnership in 1992 (S. Hooker pers. comm. to D.F.M. 13 January 2022) and a second report undertaken by DFO scientists and biologists in the company of a veterinarian but not on file with CWHC. As we show below, relatively few veterinary necropsies have been completed on ziphiids in eastern Canada. Finally, we had eight, dermestid-cleaned, full skeletons of Northern Bottlenose Whale (n = 2), Sowerby's Beaked Whale (n = 4), and Cuvier's Beaked Whale (n = 2) from eastern Canada available to us in the collections of the NBM and these were carefully examined for signs of healed fractures indicative of past blunt force trauma, perhaps from vessel strikes.

Results

Stranding incident numbers throughout the text follow Table 1 and are keyed to Figure 1. Figures 1a–e map the geographic location of stranding incidents by species. Among those strandings documented here are the first confirmed records for Sowerby's Beaked Whale for PEI and NB, the first records of True's Beaked Whale from QC, the Gulf of St. Lawrence, and NF, and the first records of Cuvier's Beaked Whale from NB and the Gulf of St. Lawrence. Ziphiid strandings from Sable Island, NS, include the first east coast stranding for Canada of Cuvier's Beaked Whale.

All cases known to us of live and dead-stranded ziphiids in eastern Canada up to 31 December 2021 are reported in Table 1. The number of strandings reported as live-at-discovery (i.e., on shore) as a component in a stranding narrative (n = 24; 28.6%) undoubtedly underrepresents live-strandings as some animals may have stranded live, only to be first discovered and reported after death. The outcome of a live-stranding may be either a successful effort by stranding network staff to return the animal to the water, with the fate of the animal usually unknown, although an animal may live-strand again or be discovered dead-stranded at a later time. An animal in shallow water may also move into deeper water under its own power.

The first eastern Canadian ziphiid stranding incident, for a Blainville's Beaked Whale, occurred 24 February 1934 at Duck Cove, Saint John, NB (Table 1, 66.1, Figure 1c). Since then, ziphiid stranding incidents have been reported sporadically in eastern Canada, but with increasing frequency, through to our cut-off date (Figure 2). These incidents involved 37 males, 28 females, one intersex, and 18 of sex undetermined. In total, 78 incidents involving 84 individuals of five beaked whale species are documented from inshore eastern Canada. Four intentional killings occurred, one each in 1938 (70.1) and 1940 (67.1), and two in 1953 (2.1, 34.1). The first of these animals (True's Beaked Whale) was shot, the second was "captured" (Blainville's Beaked Whale), while the third (Northern Bottlenose Whale) and fourth (Sowerby's Beaked Whale) were animals harpooned by small whale hunters at Dildo Arm in Trinity Bay and Notre Dame Bay, NF, respectively. A Northern Bottlenose Whale that live-stranded at Cap Martin, QC, in 1940 was also shot on shore (1.1). Only four (4.8%) of the ziphiid strandings included here were reported to show signs of interactions with fishing gear. Likewise, only eight (9.5%) animals were reported to show signs of vessel strikes.

Figure 3 provides photo-confirmation for 36 of the 84 individual ziphiids stranded. Other incidents are represented by images or descriptions elsewhere in the literature, or by specimens deposited in museum collections. For three of the 84 strandings we were unable to find independent confirmation (e.g., news reports, published papers, photos, specimens, necropsy reports) of species identity. However, we feel confident in the species assigned based on verbal descriptions provided either by, or to, experienced marine mammalogists for two of these strandings (14.1, 23.1). The identity of the ziphiid species involved in the remaining stranding (78.1) is unknown.

There has been a noticeable increase in stranding reports of ziphiid species in eastern Canada since 2000 (Figure 2). Since 2000 inclusive, 48 individual ziphiids, involving four ziphiid species, have stranded in eastern Canada (average 2.2 stranded individuals/

Table 1. Records of ziphiid whale stranding incidents in eastern Canadian inshore waters, 1934–2021. The first one to two digits of No. are the stranding incident number. Incident numbers are arranged sequentially by date from the earliest to the most recent for each species. A final, fractional digit has been assigned to each individual whale within each stranding incident. Most stranding incidents involve only a single animal. NB = New Brunswick, NF = Newfoundland, NL =Labrador, NS = Nova Scotia, PEI = Prince Edward Island, QC = Quebec.

No.*	Location	Co-ordinates	Date	Sex	Length (m)	Incident narrative†	Source‡
Northern Bottlenose Whale (*Hyperoodon ampullatus*)							
1.1	Cap Martin, QC	47.355°N, 70.083°W	4 September 1940	Female	6.73	5, 6	Beauge (1941)
2. 1	Dildo Arm in Trinity Bay, NF	47.537°N, 53.561°W	27 July 1953	Male	6.70	3, 4	Sergeant and Fisher (1957)
3. 1	South Beach, Sable Island, NS	43.928°N, 59.978°W	12 January 1968	Male	8.70	10	Sergeant *et al.* (1970)
4. 1	Cobequid Bay, NS	45.316°N, 63.776°W	5 October 1969	Male	6.15	10	CMN[A] 42836[1,2], Case and Densmore (1970), Mitchell and Kozicki (1975)
5. 1	South Beach, Sable Island, NS	43.928°N, 59.978°W	2 February 1974	Male	8.23	10	Mitchell and Kozocki (1975)
6.1	South Beach, Sable Island, NS	43.928°N, 59.978°W	1 July 1985	Male	5.25	10	Lucas and Hooker (2000)
7. 1*	Iles de la Madeleine, QC	47.532°N, 61.709°W	8 October 1987	Female	5.48	3, 5, 8, 9	Béland (1987), Hooker (1999)
8.1	Dildo, Trinity Bay, NF	47.565°N, 53.559°W	5 September 1990	?	?	1, 2	Lien *et al.* (1990b)
9. 1	Sable Island, NS	43.928°N, 59.978°W	18 May 1992	Female	7.50	10	Lucas and Hooker (2000)
10.1*	North Sydney, NS	46.211°N, 60.199°W	8 October 1992	Male	5.94	3, 8, 10	NBM 5671, Daoust (1992)
11.1*	Montmagny, QC	46.990°N, 70.560°W	6 November 1994	Female	7.40	5, 9	Anonymous (1994/1995), Lair et Martineau (1994a), Fontaine (1995)
12.1*	St-Roch des Aulnaies, QC	46.990°N, 70.560°W	9 November 1994	Male	3.88	10	Anonymous (1994/1995), Lair et Martineau (1994b), Fontaine (1995)
13.1	Sept Iles, QC	50.206°N, 66.300°W	8 September 1997	Male	6.60	5, 9	USNM 594511, Sylvestre (1997), Figure 3.1
14.1	Makovik, NL	55.080°N, 59.169°W	? September 2002	?	?	10	Verbal only
15.1	Fortune Bay, NF	47.229°N, 55.379°W	22 July 2004	?	?	10	Figure 3.2
16.1	Culls Harbour Point, NF	48.667°N, 53.957°W	6 August 2004	Male	6.50	5, 9	NBM MA-11490
16.2	Culls Harbour Point, NF	48.667°N, 53.957°W	6 August 2004	Female	6.45	5, 9	Figure 3.3
17.1	Milltown-Head Bay d'Espoir, NF	47.928°N, 55.754°W	4 August 2005	?	?	5, 9	Ledwell and Huntington (2006)
18.1	Golden Bay, Cape St. Mary's, NF	46.827°N, 54.148°W	19 March 2007	Male	?	10	Ledwell and Huntington (2007a), Figure 3.4
19.1	Milltown-Head Bay d'Espoir, NF	47.928°N, 55.754°W	6 May 2007	Female	4.90	10	Figure 3.5
20.1	Lawn, Burin Peninsula, NF	46.939°N, 55.545°W	26 June 2007	?	6.53	10	Ledwell and Huntington (2007b), Figure 3.6
21.1	Ellen Island, Hopedale, NL	55.607°N, 60.275°W	6 September 2008	?	?	10	Figure 3.7
22.1	W of Lamaline, NF	46.784°N, 56.089°W	7 June 2011	Male	4.00–5.00	10	Figure 3.8
23.1	Mattis Point, NF	48.486°N, 58.428°W	26 June 2011	?	7.60	10	Verbal only
24.1	Prospect/ Spry Bay, NS	44.830°N, 62.580°W	6-8 October 2013	?	?	3, 12	Figure 3.9
25.1	Stephenville Crossing, NF	48.498°N, 58.439°W	~12 June 2014	?	~7.60	10	Ledwell *et al.* (2014), Figure 3.10

TABLE 1. *Continued.*

No.*	Location	Co-ordinates	Date	Sex	Length (m)	Incident narrative†	Source‡
26.1	Leamington, NF	49.344°N, 55.396°W	2 September 2016	?	?	3, 12	Figure 3.11
27.1	Harbour Mille, Fortune Bay, NF	47.579°N, 54.886°W	11 August 2019	Female	7.20	5, 9,12	Ledwell *et al.* (2020), Desforges *et al.* (2021), Figure 3.12
28.1	Sable Island, NS	43.936°N, 59.976°W	~15 March 2021	?	?	10	Figure 3.13
29.1	Boyd's Cove, NF	49.444°N, 54.660°W	16 February 2021	Female	7.30	10	Ledwell *et al.* (2021), Figure 3.14
30.1	Musgrave Harbour, NF	49.447°N, 53.941°W	7 March 2021	Male	8.35	10, 11	Ledwell *et al.* (2021), Figure 3.15
31.1*	Point-à-la-Croix, QC	48.010°N, 66.738°W	30 September 2021	Male	6.00	5, 9	Bourque (2021), Figure 3.16
31.2	Point-à-la-Croix, QC/NB	48.010°N, 66.738°W	30 September 2021	Female	~ 5.98	5, 7, 10	Figure 3.17
32.1	Mortier Bay, Marystown, NF	47.166°N, 55.148°W	1 October 2021	Male	5.90	10	Ledwell *et al.* (2021), Figure 3.18
Sowerby's Beaked Whale (*Mesoplodon bidens*)							
33.1	Chapel Arm, Trinity Bay, NF	47.527°N, 53.670°W	26 August 1952	Male	4.72	10	CMN 26484[1,2], Sergeant and Fisher (1957)
34.1	Wild Bight, Notre Dame Bay, NF	51.607°N, 55.895°W	23 September 1953	Female	4.30	3, 4	CMN 26483[1,2], Sergeant and Fisher (1957)
35. 1	Double Mer, NL	54.142°N, 58.854°W	September 1973	Female	?	10	USNM 504146[1,2], Lien and Barry (1990)
36.1	Port de Grave, Conception Bay, NF	47.510°N, 53.134°W	26 July 1984	Male	4.10	1, 2, 10	Lien, *et al.* (1984), Dix *et al.* (1986)
37.1	Carmanville, NF	49.417°N, 54.267°W	29 August 1986	?	?	3, 5, 7, 13	Lien *et al.* (1986, 1990a)
37.2	Carmanville, NF	49.417°N, 54.267°W	29 August 1986	?	?	3, 5, 7, 13	Lien *et al.* (1986, 1990a)
37.3	Carmanville, NF	49.417°N, 54.267°W	29 August 1986	?	?	3, 5, 7, 13	Lien *et al.* (1986, 1990a)
37.4	Carmanville , NF	49.417°N, 54.267°W	29 August 1986	Male	4.62	3, 5, 9	CMN 1987-143.1[1], Lien *et al.* (1986, 1990a)
38.1	Carmanville , NF	49.417°N, 54.267°W	31 August 1986	Male	4.85	3, 5, 7, 10	CMN 1987-143.3[1], Lien *et al.*(1986, 1990a)
39.1	Davidsville, NF	49.333°N, 54.433°W	31 August 1986	Male	4.95	3, 5, 7, 10	CMN 1987-143.2[2], Lien *et al.* (1986, 1990a)
40.1	Norris Arm, Bay of Exploits, NF	49.090°N, 55.271°W	15 September 1987	?	?	5, 7, 13	Lien *et al.* (1990a)
41.1	Norris Arm, Bay of Exploits, NF	49.090°N, 55.271°W	17–18 September 1987	?	4.80	3, 5, 7, 13	Lien *et al.* (1987, 1990a)
42.1	Rattling Brook, Bay of Exploits, NF	49.074°N, 55.308°W	18 September 1987	Female	4.62	3, 10	Lien *et al.*(1990a)
43.1	Seal Cove, Conception Bay, NF	47.473°N, 53.077°W	9 June 1990	Male	4.9	9	NFM MA-70[1, 4], Lien *et al.* (1990b)
44.1	Roberts Arm, NF	49.489°N, 55.807°W	23 August 1995	Male	4.50	10	NFM MA-340[1], Figure 3.19
45.1	South Beach, Sable Island, NS	43.9281°N, 59.978°W	20 June 1997	Female	4.88	10	NBM MA-18027[3], Lucas and Hooker (2000)
46.1	Port Albert, Notre Dame Bay, NF	49.543°N, 54.527°W	5–6 July 2001	Female	4.70	3, 5, 9	Ledwell *et al.* (2001), Lein *et al.* (2002)
47.1	Boyd's Cove, Notre Dame Bay, NF	49.444°N, 54.659°W	7–8 October 2001	Male	4.42	3, 5, 10	Ledwell *et al.* (2001), Lein *et al.* (2002), Figure 3.20
48.1	Western Bay, Conception Bay, NF	47.908°N, 52.980°W	15 June 2004	Female	4.79	10, 12	NBM MA-11488[1,2], Ledwell *et al.* (2005)
49.1	Forillion National Park, QC	48.970°N, 64.342°W	22 June 2006	Male	?	10	Figure 3.21

Table 1. *Continued.*

No.*	Location	Co-ordinates	Date	Sex	Length (m)	Incident narrative†	Source‡
50.1	Penouille, QC	48.849°N, 64.432°W	29 June 2006	Male	4.30	10	Figure 3.22
51.1	Kings Point, NF	49.577°N, 56.185°W	17 September 2006	Female	3.35	10, 11	NBM MA-11494[1,2], Ledwell and Huntington (2007a)
52.1	Harcourt, Trinity Bay, NF	48.198°N, 53.868°W	22 May 2008	Male	4.40	3, 10	Ledwell and Huntington (2009), Figure 3.23
53.1	South Beach, Sable Island, NS	43.927°N, 59.949°W	3 June 2011	Male	4.55	10	Figure 3.24
54.1*	NNW of North Rustico, PEI	46.497°N, 63.349°W	5 June 2013	Male	4.76	10, 12	NBM-MA-12438[1,2], Daoust (2013)
55.1*	Îles aux Pommes, QC	48.106°N, 69.322°W	3 July 2013	Male	4.69	10	Lair *et al.* (2013), Figure 3.25
56.1	South Beach, Sable Island, NS	43.927°N, 59.949°W	17 June 2014	Female	2.12	10	Figure 3.26
57.1	Fogo, Fogo Island, NF	49.715°N, 54.269°W	21 July 2015	Female	4.67	3, 5, 10	Ledwell *et al.* (2015), Figure 3.27
58.1	Mira Gut, NS	46.054°N, 59.902°W	21 April 2016	Male	3.96	10	NSM[E] 78307[1,2]
59.1*	Gaspesie/Escuminac, QC/NB	48.113°N, 66.485°W	13 June 2016	Male	4.75	10	NBM MA-16530[1,3,4], Daoust (2016a)
60.1*	North Sydney, NS	46.210°N, 60.199°W	23 October 2016	Female	4.82	5, 7, 10	NBM MA- 16536[1,2,,3], Daoust (2016b)
61.1*	Sable Island, NS	43.935°N, 60.019°W	6 April 2017	Male	4.18	10	NBM MA-18143[1,3,4], Bourque (2017a), Figure 3.28
62.1*	Sable Island, NS	43.934°N, 59.915°W	13 May 2017	Female	4.72	10	NBM MA-19234[1,2,3], Bourque (2017b), Figure 3.29
63.1	Sable Island, NS	43.934°N, 59.915°W	12 January 2018	Male	3.90	5, 8, 9	Figure 3.30
64.1	Rivière-au-Tonnerre, QC	50.273°N, 64.770°W	17 September 2018	Female	4.60	10	Figure 3.31
65.1	Notre-Dame-des-Sept-Douleurs, QC	48.001°N, 69.464°W	26 August 2019	?	?	3, 5, 7, 13	Figure 3.32
Blainville's Beaked Whale (*Mesoplodon densirostris*)							
66.1	Duck Cove, NB	45.243°N, 66.091°W	24 February 1934	Male	4.60	10	McAlpine and Rae (1999)
67.1	Peggy's Cove, NS	44.493°N, 63.918°W	4 February 1940	Male	4.39	3, 6	AMNH[F] M-139931[1,2], Raven (1942)
68.1	Fourchu Bay, Cape Breton, NS	45.7227°N, 60.239°W	December 1968	Male	?	10	Sergeant *et al.* (1970)
69.1	Sable Island, NS	43.934°N, 59.915°W	26 November 1999	Female	4.40	10	NBM MA-18882[1]
True's Beaked Whale (*Mesoplodon mirus*)							
70.1	South Gut, St. Anne's Bay, NS	46.296°N, 60.542°W	5 August 1938	Female	5.03	3, 6	MCZ[G] 37274[1], Allen (1939)
71.1	Saint-Thomas-de-Kent, NB	46.435°N, 64.628°W	28 September 1993	Female	4.80	10	McAlpine and Rae (1999), Figure 3.33
72.1*	Point Lance, NF	46.809°N, 54.086°W	7 February 2015	Female	4.60	10, 12	Ledwell *et al.* (2015), Figure 3.34
73.1	Pointe-aux-Loups, Iles de la Madeleine, QC	47.532°N, 61.709°W	13 October 2017	Female	5.20	10	NBM MA-18276[2], Figure 3.35
73.2	Pointe-aux-Loups, Iles de la Madeleine, QC	47.532°N, 61.709°W	13 October 2017	Intersex	2.7	10	NBM MA-18280[1], Einfeldt *et al.* (2019a,b)

TABLE 1. *Continued.*

No.*	Location	Co-ordinates	Date	Sex	Length (m)	Incident narrative†	Source‡
Cuvier's Beaked Whale (*Ziphius cavirostris*)							
74.1	South Beach, Sable Island, NS	43.927°N, 59.949°W	3 May 2000	Female	5.60	10	NBM-MA-18883[1], Naughton (2012)
75.1*	Blanford, NS	44.493°N, 64.109°W	7 February 2016	Male	4.85	5, 9, 12	NBM MA-16513[1,2,3,4], Daoust (2016c)
76.1	Lumsden, NF	49.301°N, 53.600°W	24 July 2018	Female	5.67	10	Figure 3.36
77.1*	Val Comeau, NB	47.456°N, 64.877°W	9 December 2019	Male	5.50	10, 12	NBM MA-18233[1,2,3,4,6], Bourque (2019)
Unidentified ziphiid							
78.1	Bona vista, NF	48.651°N, 53.119°W	5 August 1989	?	?	10	Lien *et al.* (1990c)

*Veterinary necropsy performed.
†Incident narrative: 1. Live entanglement in fishing gear. 2. Successfully released from gear. 3. Observed live inshore. 4. Harpooned. 5. Live on shore at discovery. 6. Shot. 7. Rescued and released. 8. Attempted rescue. 9. Died on shore. 10. Dead at discovery. 11. Evidence of possible gear entanglement. 12. Evidence of possible ship strike. 13. Outcome unknown.
‡Source: [A]Canadian Museum of Nature; [B]New Brunswick Museum; [C]United States National Museum; [D]Newfoundland Museum; [E]Nova Scotia Museum; [F]American Museum of Natural History; [G]Museum of Comparative Zoology; [1]skull, [2]post-cranial, [3]frozen/dried tissue, [4]anatomical, [5]stomach contents, [6]parasites.

year). In comparison, there were only 36 individual strandings documented from 1934 to 1999 inclusive (average 0.55 individual stranded ziphiids/year).

Simultaneous ziphiid strandings of multiple individuals in eastern Canada are rare. Among the 78 incidents involving 84 individuals we report, there are only two cases of female with calf strandings: two incidents three days apart for Northern Bottlenose Whale where a calf stranded after the female (11.1, 12.1) and one incident for True's Bottlenose Whale (73.1, 73.2). A calf that is not known to have stranded, was also reported in the company of a female True's Bottlenose Whale that ultimately stranded at Point Lance, NF (72.1). A further two incidents encompass mass strandings of ziphiid pairs, both involving adult female–juvenile male Northern Bottlenose Whale (16.1, 16.2 and 31.1, 31.2), the latter occurring in the Gulf of St. Lawrence. Six incidents appear to qualify as two atypical mass strandings. The first atypical mass stranding is a remarkable event involving six Sowerby's Beaked Whales (37.1, 37.2, 37.3, 37.4, 38.1, 39.1) that stranded at two sites across about 35 km of coast over three days. Three of the animals were sexed as mature males. Unfortunately, the sex and length of the remaining animals is unknown. The second atypical mass stranding involves three Sowerby's Beaked Whales (40.1, 41.1, 42.1) that stranded at two sites about 2 km apart over a three- to four-day period.

A summary of the results of stranding incidents by species follows, with comments on seasonality, sex and age, and cause of death. We note where cause of death data are drawn from a non-veterinary necropsy report. All of these non-veterinary reports included valuable information. Otherwise, details provided and conclusions drawn are based on veterinary reports as defined above. Unfortunately, few veterinary necropsies have been performed on those ziphiids stranded in eastern Canada ($n = 14$), so detailed investigations on cause of death are often limited.

Annotated Species Accounts

Northern Bottlenose Whale

There have been 32 Northern Bottlenose Whale stranding incidents involving 34 individuals in eastern Canadian waters (Figure 1a, Table 1: 1.1 to 32.1), including six incidents (seven animals) in the Gulf of St. Lawrence. Nineteen Northern Bottlenose Whale stranding incidents (involving 21 animals) have occurred since 2002 inclusive, with two incidents in NL (14.1, 21.1) and one (involving two animals) reported from the Gulf of St. Lawrence (31.1, 31.2).

Seasonality—Eastern Canadian strandings of Northern Bottlenose Whale have occurred in all months of the year except April and December. However, there

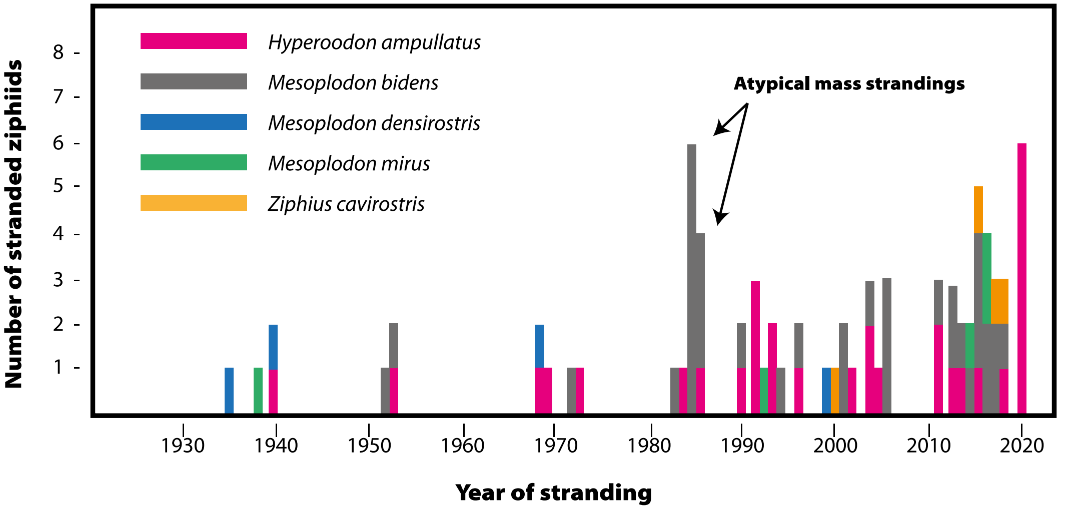

FIGURE 2. Yearly frequency of ziphiid whale stranding incidents from the inshore waters of eastern Canada by species (Northern Bottlenose Whale [*Hyperoodon ampullatus*], Sowerby's Beaked Whale [*Mesoplodon bidens*], Blainville's Beaked Whale [*Mesoplodon densirostris*], True's Beaked Whale [*Mesoplodon mirus*], and Cuvier's Beaked Whale [*Ziphius cavirostris*]), 1934–2021.

is a decided trend, with stranding incidents concentrated (62.5%) in the summer–early autumn period from July to October.

Sex and age—Fourteen males, nine females, and 11 of sex undetermined have stranded. Among strandings of known sex (n = 23) there are three adult males (13.0%), 11 juvenile males (47.8%), seven adult females (30.4%), and two juvenile females (8.7%). Most strandings incidents were single animals (87.5%) but there were two strandings of an adult female with a juvenile male (16.1, 16.2 and 31.1, 31.2), plus a single mother-male calf pair (11.1 and 12.2).

Cause of death—Five eastern Canadian strandings of this species have undergone veterinary necropsies (7.1, 10.1, 11.1, 12.1, and 31.1). Three animals were judged to be in good nutritional condition (7.1, 11.1, 12.1) and one was reported to be in "adequate" nutritional condition (10.1). In four of the animals cause of death was reported to be undetermined (7.1, 11.1, 12.1, and 31.1) and in one attributed to "mishap" associated with shallow water (10.1). Animal 10.1 was free-swimming in inshore waters for nine days before an attempt was made to harness the whale and tow it to deeper water. The animal escaped but was found dead-stranded two days later, with the veterinary report speculating that direct cause of death may have been related to capture myopathy. The first stomach compartment of one animal (7.1) contained an abundance of plastic and the veterinary report implied this might have been related to the death of this whale.

Details on four non-veterinary necropsies for Northern Bottlenose Whale were available to us (27.1, 29.1, 30.1, and 32.1). For 29.1, 30.1, and 32.1 cause of death is "unknown", but signs of a possible ship strike were reported for 27.1 (bruising, scarring, broken left nasal bone). The animal was emaciated and the stomach contained plastic debris, along with cod (gadoid) and squid remains (Ledwell *et al.* 2020). Necropsy revealed a ball of rope in the stomach of 30.1 (Ledwell *et al.* 2021). This animal showed signs of scarring believed to be the result of past entanglement in fishing gear.

Examination of the skeletons of NBM-MA-5671 (10.1) and 11490 (16.1) for healed fractures revealed a smooth bony callus surrounding a chronic malunion fracture and a fracture to a dorsal vertebral process of a thoracic vertebra in NBM-MA-11490, but no evidence of fractures in NBM-MA-5671.

Sowerby's Beaked Whale

Many of the 33 eastern Canadian stranding incidents involving 36 Sowerby's Beaked Whales are reported from eastern NF (33.1 to 65.1; 17 incidents involving 21 animals); others have been reported from QC and the Maritime provinces, including Sable Island (Figure 1b). Incidents from near North Rustico, Queens County, PEI (54.1) and near Campbellton (Richardsville), Restigouche County, NB (59.1) are the first confirmations for Sowerby's Beaked Whale for these provinces. A Sowerby's Beaked Whale found dead at Seal Cove Conception Bay, NF, 9 June 1990 (43.1) is reported in the literature (see

FIGURE 3. Images confirming the identity of ziphiid whale stranding incidents from the inshore waters of eastern Canada, 1934–2021. Dates given are stranding dates, not necessarily dates images were taken, and stranding incidents are as identified in Table 1. **Northern Bottlenose Whale (*Hyperoodon ampullatus*). 1.** Sept Illes, Quebec [QC], 8 September 1997 (Table 1: 13.1). Photo: J.-P. Sylvestre. **2.** Fortune Bay, Newfoundland [NF], 22 July 2004 (Table 1: 15.10). Photo: unknown/WR&S [Whale Release & Strandings Group]. **3.** Culls Harbour, Samson Point, NF, 6 August 2004 (Table 1: 16.2). Photo: W. Ledwell/WR&S. **4.** Golden Bay, Cape St. Mary's, NF, 19 March 2007 (Table 1: 18.2). Photo: T. Power. **5.** Milltown-Head, Bay d'Espoir, NF, 6 May 2007 (Table 1: 19.1). Photo: W. Ledwell/WR&S. **6.** Lawn, Burin Peninsula, NF, 26 June 2007 (Table 1: 20.1). Photo: W. Ledwell/WR&S. Figure continued on the next page.

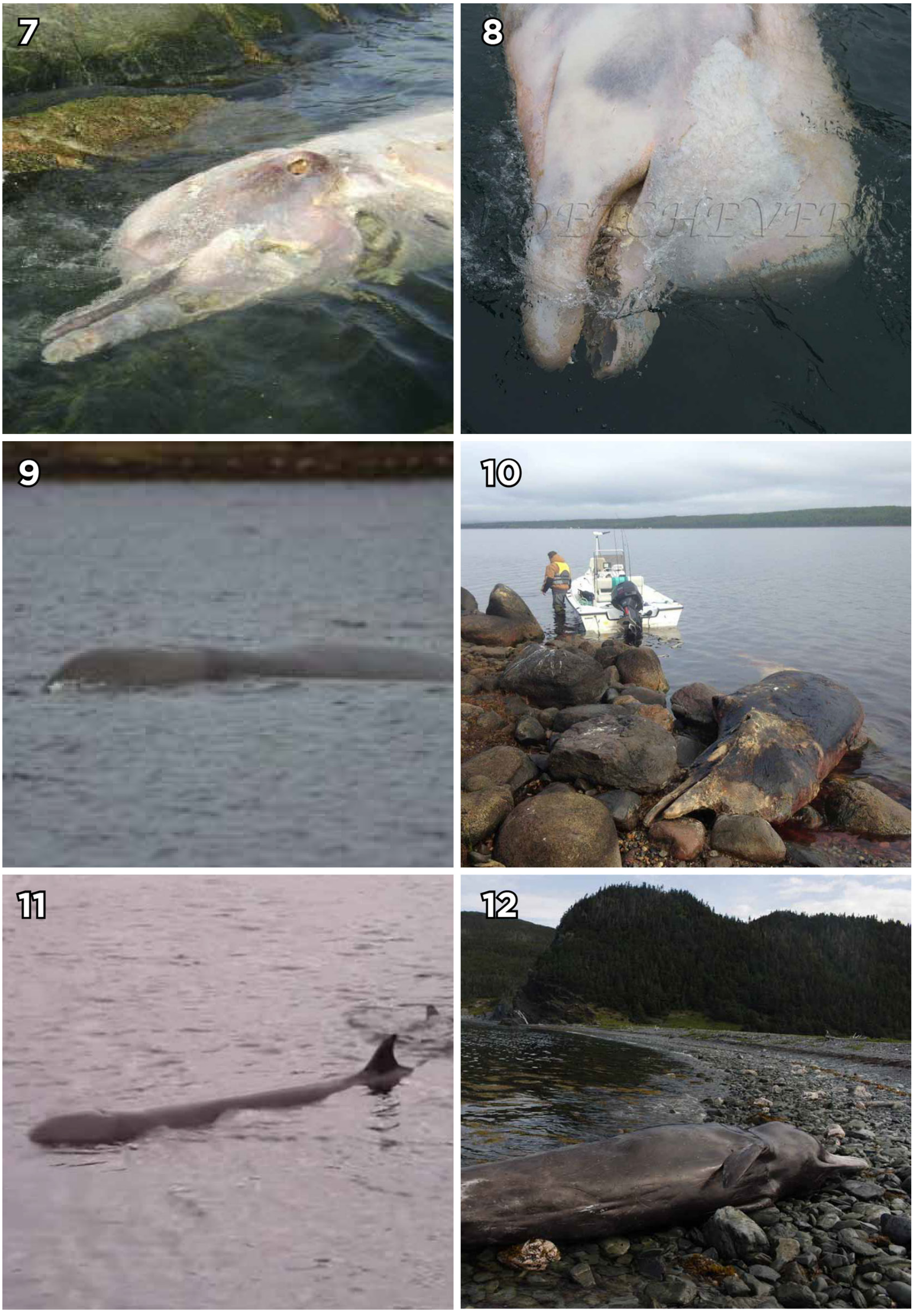

Figure 3. *Continued*. **Northern Bottlenose Whale (*Hyperoodon ampullatus*). 7.** Ellen Island, Hopedale, Labrador [NL], 6 September 2008 (Table 1: 21.1). Photo: F.P. Boase. **8.** W of Lamaline, NF, 7 June 2011 (Table 1: 22.1). Photo: G. Detcheverry. **9.** Prospect-Spry Bay, Nova Scotia [NS], 6–8 October 2013 (Table 1: 24.1). Photo: MARS [Marine Animal Response Society]. **10.** Stephenville Crossing, NF, ~12 June 2014 (Table 1: 25.1). Photo: Perry Bennett/Department of Fisheries and Oceans Canada [DFO]. **11.** Leamington, NF, 2 September 2016 (Table 1: 26.1). Photo: unknown/WR&S. **12.** Harbour Mille, Fortune Bay, NF, 24 July 2019 (Table 1: 27.1). Photo: W. Ledwell/WR&S.

FIGURE 3. *Continued*. **Northern Bottlenose Whale (*Hyperoodon ampullatus*). 13.** Sable Island, NS, ~15 March 2021 (Table 1: 28.1). Photo: Z.N. Lucas. **14.** Boyd's Cove, NF, 16 February 2021 (Table 1: 29.1). Photo: W. Ledwell/WR&S. **15.** Musgrave Harbour, NF, 9 March 2021 (Table 1: 30.1). Photo: W. Ledwell/WR&S. **16.** Point-à-la-Croix, QC, 30 September 2021 (Table 1: 31.1). Photo: A. François. **17.** Point-à-la-Croix, QC/New Brunswick [NB], 30 September 2021 (Table 1: 31.2). Photo: M. Guitard. **18.** Mortier Bay, Marystown, NFL, 1 October 2021 (Table 1: 32.1). Photo: W. Ledwell/ WR&S.

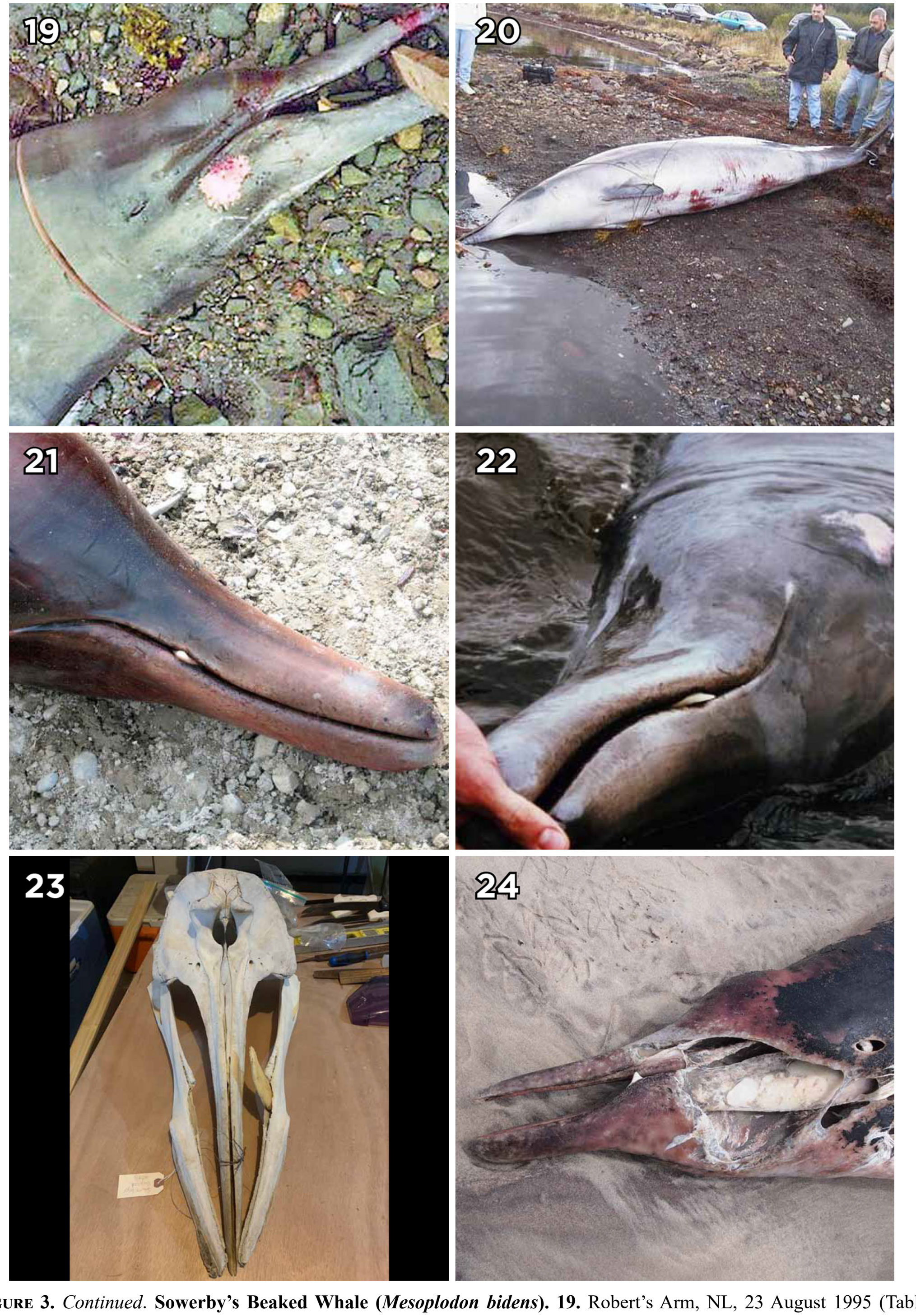

Figure 3. *Continued*. **Sowerby's Beaked Whale (*Mesoplodon bidens*). 19.** Robert's Arm, NL, 23 August 1995 (Table 1: 44.1). Photo: unknown/J. Maunder. **20.** Boyd's Cove, Notre Dame Bay, NF, 7–8 October 2001 (Table 1: 47.1). Photo: unknown. **21.** Forillion National Park, QC, 22 June 2006 (Table 1: 49.1). Photo: D. Boily. **22.** Penouille, QC, 29 June 2006 (Table 1: 50.1). Photo: Maurice Lamontagne Institute. **23.** Harcourt, Trinity Bay, NF, 22 May 2008 (Table 1: 52.1). Photo: unknown/WR&S. **24.** South Beach, Sable Island, NS, 3 June 2011 (Table 1: 53.1). Photo: Z.N. Lucas.

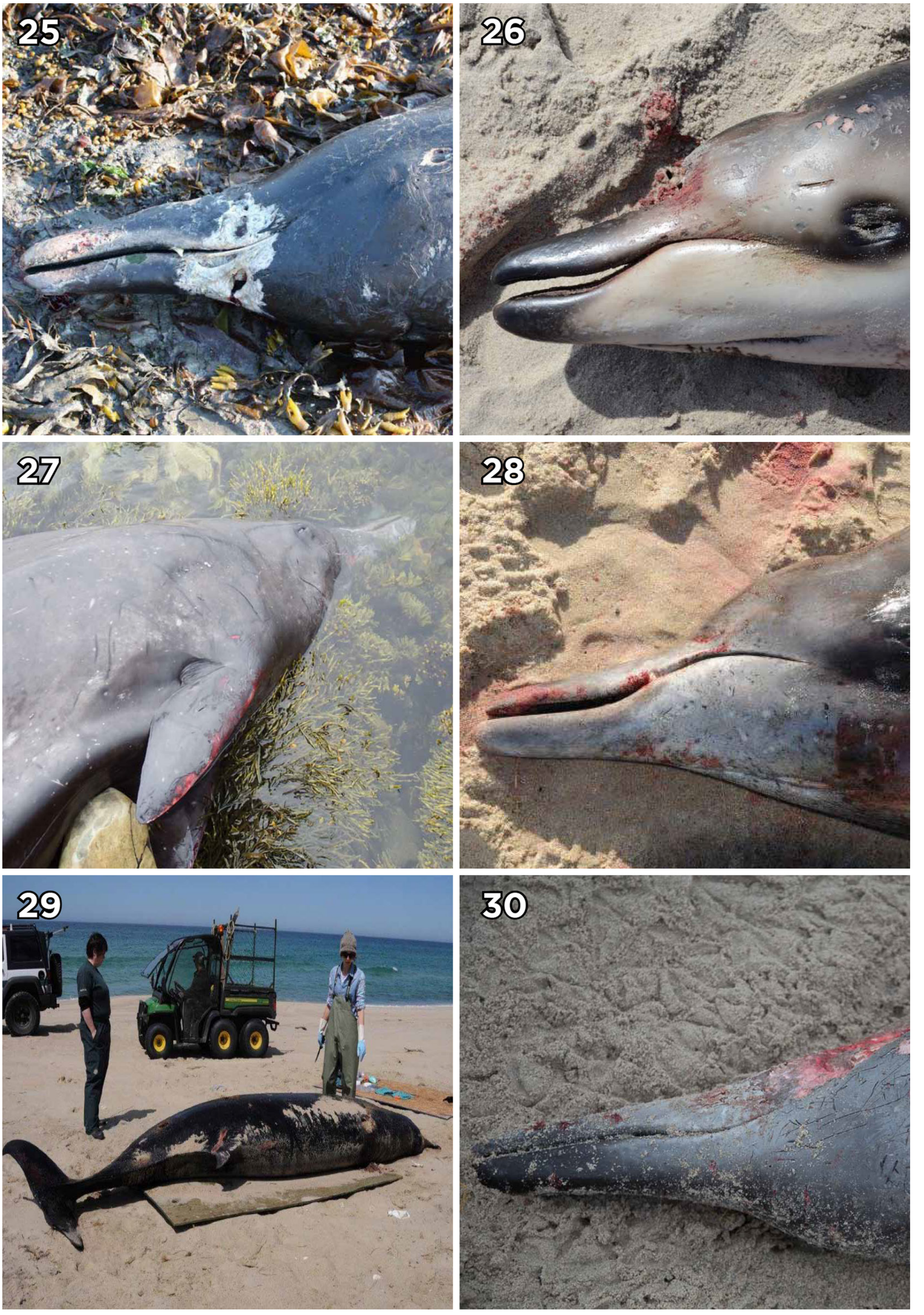

FIGURE 3. *Continued*. **Sowerby's Beaked Whale (*Mesoplodon bidens*). 25.** Îles aux Pommes, QC, 3 July 2013 (Table 1: 55.1). Photo: S. Lair. **26.** South Beach, Sable Island, NS, 17 June 2014 (Table 1: 56.1). Photo: Z.N. Lucas. **27.** Fogo, Fogo Island, NF, 21 July 2015 (Table 1: 57.1). Photo: unknown/WR&S. **28.** Sable Island, NS, 6 April 2017 (Table 1: 61.1). Photo: G. Stroud. **29.** Sable Island, NS, 13 May 2017 (Table 1: 62.1). Photo: G. Stroud. **30.** Sable Island, NS, 12 January 2018 (Table 1: 63.1). Photo: D. Lidgard.

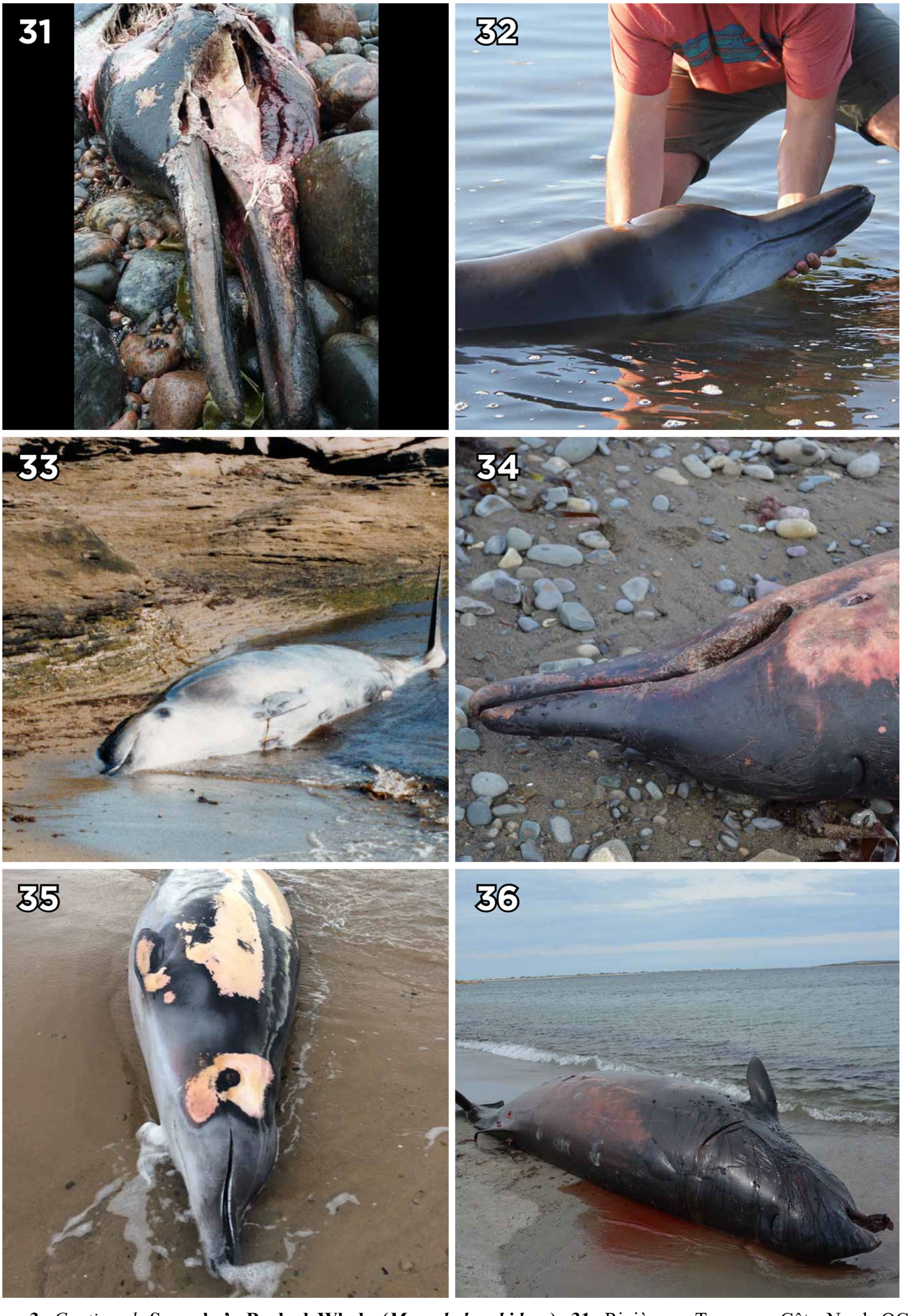

Figure 3. *Continued*. **Sowerby's Beaked Whale (*Mesoplodon bidens*). 31.** Rivière-au-Tonnerre, Côte Nord, QC, 17 September 2018 (Table 1: 64.1). Photo: S. Pagès. **32.** Notre-Dame-des-Sept-Douleurs (Bout-d'en-Haut), QC, 26 August 2019 (Table 1: 65.1). Photo: L. Newbury. **True's Beaked Whale (*Mesoplodo mirus*). 33.** Saint-Thomas-de-Kent, NB, 28 September 1993 (Table 1: 71.1). Photo: B. Boulianne. **34.** Point Lance, NF, 7 February 2015 (Table 1: 72.1). Photo: DFO. **35.** Pointe-aux-Loups, Iles de la Madeleine, QC, 13 October 2017 (Table 1: 73.1). Photo: C. Bourque. **Cuvier's Beaked Whale (*Ziphius cavirostris*). 36.** Lumsden, NF, 24 July 2018 (Table 1: 76.1). Photo: unknown/WR&S.

Sources in Table 1) as female. However, the stated sex of this animal is in error. The skull, now housed in The Rooms Corporation of Newfoundland and Labrador, is male, and correspondence from the Lien Lab to then Newfoundland Museum curator John Maunder (N. Dejan-Chekar/J. Maunder pers. comm. to D.F.M. 22 February 2022) identifies the stranding as that of a male. We have recorded the sex as male (Table 1: 43.1).

Seasonality—Strandings of Sowerby's Beaked Whale have occurred almost exclusively April through October (97.2% of individuals) with only a single stranding outside this period, in January. There is a preponderance of strandings from June through September (77.8% of individuals).

Age and sex—Among 28 animals of known sex *and* total length, there are 17 males (60.7%) and 11 females (39.2%), of which 58.8% and 54.5%, respectively, are judged to be sexually immature.

Cause of death—Six of 35 Sowerby's Beaked Whale stranded in eastern Canada have been subjected to veterinary necropsies. Five of these animals were judged to be in good nutritional condition (54.1, 55.1, 59.1, 61.1, and 62.1), while one, a mature female (60.1), was reported to be in moderate nutritional condition. The final diagnosis for this latter animal included pneumonia and acute trauma (fracture of the caudal region of both jaws). The degree of inflammation of the right lung suggested that the pneumonia may have pre-dated stranding. Cause of death for the remaining veterinary necropsies of Sowerby's Beaked Whale have been reported as undetermined. Incidents 37.1 to 37.4; 38.1 and 39.1; and 40.1, 41.1, and 42.1 are here reported as three atypical mass strandings events (originally reported as mass strandings by Lien *et al.* 1990a) that occurred in eastern NF in August 1986 and September 1987. While it is not known why these whales were in nearshore waters, the steeply sloped and highly indented NF shoreline may have confused these normally deep water animals and been the primary cause of their stranding. However, it is noteworthy that the animals of incidents 37.1 to 37.4, 38.1, and 39.1 were reported to move erratically, one of them colliding repeatedly with a wharf and the hull of a moored ship in the days prior to stranding. Unfortunately, the animals did not undergo veterinary necropsies and no cause of death could be determined.

For two Sowerby's Beaked Whale that underwent veterinary necropsies, computed tomographic (54.1, from the Gulf) and magnetic resonance imagery (62.1, from Sable Island) of the auditory bullae showed no evidence of fractures or intracranial haemorrhage that might be associated with exposure to high amplitude underwater noise.

Entrapment in fishing gear has been reported for one Sowerby's Beaked Whale (36.1) and a second animal showed signs of entanglement (51.1, not a veterinary necropsy). Although a Sowerby's Beaked Whale that stranded in Conception Bay, NF (48.1) showed no external evidence of trauma, a non-veterinary necropsy suggested that fractures to the right jaw, five ribs, and the rostrum, as well as internal haemorrhaging prior to death, indicated a ship strike. A non-veterinary necropsy of a fresh carcass stranded at Trinity Bay, NF (52.1), found no evidence of entanglement in fishing gear or trauma and cause of death was undetermined. A non-veterinary necropsy reported a plastic bottle cap in the gut of a Sowerby's Beaked Whale that live-stranded at Fogo Island, NF (57.1). A veterinary necropsy of a Sowerby's Beaked Whale (54.1) detected previous fractures of two right ribs and possibly the dorsal processes of three thoracic vertebrae. This was confirmed during examination of the skeleton of NBM MA-12438 (54.1; Figure 4a). Skeletons NBM MA-16530 (59.1), 16536 (60.1), and 18143 (61.1) showed no evidence of fractures.

Blainville's Beaked Whale

Four incidents, one animal per incident, have been reported since 1934 (Table 1: 66.1 to 69.1), none of which have occurred in the Gulf of St. Lawrence

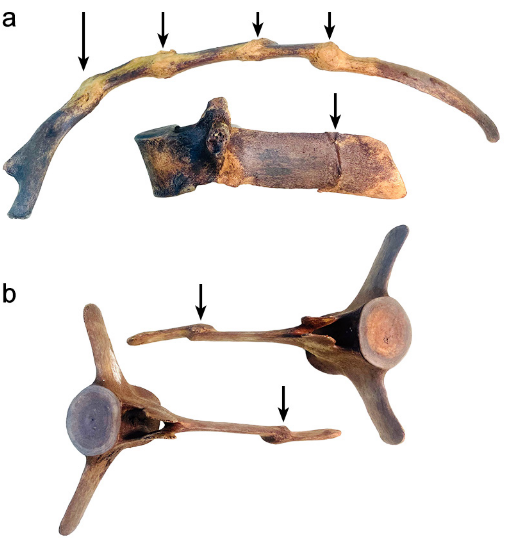

FIGURE 4. Healed skeletal fractures in ziphiid whales stranded in eastern Canada, possibly the result of past vessel collisions. Arrows mark fracture sites. a. Sowerby's Beaked Whale (*Mesoplodon bidens*) NBM- MA-12438 (see Table 1: 54.1), showing a fractured and healed rib and a healed fracture of the dorsal process of a thoracic vertebra. b. Cuvier's Beaked Whale (*Ziphius cavirostris*), NBM-MA-16513 (see Table 1: 75.1), showing healed fractures of the dorsal processes of two thoracic vertebrae. Photos: D.F. McAlpine.

(Figure 1c). The tooth and part of the left mandible were collected from the Forchu Bay, NS, animal (68.1); the tooth is illustrated in Sergeant *et al.* (1970). Efforts to locate these samples have been unsuccessful. The reported length for the animal is estimated at 18–20 feet (5–5.6 m), but this is certainly an overestimate because this exceeds the published maximum length of 4.7 m (Pitman 2018). Although we have reported length for this whale as unknown (Table 1), it is clear that this was an adult.

Seasonality—There are four eastern Canadian stranding incidents, including a "capture" and one animal shot, all during the winter months from November to February.

Age and sex—The three males and one female are believed to be adults. The reported total length for three of the animals ranged from 4.39 to 4.6 m.

Cause of death—The 1940 record from Peggy's Cove, NS (67.1), is one of four beaked whales reported here that were intentionally killed in inshore waters, rather than found stranded. This animal was shipped frozen and whole to the American Museum of Natural History where it was dismembered. The animal was reported as "old" and extremely thin. None of the remaining three Blainville's Beaked Whale involved in the eastern Canadian stranding incidents (66.1, 68.1, and 69.1) was necropsied, so cause of death is unknown.

True's Beaked Whale

Only four incidents involving five True's Beaked Whale (four females, one intersex) have occurred in eastern Canada up to December 2021 (Figure 1d, Table 1: 70.1 to 73.2). One incident (73.1, 73.2), involving an adult female and an intersex juvenile, occurred on Iles de la Madeleine in the Gulf of St. Lawrence in 2017. A ziphiid stranded at Saint-Thomas-de-Kent, NB, in the Gulf of St. Lawrence, 28 September 1993 (71.1) was originally reported as a Sowerby's Beaked Whale. Unfortunately, this animal was buried before it could be conclusively identified and is documented only on the basis of photographs now on file with the NBM (Figure 3.33). On the basis of head shape, jaw line, and distinctive light colouration, we now believe this animal to be True's Beaked Whale and provisionally report this specimen here as such, the only record for this species from the NB coast. Subsequently, a 1023 kg female True's Beaked Whale dead stranded at Point Lance, NF, on 7 February 2015 (72.1; Figure 3.34). A veterinary necropsy determined the animal had a postpartum uterus and was lactating. A *Mesoplodon* sp., assumed to be the same individual, was reportedly seen in the area, with what is presumed to be a calf, several weeks earlier.

Seasonality—Strandings have occurred from late summer (August) through the autumn (September–October) to winter (February), but there are too few records to determine if the lack of spring or summer strandings is meaningful.

Age and sex—Five individuals, include four adults/juveniles of 4.6–5.2 m total length and an intersex calf of 2.7 m.

Cause of death—The previous most northerly record for the western North Atlantic for True's Beaked Whale was an animal purposely killed in Saint Anne's Bay, Cape Breton, NS, in 1938 (70.1). The only eastern Canadian veterinary necropsy undertaken on this species, the animal discovered on the shore at Point Lance, NF (72.1), found evidence of a possible ship strike (ribs broken prior to death).

Cuvier's Beaked Whale

The four eastern Canadian records for this species have all occurred since 2000 (Figure 1e, Table 1: 74.1 to 77.1). A 5.6 m female that stranded 3 May 2000 on Sable Island, NS, is the first eastern Canadian stranding for the species (74.1). A 4.85 m live-stranded male near Blandford, NS, on 7 February 2016 (75.1) is the first mainland eastern Canadian stranding.

Seasonality—Two of the four eastern Canadian strandings occurred in winter (February, December), one in spring (May), and one in summer (July), too few to indicate any seasonality.

Sex and age—Strandings comprise two males and two females, ranging in length from 4.85 to 6.67 m. The shortest eastern Canadian animal (75.1), a male, was identified at veterinary necropsy as immature based on total length. This is supported by a testis length in this animal of 12.5 cm, which is much shorter than the few testes lengths reported for mature animals (Heyning 1989). The other three eastern Canadian strandings are considered adult based on total length. Unfortunately, no eastern Canadian females have been necropsied.

Cause of death—There have been two veterinary necropsies of eastern Canadian strandings of this species (75.1 and 77.1). Both animals were determined to be in good nutritional condition. Both also showed evidence of severe arterial sclerosis, a condition in Cuvier's Beaked Whale associated with infection with the renal parasite *Crassicauda* sp.; however, in neither of the eastern Canadian animals was the parasite judged to be the cause of death. Cause of death in both animals was undetermined, although one (77.1) showed significant trauma to the head, suggesting a possible ship strike. Examination of the skeletons of NBM MA-16513 (75.1) and 18233 (77.1) showed healed fractures of the dorsal processes of two thoracic vertebrae in NBM MA-16513 (Figure 4b), but no evidence of fractures in NBM MA-18233.

Discussion

As one of the least known cetacean families, understanding the biology and ecology of ziphiid species is fundamental to ensuring their protection, particularly from human-caused disturbance, harm, and mortality (Hooker *et al.* 2019). In eastern Canada, much of what is known about ziphiid whales comes from investigations of stranding incidents involving dead or distressed animals. The only exceptions are the well-studied Northern Bottlenose Whale population occupying the Scotian Shelf (Wimmer and Whitehead 2004; Dalebout *et al.* 2006; Whitehead and Hooker 2012; O'Brien and Whitehead 2013; Feyrer 2021) and those ziphiids monitored via acoustic means (e.g., Stanistreet *et al.* 2017; Delarue *et al.* 2018) in the region.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assessed the Scotian Shelf population of Northern Bottlenose Whale as Endangered (COSEWIC 2011) and the species is listed as such under the Canadian *Species at Risk Act* (SARA; SARA Registry 2023a). The population, estimated at 174 individuals (Feyrer 2021), is considered to have a limited geographic range (Wimmer and Whitehead 2004; Dalebout *et al.* 2006) and is genetically distinct from the more northern Davis Strait-Baffin Bay-Labrador Shelf population (Feyrer *et al.* 2019). However, the boundary between these two populations is not well understood, especially as sightings are nearly continuous along the continental shelf from the Scotian Shelf to NL (COSEWIC 2011). The Davis Strait-Baffin Bay-Labrador Shelf population was assessed as Special Concern by COSEWIC (2011) but is not listed under SARA (SARA Registry 2023b). Recently, a concentration of bottlenose whales was discovered off eastern NF (Feyrer *et al.* 2019). Efforts should be made to sample future eastern Canadian strandings of this species for genetic analysis to confirm the source of stranded animals.

Northern Bottlenose Whale and Sowerby's Beaked Whale have been documented visually and acoustically in the deeper waters along the continental shelf and shelf break off NS, around the Grand Banks to northern NF and, in the case of Northern Bottlenose Whale, also into Davis Strait and Baffin Bay (MacLeod 2000, 2006; Whitehead and Hooker 2012; O'Brien and Whitehead 2013; Whitehead 2013; Stanistreet *et al.* 2017; Delarue *et al.* 2018; COSEWIC 2019). Not surprisingly, these two species comprise more than 80% of all individual ziphiids reported stranded from eastern Canada to date.

Sowerby's Beaked Whale was first designated Special Concern by COSEWIC in 1989 (COSEWIC 2019) and in 2011 was listed as Special Concern under SARA (SARA Registry 2023c). Since about 2000, there has been a dramatic increase in the number of sightings of Sowerby's Beaked Whale in The Gully Marine Protected Area and associated canyons at the edge of the Scotian Shelf (Whitehead 2013). Although the occurrence of these species in the region should not be considered unusual, their occurrence in nearshore waters, particularly in the Gulf of St. Lawrence, is certainly atypical behaviour, considering their dependence on deep water habitat.

Blainville's Beaked Whale and True's Beaked Whale appear to reach their northern range limit in the western North Atlantic (MacLeod 2000, 2006), which would account for apparent rarity in our study area. Both species have been assessed as Not at Risk in Canada by COSEWIC (SARA Registry 2023d,e) but these assessments (Houston 1990a,b) are now more than three decades old. Virtually nothing is known about the natural history of True's Beaked Whale. The species was believed to also be present in the southern hemisphere until Carroll *et al.* (2021) identified that population as a distinct species. All eastern Canadian strandings of True's Beaked Whale have occurred north and northeast of the few identified acoustic detections for this species that were recorded with a ship-towed hydrophone array off George's Bank (DeAngelis *et al.* 2018). Due to overlap in acoustic properties with Gervais Beaked Whale, published studies have yet to evaluate the presence of True's Beaked Whale in Canadian waters (e.g., Martin *et al.* 2017; Stanistreet *et al.* 2017).

Although stranding incidents involving Cuvier's Beaked Whale in the region are rare, acoustic monitors have detected the low, but consistent, presence of Cuvier's Beaked Whale in the deeper waters of the Gully Marine Protected Area, off NS, during 2012–2016 (Martin *et al.* 2017; Stanistreet *et al.* 2017), along the Scotian Shelf, the Grand Banks, and off eastern NF (Delarue *et al.* 2018). As few Cuvier's Beaked Whale have been observed along the Scotian Shelf (Whitehead 2013), Stanistreet *et al.* (2017) suggested the species may not have been historically present in the Gully and that recent acoustic data may reflect a trend towards increasing presence of this elusive and vessel-shy species in this habitat. Cuvier's Beaked Whale was assessed as Not at Risk in Canada by COSEWIC in 1990 (SARA Registry 2023f) but this was prior to the presence of any Atlantic Canadian reports for the species, all of which have occurred since 2000. Currently Cuvier's Beaked Whale is a mid-priority candidate for reassessment (COSEWIC 2024). In Canada, strandings for Cuvier`s Beaked Whale are far more frequent on the Pacific coast than the Atlantic (MacLeod *et al.* 2006; Naughton 2012).

Records suggest that prior to about 2005 ziphiid stranding incidents in eastern Canada occurred primarily in eastern NF and most frequently involved Sowerby's Beaked Whale. However, consistent response networks and reporting hotlines for QC and the Maritime provinces were not in place until the early 2000s, unlike NF & NL, where the late Jon Lien began attending cetacean entrapments in fixed fishing gear and strandings in the late 1970s (Lien 1994). Thus, early patterns are likely biased by uneven reporting effort. Wimmer and Maclean (2021) also show an upward trend between 2004 and 2019 for all cetacean stranding events in eastern Canada, including more frequent ziphiid reports, coincident with the establishment of regional marine mammal reporting hotlines and increased monitoring associated with North Atlantic Right Whale (*Eubalaena glacialis*) protection efforts by the Canadian government since 2017. Coombs *et al.* (2019) have likewise reported a dramatic increase in cetacean strandings along the United Kingdom coastline that correlates with the establishment of stranding networks since the 1980s.

Truchon *et al.* (2013) concluded that marine mammal stranding incidents in QC waters of the northern Gulf of St. Lawrence have increased since 1994, with higher frequencies of strandings of rare cetacean species correlated with positive North Atlantic Oscillation indices. Low ice volume in the Gulf was also correlated with an increased frequency of stranding incidents. Coombs *et al.* (2019) analyzed the large (n = 17 491), long-term (1913–2015) record of cetacean strandings for the United Kingdom but were unable to find any correlation between the numbers of cetacean strandings and potential environmental factors (including the North Atlantic Oscillation) and anthropogenic predictors. Coombs *et al.* (2019) did identify hotspots for strandings and attributed these to ocean currents transporting carcasses and regional areas of high cetacean diversity. The adjacency of deep waters and populations of Northern Bottlenose Whale and Sowerby's Beaked Whale to the eastern NF shoreline is probably a factor in the prevalence of strandings in this region for these species.

Dix *et al.* (1986) and Lien and Barry (1990) considered the contention of Sergeant and Fisher (1957) that the inshore occurrence of Sowerby's Beaked Whale was associated with an abundance of squid, but discounted this, noting that NF strandings for Sowerby's Beaked Whale were sometimes associated with years of low squid abundance. Whitehead and Hooker (2012) reviewed suggestions that Northern Bottlenose Whale may migrate, which could influence the timing of stranding incidents in eastern Canada. They concluded that the Scotian Shelf population of Northern Bottlenose Whale, and likely the Baffin-Labrador population, were both resident. Although there is evidence of migration within several species of ziphiids (Pitman 2018; Savage *et al.* 2021), knowledge about migration within ziphiid species is limited (MacLeod 2014).

While there has been an apparent increase in ziphiid stranding incidents in the Gulf of St. Lawrence since 2000 (62.5% of Gulf stranding incidents reported here), it is unclear how much of this increase may be the result of improved reporting, rather than the environmental changes referred to by Truchon *et al.* (2013), changes in distribution (e.g., Cuvier's Beaked Whale; Stanistreet *et al.* 2017), population growth (Sowerby's Beaked Whale; Whitehead 2013), or increased direct or indirect interactions with human activities. In summary, what prompts ziphiids to enter the inshore waters of eastern Canada remains unclear.

Potential causes of ziphiid mortality in eastern Canada

Underwater noise—One of the most widely recognized threats to beaked whales may be impacts from anthropogenic underwater noise, particularly seismic surveys and naval sonar (Miller *et al.* 2015; Bernaldo de Quirós *et al.* 2019; Hooker *et al.* 2019; Wensveen *et al.* 2019). Bernaldo de Quirós *et al.* (2019) note the rarity of global mass stranding events of beaked whales prior to the 1960s and the apparent association of such events with the introduction of naval mid-frequency active sonar since then. Most of these events have involved Cuvier's Beaked Whale (Bernaldo de Quiros *et al.* 2019), although this threat is considered to be potentially significant for Northern Bottlenose Whale and Sowerby's Beaked Whale in Canadian waters (DFO 2016, 2017a,b). Anthropogenic noise is also believed to have a greater detrimental impact on immature ziphiids (Cox *et al.* 2006). Arbelo *et al.* (2013) identified atypical mass strandings linked to naval exercises in 48.1% of ziphiid mortality incidents in the Canary Islands from 1999 to 2005.

Strandings (both live and dead) associated with noise exposure are believed to result more frequently from behavioural disturbance responses than from direct acoustic trauma. As a result, at necropsy there may be no physical evidence of noise exposure (Cox *et al.* 2006; Tyack *et al.* 2006). It should be noted that the ability to determine impacts of anthropogenic noise requires that any carcasses examined be fresh (Bernaldo de Quirós *et al.* 2019). It is therefore important not to underestimate the various sub-lethal impacts to cetaceans that may arise from exposure to noise pollution (Wright *et al.* 2011; Miller *et al.* 2015; Wensveen *et al.* 2019). Soto *et al.* (2006) provided circumstantial evidence that the noise of motorized commercial ship traffic may mask echolocation and communication in Cuvier's Beaked Whale and also disrupt foraging in this species. Stanistreet *et al.* (2022) monitored sonar signals from beaked whales before and after a 2016 naval exercise off Canada's east coast and found a significant reduction in echolocation clicks for Cuvier's Beaked Whale and the total absence of clicks for an unidentified mesoplodont. They concluded that beaked whales avoided and ceased foraging in the area. Behavioural changes may result in animals moving to unfamiliar or unsuitable habitat (e.g., the Gulf of St. Lawrence), where they may be exposed to additional threats (e.g., Wright *et al.* 2013; Davies and Brillant 2019) that can include vessel strikes and entanglement in fishing gear. Non-lethal, behavioural impacts may also result in prolonged stress (measured via the examination of stress-related hormones; Rolland *et al.* 2012), as well as long-term impacts on health, reproductive success, and longevity. Unfortunately, the sub-lethal impacts of noise pollution, including those from pervasive, chronic sources, such as marine traffic, have not been well documented or studied in ziphiids, either in eastern Canada or elsewhere. This highlights the importance of conducting professional necropsies, including examination for the pathologies associated with behaviourally induced decompression sickness and gas and fat embolic syndrome (Bernaldo de Quirós *et al.* 2011, 2019). Simonis *et al.* (2020) recommend improved coastline monitoring for stranded cetaceans before, during, and following naval exercises which suggests a possible role for stranding networks. Given the location for the atypical mass stranding incidents of Sowerby's Beaked Whale included here (facing the open Atlantic), and the associated puzzling behavioural observations, mid-frequency sonar as a possible catalyst for these (or any other) ziphiid strandings should not be discounted.

Interactions with commercial fishing gear—This remains one of the most pressing conservation issues facing cetaceans globally (Read *et al.* 2006; Lewison *et al.* 2014). Evidence includes live and dead animals entangled with fishing gear, those incidentally captured in stationary fishing structures, and animals possessing injuries and scars indicative of interactions with fishing gear. Unfortunately, ziphiids have not escaped the impacts of fishing activity. Ziphiids in eastern Canada having been reported entangled in fishing gear (DFO 2016, 2017b; COSEWIC 2019), and Waring *et al.* (2002) note that Sowerby's Beaked Whale is the most frequently recorded mesoplodont taken as bycatch in the east coast North American fishery. Feyrer *et al.* (2021) provide a summary of 66 ziphiid entanglements (mainly Northern Bottlenose Whale) in fishing gear reported from offshore in the Atlantic region since 1989. Evidence from research on live, free-swimming, cetaceans demonstrates that a substantially greater number of animals are interacting with fishing gear than those observed entangled or reported to incident hotlines as live or dead-stranded (Knowlton *et al.* 2012; Ramp *et al.* 2021). Although few studies exist on the impacts of fishing activities on free-swimming ziphiids, Hooker *et al.* (2019) and Feyrer *et al.* (2021) have suggested that scarring observed on Scotian Shelf Northern Bottlenose Whale from 1988 to 2019 is indicative of probable entanglement or propeller-vessel strikes. At minimum, scarring occurred on 6.6% of the Scotian Shelf Northern Bottlenose Whale population. Although we found few ziphiids stranded in eastern Canada were reported to show signs of interactions with fishing gear, most animals were not necropsied or even examined closely. Others were so badly decomposed that signs of interactions with fishing gear were likely difficult or impossible to detect.

As with ocean noise, there are also sub-lethal impacts arising from cetacean interactions with fishing activities. These include long-term effects on health, foraging ability, and reproductive capacity (Moore and van der Hoop 2012; van der Hoop *et al.* 2016; Rolland *et al.* 2017). Without further documentation and investigation, the full impact of fishing activity on eastern Canadian ziphiids will remain unknown.

Vessel strikes—Schoeman *et al.* (2020) reviewed the incidence and consequences of marine animal collisions with vessels, with a particular interest in mitigating vessel strikes of smaller cetacean species. While the extent of vessel collisions with small cetaceans is poorly known, there is clearly a reporting bias against small whales, in part perhaps because vessel operators may not even be aware such collisions have occurred. Although Schoeman *et al.* (2020: 5–6) report that the frequency of collisions with Cuvier's Beaked Whale can be "noticeable locally", for the eight other ziphiid species listed as struck by vessels (including Sowerby's Beaked Whale and True's Beaked Whale), such occurrences are reported as "rare". Schoeman *et al.* (2020) suggest that the criteria for identifying blunt force trauma (versus sharp force trauma) in small cetaceans may be lacking and cite a need for species-specific necropsy protocols that will allow the identification of collision-related blunt-force trauma. How practical this might be is unclear and the suggestion that veterinary pathologists are overlooking blunt force trauma as a cause of death in small cetaceans is arguable. Certainly, the Gulf of St. Lawrence, gateway to the Great Lakes, is one of the busiest coastal regions for vessel traffic in northeastern North America. Tracks for vessel density suggest that the lower St. Lawrence River estuary is likely to be a zone of relatively high risk for marine mammal vessel strikes, but there are clearly risks for any cetacean traversing any part of the Gulf

(Réseau d'observation de mammifères marins 2014), as well as at pinch points such as the Cabot Strait and Strait of Belle Isle. With more than 7000 commercial shipping voyages up the St. Lawrence River in 2018 (Laurentian Pilotage Authority 2019) and ~5000 fishing vessels active throughout the Gulf in that year (see https://dfo-mpo.gc.ca/stats/commercial/licences-permis/vess-embarc/ve18-eng.htm), the relative risk of small whale strikes would seem to be high.

Díaz-Delgado *et al.* (2018) identified anthropogenic, rather than natural, causes of death (foreign body associated pathology, vessel collision) for 44.4% of cases among 18 veterinary necropsies of ziphiids stranded in the Canary Islands 2006–2012. The authors were apparently able to distinguish both sharp and blunt force trauma. While vessel strikes are less likely to be a significant source of mortality for ziphiids in offshore waters, the importance of vessel strikes to beaked whales that may move to inshore areas off eastern Canada remains uncertain, largely due to the very limited number of veterinary necropsies of dead-stranded ziphiids undertaken to date. Although we found few ziphiids stranded in eastern Canada were *reported* to show signs of vessel strikes, very few animals underwent necropsy. Others were so badly decomposed as to obscure any obvious signs of interactions with vessels. Nonetheless, although our sample size of ziphiid skeletons is small ($n = 8$), it is noteworthy that at least 25% of the specimens available to us showed signs of healed fractures from previous blunt force trauma.

Marine debris and contaminants—Ingestion of marine debris and impacts from ocean contaminants are also of concern with respect to beaked whale mortality (Lusher *et al.* 2015; Baini *et al.* 2020). MacLeod (2018) noted that the ingestion of plastic debris may be a particular problem for beaked whales in specific regions where such debris is particularly common. With a diet predominantly of cephalopods (Hooker *et al.* 2001; Whitehead *et al.* 2003) and an intake mechanism referred to as "suction feeding", beaked whales may be prone to ingest micro- and macro-plastics (Lusher *et al.* 2015; Nelms *et al.* 2019; Zantis *et al.* 2020).

Information on contaminants in beaked whale species is limited, although Hooker *et al.* (2008) determined that levels measured in Scotian Shelf Northern Bottlenose Whale were not believed to be high enough to cause health problems. Nonetheless, contaminants have been identified as a serious issue for other cetaceans in the region (see Simond *et al.* 2020 and references cited therein) and at least one of the stranding mortalities we report here (7.1) may be associated with plastic ingestion (Béland 1987). Desforges *et al.* (2021) reported concentrations and patterns of persistent organic pollutants in Northern Bottlenose Whale from eastern Canada, including one animal stranded in NF (27.1). None of the whales sampled showed contaminant levels that exceed the established toxicity threshold for general immune or reproductive effects, and levels were generally lower than those reported for beaked whales in other parts of the world. However, most did show levels above a molecular toxicity threshold, suggesting effects at the molecular and cellular level. While individual ziphiids may face risks associated with marine debris and contaminants, more investigation is required as to the extent and impact of these potential sources of mortality. To date, few samples have been collected for contaminant analysis from ziphiids stranded in eastern Canada.

Emerging infectious diseases—Van Bressem *et al.* (2009) have reviewed the role of emerging infectious diseases in cetacean mortality, especially those coupled with anthropogenic environmental stressors. Although the authors note that those cetaceans resident inshore and in estuarine habitats are at greater risk than offshore species, the latter are not immune. Environmental pollution transported offshore from heavily polluted waterways (such as the St. Lawrence), heavy ship traffic, and offshore industrial activity may lead to stress and lowered immune response (Romano *et al.* 2004; Rolland *et al.* 2012). Cases of toxoplasmosis in cetaceans offshore have been linked to ship runoff or cases where rodents, cats, or contaminated soils are present on board (Van Bressem *et al.* 2009). Together Arbelo *et al.* (2013) and Diáz-Delgado *et al.* (2018) found 69.3% of 362 cetacean strandings in the Canary Islands 1999–2012 were attributed to natural pathologies. Although Díaz-Delgado *et al.* (2016) report that crassicaudiasis appears to be a leading natural cause of mortality in Cuvier's Beaked Whale in the Canary Islands Archipelago, this was not judged to be the cause of death for animals so infected in eastern Canada. Unfortunately, conclusively linking mortality from what may appear to be entirely natural pathologies to anthropogenic environmental stressors is hampered by a lack of base-line data on the incidence of disease in cetaceans.

Ziphiid strandings in eastern Canada and conservation research

Although the biology of the Scotian Shelf population of Northern Bottlenose Whale may be better known than that of any other ziphiid (e.g., Whitehead and Hooker 2012; Feyrer *et al.* 2020), there remains a scarcity of data regarding ziphiid species in general (Li and Rosso 2021). This includes four of the five species that have been recorded stranded in eastern Canada. Also, virtually nothing is known about the Davis Strait–Baffin Bay–Labrador Shelf population of Northern Bottlenose Whale (Feyrer *et al.* 2019). Although sources of potential mortality in eastern Canada noted above have been identified as of particular concern for ziphiid whales, much remains to be learned about the impact of ecosystem changes now underway and impending on these animals, particularly those associated with climate change. Meyer-Gutbrod *et al.* (2018) have commented on climate-mediated range shifts in marine mammals (with emphasis on North Atlantic Right Whale) and the need for expanded monitoring of cetaceans in the Gulf of St. Lawrence and elsewhere. MacLeod (2014) has noted that water temperature, for reasons that remain unclear, seems to play a significant role in determining distribution among beaked whales, suggesting that warming seas could have a significant impact on ziphiids. Deep water temperatures have been increasing overall, including in the Gulf of St. Lawrence (Galbraith *et al.* 2017), which may be responsible for changes in species observed and their perceived distributions.

Although passive acoustic monitoring and tagging technologies have started to help researchers better understand ziphiid biology and ecology (Schorr *et al.* 2014; Martin *et al.* 2017; Stanistreet *et al.* 2017), response to stranding incidents remains an important source of unique information for this group of marine mammals (e.g., Cook *et al.* 2006; Lusher *et al.* 2015; Einfeldt *et al.* 2019a,b) and is likely to remain so. MacLeod *et al.* (2006) identified the value of stranded carcasses and museum collections of ziphiid specimens as an important source of data for research. Smith *et al.* (2021) collated information from museum skeletal collections of Sowerby's Beaked Whales worldwide (including specimens reported here) to reveal new findings about the species. Unfortunately, only a minority (34.5%) of dead eastern Canadian ziphiids have had skeletons, tissue, parasites, stomach contents, or anatomical parts deposited in publicly accessible museum collections. Many institutions now maintain frozen tissue collections in support of genetic studies, which have demonstrated the potential to provide unique insights into ziphiid biology (e.g., Dalebout *et al.* 2008; Thompson *et al.* 2016). There is also a need to support expert examination, especially veterinary necropsies, of dead-stranded ziphiids (for that matter, all cetaceans) at every opportunity. Prior to the establishment of the CWHC partnership in 1992 and the establishment of formal stranding response networks in eastern Canada, the opportunities for such necropsies in the Maritimes were few. Most eastern Canadian ziphiid strandings have occurred on the island of Newfoundland. With a coastline of over 10 000 km, much of it dominated by cliffs and often without easy access to the shoreline, there are often considerable challenges in reaching cetacean strandings and conducting necropsies, whether veterinary or non-veterinary. Furthermore, a number of ziphiid strandings have occurred on Sable Island, which is 175 km offshore and not easily accessible. Support to enhance the monitoring, reporting, and necropsy of fresh beaked whale carcasses before, during, and after acoustic events involving military sonar or seismic testing should be made available so that such threats can be adequately assessed at every opportunity. As Wimmer and Maclean (2021) note, critical data are being lost because a consistent and coordinated approach to marine mammal incident response and health surveillance in Canada is lacking.

Data from non-veterinary necropsies was sometimes difficult to locate and access for our review, suggesting opportunity for better data handling. Stranding networks, which do the "heavy-lifting" in documenting marine mammal strandings in eastern Canada (e.g., operating hotlines, training and equipping responders, facilitating necropsies, collecting data and samples) are generally under-staffed, over-prescribed, and under-funded. Support for systematic and collaborative reporting, response, and handling of stranding data and samples are needed. This would enable networks to have the support to produce and publicly post annual reports and provide information on strandings and the results of investigations, including veterinary, and especially non-veterinary, necropsies. This would enhance transparency and help capture data that might otherwise be lost, particularly as several species are considered of conservation concern under Canadian law. There are several good models for annual reports which exist that could be adopted (e.g., Newfoundland Whale Release and Strandings Program annual reports: Ledwell *et al.* 2020; Scottish Marine Animal Stranding Scheme: Davison and ten Doeschate 2021).

Data derived from stranding incidents will be an important source of support for several of the research priorities for ziphiids outlined by Hooker *et al.* (2019), and can also inform federally mandated SARA recovery strategies, as well as action and management plans for those ziphiid species-at-risk (DFO 2016, 2017a,b). Collection of such data from eastern Canadian stranding incidents will help the Government of Canada meet its priorities related to understanding whale health, national, and international commitments for ensuring industry sustainability, the goal of reducing the incidence of human-caused harm and mortalities to cetaceans, and protecting biodiversity more generally. The ongoing documentation of eastern Canadian cetacean stranding incidents, but especially for species of conservation concern and those that reach their edge of range in the western North Atlantic, should remain a priority for those concerned with the management and conservation of cetaceans in the region.

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Writing – Original Draft: D.F.M. and T.W.; Writing – Review & Editing: All; Conceptualization: D.F.M., T.W., P.-Y.D., W.B., L.B., and W.L.; Visualization: D.F.M. and T.W.; Data Curation: W.L., G.A.R., T.W., J.W.L., S.L., Z.N.L., D.F.M., R.M., and W.B.; Investigation: D.F.M., P.-Y.D, L.B., W.L., T.W., G.A.R., J.W.L., Z.N.L., S.L., and A.F.; Funding Acquisition: D.F.M. and T.W.

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