The Evidence

That the Offshore Wind Energy Vessel Surveys are the Cause of the Recent New Jersey Whale & Dolphin Deaths

November 2, 2023

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The Agencies and Government Officials promoting the offshore wind projects repeatedly state that the survey vessels offshore using high intensity noise devices to characterize the seabed for wind turbine placement are not the cause of the recent whale and dolphin deaths. They say that there is no evidence linking the two, but at the same time, present no evidence to support their conclusion. They say that the experts say this, but they do not identify the experts. They say that an investigation is ongoing, but they do not identify the investigators. They say that those who say the opposite, like us, are colluding with the fossil fuel industry to denigrate the program, but that is false and on that we agree there is no evidence.

In fact, they just haven't looked because there is ample evidence leading to a plausible conclusion that the surveys were the most likely and logical cause. To help them out we assembled that evidence and this report.

The evidence consists of the following elements, listed and then presented in detail below.

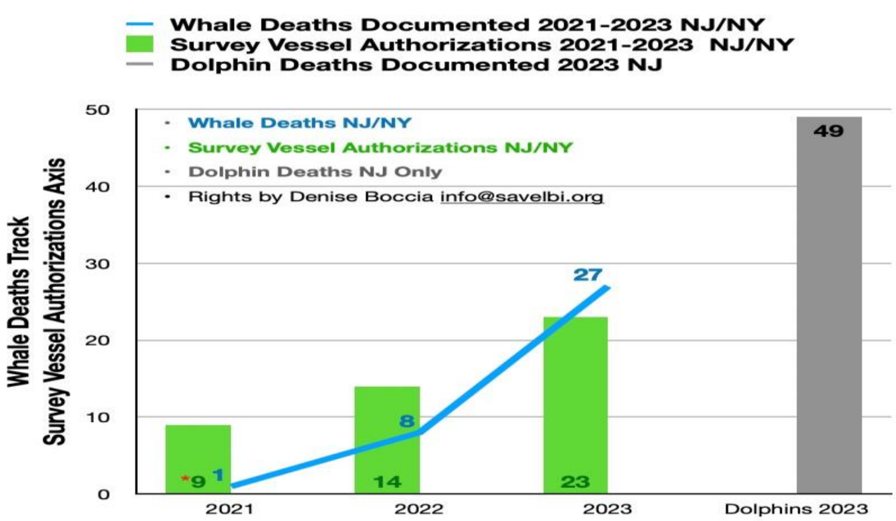
1. **There have been recent unprecedented spikes in whale deaths**
2. **The deaths began when the number of vessel surveys increased.**
3. **The time and place of the whale deaths coincides with survey vessel presence**.
4. **The use of an unsupported low noise source level and a high transmission loss factor underestimates the elevated noise range from the vessel and the number of animals affected.**
5. **The primary impact on those animals, i.e., "disturbance" of their behavior which can lead to serious harm and fatality, is not addressed in survey approvals, nor is the cumulative impact of multiple vessels operating in the same area.**
6. **There have been many whale stranding events worldwide associated with noise devices with similar horizontally directed and more impacting noise patterns, and**
7. **No other plausible cause of the deaths has been put forward.**

1. Unprecedented Spikes in Whale Deaths.

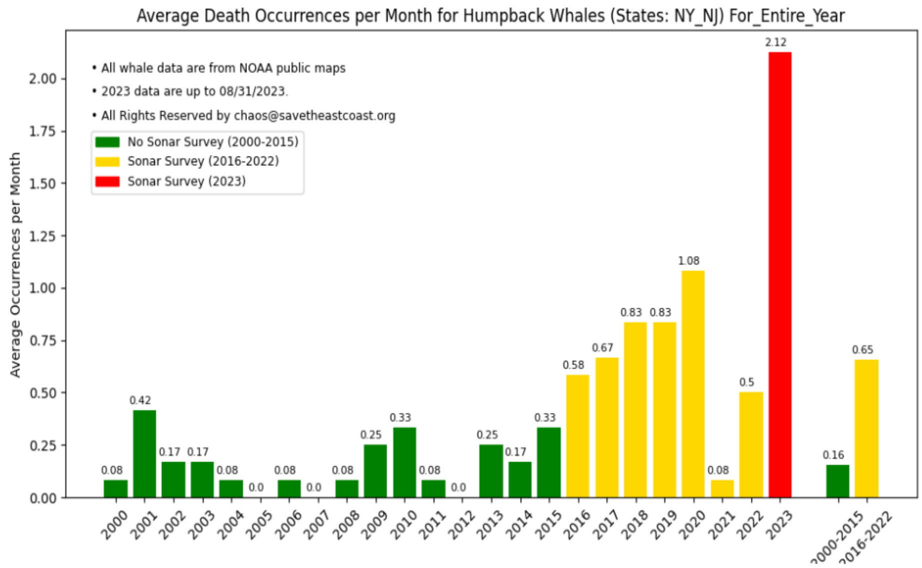
There was an unprecedented spike in whale and dolphin deaths off the New Jersey/New York coasts beginning in December 2022 through March 2023. Lesser but notable spikes have occurred along the east coast beginning in 2016.

2. **The spikes began when vessel surveys increased.**

Off New Jersey, the number of vessel surveys increased from two in November to six in December, 2022 when the deaths began. Elsewhere, deaths began in 2016 when the vessel surveys began. The two charts below shows the correlation of the whale deaths with the increasing number of survey vessel authorizations.

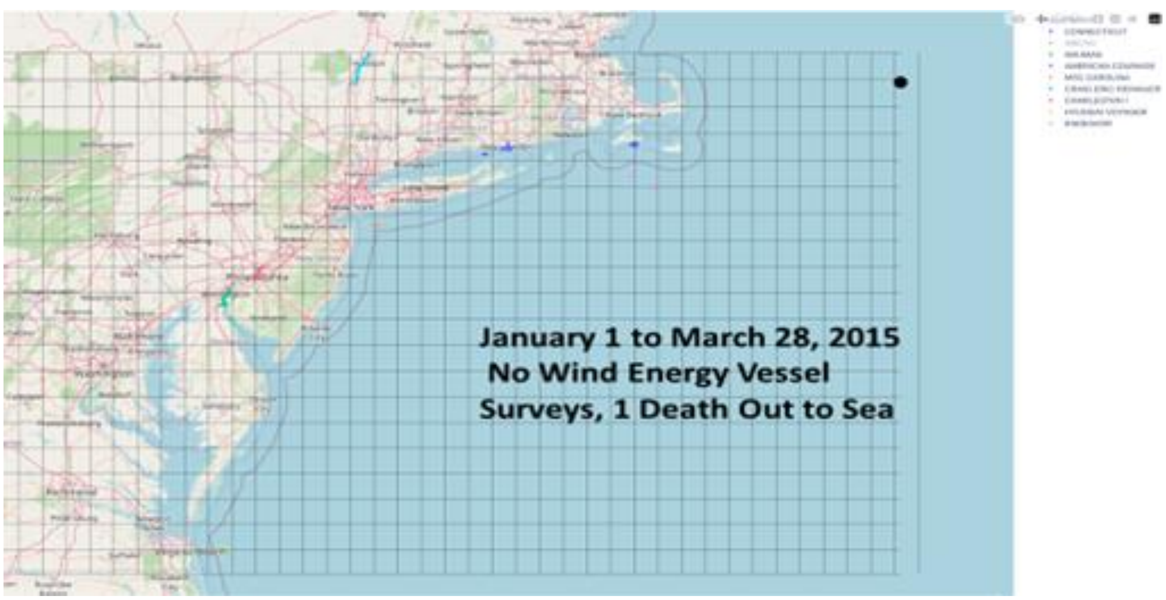


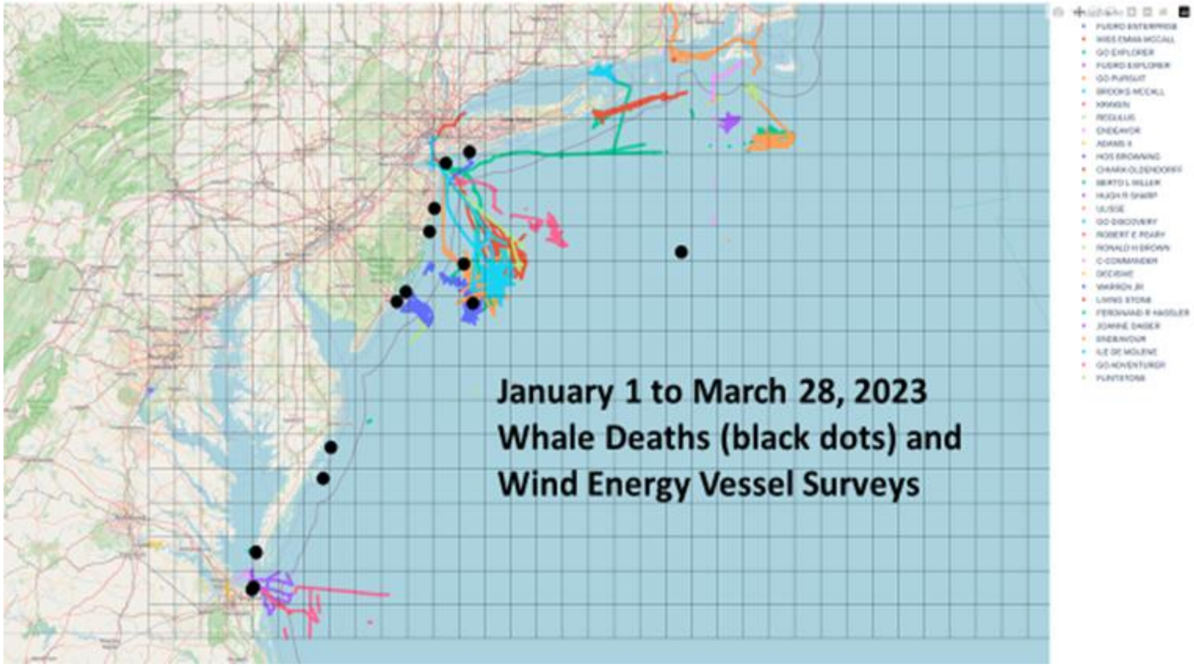
- Active Vessel Authorizations per year on paper during Covid 2021* although CDC placed restrictions on Vessel Control Actions USCG LMN 1/2021
- Source: North East Ocean Data, NOAA New England/Mid-Atlantic
- Whale Deaths Per Year: Humpback, Sperm, Minke, Baleen
- Dolphin Deaths 2023: Bottlenose, Common, Porpoise
- Data as of 10/31/2023

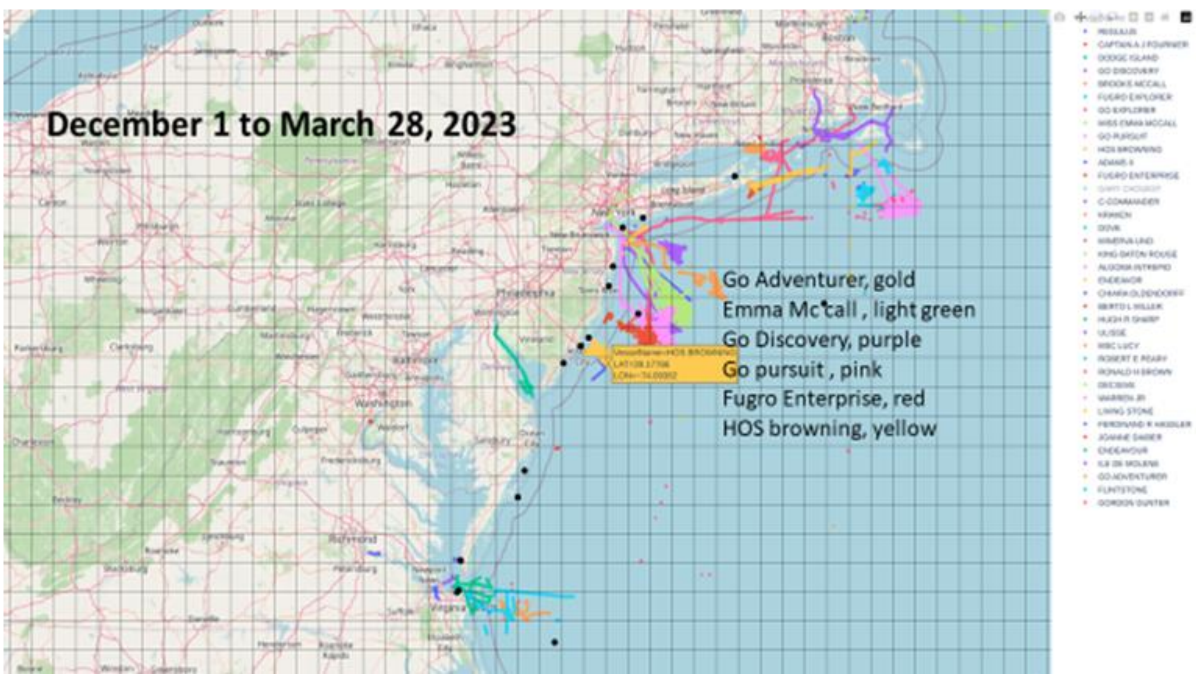


3. The Time and Place of Whale Deaths Correlate with Vessel Presence.

The three charts below for the same monthly time frames in different years show the absence of whale deaths when survey vessels are absent, and the presence of whale deaths when the surveys are present.

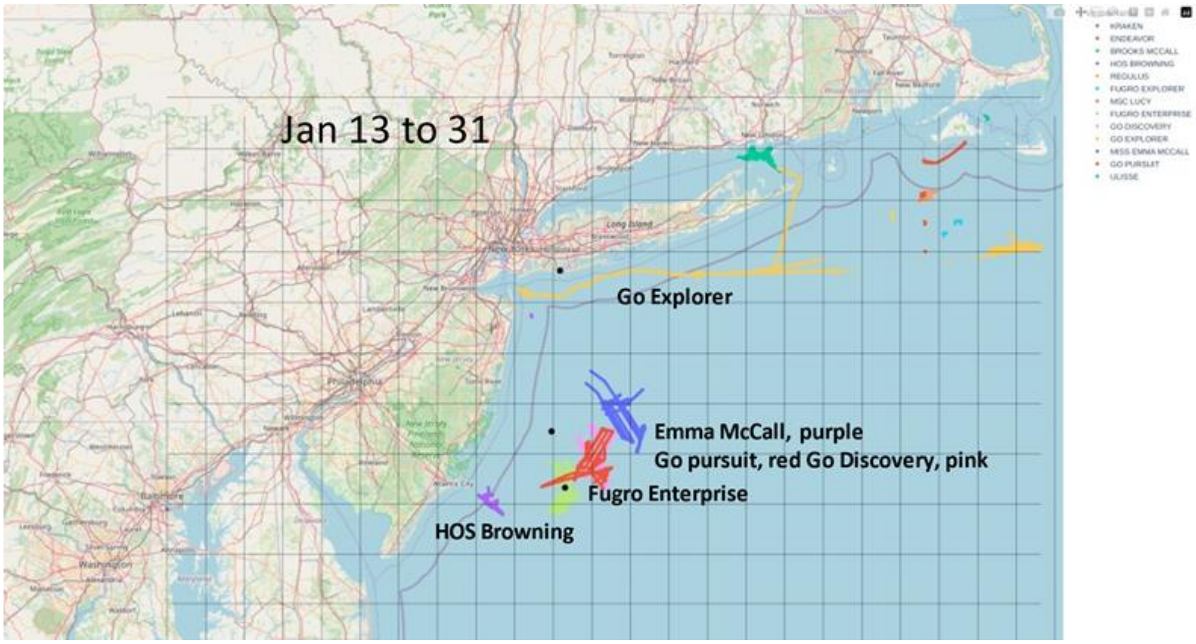




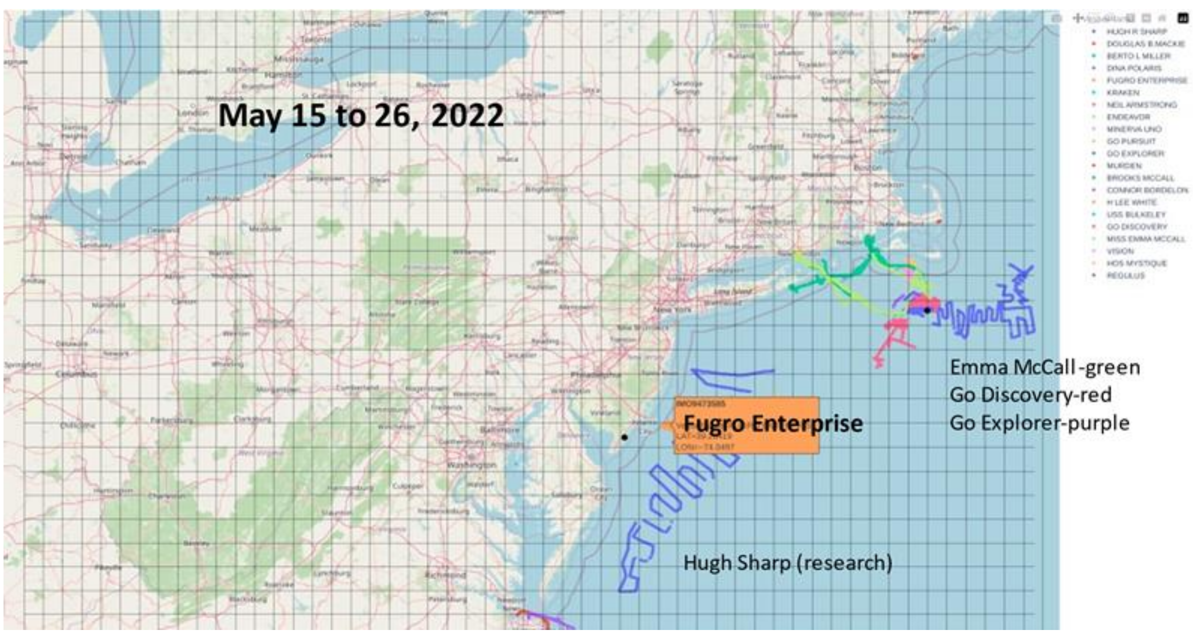


Other maps are shown below for narrower time frames that show similar correlations.

The correlation of survey vessel and noise device presence with whale deaths offshore (black dots) for a 2-week period in January, 2023 is shown below.

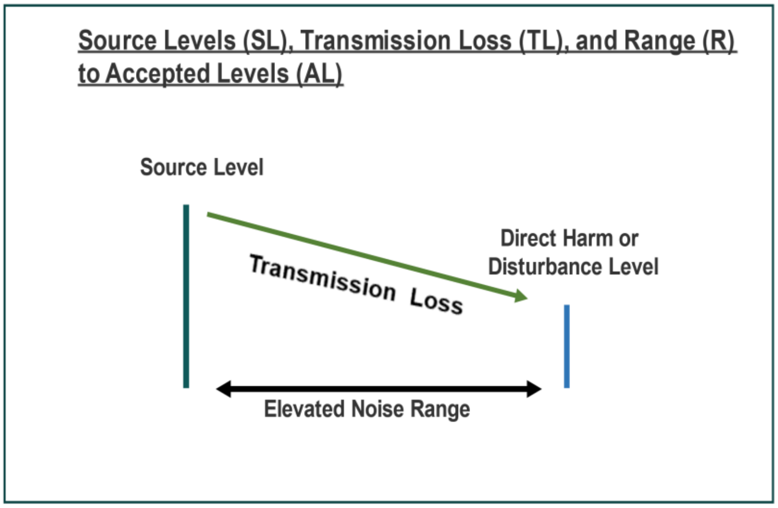


The following map shows a correlation of survey vessel and noise device presence with two whale deaths occurring in late May, 2022, one washed up and one out to sea.   The Fugro Enterprise uses the Dura- Spark device with a high noise source level as shown in the Table below.



4. The range of elevated noise from the vessel that can harm or disturb the whale's behavior has been underestimated.

The noise impact assessments prepared by the agency and applicant consultants are lengthy and appear incredibly complicated. But the issue comes down to four basic things: the noise level you start with at the source, how rapidly it loses strength as it propagates what level you end up with that’s considered acceptable-- as shown below, and lastly how much of that noise the whales actually hears –not shown and not known well to us.



The noise levels are measured in the decibel (dB) scale which makes it easy for humans to count, but in which every plus 10 increase in decibels means that the noise energy or intensity being produced is 10 times as great as before. Also, the range at which elevated noise levels exist above criteria varies exponentially with the difference between the source level and the criteria level divided by the transmission loss, so relatively small decibel changes in any of those, can mean very large changes in the affected range and area-and then the number of animals affected.

The Agency authorizations for those surveys relied on arbitrary, scientifically unsupported assumptions resulting in a significant underestimation of noise extent. For example, for the Atlantic Shores project’s surveys:

(a) It relied on an improper low noise source level of 203 dB for the maximum noise-controlling Dura-Spark unit, obtained from a much smaller less powerful surrogate device, as opposed to using a higher source level of 211 dB from measured data for the Dura-Spark unit itself.

The measured noise source levels for the Dura-Spark unit, which is the controlling one in terms of noise source level and directionality, are shown in Table 10 below from the Crocker and Frantantonio Report of 2016 that the NMFS often cites. The RMS-root mean square-number is the relevant one to use here for noise propagation. The survey approvals refer to the Dura-Spark unit in the 240- tip mode at energy inputs of around 750 joules. Based on Table 10 that would result in an RMS source level of 211 dB as opposed to 203 dB. Instead of using this data and interpolating between various energy levels, the national marine Fisheries Service (NMFS) uses a 203 dB level obtained from a less powerful, smaller device, the Sig-Electric 820 unit at 750 joules at a 5-meter depth, for all their sparker unit settings and noise inputs. That is technically not justified.

Vessel Noise Device –Source Level

Table 10. Applied Acoustics Dura-Spark Acoustic Characteristics

Source Settings		Source Level (dB re 1µPa@1m)				Pulse Width (ms)	Bandwidth 3 dB (kHz)
Energy (Joules)	Tips	Pk-Pk	Pk	RMS	SEL		
100	80	213	207	200	173	2.2	2.6
200 (high)	80	216	212	203	177	2.2	2.8
400 (low)	80	222	218	207	182	2.8	1.9
500 (high)	240	223	219	209	181	1.4	4.4
1,000 (high)	240	228	223	213	186	2.1	3.2
1,250 (high)	240	229	225	214	187	2.3	2.8
500 (high)	400	216	211	203	174	1.1	4.6
2,000 (high)	400	229	224	214	188	2.4	2.8
2,400 (high)	400	229	225	214	188	2.2	2.9
2,400 (high)*	400	226	221	212	185	2.3	2.7

* Source moved closer to side wall

As shown in the Table below, a number of the other survey vessels have noise source levels even higher than the 211 dB discussed above. This results in even larger distances from those vessels with elevated noise levels that will harm or disturb.

How High are the Vessels Noise Source Levels?

Project/Vessels	Devices, Settings	Source Level(dB)	Range to 160 dB (miles)	Range to 140 dB (miles)
NMFS/All/All	All	203 dB	0.1 @ 20 dB 0.5 @ 15 dB	10
Atlantic Shores Fugro Enterprise, Bella Marie HOS Browning(drilling)	Dura Spark 240, 750 joules Hammering-impl Vibrating-contin	211 (1) 197 (5) 159 (5)	2 0.2	34 4 0.25(to 120 dB)
Community Wind Go Discovery, Go Pursuit Westerly	Dura Spark 400+400, 300 to 1000 joules	210-216(2)	1 -3	29-72
Bluepoint Wind -Gerry Bordelon Go Adventurer, Regulus (new) Time & Tide, Atlantic Surveyor	Dura Spark 400 tip, 500-2000 joules	214 (3)	2.5	53

Vessels Noise Source Levels, con'd

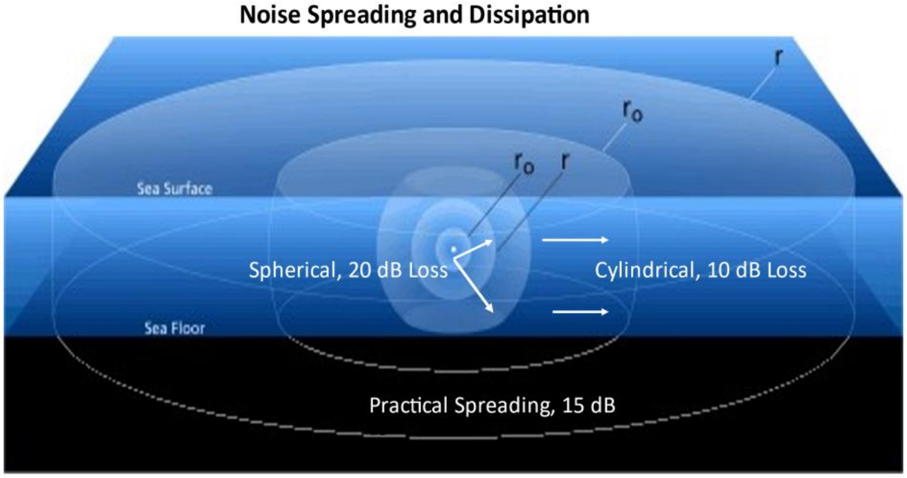
Project/Vessels	Devices, Settings	Source Level(dB)	Range to 160 dB (miles)	Range to 140 dB (miles)
Attentive Energy Emma McCall, M. Bordelon Regulus(prior drilling)	Dura Spark 400 tip, 500-2000 joules	214 (3) 197/159 (5)	2.5 0.2/NA	53 4/.3(120 dB)
Invenergy/Leading Light Go Explorer Go Seeker- previous	Dura Spark 240 tip, 500 joules or 400+400, 500 joules	209-212 (4)	1-2	25-39
Ocean Wind 1 & 2	Dura Spark 400+400, up to 1000 joules	210-216 (2)	1-3	29-72

(1) Table 10, Crocker & Frantaninio, 240 tips , interpolation for 750 joules
(2) Table 10, 400 tip, 1000 joules =207 +3 dB for 2 units, operated with 240 tips, 1000 joules = 213 + 3 = 216 dB
(3) Table 10, 400 tip, 2000 joules = 214 dB
(4) Table 10, 240 tip, 500 joules = 209 dB, 400+400 operated with 240 tips, 500 joules = 209 + 3 = 212 dB
(5) From Long-Fei Wong, Underwater Noise Characteristics of Exploratory Drilling, Impact on Marine Mammals.

(b) It uses a high spherical spreading noise dissipation rate of 20 dB for every 10-fold increase in distance beyond the water depth distances here where such spreading does not occur, versus a more commonly used and accepted rate of 15 dB used and recommended elsewhere by the NMFS, the Bureau of Ocean energy management (BOEM), and other researchers.

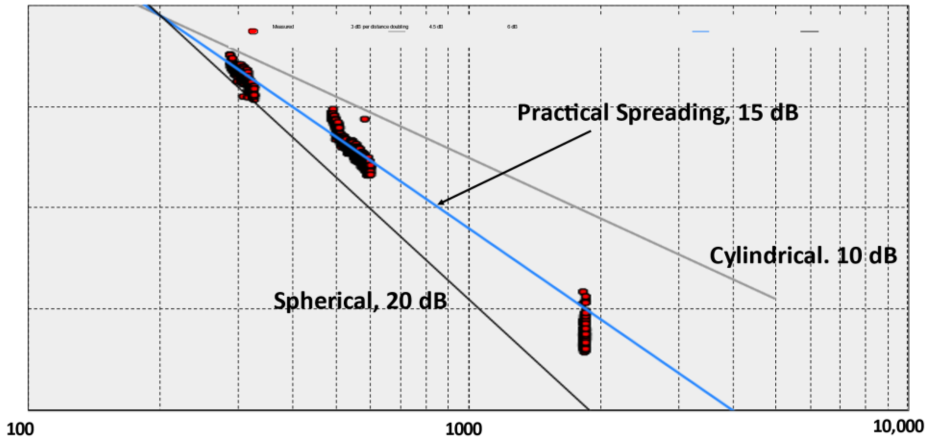
Regarding transmission loss, the diagram below shows the dynamics and physics at work. The sound waves from the source will spread out in a semi-spherical manner (at a loss rate of 20 dB for every 10-fold increase in distance) until the wave hits the seabed or surface, at which point it will reflect back into the water column and move horizontally, now spreading out in a cylindrical shape with a loss rate of 10 dB per ten-fold distance increase. A "practical spreading" formula of 15 dB times the logarithm of the distance from the source has been used for many other authorizations by the NMFS and by many researchers to marry the effect of both regimes.

Noise Spreading and Dissipation



The most compelling evidence for the 15 dB loss is shown below, where it provides the closest match to actual noise measurements -the green and red dots.

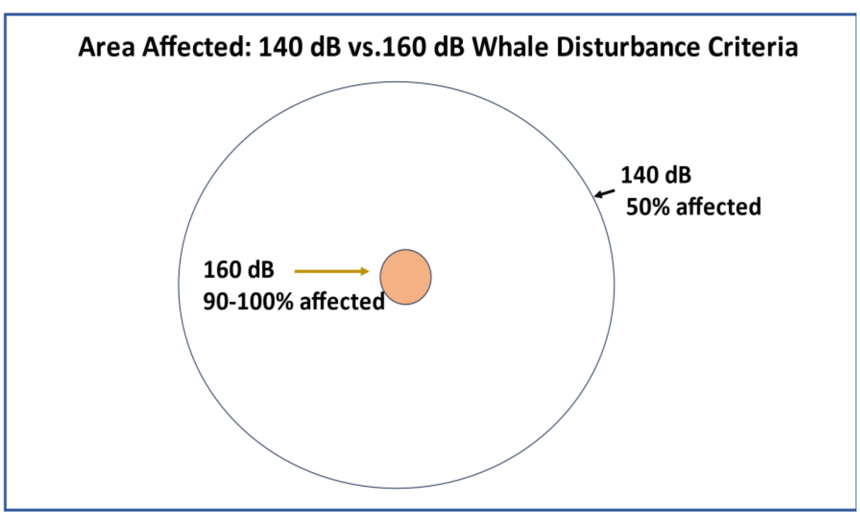
<u>Measured</u> noise levels versus distance in Figure 6 of the report titled "Underwater noise emissions from offshore wind turbines", 2005, Klaus Betke, also show **a match with a 15 dB loss rate**, as shown below.



However, for the vessel surveys, the NMFS applies the spherical spreading factor of 20 dB well beyond the water depths encountered here. That is not just a bad assumption, it is inconsistent with the physical laws governing noise propagation in a shallow water environment. The use of the 20 dB factor is also contradicted by existing NMFS and BOEM Guidance documents.

(c) The vessel approval relies on a single, scientifically unsupported behavior disturbance criterion of 160 dB at which 100 percent of animals are assumed affected versus a science-based and field-verified approach of a graded probability of response approach for 120,140 and160 dB levels that is used for impulsive noise in the Atlantic Shores Take Authorization construction application.

If that probabilistic approach was used for the vessel surveys, the incidences of harm and disturbance would be much higher. The situation is illustrated in the chart below.



Within the area bounded by the 160 dB level the take numbers using the NMFS 160 dB approach (NMFS assumes 100% of animals affected) and the probability approach (assumes 90% of the animals affected) are similar. But the other approach adds an extra dimension, that at least 50 percent of the animals in between the 160 dB and 140 dB areas would also be affected. Of course, 50 percent is less than 100 percent, but the area affected has increased exponentially many fold to override that, and if the densities of marine mammals there are comparable to those within the 160 dB area, the number of elevated noise incidences would increase substantially.

Taken together, these assumptions seriously underestimate the range and number of incidences of harm and behavioral disruption. The use of the proper noise source and transmission loss factors just with the 160 dB criterion increases the range from the vessel where the elevated noise occurs18-fold (from 0.09 to 1.6 miles), as shown below, with a corresponding increase in the number of animals affected.

Key Issues of Arbitrary Assumptions

Parameter	NMFS	Realistic
Source Level	**203 Decibels (dB)**	**211**
Transmission Loss	**20 dB**	**15 dB**
Affected Range	**1/10-mIle**	**1.6-miles**

5. The primary impact on marine mammals is dismissed.

The elevated noise levels from the survey devices are in the frequency range of the whales hearing and vocalizations, and will disturb their behavior which can then lead indirectly to serious harm and fatality.

The NMFS claims that such “level B” behavioral harassment would only result in temporary avoidance of the area or decreased foraging, which are reactions of low severity with no lasting biological consequences.

But under the Marine Mammal Protection Act (MMPA), a “Level A” incident or “take” of serious injury or fatality includes any **annoyance** that has the **“potential to injure”** a marine mammal. Also, the NMFS’s own December 21, 2016, interim guidance, defines the term “harass,” under the Endangered Species Act (ESA), to “create the **likelihood of injury** to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering”.

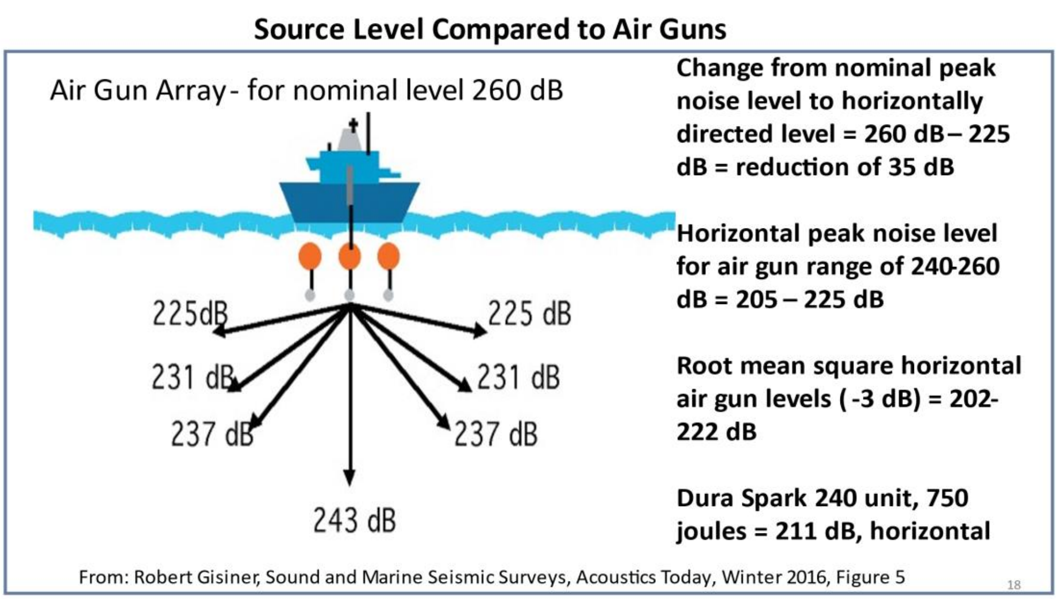
The vessel surveys do create the “potential to injure” or the “likelihood of injury”. For example, such Level B disturbances can lead to: (1) avoiding the noise or “standing off” from it in an undesirable direction or location, and in a migratory setting, obstructing or blocking it, (2) If the mammal is between the shore and the vessel source, being driven towards the shore seeking relief, with loss of its navigation capability and potentially beaching itself, (3) surfacing (demonstrated experimentally) to seek a lower noise level and becoming more vulnerable to vessel strike, (4) the separation of mothers and calves due to the “masking” of their normal communications, which would be fatal for the calf, (5) the cessation of feeding or mating, (6) the loss of energy and (7) the loss of its navigational capability and the ability to detect predators or oncoming ships.

Because whales use sounds to determine the very nature of their surroundings, the effects may be much more profound than we know. So, behavior disturbance is not as innocuous as NMFS says. If it were, the Congress would not have placed it in the MMPA to receive the scrutiny that it should.

In addition, the MFS does not consider the cumulative impact on the animals from a number of vessel surveys operating in the same area concurrently. That would result in a significant increase in the number of Level B takes to the same group of animals. The effect of such an increased number and repeated disturbance instances to the same animal is not addressed.

6. Many Other Similar Whale Stranding Have Occurred World-wide.

Similar marine mammal stranding events have been observed worldwide associated with surveys using air guns and mid-frequency sonar devices that have similar frequencies and noise level propagation in horizontal directions, where most marine mammals are present, to the sparker units here, as shown below. Some of these events are described In Addendum A.



Those who previously opposed vessel surveys when they were for oil and gas development, say that the air guns and mid frequency sonars had higher noise source levels, which is generally true. But they fail to mention that those devices are directional and that a good part of their energy is directed downward. As shown above, when you look at the noise energy directed horizontally, where most of the animals will be, they are not that dissimilar from the Dura-Spark units here which emit noise in all directions.

7. No Other Plausible Causes for the Deaths Have Been Put Forward.

Some say that the recent whale and dolphin deaths are due to vessel strike and entanglements or changed feeding patterns due to climate change. These do not bear up. Vessel activity in the area actually decreased from November during the time of the whale deaths. Only 20 percent of the whale deaths have been connected by the NJ Marine Mammal Stranding Center to “blunt force trauma” and “possible vessel strike”, and even there that could have been precipitated by disorientation from the vessel survey noise. The agencies often transmute blunt force trauma and possible vessel strike to vessel strike, and cite a 40 percent number, but that is 40 percent of the whales examined, and only half are examined. So increased vessel traffic and strike is not the cause.

Climate changes are long-term. No climate change event unique to New Jersey has been identified that came and went so rapidly, nor has any explanation being given as to why the whales would die from a change in feeding location.

Rather than grasping at straws, it would seem more sensible if the agencies would look at the only identifiable changed circumstance in the area in front of them- the presence of the multiple vessel surveys.

Conclusions

Based on the physics of noise propagation in a shallow water environment, real-world observations of the locations and times of the whale deaths and the vessels, the data from the New Jersey Marine Mammal Stranding Center, the lack of any serious alternative causes having been put forth, and injecting some common sense, the vessel surveys are the likely cause of the recent spike in whale and dolphin deaths:

- There have been recent unprecedented spikes in whale deaths
- The deaths began when the number of vessel surveys increased.
- The time and place of the whale deaths coincides with survey vessel presence.
- The use of an unsupported low noise source level and a high transmission loss factor underestimates the elevated noise range from the vessel and the number of animals affected.
- The primary impact on those animals, i.e., “disturbance” of their behavior which can lead to serious harm and fatality, is not addressed in survey approvals, nor is the cumulative impact of multiple vessels operating in the same area.
- There have been many whale stranding events worldwide associated with noise devices with similar horizontally directed and more impacting noise patterns, and
- No other plausible cause of the deaths has been put forward.

The surveys should cease at least until a proper, thorough, independent investigation is done.

For additional information contact;

Bob Stern, President
Save BLI, drbob232@gmail.com, 917.952.5016

Addendum A

Save LBI
PO Box 579
Ship Bottom NJ 08008
www.savelbi.org

Worldwide Whale Stranding, Seismic Survey Associations and Device Comparisons

May 30, 2023

Background

The vessel surveys being conducted off the New Jersey/New York coasts using high intensity noise devices to characterize the seabed are a potential cause of the recent spate of whale and dolphin deaths. Using reliable, measured noise source levels, mainstream noise dissipation factors, and pertinent baleen whale disturbance noise level criteria, elevated noise from these vessels can extend miles, disturb whale behavior and lead to serious outcomes.

The responsible agencies have summarily dismissed this relationship with various claims summarized below with our response.

***Claims Being Made Regarding Vessel Surveys and Recent Whale and Dolphin Deaths*.**

The vessel survey approvals by the federal agency and a government sponsored study at the Woods Hole Oceanographic Institution show elevated noise only close to the vessel.

Response: both the recent approvals and that study use a high scientifically unsupported noise dissipation rate that was not used by the federal agency in other marine mammal authorizations***.*** Using reliable, measured noise source levels, mainstream science noise dissipation factors, and baleen whale noise disturbance criteria, the elevated noise from these vessels can extend miles, disturb whale behavior and lead to serious outcomes. The vessel surveys therefore are a potential cause of the recent spate of whale and dolphin deaths, and the place and time coincidence of recent multiple vessels and whale deaths should be independently investigated.

Claim Made: There Is No Direct Evidence of Whale Deaths from The Vessel Surveys.

Response; “Direct” hearing damage is not the main issue, but rather disturbance of the whale’s behavior at lesser noise levels compromising its noise-using capability and leading indirectly to serious harm and fatality. The post-mortem examinations do not often look for hearing damage and cannot detect whether noise was a precipitating factor in such outcomes. So, they cannot be relied on to determine whether the surveys are a cause, rather a detailed investigation of the vessel locations, and the noise devises used at the times of the whale deaths, needs to be conducted.

Claim Made: At a Media Teleconference on January 18, 2023, a NOAA official stated that: “We can say that these active acoustic systems that are used during these surveys are commonly used around the world. There are no historical stranding events that have been associated with use of systems like these.”

Response: Actually, there have been many documented cases of whale stranding worldwide coincident with nearby seismic surveys using air guns and mid-frequency sonars, which create noise levels away from the vessels somewhat higher but comparable to the sparker units used here. There are no cases recorded in the U.S. because the agencies and Stranding Centers here do not investigate a correlation of nearby seismic surveys with stranding.

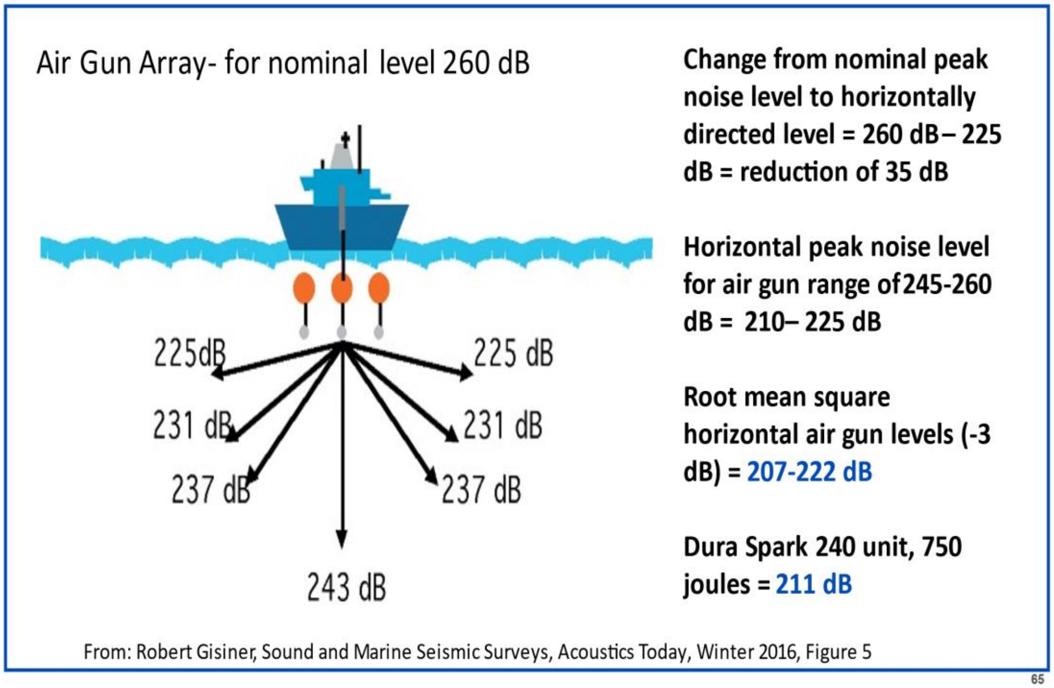
The third claim is addressed here in greater detail. The key issue in the claim is in the phrase,” systems like these”, So the similarities of the acoustic devices being used here to those coincident with those past stranding is discussed first. That is followed by numerous examples of whale stranding associated with the presence of seismic surveys, indicating that the second claim is not valid.

Most of those stranding events involved vessel surveys using air guns or sonar systems. Regarding the current wind energy surveys, those events are often dismissed because the noise levels of the air guns and sonar are alleged to be much higher, but in fact a closer look reveals that the noise propagation in the horizontal direction where most of the marine mammals will be is similar for the current survey devices and the air gun and sonar ones. Therefore, the relevance of those worldwide events and studies to the current surveys cannot be dismissed.

A. Air Gun Similarities.

One of the claims made is that the numerous cases worldwide, some described in this report, of whale stranding associated with seismic surveys using air guns are not relevant here because the air guns are much more noise intense than the sparker units being employed here. It was recently stated at a New Jersey Senate hearing that the air guns are 100,000 times more intense, which implies a 50 decibel(dB) difference between the two systems. Those statements are misleading because they do not account for the downward directionality of the air gun source versus the omni-directional nature of the sparker.

As shown below in a schematic below from Robert Gisiner, the Director of Marine Environmental Science and Biology for the International Association of Geophysical Contractors, there is a significant difference of 35 dB between the nominal noise level for an air gun array (in this example a high-end number of 260 dB) and the resulting noise level that emanates horizontally which will impact the great majority of marine mammals in the area. Typical nominal levels for air gun arrays are 245 to 260 dB resulting in horizontally directed levels from 210 to 225 dB. Adjusting the peak levels in the schematic downward by another 3 dB [(1)] to convert them to root mean square levels to allow a comparison with the sparker units used here, results in horizontally directed noise levels of 207 to 222 dB for air gun arrays. The 211 dB for the Dura-spark 240 unit operated at 750 joules of energy input intersects the lower end of the air gun range, and while most of that range is still above the sparker unit, it is nowhere near the energy intense difference that has been suggested. Also, as shown in the body of the Report above, other devices being used here have source levels higher than 211 dB.



A similar analysis comes from other sources [22]. In that Study it was stated that typical air gun source peak to peak levels ranged from 240 to 246 decibels (dB) relative to one micro-Pasqual-meter, vertically downward, and that the energy sent out by typical air gun arrays is dominantly directed vertically downward. The amplitude levels of the sound emitted horizontally, which would affect the greater number of animals was stated as being from 15 to 24 dB lower. This produces a root mean square noise level range from 220 to 230 dB emanating horizontally.

Another analysis comes from other sources [1]. In that Study it was stated that typical air gun source peak to peak levels ranged from 243 to 249 decibels (dB) relative to one micro-Pasqual-meter, vertically downward, and that the energy sent out by typical air gun arrays is dominantly directed vertically downward. The amplitude levels of the sound emitted horizontally, which would likely affect the greater number of animals was stated as being from 15 to 24 dB lower. This produces a peak noise source level range from 219 to 234 dB, for sound emanating horizontally. Those peak-to-peak numbers can be reduced by 3 dB [1, page 34] to convert them to a root mean square noise level that can be compared to the levels presented in current ITA applications, resulting in an air gun array source level of 216 to 231 dB, emanating horizontally.

The 211dB noise source level for the omni-directional Dura spark 240 unit operating at 750 joules of energy input which is apparently the case for the Atlantic Shores project vessel surveys is lower than that, but not too far from the lower air gun range. It is still quite capable of generating noise levels out miles horizontally before it dissipates down to the 160 dB disturbance level for the general mammal population and to the more appropriate 140 dB criteria for baleen whales.

The actual noise energy transmitted horizontally depends on the noise level but also on the time over which it is generated. The time depends on two things: the time duration of a single pulse of noise generated and the number of times a pulse is generated in a given time period. Regarding the latter, the Dura-spark unit generates a pulse every two seconds [(21)]. Air gun arrays typically generate a pulse at a minimum of 10 seconds [22].

According to Reference 3, Table 1, the maximum duration of an air gun array pulse is a few milli-seconds which is comparable to the 3.4 milliseconds in Table 1-2 of the Atlantic Shores Offshore Wind Take application for the Dura-spark unit [(21)]. So, in that case, using a noise level of 216 to 231 dB for the air guns and 211 dB for the sparker 240 unit, the sparker unit would actually generate five times as much energy projected horizontally because it fires more frequently. Other sources [2] show a larger air gun pulse duration of 30 milliseconds, in which case the sparker unit would be generating about 54 percent of the energy of the air gun array horizontally. So, the actual noise energy transmitted horizontally by either system can be comparable.

Therefore, the numerous cases of stranding associated with air gun and mid-frequency sonar use cannot be dismissed. The sparker units are quite capable of producing elevated noise levels above criteria for miles from the vessel similar to the air guns.

Regarding frequency similarity, the frequency range of the Dura-Spark units has not been disclosed, but sparker units in general can create a sound pulse with main frequencies from 50 to 4,000 Hz, [(3)]. Air guns typically operate at lower frequencies, around 250 Hz [(3)], but both are below 1000 Hz, within the hearing range of baleen whales. The sparker unit may also be emitting significant energy at higher frequencies.

Therefore, there are differences in these two survey devices but also similarities. As presented in our complaint, using the proper number of electrode tips, noise source levels, dissipation factors and disturbance criteria, the noise level from the sparker units require large distances to bring those levels down to the 160 dB or 140 dB criteria, affecting many marine animals within that area.

B. Sonar Comparison.

There are three types of sonar systems, low (less than 1000 Hz), mid (1,000-20,000Hz) and high (greater than 20,000 Hz) in frequency. They operate horizontally or omni-directionally similar to the sparker systems.

Regarding frequency similarity, the frequency range of the Dura-Spark units has not been disclosed, but sparker units in general can create an omnidirectional sound pulse with main frequencies from 50 to 4,000 Hz, [(3)], so there can be frequency overlap with the mid-frequency sonars.

The noise source levels for the low frequency systems range from 195 to 235 dB [(2).] The source level for the mid frequency sonars is about 235 dB. A number of the stranding events described below are associated with the mid frequency sonars.

II. Stranding Incidents Associated with Nearby Seismic Surveys

There have been a number of stranding incidents worldwide associated with the air gun and sonar systems, some of which are presented below.

Given that the US agencies and stranding networks and other international networks as well rarely engage in comprehensive and detailed investigation of stranding events occurring in the vicinity of seismic surveys or naval exercises, it can be argued that the connection between the seismic surveys and stranding is seriously underestimated.

The first five events of multiple-animal stranding (mass standings) described just below were associated with the use of high intensity sonar during naval operations and with the use of air guns during seismic reflection profiling. They predominantly involved beaked whales particularly Cuvier's beaked whales [(2) Table 7.5] An increasing number of such stranding from 1950 to 2000 can be correlated with the increasing use of mid frequency anti-submarine warfare (ASW) sonar [(2)], figure 7.1. As mentioned above the mid frequency sonar has similarities to the sparker units being employed off the New Jersey coast.

Event six a mass-stranding on Kauai, Hawaii on July 3 and 4, 2004 where an estimated 150-200 melon-headed whales packed into shallow Hanalei Bay for a period of about 28 hours. While not conclusively proven, NOAA acknowledged a correlation with sonar in the mass stranding of melon-headed whales that occurred there. At the time of the stranding, the Navy was conducting exercises involving loud sonar in the area. "Sound propagation models suggest that sonar transmissions were likely detectable over a large area around Kauai for many hours on the day prior to the stranding, as well as within Hanalei Bay when the animals were there," said Brandon Southall, NOAA Fisheries Service's Acoustics Program Director. They were finally gently herded out by members of the community including the Hanalei Canoe Club, local and federal employees, and volunteers and staff with the Hawaiian Islands Stranding Response Group.

Event seven involving a large group of melon headed whales (Peponocephala electra) was reported to be deep within the Loza Bay mangrove system in northwest Madagascar, May 31, 2008.

While aspects of this event will remain unknown, the ISRP noted that a high-power 12 kHz multi-beam echo sounder system (MBES) operated intermittently by a survey vessel moving in a directed manner down the shelf-break the day before the event, to an area ~65 km offshore from the first known stranding location. The ISRP deemed this MBES use to be the most plausible and likely behavioral trigger for the animals initially entering the lagoon system. This conclusion is based on:

(1) Very close temporal and spatial association and directed movement of the MBES survey with the stranding event. The MBES vessel moved in a directed manner transmitting sounds that would have been clearly audible over many hundreds of square kilometers of melon-headed whale deep-water habitat areas (and extending into some shallower waters along the shelf break) from 0544 until 1230 local time on 29 May and then intermittently in a concentrated offshore area (located ~65 km from the mouth of the lagoon) between 1456 and 1931 on 29 May; these preceded the first known stranding during the day of 30 May and sighting of live animals within the lagoon at 2300 on 30 May.

(2) The unusual nature of this type of stranding event coupled with previous documented apparent behavioral sensitivity in this pelagic species (albeit to other sound types - discussed in more detail below) [(4)]

(3) The fact that all other possible factors considered were determined by the ISRP to be unlikely causes for the initial behavioral response of animals entering the lagoon system.

Quoting from the Exxon EIA (2008):

"ExxonMobil Exploration and Production (Northern Madagascar) Limited (EMEP (NM) L), plans to carry out a high resolution 2D seismic survey over prospective drilling locations of the Sifaka Prospect, take sea floor and water samples in the prospect area for an Environmental Baseline Study, conduct a multi-beam bathymetry study and survey the upper slope to identify shallow water features in the Ampasindava Block, offshore Madagascar. The work will be conducted in May to June, 2008 for a period of approximately 30 days."

Event eight includes a lawsuit filed by Public Employees for Environmental Responsibility (PEER) regarding the largest recorded mass beaching of rare Stejneger's beaked whales (also known as Bering Sea beaked whales or saber-toothed whales) that took place in August 2018 on the beaches of the Aleutian island of Adan. While the final cause of these deaths has not been determined, this type of mass stranding has been known to follow active acoustic (sound generating) activity by naval or other ships that can scare these deep-diving whales quickly to the surface, causing fatal decompression impacts.

Just prior to the 2018 beaked whale mass stranding, recording devices from the Alaska Volcano Observatory in the region recorded distinct anthropogenic acoustic sources, repeating at regular intervals, for hours at a time. The source of these sonic pulses remains unknown, and Professor Richard Steiner sought to identify potential sources. Through FOIA inquiries with NOAA, the U.S. Navy, and the U.S. Geological Survey (all of which were answered in a timely fashion), Prof. Steiner was able to determine that no domestic vessels were permitted to operate any active source sonic equipment in that area during that time. We understand from the Research Application Tracking System (RATS) that State requires the following: "If the research involves the study or incidental take of marine mammals or species listed under the Endangered Species Act, include the appropriate authorization from the NOAA Office of Protected Resources (i.e., Research Permit or an Incidental Take Permit/Authorization)." NOAA confirms that no Incidental Harassment Authorizations (IHAs) were issued for such activity in the Aleutians that year.

From those FOIA requests, and the Alaska Marine Exchange's Automatic Identification System (AIS) tracking data, Prof. Steiner learned that three Japanese research ships had operated in the area during the period in question. One of these was the Yushin Maru #2, a notorious Japanese whaling ship (owned and operated by the Japan Institute for Cetacean Research), that had been permitted to deploy as many as 240 acoustic sonobuoys in the water for its cetacean research in the Bering Sea/Aleutian Islands that summer.

Significantly, later that year, after a long, tense diplomatic dispute with the U.S. and other anti-whaling nations, Japan withdrew from the International Whaling Commission (IWC) in order to resume commercial whaling. Prof. Steiner was trying to determine precisely what these, or other, foreign research ships were doing in those waters at that time, and whether they may have conducted acoustic activities, permitted or not, that caused the mass stranding – and the State MSR consent letters appear to be the only source of this information.

A new scientific paper suggesting that seismic activity may have been involved in a mass stranding death of whales along the Aleutian Islands. The 2018 event on Adak is the largest known mass stranding of Stejneger's beaked whales.

When whales strand along the shores of Alaska's remote and far-flung Aleutian Islands, they may never be discovered by humans. The chain of small, sparsely populated islands arc from the tip of the Alaska Peninsula west 1,100 miles to Attu Island.

The U.S. State Department approves foreign vessels to conduct scientific research in U.S. waters without public notice or ensuring they obtain the same permits domestic researchers must or monitoring their activities. Pointing to the largest recorded beaching of rare Bering Sea beaked whales while Japanese whaling "researchers" operated nearby, Public Employees for Environmental Responsibility (PEER) is calling for system-wide reform.

In March 2021, Professor Steiner submitted FOIA requests to NOAA, the Navy, and the U.S. Geological Survey. All were answered in a timely fashion and indicated that there were no domestic vessels, military or research, permitted to conduct active acoustic activity in the area in 2018.

However, Professor Steiner then learned that there had been three Japanese research ships in the Bering Sea in the summer of 2018, including the Yushin Maru #2, a notorious whaling outlaw, that had been approved to conduct cetacean "research" using acoustic sonobuoys in the Bering Sea/Aleutian Islands for the International Whaling Commission. Such research activities are required to obtain Incidental Take/Harassment Authorizations, but NOAA confirms that no authorizations were issued for such work in Alaska that year. To date, the source of the recorded (illegal) underwater sounds waters that may have caused the mass stranding remains undetermined.

1. Kyparissiakos Gulf, Greece 1996 [2]

One mass stranding of Cuvier beaked whales in the Ionian Sea coincided with tests of ASW sonar by NATO. The stranding coincided with a four-day period when the vessel R/V Alliance was towing an acoustic source in the vicinity. The source generated both low and mid-frequency sound at source levels of 226 dB projected horizontally. The Greek government temporarily stopped seismic surveys as a result.

Along 56 km of coastline, 14 Cuvier beaked whales were stranded during 12–13 May 1996. Twelve of 14 animals stranded alive, with no apparent disease or pathogenic cause. These stranding corresponded with a four- day period (12–16 May) when the vessel *NRV Alliance* was towing an acoustic source in the vicinity. The acoustic source generated both low-frequency and mid-frequency sound at source levels of 226 dB re 1µPa @ 1m. The transmitted low-frequency signal included a 2 sec upsweep at 450-650 Hz, and a 2 sec cw tone at 700 Hz. The mid-frequency signal included a 2 sec upsweep at 2.8-3.2 kHz and a 2 sec tone at 3.3 kHz. Both sources projected horizontally directed beams of sound with vertical beam widths of about 23 degrees. Three source tows of about 2 hours duration were conducted each day; and the stranding occurred most closely in time with the first two source runs of May 12th and the last two source runs of May 13.

The association of stranding locations and acoustic source tracks in space and time is compelling evidence that these animals were affected by the ASW sonar. There is a general correlation between the offshore source track locations and the inshore stranding locations. The May 13th source tow track is shifted northward from the May 12^{th} track, and likewise some of the May 13^{th} stranding locations are farther north. Correlation of stranding times and source track locations for May 12 th suggests that at least three of the six animals with known stranding times were affected by the 0600-0800 source tow (run 9) as their stranding times precede the 1100-1300 source tow (run 10). Assuming that they were near the source when they were exposed to a high sound level, their swimming distances were approximately 30 nm to reach the shore, covered at speeds of approximately 10 knots. The two stranding in the afternoon of May 12th with known times likewise required swimming distances of 20-30 nm

2. *The Bahamas March 15 -16th, 2000* [(2)]

Sixteen cetaceans were found stranded along the providence channel in the Bahamas Islands during a two-day period in March, 2000 and the episode was correlated with ta US Navy training exercise using mid frequency ASW sonar. Gross necropsy results on five of the dead whales suggested that they were in good body condition, none showed evidence of debilitating disease. The five Navy ships operating ASW sonars in the area showed a close correlation in space and time with the stranding locations as shown in Figure 7.3 [(2)] The noise source levels were 235 dB with operating frequencies between 2.6 and 3.3 kHz.

The stranded animals were predominantly beaked whales. At least two minke whales *were* also found stranded. One dolphin stranded at a somewhat distant location and may have died of unrelated causes. Eight of the beaked whales died, and the remaining animals were re-floated and their fate is unknown. None of these animals has been recognized as re-stranded or re-sighted. Tissue samples were collected from five of the dead beaked whales. Gross necropsy results suggested that all five were in good body condition; none showed evidence of debilitating disease. Some kind of auditory damage was found in four of the beaked whales examined.

Hemorrhages were found in the acoustic fats of the head, the inner ears, and some spaces around the brain, with no evidence of external blunt force trauma. The pattern of injury in the freshest specimens suggested that the ears were structurally intact and the animals were alive at the time of injury.

Four U.S. Navy ships were operating hull-mounted ASW sonars in the area, two SQS-53C and two SQS-56. The SQS-53C sonars were operated at 2.6 and 3.3 kHz with a source level of 235 dB re 1µPa @ 1 m or higher, and 0.5 - 2 sec ping lengths alternating between tones and frequency-modulated sweeps. The SQS- 56 sonars were operated at 6.8, 7.5, and 8.2 KHz at 223 dB re 1µPa @ 1 m. Integrated sound exposure levels greater than 160 dB for 10-30 sec were found throughout much of the Providence Channel during March 15th 2000.

The association of stranding locations and acoustic source tracks in space and time is compelling evidence that these animals were affected by the high-intensity sound sources. The acoustic source tracks and stranding locations divided into the morning (0700-1100) and afternoon (1200-1430). During the morning two source ships were in the Providence Channel off the southwest end of Abaco Island and moving toward the west, and the other two source ships were entering the channel from the east.

A cluster of stranding occurred at the south end of Abaco Island during this time, at minimum ranges of 10-30 nm from the ships' closest points of approach. During the afternoon, the source ships moved northwestward, approaching Grand Bahama Island. A cluster of noon and afternoon stranding occurred on the south coast of Grand Bahama Island, again with minimum source-to-shore ranges of 20-30 nm. Assuming that these animals received peak sound exposures at locations near the source tracks, then immediately following exposure they would have swum toward the stranding sites at high speed (~ 10 knots). Alternatively, lower exposure levels more distant from the source tracks and closer to the stranding sites would imply slower swim speeds.

3. Madeira, May 2000 (2)

A stranding of three Curvier beaked whales occurred in May 2000 on the Madeira Archipelago, in the northeastern Atlantic (Luis Freitas, Madeira Whale Museum, pers. comm.). The deep-water channel between islands has been the site of repeated observations of live animals. The animals that stranded in May 2000 consisted of two sub adults (one male, one female) and a female of unknown age. The two sub adults were examined and found to have hematomas, eye hemorrhages, pleural hemorrhages, and lesions of the lung. The third animal was found in an advanced state of decomposition and did not receive a detailed examination. The presence of a NATO exercise was signaled by naval vessels and aircraft in the deep-water channel, coincident with the stranding events. Details of the acoustic sources in use during this exercise are lacking at this time.

4.Canary Islands, September 24, 2002 (2)

A mass stranding of 14 to 19 beaked whales occurred in the Canary Islands on September 24-25, 2002 that were associated with naval maneuvers by Spain and other NATO countries. Necropsies and dissections revealed no visible signs of traumatic lesions physically caused by a ship strikes, fishing activities or blunt trauma generally. Considerable hemorrhaging was observed along acoustic paths in the head and in the brain and spinal cord. The source levels of the sonars were approximately 223 dB at middle frequencies from 3,000 to 10,000 Hz.

On 24 September a total of 14 animals were found stranded; five were dead, three were alive and subsequently died, and six were pushed back to sea. Five more animals were found dead and in a state of decomposition between 25 and 28 September. It is possible that these included animals that had been pushed out to sea and subsequently stranded. Preliminary necropsy results for six of the beaked whales suggest that they were healthy. The stranding occurred at dawn or in the early morning, and the animals that were found alive all appeared disoriented. Those that were found dead had been feeding recently.

Necropsies and dissections revealed no visible signs of trauma. Hemorrhages were observed along acoustic paths and in the brain and spinal cord. All animals were bleeding profusely in the eyes. Multifocal petechial (pinpoint) hemorrhages were observed, similar to decompression sickness. Fat embolism was observed, which could have been responsible for hemorrhages in the macrovascular system. Degeneration (in vivo) of vestibucochlear portions of the ear were noted, specifically, degeneration and resorption of some hair cell bundles and associated nerve fibers. This may suggest a chronic condition, and that some damage to the cochlea had occurred prior to this stranding event.

The stranding occurred along the southeastern coast of the islands of Fuerteventura and Lanzarote. At the time of the September 24 -25 stranding, 10 NATO countries — Germany, Belgium, Canada, France, Greece, Norway, Portugal, Britain, Turkey, and the United States — were conducting a multinational naval exercise; however, the acoustic sources employed during the exercise are not known at this time. There have been seven mass stranding of curvier beaked whales *in* the Canary Islands since 1985, and naval exercises have been recorded as associated with five of them (Table 5).

5. *Gulf of California September 24, 2002* (2)

Two beaked whales were stranded on Isle San Jose in the Gulf of California, Mexico on September 24, 2002 coincident with seismic surveying by the R/V Maurice Ewing operated by Columbia University. The vessel had an effective broadband source level of 256 dB, or approximately 236 dB in the horizontal directions, with maximum energy at low frequencies of 40 to 90 Hz.

On September 24th at about 2 to 4 PM local time (2100–2300 GMT), fishermen discovered two live stranded whales and unsuccessfully attempted to push them back out to sea. A group of marine biologists found the whales dead on September 25th. By September 27th, when one carcass was necropsied, the advanced state of decomposition did not allow the cause of death to be determined.

On September 24th the *R/V Ewing* had been firing an array of 20 air guns with a total volume of 8500 cubic inches. These air guns have an equivalent broadband source level of 256 dB re 1µPa @ 1m, with peak energy frequencies at 40-100 Hz. Source levels at mid-frequencies (1-5 kHz) may be diminished by 20 to 40 dB (Goold and Fish 1998). The air guns were fired with an approximately 20 sec repetition rate (50 m distance between shots). Figure 3 indicates the ship track for 24–25 September; the *R/V Ewing* was on a transect line directed toward the stranding site and reached the closest point-of-approach (within 22 km) at 1400 local time (2100 GMT) range.

6. *Kauai, Haw Hawaii, 2004* (4) (5)

While not conclusively proven, NOAA acknowledged a correlation with sonar in a mass stranding of melon-headed whales that occurred in Hanalei Bay, Kauai, Hawaii in 2004.

The military has already been forced by a federal judge to limit deployment of a different sonar project -- a $350 million cutting-edge, low-frequency sonar system it wants to deploy worldwide. The judge concluded last year that the government had not properly considered environmental effects before allowing the Navy to use the new sonar. That led to an agreement between the Navy and environmental groups to restrict the sonar to a limited section of the Pacific Ocean off East Asia, but the Navy has appealed several aspects of the decision.

At the time of the stranding, the Navy was conducting exercises involving loud sonar in the area. "Sound propagation models suggest that sonar transmissions were likely detectable over a large area around Kauai for many hours on the day prior to the stranding, as well as within Hanalei Bay when the animals were there," said Brandon Southall, NOAA Fisheries Service's Acoustics Program Director. "Active sonar transmissions on the 2nd and 3rd of July are a plausible, if not likely, contributing factor to the animals entering and remaining in the bay." more than 100 melon-headed whales became stranded on the coast of Madagascar. A study published in the journal "Aquatic Mammals" suggested that the stranding may have been linked to a seismic survey that was being conducted in the area at the time.

The melon-headed whale was first identified in Hawaii off the coast of Hilo on Hawaii Island's eastern side in 1841. As the name indicates, the front of the head is rounded which gives it a melon-shape. These marine mammals, which are actually members of the dolphin family, grow to nine feet and weigh over 200 pounds, use echolocation, are gray in color except for darker hues around their face.

Melon-headed whales are not usually seen by many because the majority of their time is spent in the deep ocean far from shore. Social animals by nature, they travel in groups of over 1,000 and play, rest, hunt and socialize together. They've been known to follow boats to catch waves off the wake. Their dorsal fin has a pointed tip which helps with identification. As one of the many special creatures in the Pacific Ocean that cradles our beautiful islands, they are beloved by many.

There's been no conclusive evidence why this atypical behavior happens although some hypothesize sonar may be the cause. Low frequency sonar (LFA) is the loudest sound known to be put in the ocean. It's an unnatural sound in the sea. At over 240 dB it's been introduced, by the Navy, despite being documented as surpassing verified pain levels in some marine mammal. Echolocation, a primary navigation tool of many marine mammals, when distorted may cause loss of direction, shatter eardrums and create unusual behavior.

The standing of the melon-headed whales should be investigated through further research, community outreach, education, and dialogue, solutions in order to protect the lives of the ocean, which sustains our lives in many ways.

7. Madagascar, 2008 [(6)]

An independent scientific review panel has concluded that the mass stranding of approximately 100 melon-headed whales in the Loza Lagoon system in northwest Madagascar in 2008 was primarily triggered by acoustic stimuli, more specifically, a multi-beam echo sounder system operated by a survey vessel contracted by ExxonMobil Exploration and Production (Northern Madagascar) Limited.

WCS and IFAW support these conclusions that add to a mounting body of evidence of the potential impacts of anthropogenic noise on marine mammals," said Dr. Howard Rosenbaum, Director of the Ocean Giants Program for WCS. "Implications go well beyond the hydrocarbon industry, as these sonar systems are widely used aboard military and research vessels for generating more precise bathymetry (underwater mapping). We now hope that these results will be used by industry, regulatory authorities, and others to minimize risks and to better protect marine life, especially marine mammal species that are particularly sensitive to increasing ocean noise from human activities.

Madagascar ISRP Final Report considered all known causes of previous marine mammal stranding and assessed the relative strength of evidence regarding whether each factor could have played a role in either contributing directly or secondarily to the stranding. This segregation within the assessment was important given that this event apparently involved an initial response that caused the animals to clearly depart their natural habitat en masse in such an unusual manner, and a number of secondary, interacting factors that ultimately contributed to later stranding and mortality once the animals were compromised in an out-of-habitat situation.

The seismic survey was "utilizing an air gun source" and planned to be conducted "in the southwest part of the Ampasindava block… approximately 35 km northwest of Nosy Lava" and it was "anticipated [that] the vessel will not come closer than 15 km to the Madagascar coast, remaining in water depths exceeding 200 meters." In addition to the seismic survey, two forms of bathymetry mapping using sonar sources were planned. A side-scan sonar survey using "a fish towed behind the vessel close to the seabed" which was to be conducted "along the upper edge of the slope measuring the water depths as shallow as 30 meters" and "for the most part remain more than 10 kilometers from the Madagascar mainland." In addition, a "multi beam echo-sounder bathymetry survey" was conducted, with the "echo-sounder…mounted to the hull of the vessel and…operated simultaneously [with the seismic survey operation] to supplement the seismic and side scan sonar bathymetry data."

The EIA provides some detail for operations and sound sources used. Air guns sound level output was expected to be between 190-200 dB re: 1μPa and predominant energy in the frequency range of 10-300 Hz; side scan sonar (EG&G model 260TH Recorder and Model 272-T tow fish) operated at 100kHz and/or 500kHz, with no source level provided; and the multi-beam echo-sounder (SIMRAD EM1002, mounted to hull) specified with a sound pressure level of 235 dB re: 1μPa and peak frequency of 12 kHz. In is noted in Figure 5.1 of the EIA, that the side scanning sonar bathymetry survey would be conducted along the shelf edge and shelf break immediately offshore of Nosy Lava and the Loza Lagoon system.

The EIA notes the likely presence of P. electra in the Ampasindava block, described in Table 5.4 as occurring in all three of the sub-divided regions (Mid-channel, Offshore and Coastal) in "substantial numbers". The EIA also acknowledges that "key potential impacts with respect to underwater noise" include:

- Pathological effects (lethal or sub-lethal injuries): potential injury or fatality of marine fauna from exposure to significant noise levels.

Behavioral disturbance leading to behavioral changes or displacement.

8. Alaska, 2018 [7] [8] [9] [10] [11]

A new scientific paper suggesting that seismic activity may have been involved in a mass stranding death of whales along the Aleutian Islands. The 2018 event on Adak is the largest known mass stranding of Stejneger's beaked whales.

When whales strand along the shores of Alaska's remote and far-flung Aleutian Islands, they may never be discovered by humans. The chain of small, sparsely populated islands arc from the tip of the Alaska Peninsula west 1,100 miles to Attu Island.

NOAA Fisheries marine mammal experts contacted the U.S. Navy shortly after the 2018 mass stranding. It confirmed that they had not conducted training or testing activities using sonar or explosives anywhere in Alaskan waters since May 2017.

However, the U.S. Geological Survey's Alaska Volcano Observatory's monitors had detected human-caused seismic survey activity at regular intervals for hours at a time along the Aleutian Islands between July 5 and 20, 2018. Based on triangulation of data from multiple seismometers, the observatory determined the source of the noise likely centered about 40 miles northwest of Adak. Scientists still do not know the source of the seismic activity. Fourteen days passed between the last detection of the seismic activity and the discovery of the first whale that was part of the 2018 Adak mass stranding event. However, a link between the Stejneger's beaked whale mass stranding and the seismic activity cannot be ruled out.

Additional events are presented below, but the list is by no means exhaustive.

9. Brazil, 2019 [12]

In September 2019, over 80 false killer whales were found stranded in the Arraial do Cabo region of Brazil. While the cause of the stranding is not entirely clear, some experts have suggested that seismic surveys in the area may have contributed to the event.

10. Scotland, 2011 [13]

In 2011, 16 pilot whales stranded themselves in the Firth of Forth in Scotland. An investigation by the Scottish government found that the whales had likely been exposed to underwater noise from a seismic survey being carried out by an oil and gas exploration company in the area.

11. Gulf of Mexico, 2012 [15]

In 2012, a group of researchers published a study in the journal "Conservation Biology" suggesting that the use of air guns in seismic surveys in the Gulf of Mexico may be contributing to a higher rate of stranding of several species of whales and dolphins in the area.

12. New Zealand, 2017 [18]

In February 2017, more than 400 pilot whales become stranded on the coast of New Zealand. While the cause of the stranding is not entirely clear, some experts have suggested that it could be linked to a nearby seismic survey that was being conducted around the time of the event.

13. Chile, 2014 [19]

In April 2014, more than 300 sei whales were found stranded along the coast of Chile. While the exact cause of the stranding is not clear, some experts have suggested that a seismic survey that was being conducted in the area may have played a role

Summary of Beaked Whale Stranding Events

Repeated mass stranding of beaked whales following high-intensity sound exposure demonstrate a pattern of events. Cuvier's beaked whales are, by far, the most common species involved in these stranding events; they make up 81 percent of the total number of stranded animals. Other beaked whales comprise 14 percent of the total, and other species are sparsely represented. It is not clear whether (a) *the Cuvier beaked whale* is more prone to injury from high- intensity sound than other species, (b) its behavioral response to sound makes it more likely to strand, or (c) it is substantially more abundant than the other affected species in the areas and times of the exposures leading to the mass stranding. One, two, or three of these possibilities could apply. In any event, it has proven to be the "miner's canary" for high-intensity sound impacts. The simultaneous deployment of naval ASW sonars in the 1960s and the coincident increase in *its* mass stranding suggest that lethal impacts of anthropogenic sound on cetaceans have been occurring for at least several decades.

The settings for these incidents are strikingly consistent: an island or archipelago with deep water nearby, appropriate for beaked whale foraging habitat. The conditions for mass stranding may be optimized when the sound source transits a deep channel between two islands, such as in the Bahamas incident. When exposed to high sound levels, beaked whales rapidly swim to the nearest beach. The animals appear on the beach not as one tight cluster of individuals but rather distributed over miles of coastline. Hypothermia ensues, and the animals die if they are not returned to the sea by human intervention. The fates of those animals that are returned to the sea are unknown. Necropsies of stranded animals suggest internal bleeding in the eyes, ears, and brain, as well as fat embolisms.

The implicated sound levels involve long-duration (~ 1 sec) and high-intensity (235 dB re 1µPa @ 1 m) sonar pings or equivalent air gun blasts. Mid-frequency (1-6 kHz) sound is clearly implicated in the sonar- induced stranding incidents. It is unclear whether low-frequency sound also causes injury to beaked whales. Although air guns create predominantly low-frequency energy, they also have ample mid - frequency energy, which may be related to the associated injuries.

Conclusions

As shown in the device comparisons, these events, involving air-guns and mid-frequency sonars have sound levels emanating outward horizontally comparable to or somewhat higher than the Dura Spark 240 unit here, However, the noise source level and all-direction propagation of the noise from the sparker unit is sufficient to require a considerable distance to dissipate down to the 160 or 140-dB criteria, and thus likely to disturb a large number of animals.

In addition, the noise intensity and affected ranges from the sparker units increases exponentially with input power. Although certain power levels are mentioned in the animal Take Authorizations here, there is apparently no record being kept of the electrode settings and power inputs to the devices. Save LBI asked for such information from the National Marine Fisheries Service in a Freedom of Information Act request but has received no data. So, it is possible that the units are being operated at higher power inputs and generating higher noise source levels emanating horizontally even closer to those of the air-guns and mid-frequency sonars.

There are differences but also similarities among the air-gun, mid-frequency sonars and sparker units. Therefore, the evidence from the air-gun and sonar events cannot be ignored in assessing the potential for the current surveys as a cause of the recent whale and dolphin stranding.

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