Strandings of southern right whales (*Eubalaena australis)* at Península Valdés, Argentina from 2003-2007

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ABSTRACT

More southern right whales die and strand each year on their nursery ground at Península Valdés, Argentina than anywhere else in the world. The Office of Protected Resources of the US National Marine Fisheries Service (NMFS) has provided support to the Argentine Programa de Monitoreo Sanitario de Ballena Franca Austral (PMSBFA) since 2003 to develop a better understanding of the health risks and disease susceptibilities of right and other baleen whales. Between 2003 and 2007, the PMSBFA team photographed, measured and collected tissue samples from 192 dead southern right whales including 170 calves, 15 adults and 7 juveniles. Stranded calves ranged in length from 3.78-9.83 m, and the apparent mean growth rate, determined by calf length and estimated date of death, was 2.5cm/day. Ten calves less than 4.24 m were recorded from June through November possibly indicating a broad birthing period. In relation to the last 30 years, calf deaths increased sharply in 2005 and 2007. The population experienced an apparently severe mortality event in 2007 in Golfo Nuevo, the southern gulf of the Península Valdés. Sixty calves died between October 4th and December 16th. Unfortunately, most calves died offshore and were in advanced states of decomposition when they stranded. With assistance from a team of specialists sent to Argentina by NMFS, a number of dead whales were thoroughly examined. Though harmful algal blooms in the area are hypothesized to be linked to these deaths, no conclusive evidence was found in our investigations.

KEYWORDS: MORTALITY RATE, GROWTH, HABITAT, STRESS, TRENDS

BACKGROUND

Southern right whales (*Eubalaena australis*) are recovering from whaling with most populations growing at 7-8% per year while their sister species in the northern hemisphere could be facing extinction (IWC report, 2001). Península Valdés, Argentina is a major nursery ground for the southwest Atlantic population. Many calves are born here. They and their mothers typically spend about three months in shallow waters near the shores of the Península's two large sheltered bays, Golfo Nuevo (GN) and Golfo San José (GSJ) (Payne, 1986; Taber and

Thomas, 1982; Thomas and Taber, 1984). The population has been studied continuously since 1970 through annual aerial surveys and boat and cliff-top observations (Payne, 1986; Rowntree *et al*., 2001*)*. Whales begin arriving at the Península in April, reach maximum numbers in September and most have left for their feeding grounds by the end of December (Payne 1986). Most calves are born in August (Whitehead and Payne, 1981). The population was estimated at 2,577 whales in 1997 (IWC report, 2001), with an annual growth rate of 6.9% per year (Cooke *et al.*, 2001).

More right whales die and strand on the beaches of Península Valdés each year than in any other region of the world, making it a unique location to evaluate right whale health through post mortem examinations. The topographic and oceanographic characteristics of the Península, such as its large bays with gradually sloping beaches and 7-8m tides probably contribute to the high number of strandings. Research effort devoted to strandings of right whales at Península Valdés was variable and somewhat opportunistic between 1971 and 2002. Systematic efforts began in 2003, with the establishment of the Programa de Monitoreo Sanitario de Ballena Franca Austral (PMSBFA), with financial support from the Marine Mammal Health and Stranding Response Program of the Office of Protected Resources of the National Marine Fisheries Service, USA. The objective of PMSBFA is to evaluate the health risks and disease susceptibilities of right and other baleen whales through necropsies. Field research is carried out by Argentine biologists, veterinarians and volunteers associated with the Wildlife Conservation Society, the Whale Conservation Institute/Ocean Alliance, the Instituto de Conservación de Ballenas, Fundación Patagonia Natural, and Fundación Ecocentro. Logistical support is provided by local government agencies including the Subsecretaría de Turismo y Areas Protegidas and Dirección de Flora y Fauna Silvestres from Chubut Province, the Administración del Area Natural Protegida Península Valdés and Prefectura Naval Argentina (coast guard) and a stranding network that has grown over the years to include more than 70 individuals who live and work at locations dispersed widely throughout the Península. The network notifies the field team of strandings as they are found. Network members include local residents, park rangers, fishermen, whale-watch boat operators, divers, tour guides, pilots, scallop fishermen, members of CENPAT/CONICET (a local research center from the Argentina National Research Council), other researchers, NGOs and the Prefectura Naval Argentina.

Tissue samples collected at strandings are being analysed for fatty acids, stratification and thickness of blubber, persistant organic pollutants and trace metals, population genetics, stable isotopes, bacteriology and virology, biotoxins, infectious diseases using serology and histopathology, and responses of cells to toxins. Data collected from stranded right whales including morphometric measurements and hisotpathology reports will be available to interested researchers through the NMFS website (NMFS's Office of Protected Resources, Marine Mammal National Data base in the Marine Mammal Health and Stranding Response Program, contact: mmhsrp.nationaldb@NOAA.gov for access). Here we describe the program's activities and findings from 2003 through 2007, with special attention to a large cluster of strandings that occurred in October-December of 2007.

METHODS

The PMSBFA field team is active throughout the period when right whales are abundant (June through December). Every year the PMSBFA team renews contact with members of the stranding network and establishes a biweekly survey schedule. Surveys include truck surveys and walking and scanning inaccessible beaches with a telescope in areas where whales concentrate. Survey effort has varied depending on vehicle availability and intensity of stranding reports by the network –ie. if the team was busy visiting a number of strandings on a given week, the survey for that week was cancelled or postponed. Some years the stranding team has also made monthly aerial surveys of the coasts of the two gulfs that form the Peninsula with support from the Administración del Área Natural Protegida Península Valdés. When a boat and captain are available and a whale is found floating, a rope is fastened around its tailstock and the animal is secured to shore at high tide to make it available for necropsy as the tide retreats (this procedure has only been done exceptionally). The body is examined for evidence of external injuries, measurements are taken, and tissue samples are collected depending on the state of decomposition of the carcass. A necropsy protocol for right whales was developed for this project by M. Uhart, L. La Sala and L. Pozzi, based on protocols developed by McLellan *et al.* (2004), F. Gulland (pers. comm), A. Carribero (pers. Comm.) and Geraci et al (1993).

RESULTS AND DISCUSSION

Since the establishment of PMSBFA in 2003, 192 strandings have been recorded including 170 (89%) calves. Seventy-two percent of the strandings were in the southern gulf (Golfo Nuevo) (Figure 1). The age distribution of stranded whales is shown in Table 1. Females accounted for 47% (90) of stranded whales, males for 30% (56) and 23% were not identified. During this period and increasingly over the years, most strandings have been found by members of the network (78%), while others were identified by the field team during biweekly surveys

of beaches. For comparison, from 1971 through 2000, only 127 right whale strandings were recorded at Península Valdés.

Strandings over time. In comparison to the last 30 years, calf strandings appear to have increased significantly since the beginning of 2003. However, there are two factors that might account for some of the increase. One is the systematization and higher detection capacity of the stranding program since 2003, and the other is the effect of the unusually high mortalities of 2005 and 2007 on the average numbers of stranded whales. For the purpose of putting these numbers in context, calf strandings between 1971 and 2004, increased at a rate of 7.4% per year (Figure 2, right, lower line), while the maximum number of living calves counted each year during photoidentification aerial surveys (Whale Conservation Institute/Instituto de Conservación de Ballenas) increased at 6.8% per year (Figure 2, left). However, if all years through 2007 are included, the apparent mean rate of increase in calf strandings is 8.5% (Figure 2, right, upper line) (note that stranding numbers for 2001 and 2002 are represented by lighter bars to indicate that they are estimates as there is no data for those two years). Given the limitations of stranding data collected prior to 2003 and the high annual variability observed in the last 5 years (Fig. 1 and 2), it is possible that we are under-estimating stranding rates.

Fig. 1. Peninsula Valdes, Argentina, with the distribution of right whale strandings in 2007. Pins indicate strandings. Filled circles indicate the locations of stranding network participants.

Table 1. Numbers of stranded whales and their age distribution, 2003-2007.

Year	Calves	Juveniles	Adults	Total
2003	29	1	1	31
2004	13	0	0	13
2005	36	4	7	47
2006	17	1	2	18
2007	77	1	5	83
Total	170	7	15	192

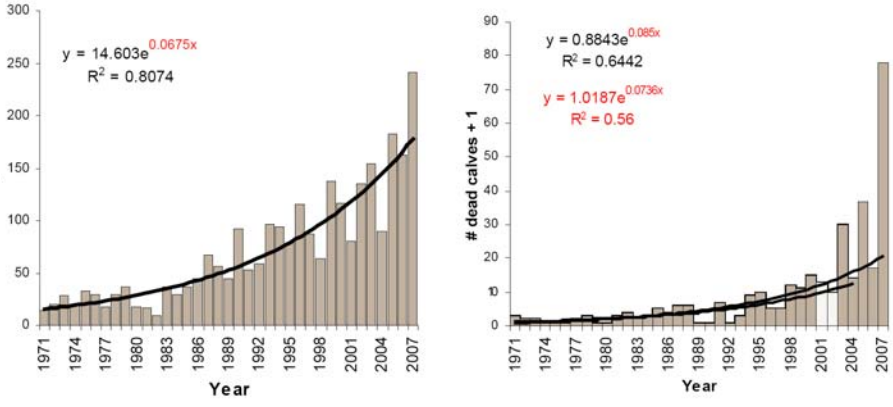

Fig. 2. Rate of increase in the maximum number of calves counted each year during aerial photographic surveys, in the number of dead calves recorded each year from 1971 to 2007.

Spatial distribution of strandings. The number of strandings varies greatly between the two gulfs as well as between years (Figure 3). (More calves have stranded in the southern gulf (Golfo Nuevo, GN) than in the northern gulf (Golfo San Jose, GSJ) in all years with the exception of 2006, but the difference is more pronounced in years with many strandings (Figure 3). The simplest explanation for this difference would be that more mother-calf pairs typically reside in GN than in GSJ, but this explanation is not supported by the annual aerial photo-identification surveys and other sources of data on population sizes in the two gulfs. For example, during the mortality event of 2007, many more calves stranded in GN (70) than in GSJ (7), but an aerial survey near the beginning of the event counted 136 calves in GN and 103 in GSJ ($X^2 = 29.7$, $P < 0.001$). In principle, the average mortality excess in GN might be caused by asymmetrical movement of whales from GSJ (which is smaller and to the north) to GN (which is larger and to the south) near the end of the nursery season, as was observed for some individuals in the 1970s when there were several aerial surveys per year (unpublished observations by V. Rowntree and R. Payne). But this clearly seems implausible as an explanation for the mortality cluster of 2007, suggesting that the long-term average difference might be caused by some factor or factors specific to GN.

Temporal distribution of strandings within years. The temporal pattern of strandings appears to change at the end of September. Figure 4 shows the temporal distribution of strandings for 2003-2007 (individuals of all ages, and in both gulfs, binned by 2-week intervals). In all years the number of strandings appears to increase gradually to around five strandings per two week interval until the end of September. Thereafter the trend either slowly declines to the end of the season (most years), or declines with occasional bursts of apparently high mortality (2005 and 2007). This variation does not appear to be caused by changes in survey effort, because most strandings are reported by the network which involves many people working independently and distributed broadly over the Península. The date given to a stranding is the day the team was first notified of the stranding, not the date of the necropsy.

More broadly, temporal variations could be related to a variety of habitat/environmental changes. One of these changes could be food availability with the arrival of spring, potentially including harmful algal blooms (HAB) (see below). Phytoplankton typically begins to bloom at Península Valdés in September and adult whales begin to skim-feed sporadically in October (Rowntree, Sironi and Payne pers. comm.). The whales are thought to be primarily fasting prior to these dates. Feeding bouts occur in both gulfs and last for a few minutes up to several hours, but then may not be seen again for several or many days. If toxic organisms were being ingested by adult whales, it is possible that the toxin doses would be too low to affect adults but could affect calves because of their smaller body size. However, it is unknown if toxins can be concentrated in the milk of nursing females and passed through the milk to their calves in high doses. Calves do not feed on their own during their first three month of life when they are at Península Valdés.

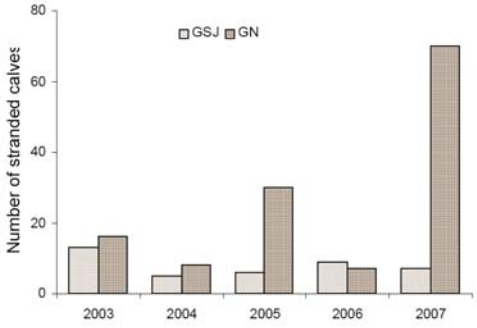

Fig. 3. Annual distribution of calf strandings between Golfo San Jose (GSJ) and Golfo Nuevo (GN).

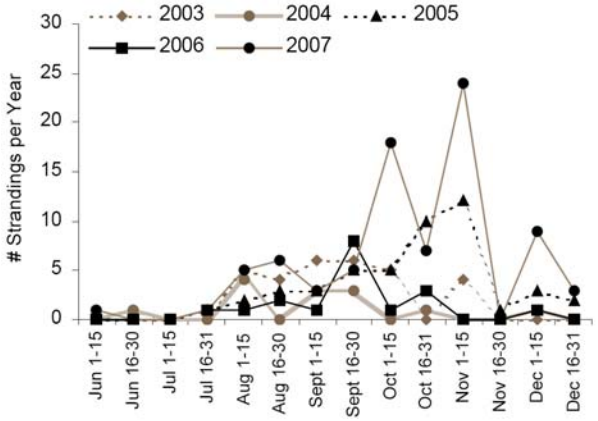

Fig. 4. Biweekly distribution of strandings within each year, 2003-2007.

Lengths of stranded calves. Figure 5a shows the distribution of calf lengths (snout tip to fluke notch) by the day of year when reported (by the network) or found (by the stranding team). If calf lengths are divided into two periods (before and after September 30th, Figure 5b), then calves that stranded prior to September 30 show no apparent temporal increase in average length ($r^2 = 0.07$, n.s.). The mean length of stranded calves before September 30 is 5.06 m (sd = 0.75 m). Best and Ruther (1992) used aerial photogrammetry to measure living right whales on the nursery ground off South Africa and found a wide range of calf sizes at any one time. They

also found that primiparous females had smaller calves, and calved later in the season than multiparous females. We also find a broad distribution of lengths of stranded calves. Best and Ruther were able to measure the same calves several times within the nursery season and found consistent growth rates of 2.8 cm/day from July through November. Figure 5a shows an average increase of 2.5cm/day for stranded calves over the entire season at Península Valdés, which is remarkably close to Best and Ruther's directly estimated growth rate off South Africa, considering that our indirect estimate is biased downward by the large number of small calves that appear throughout the season. The smallest stranded calf in the Valdés data was 3.78 m in length while the smallest living calf measured by Best and Ruther was 4.53 m. Therefore, some of the smallest stranded calves may be stillborns. Dead calves less than 4 m were found at Península Valdés from June through the middle of November (Figure 5b), indicating that calving probably occurs at the Península over a period of around five months.

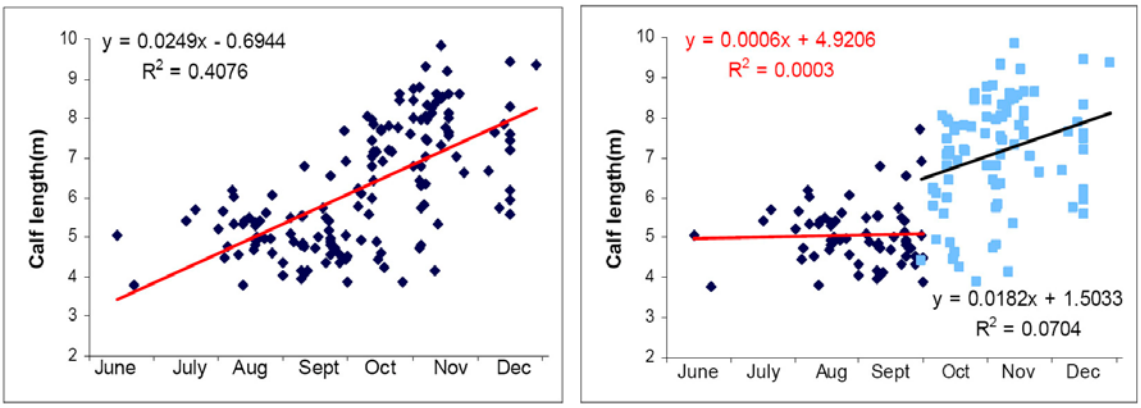

Fig. 5. Distribution of the lengths of calves that stranded at Península Valdés from 2003 through 2007, by date when they were reported or found. (a) Linear regression of length on date for all calves. (b) Separate linear regressions for calves stranded before and after September 30.

Pathology findings. Rough-surf injury, boat strikes and other sources of blunt-force trauma remain potential diagnoses for a calf that died in 2003 with extensive renal and spleen hemorrhages. In 2004 we recovered the skeleton of an adult male stranded the year before with chronic degenerative lesions in most vertebrae of the spine, with multiple fused blocks of vertebrae consistent with ankylosing spondylitis. Two episodes of possible distosia were recorded. In 2005 an adult female died holding a full term calf (female size 15.35m, calf size 4.46 m not including the head) in her uterus, and in 2007 we recorded the death of a female and her pup during parturition (the pup could be seen stuck in the birth canal). This female was very small (14.60m) and her female pup very large (5.35m).

Scars from gull attacks are commonly found on the backs of dead whales at Península Valdés In the early 1980s, kelp gulls (*Larus dominicanus*) at Península Valdés learned to feed on whale skin and blubber by landing on the whales' backs and pecking holes in their skin, then pulling pieces of skin and blubber from the open wounds (Rowntree *et al*, 1998). The gulls aim at existing lesions and enlarge them over the season. The percentage of whales with gull lesions increased from 1% in 1974 to 38% in 1990 to 68% in 2000 (WCI/ICB unpublished data). Gull attacks were initially confined to adults, but by the year 2000 calves had become preferred targets. Currently, a significant number of calves older than a month have at least one and usually a chain of gull attack lesions on their back (WCI/ICB unpublished data). Gull-inflicted lesions on the whales' backs appeared more swollen in the first week of October, 2007. Necropsies in 2007 showed that bleeding under the lesions extended through the blubber layer. In previous years these lesions were often contaminated with bacteria indicating that they could possibly lead to systemic infections.

Histopathology: Most of the 192 strandings recorded since 2003 were in advanced states of decomposition, with only 15% of the dead animals (28) (all of them calves) in fresh condition. Tissues for histopathology were collected from 37 whales (19%). Most common histopathology findings included sloughed cells and bacteria in alveoli and bronchioles, probably related to water aspiration; squames in alveoli, possibly related to fetal distress during parturition or in the periparturient period; and skin and blubber inflammation from gull inflicted lesions with varying degrees of severity and bacterial colonization. Other observed lesions include acute inflammation of the umbilicus; bacterial sepsis probably related to skin wounds; liver lesions potentially as a systemic response to stress; and spleen hemorrhage and evidence of blunt force trauma.

Infectious disease serology: Analysis were performed on serum from two dead calves found in 2004. Results were negative for *Brucella abortus*, 5 serovars of leptospirosis, calicivirus and avian influenza. Both animals had antibodies for canine herpesvirus.

UNUSUALLY HIGH SOUTHERN RIGHT WHALE MORTALITY IN 2007

Conditions prior to and at the beginning of the mortality event. The mortality event that began at Península Valdés in early October 2007 following a period of extremely high levels of chlorophyll in Golfo Nuevo, the southern gulf of the Península where most of the strandings occurred. Composite eight-day satellite images (MODIS-Aqua, oceancolor.gsfc.nasa.gov) indicated chlorophyll *a* densities from 30 September to 7 October in Golfo Nuevo at the highest range of the density scale. Toxic algae and biotoxin levels in the waters surrounding the Península are monitored on a regular basis to prevent human shell-fish poisoning. The high chlorophyll levels in Golfo Nuevo coincided with the closure of the three gulfs surrounding Península Valdés (Golfo San Matias, GSJ and GN) to scallop fishing due to high levels of paralyzing toxins in the water. In addition, researchers from the ICB/WCI conducting an aerial survey of right whales on October 5th photographed an unusual green colouring in water of GN, along its eastern shore. On October 23rd, researchers from the PMSBFA conducted another aerial survey and photographed an intense red coloration along the shores of GN.

Distribution of living calves before the mortality event. During aerial photo-identification surveys of the right whales on the 5th and 7th of October, researchers covered the entire perimeter of the Península and counted 676 whales including 241 calves (the highest number ever recorded since 1971). The numbers of calves counted in each gulf were similar (103 in GSJ, 136 in GN). Other whales were also seen along the outer coast of the Península. The whale counts during photo-identification surveys do not include all whales because many whales (including calves) are seen in the middle of the gulfs where the plane cannot fly for safety reasons (M. Sironi pers. comm.).

Because 241 calves is the largest number ever recorded during a comparable photo-identification survey (since 1971), we might also have expected to see an unusually large number of dead whales and a spatial distribution of calf strandings similar to that of living calves. However, even on a per-calf basis, the mortality in GN appears to have been extremely high relative to that in other years, and as was mentioned above, the mortality rate also appears to have been far higher in GN than in GSJ during the same period (see Figures 1, 3 and 7). Due to the timing of the peaks in mortality, the aerial survey team did not see an alarmingly high number of stranded whales on October 5 ad 7. The number of strandings had reached 27 by October 8th but by October 29th a total of 65 strandings had been recorded for the year.

Water Samples. Analyses of water samples collected in September 2007 and analyzed by Oc.Viviana Sastre (Programa de Monitoreo de Floraciones Algales Nocivas en Aguas Costeras de Chubut, Argentina) off the southwestern shore of GN showed high densities of the toxic dinoflagellate (*Alexandrium tamarense* 18,125 cells/liter) and paralyzing toxin concentrations of 3,612 UR in a species of mussel. Although this toxin concentration is above the limit for human consumption we do not know if it could be harmful for whales. The samples also had high densities of a non-toxic green dinoflagellate tentatively identified as *Lepidodinium chlorophorum* (61,488 cells/liter). The significance of this finding for the whales is unknown, as there were no mass whale mortalities observed in GN in November 2004 when densities of *L. chlorophorum* were several times higher reaching 310,848 cells/liter.

Water samples collected in GSJ in early November 2007 were examined by Drs David Kulis and Luciano Fernandes (Woods Hole Oceanographic Institution) who found high concentrations of *Pseudo-nitzschia sp.* (1-2 million cells/liter), tentatively identified as *Pseudo-nitzschia australis,*, a diatom that can produce domoic acid and was linked to the deaths of over 400 sea lions off the coast of California in 1998 (Scholin *et al.* 2000). Many of the cells in the water samples collected in GSJ lacked chloroplasts suggesting they were remnants of an earlier bloom.

The mortality event. Sixty-one whales died between the 4th of October and the 16th of December, 2007, with three whales stranding in GSJ and 58 in GN. One was an adult and 60 were calves. The strandings appeared in bursts, one in the first two weeks of October, another in the first two weeks of November, and a smaller spike in the first two weeks of December (Figure 4), perhaps indicating recurring toxic events. As was mentioned above, we do not think the bursts were related to variation in survey effort, because the field team was notified of these strandings by different members of the Stranding Network or found dead animals opportunistically when visiting a reported stranding. The US National Marine Fisheries service sent a stranding response team (W. McLellan, M. Moore and K. Touhey) to Argentina to assist with necropsies. Fifteen right whales were examined during their visit, which extended from 31 October to 9 November. The state of decomposition limited sampling in most cases, with a few carcasses found in condition code 3 (organs intact but not of histological quality) and most in

codes 4 or 5 (most organs dissolved). As is often the case at the Península, calves were dying offshore and were later stranded by the wind, currents and tides. Furthermore, throughout the die-off, the high number of stranding reports received per day greatly challenged the teams' capacity to respond in a timely matter. Given these constraints, the detail and extent of the necropsies (a total of 9 were performed) varied from minimal (dissection for colon contents only) to thorough necropsies (examination for any/all identifiable organs). Fecal samples were collected from all nine whales, and organ tissues from six. However a minimum set of samples were collected from 33 whales during the peak mortality period (skin and baleen) and measurements were recorded for 54.

A similar sudden die-off occurred in 2005 when 3 adults stranded on 19 October in adjacent beaches in GSJ. One was a female that had been seen a few weeks earlier swimming with a large and healthy calf. Twenty-four whales stranded after that (from 24 October through 25 December) including 9 in GSJ (3 adults, 4 juveniles and 2 calves) and 16 calves in GN.

Results of analyses. Samples were analysed by pathologists Denise McAloose (Global Health Programs, Wildlife Conservation Society, Bronx, NY) and David Rotstein (NOAA Center for Marine Animal Health, College of Veterinary Medicine, University of Tennessee), and by the National Ocean Service, Marine Biotoxins Program, NOAA, Charleston, SC. No evidence was found of saxitoxin, domoic acid or shared pathologies in any of the whale tissues analyzed with the exception of gull attack lesions. Poor tissue quality precluded determining the cause of death in any of the whales examined. Water samples collected before and after the first burst in strandings showed elevated densities of the potentially toxic species *Alexandrium tamarense* and *Pseudo-nitzschia sp.*

CONCLUSIONS

Although the evidence seems to suggest that the mortality cluster of 2007 may be related to harmful algal blooms, other causes cannot be ruled out.

Necropsies and histopathology from calves sampled in 2007 showed that bleeding and inflammation under gull-peck lesions extended through the blubber layer and possibly could have led to systemic infections in some cases, as was suspected in a few cases from previous years.

Southern right whale populations at Península Valdés and elsewhere might continue to grow even if high-mortality events like those of 2005 and 2007 recur. However, the remaining northern right whale populations might be devastated by even a few such events, though this might not be the single most critical threat for their populations. Because of the significance of loosing adult reproductive females and the unknown long-term population effects that these types of events might have, we think it is urgently important to understand the causes of mortality clusters such as those described here. Regular water sampling and prompt analysis might provide some warning of conditions likely to trigger increased mortality, as well as provide critical baselines, particularly for HAB events. Thorough investigation of ongoing mortality events and retrospective analysis of conditions associated with mortality clusters after they have occurred is essential, and requires significant collaborative efforts. With better logistical preparation and improved abilities to recognize mortality clusters in progress, researchers would be able to find more of the affected animals in fresh condition, and thus to gather evidence critical to determining the causes of death.

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