Health of marine mammals in the St. Lawrence Estuary and Atlantic regions

Investigation of the 2022 unusual mortality events

&

Identification of potential emerging threats for cetaceans and pinnipeds in a changing ecosystem

Summary report

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Université de Montréal
Faculté de médecine vétérinaire

CANADIAN WILDLIFE HEALTH COOPERATIVE
RÉSEAU CANADIEN POUR LA SANTÉ DE LA FAUNE

UNIVERSITY of Prince Edward ISLAND

Health of marine mammals in the St. Lawrence Estuary and Atlantic regions - *investigation of the 2022 unusual mortality events and identification of potential emerging threats for cetaceans and pinnipeds in a changing ecosystem*

Summary report - 2023

Project lead:

Stéphane Lair DMV, DES, DVSc, Dipl. ACZM
Professor
Regional Director Canadian Wildlife Health Cooperative – Quebec
Faculté de médecine vétérinaire
Université de Montréal
3200 rue Sicotte
Saint-Hyacinthe, Québec
J2S 2M2

Prepared by:

Émilie L. Couture DVM, IPSAV, DES, Dipl. ACZM
Staff clinician
Canadian Wildlife Health Cooperative – Quebec
Faculté de médecine vétérinaire
Université de Montréal
3200 Rue Sicotte
Saint-Hyacinthe, Québec
J2S 2M2

Megan E.B. Jones DVM, PhD, Dipl. ACVP
Assistant Professor (Wildlife and Anatomic Pathology)
Regional Director Canadian Wildlife Health Cooperative, Atlantic Region
Dept. of Pathology and Microbiology
Atlantic Veterinary College, University of PEI
550 University Ave
Charlottetown, Prince Edward Island
C1A 4P3

Laura Bourque DVM, DVSc, MSc, DACVP
Wildlife pathologist
Canadian Wildlife Health Cooperative, Atlantic Region
Dept. of Pathology and Microbiology
Atlantic Veterinary College, University of PEI
550 University Ave
Charlottetown, Prince Edward Island
C1A 4P3

PROJECT DESCRIPTION

Being at the top of the food chain, marine mammals are considered sentinel species for the health of the marine ecosystem. Assessing the state of health of populations of marine mammals can therefore allow us to better understand the impact that various ecosystemic changes can have on biodiversity and therefore on the resilience of marine ecosystems. Examples of potentially detrimental modifications of the ecosystem, which are largely driven by human activities, include climate change, introduction of exotic pathogens and expansion of geographical distributions of species of preys or predators.

The investigation of causes of mortality and morbidity can help to better understand potentially detrimental factors. These factors, such as infectious agents and non-infectious stressors, can have negative impacts on the sustainability of populations of marine mammals. With the exception of some species, such as the beluga and the North Atlantic right whale, for which ongoing pathology programs have been developed over the years, our knowledge of the causes of mortality of marine mammals from the St. Lawrence Waterway and the Atlantic region remains fragmentary. There is definitely a gap in our understanding of the population dynamic for most of the species of marine mammals in these regions. Because of this, detection of the emergence of new threats for these populations could be challenging.

For several years now, strandings of marine mammals in the St. Lawrence Estuary (SLE) and Maritime provinces (New Brunswick, Nova Scotia, Prince Edward Island- MP) regions have been monitored by two stranding networks, the *Réseau québécois d'urgence pour les mammifères marins* (RQUMM) and the Marine Animal Response Society (MARS), in collaboration with various stakeholders. Over the years, these networks have gathered information on documented mortality and morbidity in marine mammals in the regions of interest. However, for many instances, funding to support investigation into the cause of these strandings has not been available. Indeed, only a small percentage of the carcasses found have been submitted for complete post-mortem examination. Nevertheless, the analyses of available historical data could enable us to identify unusual mortality events, which could be associated with new threats for the affected populations. An example of this occurred in 2022 during which the RQUMM observed an increase in the documentation of mortalities of harbour seals and harbour porpoises in the Estuary and the Gulf of St. Lawrence. As part of this project, we carried out analyzes of the carcasses and samples collected during the year 2022 in order to determine the cause of the death of these animals. Although different species of marine mammals were examined, emphasis was put on the two species for which unusual mortality events were documented and for which sufficient number of carcasses were submitted for complete necropsies, i.e. the harbour seal and the harbour porpoise. Different species of odontocetes and other species of seals were also examined. The clinical significance of avian influenza was also investigated through carcasses sampled in the field or submitted for complete post-mortem evaluation. Carcasses received from the MP region by CWHC-Atlantic for post-mortem investigation were also compared to the historical average of necropsy submissions to evaluate if an increase in submissions, a potential indication of increased strandings, was also observed in the MP region, and mortality causes were investigated as for the Quebec region.

OBJECTIVES AND ANTICIPATED BENEFITS

Project objectives:

1) Identify and quantify UMEs observed in marine mammals in the SLE and Atlantic regions in 2022.
2) Determine the factor or factors that may account for these UMEs.
3) Identify the risk that the emergent HPAIV H5N1 represents for cetaceans and pinnipeds from the studied ecozone.
4) Document mortality events of anthropogenic origin, such as collisions with a boat and fishing gears entrapment.
5) Develop a classification system to characterize mortality events based on photographic documentation.

MATERIAL AND METHODS

1- IDENTIFY AND QUANTIFY UMES

For the province of Quebec, we compared the observations of sick or dead cetaceans and phocids in 2022 to the historical 10 years average for the St. Lawrence Estuary (SLE) region. This data was provided by the RQUMM. Similar information was not available for analysis from the Maritime provinces (MP). We therefore used the number of marine mammal cases submitted for necropsy at the CWHC – Atlantic regional centre as a proxy of the intensity of the mortalities observed over the years (2022 vs previous 10 years average).

2- DETERMINE FACTORS THAT MAY ACCOUNT FOR THE UMES

This project involved post-mortem examinations of marine mammal carcasses found stranded during the year 2022. Most of these carcasses were transported fresh or frozen to one of the two diagnostic laboratories (CWHC – Quebec and CWHC – Atlantic). A limited number of cases were necropsied in the field. The primary criteria for carcass selection were accessibility and levels of decomposition. A necropsy was usually done only in carcasses with an acceptable state of preservation (code 2 or 3, Geraci & Lounsbury 2005). Sex, age category and body condition were determined and standardized for each case. Age categories were attributed based on developmental stages of species-specific duration and timing, namely: newborn (peripartum individual, no obvious indication of maternal bonding; ‘pre-nursing’), dependant calf/pup (animal that is dependant upon the dam’s energetic resources-includes nursing individuals, as well as post-lactation fast in seals and early phases of weaning in cetaceans), juvenile (animal that is not dependent upon maternal energetic resources anymore, yet not

reproductively mature), adult (size/ sexually mature) and geriatric (post-reproductive, or presenting with a combination of degenerative conditions suggestive of an advanced age). Body condition was determined based on a variable combination of subjective evaluation of carcasses, species and age-category specific blubber thickness and adipocyte morphology. Attributed categories were 'Good' if the animal was in a good to excellent body condition, 'Suboptimal' when the individual presented with a mild to average loss in body condition and 'Emaciated' if a nutritional depletion was considered severe enough to lead to a systemic impairment. The complete standard post-mortem examination of each carcass (necropsy) was done by a veterinary pathologist. Samples from the main organs were taken for histopathological examination. Due to the emergence of a highly pathogenic avian influenza virus (HPAIV H5N1), samples (nasal/rectal swabs or brain) were submitted for detection of this virus by PCR in most animals. Following the histological examination of the tissues, additional examinations (e.g., virology, bacteriology, immunohistochemistry) were done as needed in order to support the final diagnoses. The most likely cause of death and potential contributing factors were then determined for each animal. Only conditions considered to have significantly contributed to death were considered and were categorized as 'Nutritional/metabolic', 'Inflammatory/infectious', 'Trauma', 'Other' or 'Undetermined'. If a chronic condition was considered to have predisposed to a more acute cause of death, this underlying cause was determined to be the main cause of death, using the rationale that the immediate cause of death would have not happened in the same way or at the same time without it. The pathologists involved in this project reviewed each case submitted to their respective centres in order to validate the criteria used to determine the cause of death.

Documented cases of marine mammals that died of HPAIV as well as additional carcasses that were tested but did not receive a complete post-mortem examination are compiled to better understand the epidemiology and significance of the disease in marine mammals in the studied ecozones in 2022. Mortality cases of anthropic origin were further detailed.

3- DEVELOP A PHOTOGRAPHIC CLASSIFICATION SYSTEM TO CHARACTERIZE MORTALITY EVENTS

Available pictures and recorded information of dead marine mammals taken at the stranding site by RQUMM personnel in the SLE region, are evaluated by the pathology team to determine, when possible, a presumed cause of death. Each stranding is categorized based on a classification system. The classification system is developed as part of this project.

RESULTS

1- IDENTIFY AND QUANTIFY UME

In the SLE region (RQUMM data), 2022 annual marine mammal stranding numbers were increased by 248% when compared to the historical 10-year average (Figure 1). A drastic increase in stranding cases was noted starting mid-May, and peaked mid-June to mid-July. Although a decrease in stranding

numbers is observed after this peak, the number of cases is still higher than the historical 10-year average up to the month of November.

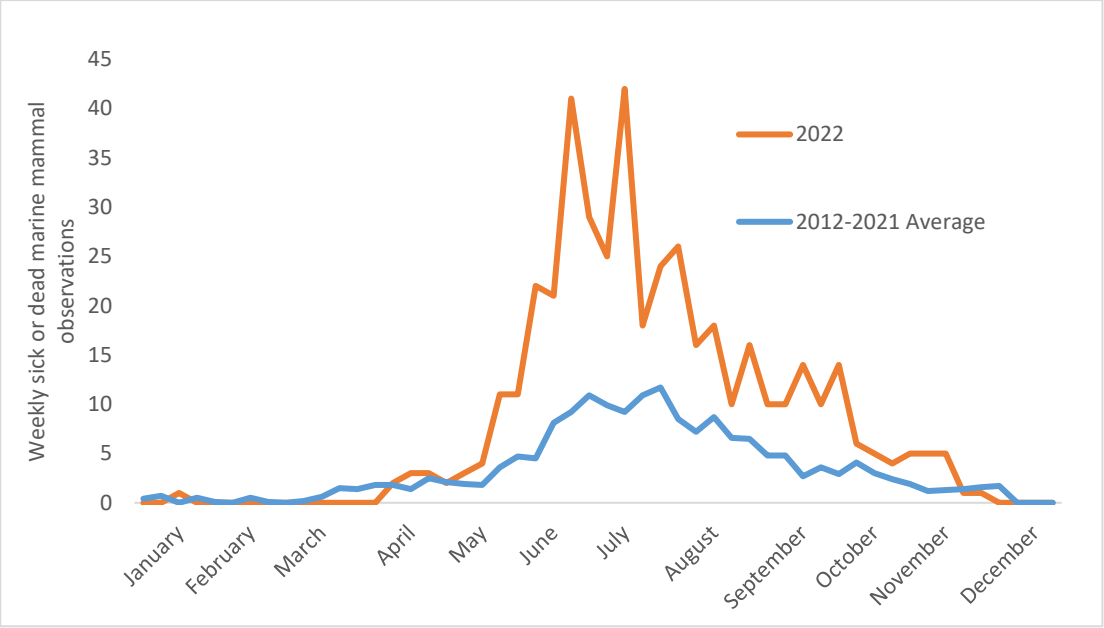

Figure 1: Weekly historical 10-year average (2012-2021) and 2022 sick or dead marine mammal observations recorded by the RQUMM (SLE region).

When using the number of carcasses examined at the CWHC – Atlantic as a proxy of the number of strandings, we did not see an obvious increase of cases in 2022 compared to the historical 10-year average (Figure 2).

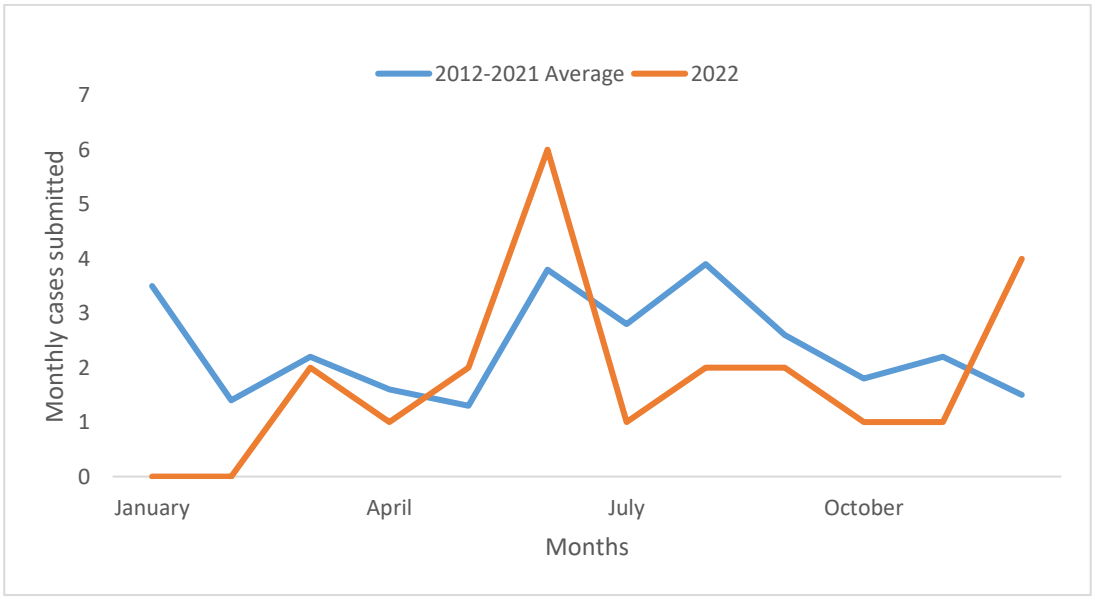

Figure 2: Monthly historical 10-year average (2012-2021) and 2022 dead marine mammal cases submitted to CWHC – Atlantic region.

Given the increased stranding numbers observed in the SLE region, sick or dead marine mammal observations were further divided in families (cetaceans) or species (pinnipeds) to investigate overt differences in 2022 that could have contributed to the overall high numbers in 2022 (Figures 3 and 4). In 2022, increases of strandings were documented in phocoenidae (harbour porpoises) (+399%), harbour seals (+555%) and grey seals (+286%) when compared to the 10-year historical data.

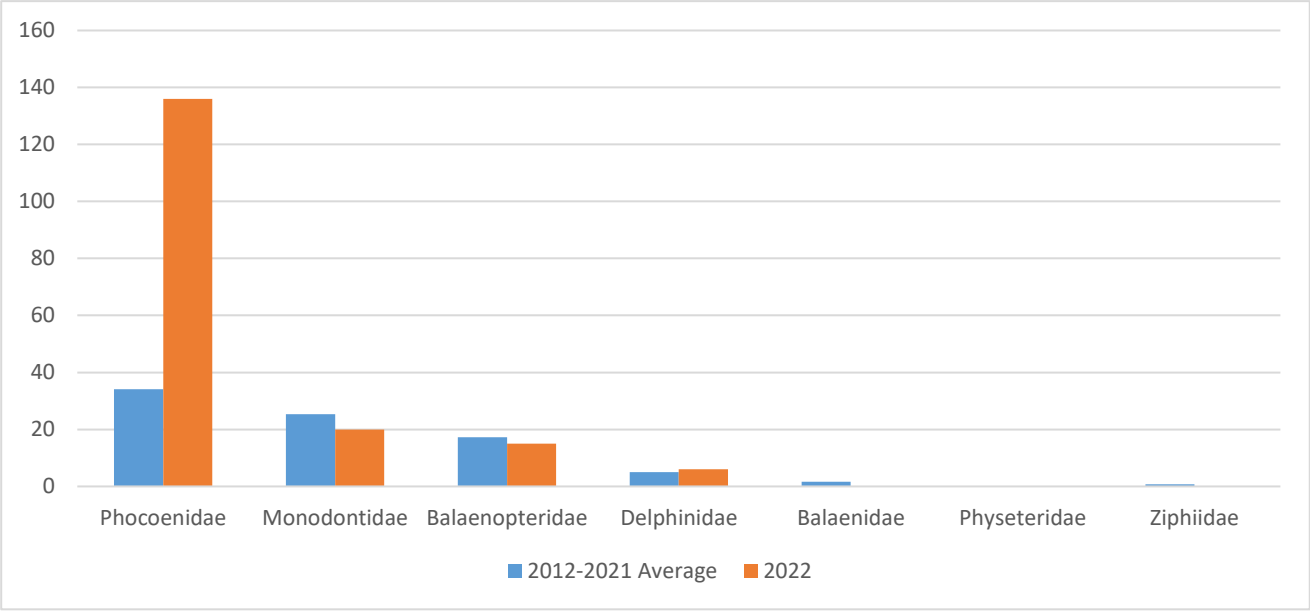

Figure 3: Sick or dead cetacean observations in the SLE region by family, comparing 10-year annual average (2012-2021) to 2022 (Data source: RQUMM).

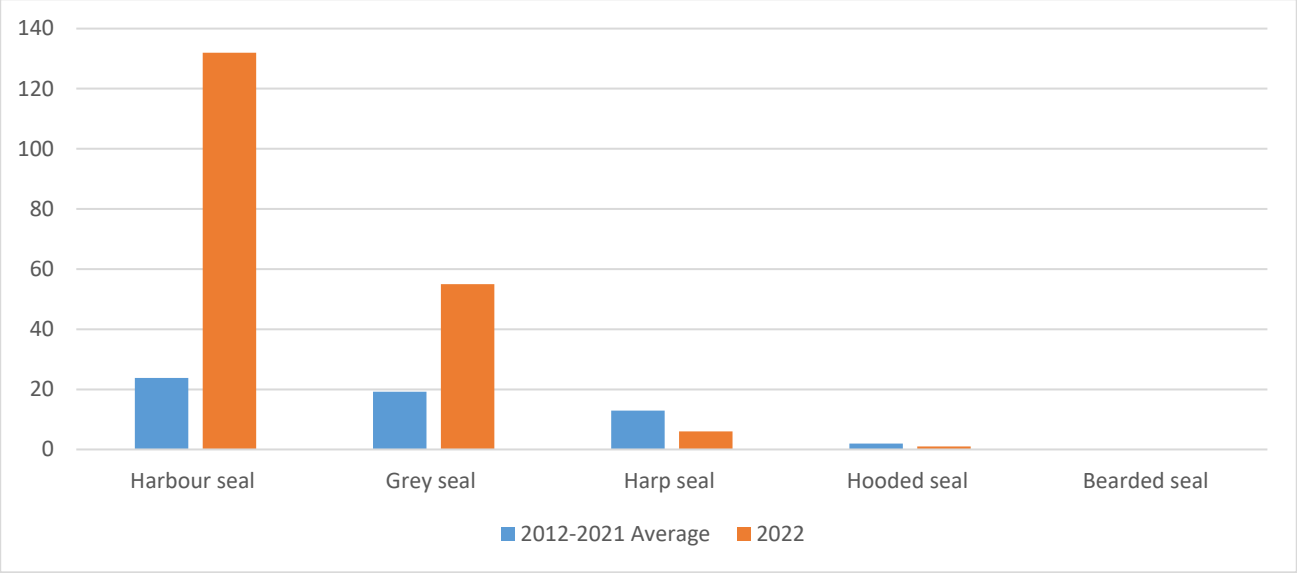

Figure 4: Sick or dead pinniped observations in the SLE region by species, comparing 10-year annual average (2012-2021) to 2022 (Data source: RQUMM).

2- DETERMINE FACTORS THAT MAY ACCOUNT FOR THE UMES

In 2022, a total of 87 marine mammals were necropsied by both centers (Atlantic= 22; Quebec= 65). Phocids and phocoenids were most represented, especially in the Quebec region (29 and 27 necropsies, respectively), which corroborates the observation data from the RQUMM. Figure 5 illustrates the proportion of necropsies performed by each CWHC regional centre in 2022.

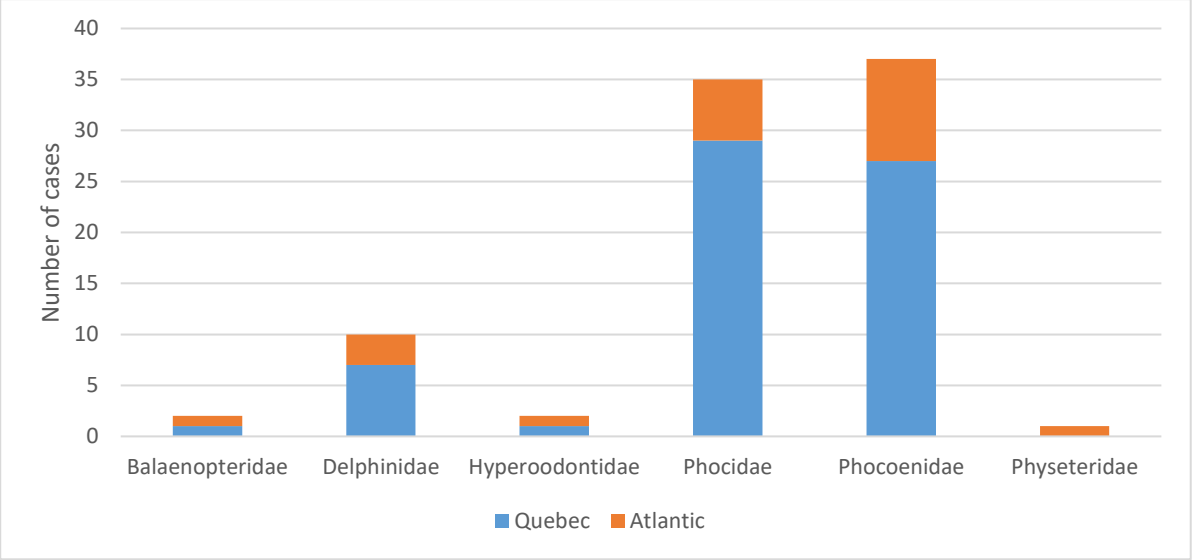

Figure 5: Number of necropsies performed by Quebec and Atlantic CWHC regional centres in 2022 for the different taxonomic groups.

CWHC – Quebec: Necropsy demographics

Harbour seals were the most represented phocid species submitted for necropsy, with newborns (n=6), dependant pups (n=8) as well as adults (n=8) being mostly represented. Most newborn and adult harbour seals were females (n=5/6 and 6/8, respectively). Harbour seals submitted for necropsy represented 17.4% (n=23/132) of the total observations recorded by the RQUMM, while grey seals examined represented 5,5% (n=3/55) of the total observations. Details of phocid demographics submitted for necropsy can be found in Figure 6.

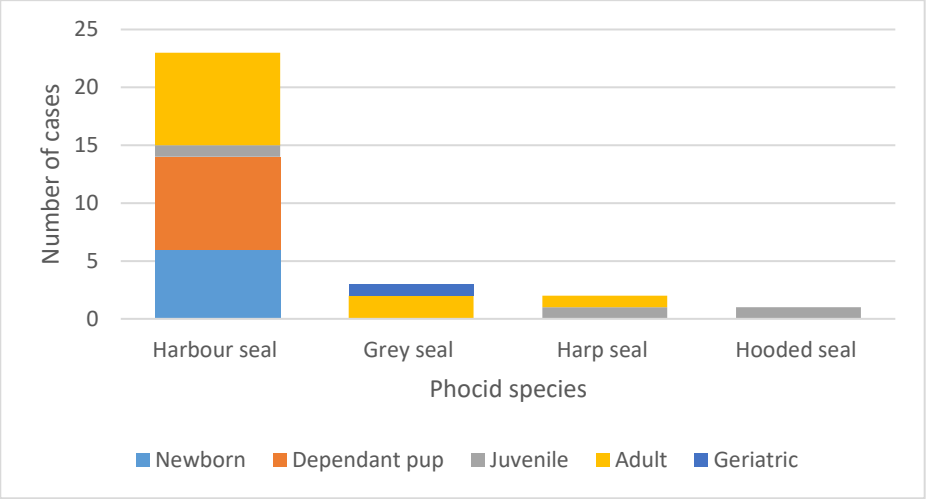

Figure 6: Age category and phocid species distribution of necropsies performed at CWHC – Quebec in 2022.

Harbour porpoises were the most represented cetacean species examined, with dependant calves (n=14) mostly represented, followed by adults (n=7), newborns (n=5) and juveniles (n=1). Post-mortem examinations in this species represented 20% (n=27/136) of the total observations of sick or dead individuals recorded by the RQUMM. Associated demographics are presented in Figure 7.

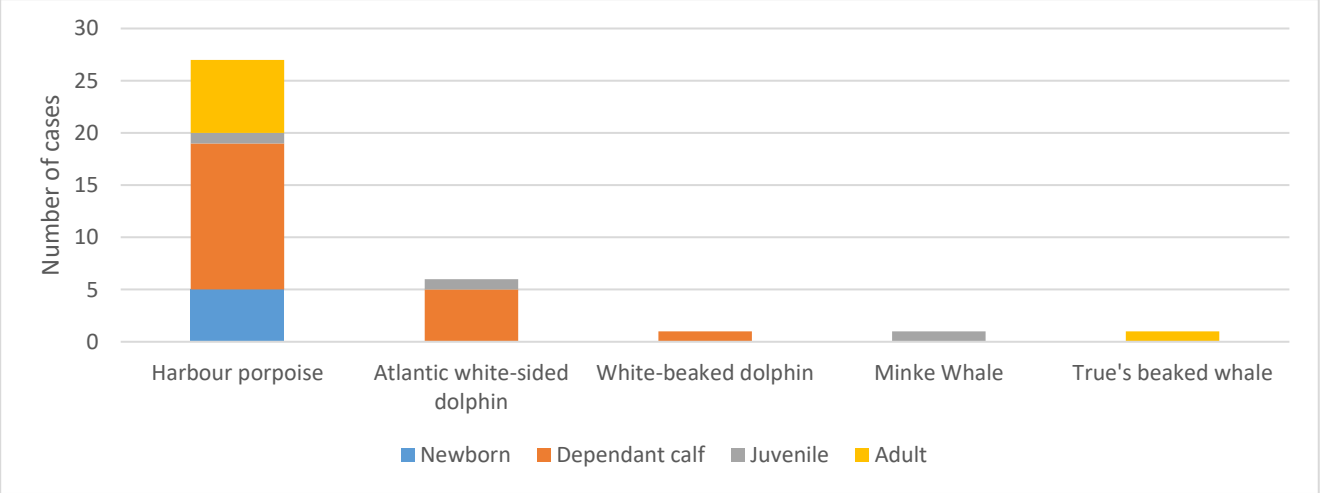

Figure 7: Age category and cetacean species distribution of necropsies performed at CWHC – Quebec in 2022.

CWHC – Atlantic: Necropsy demographics

Seals submitted to the CWHC- Atlantic consisted exclusively of dependant pups and juveniles, and there was no obvious trend in species submissions.

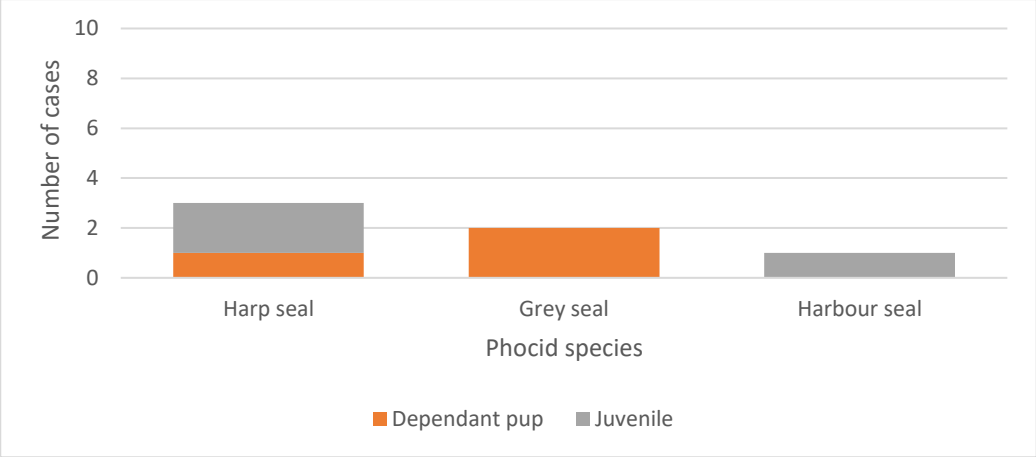

Figure 8 Age category and phocid species distribution of necropsies performed at CWHC – Atlantic in 2022.

Harbour porpoises were the most submitted cetacean species, with 10 individuals examined. Of those, most were adults (n=4), followed by dependant calves (n=3), newborns (n=2) and juveniles (n=1). Number of harbour porpoise submissions appeared comparable with the 2012-2021 historical average for this species (6.4 submissions per year, with other years sometimes reaching 10 submissions). The relatively high number of harbour porpoise submissions is likely related to the relative abundance of this species as well as their small size, allowing for easier logistics surrounding carcass collection and preservation for submission.

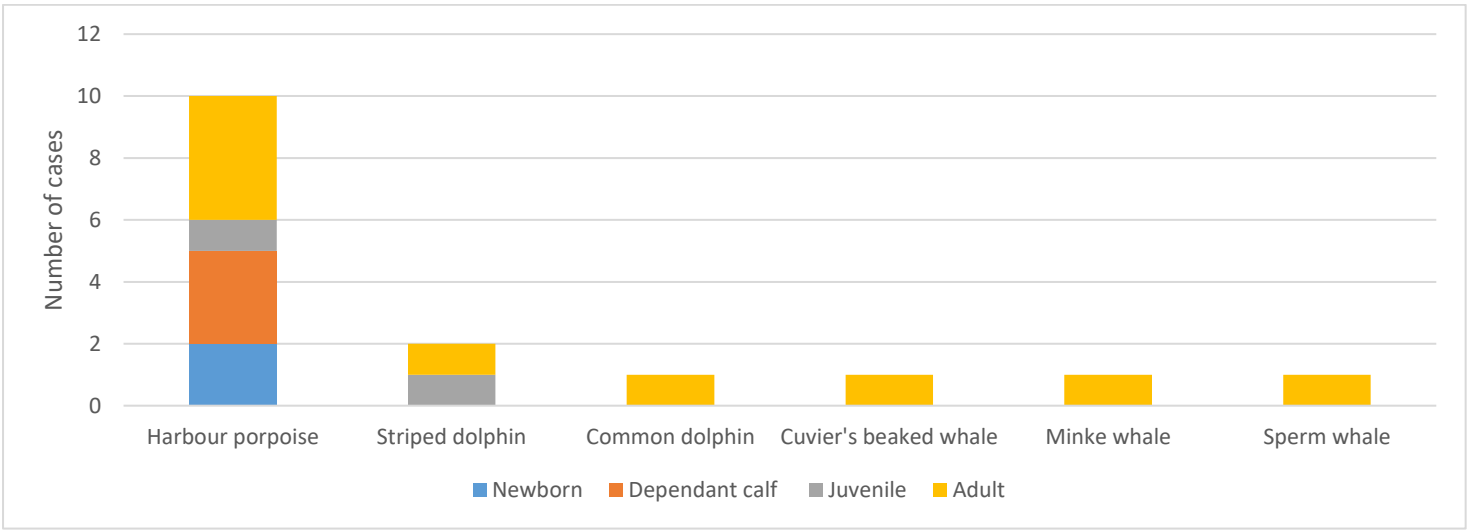

Figure 9 Age category and cetacean species distribution of necropsies performed at CWHC – Atlantic in 2022.

CWHC – Quebec: Causes of death

Overall, nutritional/metabolic causes were the most frequent cause of death (43%, n=28/65), closely followed by infectious and inflammatory conditions (32%, n=21/65), traumatic causes (11%, n=7/65), undetermined (9% n= 6/65) and other causes of death (5%, n=3/65) (Figure 8). Details pertaining to each case evaluated are presented in the appendix I, and complete necropsy reports may be accessed through the Wildlife Health Intelligence Platform (WHIP).

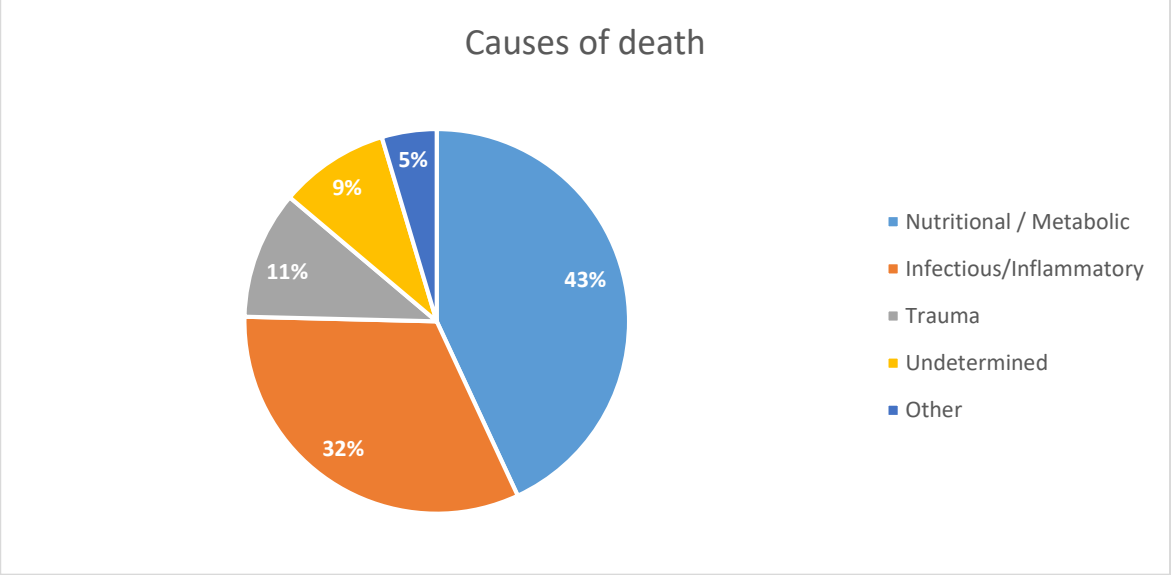

Figure 10: Repartition of causes of death categories in marine mammals submitted to CWHC – Quebec in 2022.

Nutritional/Metabolic

A total of 28 deaths (n=28/65) were attributed to nutritional/metabolic causes. In animals with a suboptimal to emaciated body condition and without a preceding underlying condition, these were linked to deficient maternal supports in unweaned juveniles (n=14/28 – 'dependant calves/pups'), to failures to thrive (i.e. inability to hunt) in weaned juveniles (n=2/28) and to primary inanition in adult individuals (n=5/28). In newborn individuals, with the absence of a significant concomitant disease, a peripartum separation from the dam and associated metabolic disturbances was circumstantially identified as the most likely cause of death (n=7/28). Nutritional/Metabolic issues were the predominant cause of death in harbour porpoises (n= 20/27), including 4 newborns, 13 dependant calves, 1 juvenile and 2 adults. Details of the repartition of cases attributed to a nutritional/metabolic condition are presented in Figure 11. In some cases, subsequent contributing factors were identified. A herpesvirus infection associated with oesophageal ulcers was notably determined to be significant in a juvenile harbour porpoise. It was also proposed that weakness associated with emaciation could have favoured predation, either by grey seals or sharks, in three dependant harbour porpoise calves. In addition, an Atlantic white-sided dolphin calf for which the cause of death was determined to be a predation event (i.e. not accounted for in this category) presented with a suboptimal body condition of unknown clinical

significance. A juvenile emaciated hooded seal was out of its natural range, which might have contributed to the inability to hunt, while verminous pneumonia might have contributed to the poor body condition noted in a juvenile harbour porpoise (> 1-year old).

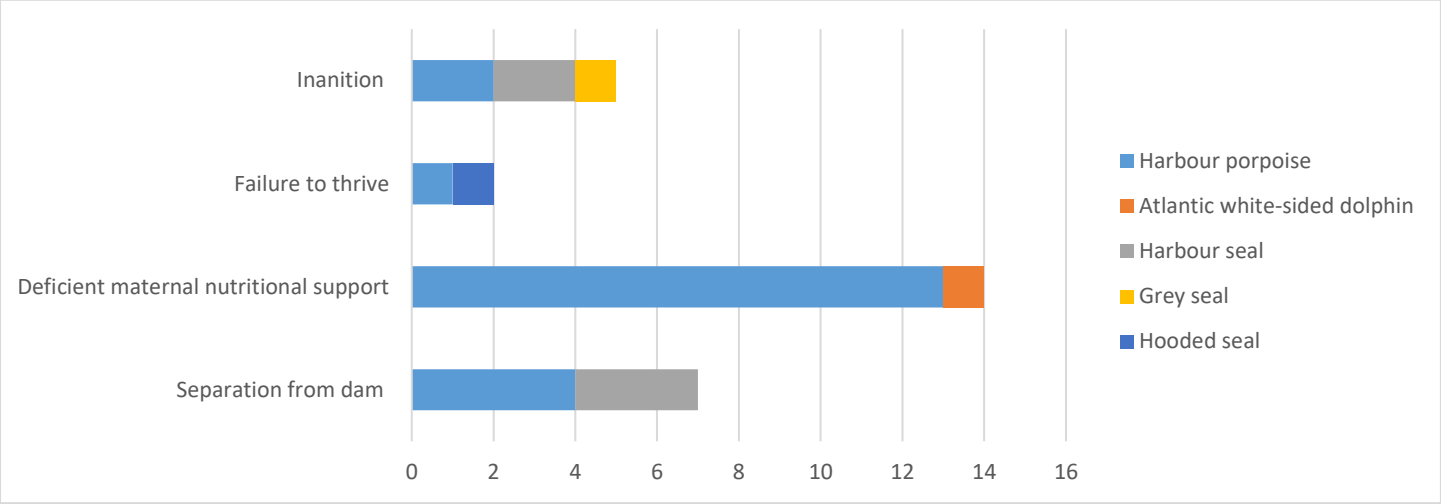

Figure 11: Repartition of marine mammal species necropsied in 2022 at CWHC – Quebec that died of nutritional/metabolic causes.

Infectious/Inflammatory

All cases in this category are linked to an infectious agent. The most frequent cause of death in this category was HPAIV, which was the cause of death in 14 harbour seals (mostly adult females, newborns and dependant pups), 1 adult grey seal and 1 juvenile Atlantic white-sided dolphin submitted to CWHC – Quebec in 2022. The other categories comprised one individual each, with a bacterial pneumonia (harbour seal), a multisystemic infection attributed to *Streptococcus phocae* (harbour seal), a perforating verminous gastric ulcer (harbour porpoise) and verminous bronchopneumonia associated or not with gastrointestinal parasitism (white-beaked dolphin and harbour seal, respectively).

Trauma

Traumatic causes of death included two cases of blunt trauma in a juvenile harbour porpoise and an adult harp seal. While the origin of the blunt trauma could not be determined based on the examination of the carcass, a collision of anthropogenic origin is possible. Other traumatic causes of death included intraspecific aggression in juvenile Atlantic white-sided dolphins (infanticide, n=2) and predation in an adult grey seal (shark predation), juvenile harbour porpoise (grey seal predation) and Atlantic white-sided dolphin (grey seal or shark predation).

Other causes of death

This last category includes a single case each of an accidental stranding (adult True's beaked whale), a peripartum mortality (adult female harbour porpoise) and a pheochromocytoma (adult harbour porpoise).

Undetermined

This category includes cases for which both gross and microscopic examination of the carcass were not suggestive of a cause of death (n=6). These cases included a juvenile minke whale that presented signs of prolonged exposition to fresh water and a suboptimal body condition as well as a juvenile harbour porpoise.

CWHC – Atlantic: Causes of death

Overall, cases with an undetermined cause of death was the most represented category (36%, n= 8/22), followed by infectious and inflammatory conditions (27%, n= 6/22), nutritional/metabolic causes (18%, n= 4/22), other causes of death (14%, n=3/22) and trauma (5%, n=1/22) (Figure 12). Details pertaining to each case evaluated are presented in the appendix I, and complete necropsy reports may be accessed through the Wildlife Health Intelligence Platform (WHIP).

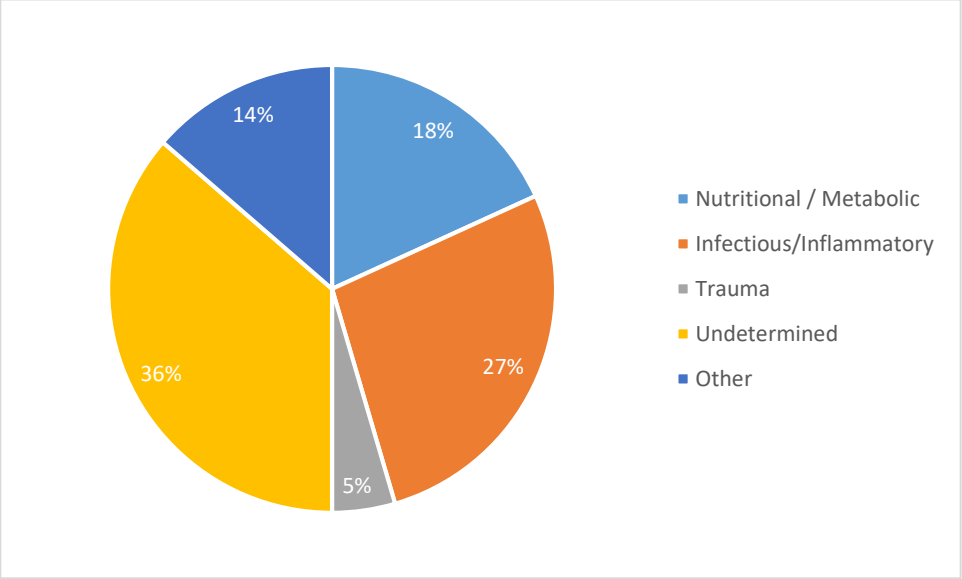

Figure 12 Repartition of causes of death categories in marine mammals submitted to CWHC – Atlantic in 2022.

Nutritional/Metabolic

A total of four deaths (n=4/22) were attributed to nutritional/metabolic causes. Of these, one was due to an anthropogenic cause of malnutrition, namely gastric impaction with fishing gear in an adult sperm whale. The other three cases were associated with probable deficient maternal nutrition (n=2) and separation from dam (n=1). Death of dependant animals is expected to a certain level in wildlife, and no overt conclusion can be made out of the few cases submitted and without considering the overall stranding data.

Infectious/Inflammatory

Despite being the second most frequent cause of death category, all six animals in this category died of different causes, indicating no common trend in this category. Details of causes may be found in appendix II.

Trauma

A single case of cranial blunt trauma, presumably anthropogenic, was reported in a dependant harp seal pup.

Other causes of death

Other causes of death included dystocia (an adult/newborn harbour porpoise pair, n=2) as well as complications associated with a benign tumor (leiomyoma) in a harbour porpoise, leading to a behavior-modifying intestinal entrapment that most likely predisposed this individual to a fatal boat strike.

Undetermined

In most cases (n=8/22), the cause of death remained undetermined. In one case each, gastric impaction with vegetation (juvenile female harp seal in good body condition) and non-fatal indications of trauma (dependant harbour porpoise calf) were of uncertain clinical significance.

3- HPAIV H5N1 IN CETACEAN AND PINNIPEDS FROM STUDIED ECOZONE

CWHC – Quebec

All odontocetes and phocids submitted for necropsy at the CWHC – Quebec in 2022 were tested for HPAIV. In addition, carcasses were swabbed in the field by RQUMM personnel to test for HPAIV. A total of 12 additional phocid carcasses were swabbed (one grey seal, 11 harbour seal), with 6 harbour seals and a grey seal testing positive for HPAIV. When considering all positive cases (necropsy and field swabs), most HPAIV cases were harbour seals, either adult females (n=9/22) or young of the year of either sex (12/22). All juveniles (n=7/7) and most adults (5/7) for which body condition could be assessed were in a good body condition, which is suggestive of a death following an acute infection. All harbour seals that tested positive for HPAIV were found between May 30th and July 8th (Figure 13). HPAIV was confirmed to be the cause of death in a single juvenile Atlantic white-sided dolphin following necropsy. Based on the necropsy investigation performed and the epidemiological context of the swabbing efforts, HPAIV (H5 N1) was considered to be the cause of death in all animals with a confirmed infection. Details of sex and age repartition of positive cases are presented in table 1.

Table 1: Age category and sex of HPAIV cases in marine mammals tested (swab only/necropsy) in the SLE region in 2022.

Species	Female		Male		ND	Total
	< 1 yr old	Adult	< 1 yr old	Adult	< 1 yr old	
Harbour seal	7	9	3		1	20
Grey seal				1		1
White-sided dolphin			1			1
Total	**7**	**9**	**4**	**1**	**1**	**22**

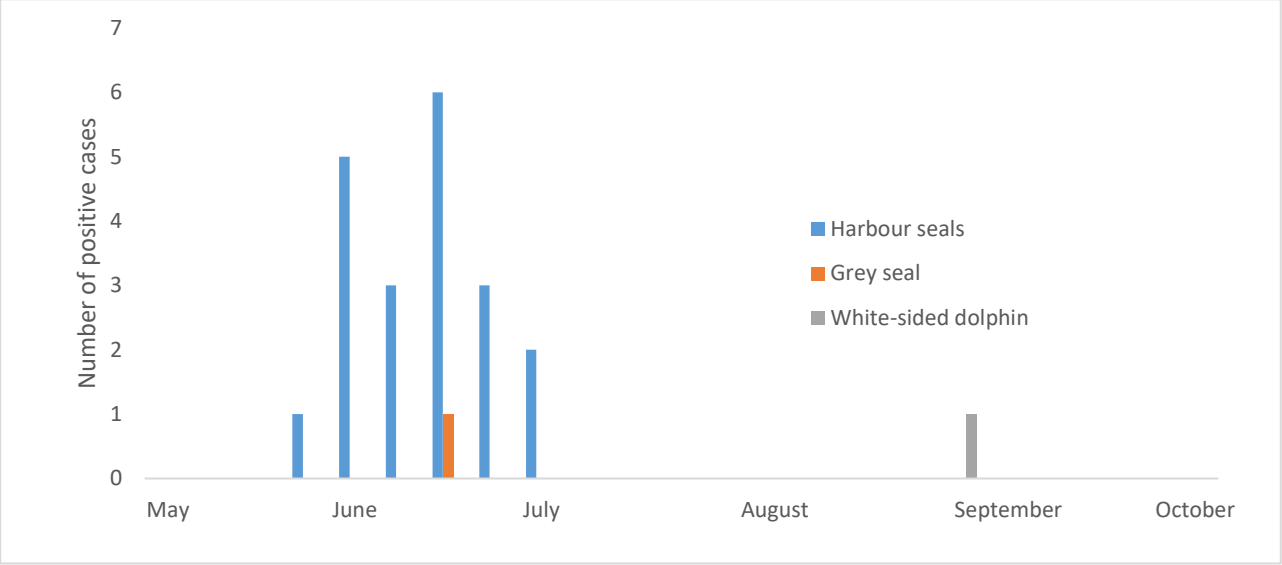

Figure 13: Temporal distribution of marine mammals that died of HPAIV.

CWHC – Atlantic

In the Atlantic region, a total of 20 samples were submitted for HPAIV testing, with no positive case detected. Of these, 15 samples were from cases submitted for necropsy (5 seals, 7 harbour porpoises and 3 delphinids), and 5 were additional samples from dead (n=3) or live, clinically normal (n=2) seals.

4- DOCUMENT MORTALITY OF ANTHROPOGENIC ORIGIN

In the cases submitted to the CWHC – Quebec in 2022, only two cases were associated with a possible, but unconfirmed, direct anthropogenic origin, namely blunt trauma potentially associated with a ship collision.

Two cases submitted to CWHC – Atlantic were associated with mortality of anthropogenic origin, including a harp seal pup presented with a blunt trauma to the head consistent with clubbing. A case of secondary inanition associated with gastric impaction of fishing gear in an adult sperm whale was

also documented. Based on the animals submitted for necropsy, mortalities of anthropogenic origin appeared uncommon in both regions in 2022. However, a larger sample size of documented carcasses is needed to better evaluate direct anthropogenic impacts on marine mammals in these regions.

5- PHOTOGRAPHIC CLASSIFICATION SYSTEM TO CHARACTERIZE MORTALITY EVENTS

A photographic classification system has been developed in order to help categorize deaths for cases that are not submitted to the CWHC – Quebec for post mortem analysis. Pictures and information submitted on the specimen are documented through categories related to identification (order, family, species, sex, age category, location, date found), state of the carcass (Geraci and Lounsbury 2005), morphometrics (length, subjective body score) and the most frequent type of lesions that can be identified from the external evaluation of a carcass (various types of wounds and their temporality, fishing gear presence, integumentary conditions), which may lead to the establishment of a presumptive diagnosis (e.g. scavenging marks, external lesions potentially associated with anthropic origin, such as entrapment, lacerations associated with boat propellers, or predation events). While presumptive diagnosis establishment is generally limited to some cases where a characteristic external lesion is noted (e.g. different types of trauma), the established categorization allows to document interesting trends mirroring observations of submitted necropsy cases, based on an initial review of available pictures for 2022 (n=104). A large number of harbour seals, mainly adult females and immature animals are noted early in the summer, and most individual appear to be in good body condition with no external lesions visible, which might be contextually associated with the diagnosed cases of HPAIV. In contrast, there appears to be more emaciated harbour porpoises documented in the late summer/early fall. However, there is an obvious overlap between the cases that were photographically documented in the field and carcasses submitted for analysis, which likely affects this perceived trend. Nevertheless, this tool will continue to be adjusted and used with submitted photographic cases. The next step in this process includes to have pictures reviewed by a second observer to validate the use of the tool, as well as to discuss with stranding network partners to provide feedback on what type of pictures are most useful for analysis and to establish what tools might be useful for volunteers and personnel of the network to help standardize photographic documentation.

DISCUSSION

Based on the data available, increased observations of sick or stranded marine mammals appeared to be restricted to the SLE region in 2022.

In the SLE region, the most significant increases in stranding numbers were noted during the summer and extended into the fall. Harbour seals and harbour porpoises were both overrepresented in sick or dead individual observations (RQUMM data). Submissions to CWHC – Quebec for post-mortem examinations represented 17 to 20% of the total observations for these species. Overall, deaths were most frequently attributed to nutritional and metabolic causes, and most harbour porpoises were found in this category. A majority of harbour porpoises that died of nutritional or metabolic causes were dependant animals. While newborn animals likely died rapidly of metabolic disturbances due to early

maternal separation associated with mismothering, juvenile, young-of-the-year individuals (‘dependant calves’) lived long enough to nurse and bond with their dam. Emaciation in these later individuals is hypothesized to be caused by a chronic caloric deficiency that could be associated with insufficient lactation from the mother. Several conditions could theoretically affect lactation in individual female harbour porpoises (e.g. mastitis). However, the important number of emaciated juveniles, and also adults, documented within the context of an historical peak in stranding numbers for this species suggest a common underlying cause that could be environmentally related. This species has a high metabolic rate associated with the need of nearly continuous foraging of high energy preys, which makes them particularly vulnerable to changes within the ecosystem and anthropogenic disturbances that could affect foraging behaviour (Booth 2020, IJsseldijk et al. 2022, Wisniewska et al. 2016). Individual porpoises have notably been reported to starve to death in less than a week (Wisniewska et al. 2016). Lactation represents an important energetic investment in females, and reduced foraging efficiency in females could result in a reduced milk production affecting dependant calf survival. We suggest that the increased stranding numbers reported in harbour porpoises were mainly associated with a reduced foraging efficiency in adult porpoises and could be associated with either or both anthropogenic disturbances and decreases in preferred prey availability within the SLE ecozone. This reduced foraging efficiency and subsequent loss in body condition likely affected calf survival. This nutritional stress could predispose individuals to concomitant conditions (viral infection, parasitic burden) and weakens individuals, increasing their risk of being predated. Anecdotal observations suggest that 2022 was a year with low fish stock in the SLE. One example of these observations was the short duration of the frequentations of baleen whales in their usual summer feeding ground in 2022 (Robert Michaud, personal communication).

HPAIV was the predominant cause of death in harbour seals and infection by this emerging virus is suggested to be the cause of the increased stranding numbers observed in this specie in the SLE region in 2022. Most individuals were adult females and young of the year pups. The temporality of the cases coincides with the pupping / lactating season in this species. During this time, both adult females and young of the year spend a significant amount of time in rookeries where they are in direct or indirect contact with marine avian species susceptible to avian influenza (Dubé et al., 2003). In this regard, harbour seal HPAIV cases were generally found in proximity with common eider (*Somateria mollissima*) nesting colonies, which were badly affected by H5N1 HPAIV outbreaks in 2022. The impact of such mortality on harbour seals population dynamics should be limited after a single pupping season. Our observations do not suggest that significant seals-to-seals transmissions of HPAIV occurred in 2022. However, recent reports of large epidemic events in pinnipeds from South America do suggest that this virus can be maintained in a population of marine mammals. Therefore, even if for now the cases of HPAIV infections observed in marine mammals in the SLE seem to have been limited to spill over from birds, the possibility of a self-supporting outbreak in populations of phocids definitely needs to be monitored. The route of exposition in the grey seal is uncertain, but this individual was also emaciated. A compromised immune function associated with emaciation as well as prolonged time passed on shore in a weakened animal could have favoured the probability of transmission (proximity with resting/nesting birds) and increased susceptibility to the infection in this animal. Since grey seals are known to predate marine birds, ingestion of a contaminated bird is definitely a potential route of infection

in this species of seals, as it has been observed in several species scavenging birds and terrestrial mammals. Reports of HPAIV infection and death are scarce in cetaceans and the documented case here is the first reported in a white-sided dolphin. As in phocid species, indirect contact with infected birds is the most likely source of infection, but the exclusively aquatic lifestyle of cetaceans suggests that the risk of infection is limited in these species. The case diagnosed in a dolphin indicates that even if infections is this group is infrequent, odontocetes are susceptible to this virus. The potential impact of this new viral agent on the endangered population of St. Lawrence beluga whale is therefore concerning.

While sick or dead grey seals were also more frequently observed in 2022 in the SLE region, carcasses examined represented a small proportion of the cases observed (5%) and no obvious trends could be detected in the causes of death in this specie. The limited number of animals submitted for evaluation could reflect the larger size of this marine mammal and logistical complexity in processing the carcasses for diagnostics.

In the MP region, based on available data, there was no obvious temporal or species-associated increase in carcass submission for necropsy, as well as no obvious trends in causes of death. The fact that 36% of the causes of death was undetermined is not surprising in wildlife pathology. This is especially true considering the inherent limitations associated with lacking antemortem clinical or environmental data/history and the variable decomposition states of carcasses being submitted, altogether hindering the capacity to draw conclusions. In pelagic delphinids, the cause of stranding is often undetermined but presumed to be associated with environmental variables such as predators, weather, or behavioural factors.

CONCLUSION

In summary, the post-mortem examinations realized on marine mammals submitted to the CWHC – Quebec indicate that the UMEs observed in harbour seals and harbour porpoises of the SLE region in 2022 were respectively most likely due to infection with HPAIV and nutritional stress. Due to their extremely high metabolic requirements, harbour porpoises could represent the ‘canaries in the mine’ regarding the foraging resources of the SLE and trends in causes of death should be closely monitored in this species. The epidemiology of HPAIV should continue to be monitored in marine mammals as the epidemic persists in wild birds. Limited numbers of animals submitted did not allow to determine the cause of the possible increase in mortality of grey seals in the SLE. However, anecdotal observations suggest that infection par HPAIV and increase of predation by sharks might have been contributing factors.

The photographic classification system currently being developed will further support the documentation of mortality in cases unsuitable for necropsies, especially as certain causes of death, such as traumatic (anthropogenic, predation, intraspecific aggression) may be suspected on the base of an external evaluation. When a presumptive diagnosis cannot be established, documentation of external factors (e.g. age class, body condition) is useful to detect trends and might direct targeted

sampling in the field based on the known causes of mortality in the region (e.g. HPAIV swabs). This acquisition of knowledge on the causes of mortality of marine mammals will allow a better understanding of the main health issues affecting this resource depending on a changing ecosystem. This type of baseline data, for both the SLE and Atlantic regions, could also be used to monitor the evolution of the causes of mortality over time in these sentinel species.

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APPENDIX I – CWHC – Quebec 2022 case summary

Specimen code	Common name	Date	Sex	Age category	Length (cm)	Weight (kg)	Body condition	COD-category	Cause of death
CWHC.217776.1	Minke whale	05-26	M	Juvenile	380	437	Good	Undetermined	Undetermined
CWHC.218696.1	Atl. white-sided dolphin	09-05	M	Juvenile	210	100	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.219578.1	Atl. white-sided dolphin	09-20	M	Dep. calf	122	20,24	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.219803.1	Atl. white-sided dolphin	09-24	F	Dep. calf	113	17,6	Sub-optimal	Undetermined	Undetermined
CWHC.220381.1	Atl. white-sided dolphin	09-24	M	Dep. calf	125	20,8	Sub-optimal	Trauma	Infanticide
CWHC.219119.1	Atl. white-sided dolphin	10-07	F	Dep. calf	127	22,88	Sub-optimal	Trauma	Infanticide
CWHC.221916.1	Atl. white-sided dolphin	11-19	M	Dep. calf	148	27	Sub-optimal	Trauma	Predation
CWHC.218434.1	White-beaked dolphin	07-11	F	Dep. calf	135	30	Good	Inf./Infl.	Verminous bronchopneumonia
CWHC.217926.1	Harbour porpoise	05-20	M	Newborn	97	9,72	N/A	Nut./Met.	Separation from dam
CWHC.217662.1	Harbour porpoise	05-21	M	Newborn	83	7,82	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.217666.1	Harbour porpoise	05-22	F	Newborn	83	8,62	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.219012.1	Harbour porpoise	06-07	M	Newborn	71	6,28	N/A	Nut./Met.	Separation from dam
CWHC.217668.1	Harbour porpoise	06-09	M	Newborn	80	6,78	N/A	Nut./Met.	Separation from dam
CWHC.217669.1	Harbour porpoise	06-20	M	Adult	152	52	Good	Undetermined	Undetermined
CWHC.217645.1	Harbour porpoise	07-09	F	Adult	160	41	Sub-optimal	Other	Peripartum mortality
CWHC.220641.1	Harbour porpoise	07-13	M	Dep. calf	93	11,52	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.218608.1	Harbour porpoise	07-20	F	Juvenile	115	16	Emaciated	Nut./Met.	Failure to thrive
CWHC.220610.1	Harbour porpoise	07-22	F	Dep. calf	80	8,257	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.218423.1	Harbour porpoise	07-28	M	Adult	165	40	Emaciated	Other	Pheochromocytoma
CWHC.218839.1	Harbour porpoise	08-04	M	Dep. calf	90	9,02	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.218550.1	Harbour porpoise	08-09	M	Dep. calf	92,4	11	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.218669.1	Harbour porpoise	08-12	M	Adult	152	37	Emaciated	Nut./Met.	Inanition
CWHC.219291.1	Harbour porpoise	08-24	M	Adult	152	34	Good	Undetermined	Undetermined
CWHC.218901.1	Harbour porpoise	09-01	M	Dep. calf	91	11,04	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.218956.1	Harbour porpoise	09-10	F	Adult	156	48	Good	Inf./Infl.	Perforating parasitic gastric ulcer
CWHC.220566.1	Harbour porpoise	09-29	F	Dep. calf	89	10,62	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.219779.1	Harbour porpoise	10-02	M	Dep. calf	88	8,94	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.220847.1	Harbour porpoise	10-02	M	Dep. calf	99,5	13,08	Emaciated	Nut./Met.	Deficient maternal nutritional support

Specimen code	Common name	Date	Sex	Age category	Length (cm)	Weight (kg)	Body condition	COD-category	Cause of death
CWHC.220063.1	Harbour porpoise	10-06	M	Dep. calf	91	10	Sub-optimal	Trauma	Predation
CWHC.219914.1	Harbour porpoise	10-09	M	Dep. calf	103	18	Good	Trauma	Blunt trauma
CWHC.221917.1	Harbour porpoise	10-24	F	Adult	159	38	Emaciated	Nut./Met.	Inanition
CWHC.221873.1	Harbour porpoise	11-13	F	Dep. calf	93,5	13,32	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.221922.1	Harbour porpoise	12-03	F	Dep. calf	103	15	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.220720.1	Harbour porpoise	12-07	M	Dep. calf	94	10,86	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.221874.1	Harbour porpoise	12-11	F	Dep. calf	93	12,58	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.219585.1	True's beaked whale	10-26	M	Adult	487	960	Good	Other	Accidental stranding
CWHC.217794.1	Grey seal	06-24	M	Adult	219	136	Emaciated	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.218347.1	Grey seal	08-20	M	Geriatric	215	128	Emaciated	Nut./Met.	Inanition
CWHC.218727.1	Grey seal	08-26	M	Adult	205	110	Sub-optimal	Trauma	Predation
CWHC.218017.1	Harbour seal	05-21	F	Newborn	82	7,2	N/A	Nut./Met.	Separation from dam
CWHC.217663.1	Harbour seal	05-29	F	Newborn	78	7,84	N/A	Inf./Infl.	Bacterial pneumonia, undetermined
CWHC.217719.1	Harbour seal	05-30	F	Adult	148	61	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217403.1	Harbour seal	05-31	F	Newborn	79	7	N/A	Nut./Met.	Separation from dam
CWHC.216969.1	Harbour seal	06-07	M	Dep. pup	87	17,54	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216970.1	Harbour seal	06-07	F	Adult	150	73	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216971.1	Harbour seal	06-08	F	Adult	142	53	Sub-optimal	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216947.1	Harbour seal	06-10	F	Adult	145	63	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216972.1	Harbour seal	06-14	F	Dep. pup	91	15,56	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217402.1	Harbour seal	06-14	M	Newborn	80	7,86	N/A	Nut./Met.	Separation from dam
CWHC.217671.1	Harbour seal	06-14	F	Adult	138	49,4	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216988.1	Harbour seal	06-20	F	Newborn	84	11,32	N/A	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217670.1	Harbour seal	06-20	F	Dep. pup	104	27,4	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216973.1	Harbour seal	06-22	F	Adult	136	48	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.216974.1	Harbour seal	06-22	F	Newborn	87	12,4	N/A	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217642.1	Harbour seal	06-26	M	Dep. pup	95	22,98	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217665.1	Harbour seal	06-26	F	Dep. pup	94	22,96	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217667.1	Harbour seal	06-26	M	Dep. pup	93	26	Good	Inf./Infl.	Highly Pathogenic Avian Influenza
CWHC.217801.1	Harbour seal	07-10	M	Dep. pup	83	11,94	Emaciated	Inf./Infl.	Multisystemic bac. infection, *S. phocae*

Specimen code	Common name	Date	Sex	Age category	Length (cm)	Weight (kg)	Body condition	COD-category	Cause of death
CWHC.219209.1	Harbour seal	08-17	F	Dep. pup	90	14,52	Good	Undetermined	Undetermined
CWHC.219698.1	Harbour seal	10-04	M	Adult	122	23	Emaciated	Nut./Met.	Inanition
CWHC.220359.1	Harbour seal	10-06	F	Juvenile	79	8,08	Emaciated	Inf./Infl.	Verminous bronchopneumonia, GI parasitism
CWHC.221920.1	Harbour seal	12-01	M	Adult	149	46	Emaciated	Nut./Met.	Inanition
CWHC.217664.1	Harp seal	04-22	F	Adult	175	115	Good	Trauma	Blunt trauma
CWHC.221919.1	Harp seal	12-06	M	Juvenile	113	37	Good	Undetermined	Undertermined
CWHC.218805.1	Hooded seal	09-14	M	Juvenile	103	19	Emaciated	Nut./Met.	Failure to thrive

APPENDIX II – CWHC – Atlantic 2022 case summary

Event code	Common name	Date	Sex	Age category	Length (cm)	Weight (kg)	Body condition	COD-category	Cause of death
CWHC.221712.1	Minke whale	06-09	U	Adult	-	-	Unknown	Undetermined	Undetermined
CWHC.222218.1	Common dolphin	12-17	F	Adult	213	-	Good	Undetermined	Undetermined
CWHC.217818.1	Striped dolphin	06-29	M	Adult	181	64,4	Good	Inf./Infl.	Non-suppurative meningitis
CWHC.217817.1	Striped dolphin	07-04	F	Juvenile	195	67	Emaciated	Inf./Infl.	Fibrinous myocarditis
CWHC.220739.1	Cuvier's beaked whale	12-06	M	Adult	584	-	Good	Undetermined	Undetermined
CWHC.217813.1	Harbour porpoise	05-09	M	Adult	150	50	Good	Inf./Infl.	Bacterial hepatitis
CWHC.217814.1	Harbour porpoise	06-05	F	Adult	106	58,5	Suboptimal	Other	Dystocia
CWHC.222221.1	Harbour porpoise	10-20	F	Adult	155	-	Good	Undetermined	Undetermined
CWHC.216002.1	Harbour porpoise	05-30	F	Juvenile	100	61,69	Good	Other	Complications associated with a leomyoma
CWHC.222222.1	Harbour porpoise	12-08	M	Adult	152	-	Good	Inf./Infl.	Hemothorax secondary to verminous pneumonka (*Halocercus* sp)
CWHC.222225.1	Harbour porpoise	08-28	F	Dep. calf	101	-	Good	Undetermined	Potential trauma
CWHC.219653.1	Harbour porpoise	09-12	F	Dep. calf	92	12,72	Suboptimal	Undetermined	Undetermined
CWHC.222219.1	Harbour porpoise	09-29	M	Dep. calf	109	-	Emaciated	Nut./Met.	Deficient maternal nutritional support
CWHC.216576.1	Harbour porpoise	06-15	F	Newborn	74	4,8	Emaciated	Nut./Met.	Separation from dam
CWHC.217814.2	Harbour porpoise	06-05	M	Newborn	83	8,6	N/A	Other	Intrauterine death (Dystocia)
CWHC.220086.1	Sperm whale	11-04	M	Adult	13716	-	Emaciated	Nut./Met.	Secondary inanition - Gastric impaction with fishing gear
CWHC.219650.1	Grey seal	04-28	M	Dep. pup	90	12,27	Emaciated	Nut./Met.	Deficient maternal nutritional support

Event code	Common name	Date	Sex	Age category	Length (cm)	Weight (kg)	Body condition	COD-category	Cause of death
CWHC.219652.1	Grey seal	03-24	F	Dep. pup	102	22,73	Suboptimal	Undetermined	Undetermined
CWHC.219207.1	Harbour seal	08-17	F	Juvenile	-	33,6	Good	Inf./Infl.	Parasitic - verminous pneumonia
CWHC.214468.1	Harp seal	04-10	M	Dep. pup	75	8,7	Good	Trauma	Cranial blunt trauma
CWHC.216130.1	Harp seal	06-01	M	Juvenile	79	13,18	Emaciated	Inf./Infl.	Streptococcal cellulitis
CWHC.222228.1	Harp seal	12-05	F	Juvenile	131	-	Good	Undetermined	Gastric impaction with vegetation