



Whales & Sonar : The Science

MILITARY ACTIVITIES & NOISE

Noise-producing military activities include:

- **military ship noise** (large and small vessels)
- **military aircraft**
- **minesweeping** (high frequency active sonar)
- **inter-submarine communication**
- **Ship-board ordnance**
- **missile & torpedo tests**
- **ship structural tests** (ship shock)
- **marine minefields**
- **submarine detection** (mid and low frequency active sonar)
 - **vessel-based systems**
 - **sonobuoys**

Of all the sources of marine noise, the impacts of mid-frequency (c. 3-7 kHz) active sonar on cetaceans is a particular concern

CETACEANS AND SONAR – WHAT'S THE PROBLEM?

**In March 2000, 16 beaked whales stranded themselves on
beaches in the Bahamas**

**At the same time the US Navy was conducting an anti-
submarine exercise in the area**

**The Navy initially denied that ships were in the area, or
that they were using sonar – they admitted to the exercise
5 weeks later**

**The Navy's own investigation found hemorrhaging around
the dead whales' eyes and ears = severe acoustic trauma**

CETACEANS AND SONAR – WHAT'S THE PROBLEM?

The US government's study of the incident established with virtual certainty that the strandings in the Bahamas had been caused by mid-frequency active sonar used by Navy ships passing through the area [Evans and England (2001)]

After the incident, all of the area's beaked whales disappeared, leading researchers to conclude that they had abandoned their habitat or died at sea

In the last year, beaked whales have been resighted, but only one has been identified from previous studies

Other whale mass strandings and deaths associated with exercises:

- 1963, 1966 - Italy
- 1974 - Bonaire
- 1974 - Corsica
- 1985, 1986, 1987, 1988, 1989, 1991, 2002, 2004 -
Canary Islands
- 1996, 1997 - Greece
- 1998, 1999 – US Virgin Islands
- 2000 – Madeira
- 2004, 2006 – Spain

Possible events

- 2005 – North Carolina, US ?
- 2008 – Cornwall, UK?

NB: not just beaked whales, but also minke whales, *Kogia* spp., etc. – and not just strandings but also injuries

OTHER INCIDENTS - HARO STRAIT

May 5, 2003 – abnormal “panic” behavior was observed in killer whales in Haro Strait, WA

While this was going on – researchers recording whale calls also recorded an extremely loud screeching sound – later revealed to be US navy mid-frequency sonar

OTHER INCIDENTS -

TAIWAN

In early 2004 (Feb. 24 –Mar. 10), there were several stranding events in Taiwan, involving pilot whales and a beaked whale among others - these coincided with a joint US/Philippine military exercise

A stranded ginkgo-toothed beaked whale was examined – the exam revealed many unusual injuries to structures that are associated with, or related to, acoustics or diving

The lesions/trauma “suggest that this beaked whale died from acoustic or blast trauma that may have been caused by exposure to naval activities south of Taiwan”

OTHER INCIDENTS - HANELEI BAY, HAWAII

At 7:30am on July 3, 2004 - 200 melon-headed whales (deep water animals) were found in shallow water in Hanalei Bay, Hawaii

The Navy was conducting an active sonar tracking exercise 20 miles NW of Kauai

The Navy initially denied using sonar before the stranding

But later admitted that they had used sonar – specifically between 6:45 and 7:10am

[Kaufman (2004)]

A report on this stranding event stated:

“we consider the active sonar transmissions of July 2-3, 2004, a plausible, if not likely, contributing factor [to the stranding event]”



OTHER INCIDENTS - JAPAN STRANDINGS

A paper presented by government scientists at the IWC analyzed Cuvier's and Baird's beaked whale mass strandings in Japan from the late 1950s – 2004

[Brownell *et al.* (2004)]

11 mass strandings (51 animals) were found- all occurred in Suruga Bay or Sagami Bay on the central Pacific coast of Honshu

These bays are adjacent to the command base for operations of the US Navy's Pacific 7th Fleet (Yokosuka)

SCOTLAND SITUATION

In 1998 whalewatching operators in two areas in Scotland protested that sightings of cetaceans

minke whale & harbor porpoise

decreased when the Royal Navy was present (conducting naval anti-submarine exercises)

A scientific analysis showed that the whalewatching operators were correct- the decrease in minke whale sightings during these exercises was statistically significant

[Parsons *et al.* (2000)]

VULNERABILITY OF BEAKED WHALES TO SONAR

**In October 2003 an article was published in the
journal *Nature* [Jepson *et al.* (2003)]**

**Necropsies had been conducted on 14 beaked whales
that stranded in the Canary Islands – 4 hours after a
NATO exercise had started using sonar**

**The necropsies showed that the animals had
symptoms of *the bends* –**

**The researchers hypothesized that exposure to high
levels of sound causes nitrogen bubbles to come out
of solution in the blood**

BEAKED WHALE WORKSHOP

An international workshop was held in 2004 to discuss the beaked whale issue [Cox *et al.* (2005)]

Biologists suggested that beaked whale blood is super-saturated with dissolved nitrogen

Normally beaked whales spend very little time at the surface

If (a) forced to stay at the surface (by noise) or (b) exposed to pressure waves (sudden noise)

Vast numbers of nitrogen bubbles could come out of solution in the blood = *bends-like effects*

[Fernández *et al.* (2004); Fernández *et al.* (2005)]

BUBBLING BLOOD & THE BENDS

Recent lab-based experimental data reinforces that pressure changes can induce bubbling in super-saturated blood [Houser *et al.*, (2001); Crum *et al.*, (2005)]

Moreover - a 2004 paper on sperm whale bones reports lesions associated with decompression sickness -adding more evidence to support the noise-induced/provoked bends scenario. [Moore & Early (2004)]

KEEPING QUIET ABOUT IT...

One interesting aspect of the super-saturated nitrogen theory is the fact that US naval authorities were aware of this issue

A military commissioned report in the mid 1990s described that high intensity, low frequency sound had the potential to cause bubbles in nitrogen saturated blood [Crum and Mayo (1996)]

Thus the US Navy had been aware of the potential impacts of sonar transmissions on cetaceans

DEPTH EFFECTS & PANIC ATTACKS

- **Another published scientific paper brings up issues which may compound the effects of sonar on whales** [Talpalar and Grossman (2002)]
- **The effects of pressure on the central nervous systems of diving cetaceans may result in “*hyperexcitability*”**
and exposure to sonar while submerged, particularly at depth:
“*may give rise to an enhanced startle response leading to disturbance in normal behaviour. A severe startle response, possibly involving fear or panic, may cause stranding as a flight response*”

RETHINKING SAFETY GUIDELINES

Prior to the studies noted above, it was thought that the main physiological impact of noise on cetaceans would be hearing damage

i.e. short term or permanent deafness [e.g. Ketten (1995)]

= *Temporary Threshold Shifts* (TTS)
or *Permanent Threshold Shifts* (PTS)

Evaluations of the potential impacts of noise on cetaceans used the likelihood of TTS or PTS occurring as an index of potential harm to cetaceans.

[e.g. National Research Council. (2000); National Research Council (2003)]

This has led to noise guidelines that considered sound sources up to **180dB** to be safe for cetaceans
= level A harassment

RETHINKING SAFETY GUIDELINES

But these safety guidelines may be very unsafe because the “bubble” effects may occur at much lower sound levels

For example: the levels of sound exposure experienced by beaked whales during the 2000 Bahamas incident “do not exceed 160-170 dB re 1 μ Pa @ 1m for 10-30 sec.” [International Whaling Commission (2004), p. 7]

i.e. levels of sound 10 – 100 times lower than 180dB for less than 30 seconds resulted in beaked whale strandings and death

INTERNATIONAL WHALING COMMISSION

In 2004 the Scientific Committee of the International Whaling Commission discussed the noise and cetacean issue

– including the Bahamas, Canaries and Japan strandings & the Taiwan incident

Over 200 of the world's whale biologists stated:

“In conclusion, the Committee agrees that there is now compelling evidence implicating military sonar as a direct impact on beaked whales in particular” [IWC 2004, p 44]

SO HOW DO WE AVOID WHALES?

At an international workshop on beaked whales convened by the U.S. Marine Mammal Commission, a scientific study noted that only one beaked whale in 50 would be detected in mitigation surveys using ship-board visual observation, assuming ideal conditions

with a 0% chance of a beaked whale being detected at 1 km from a survey vessel even when using 7x binoculars [Barlow and Gisiner (2006)]

Visual monitoring for all species will be further compromised by the Navy's use of inexperienced observers

It is well established among researchers, and has been experimentally verified, that cetacean detection is poor when inexperienced monitors are used

[Stone, C.J. (2003), *The effects of seismic activities on marine mammals in UK waters 1998-2000*, JNCC Report 323, Joint Nature Conservation Committee, Peterborough, UK; Wade, P.R. and Gerrodette T. (1993), "Estimates of cetacean abundance and distribution in the eastern tropical Pacific," *Reports of the International Whaling Commission* 43: 477-493; J. Barlow (1995), "The abundance of cetaceans in Californian waters, Part I: Ship surveys in summer and fall 1991," *Fisheries Bulletin* 93: 1-14; Jefferson, T.A. (1996), "Estimates of abundance for cetaceans in offshore waters of the northwest Gulf of Mexico, 1992-1993," *Southwestern Naturalist* 41: 279-287; Aragonés, L.V. Jefferson T.A. and Marsh H. (1997), "Marine mammal survey techniques applicable in developing countries," *Asian Marine Biology* 14: 15-39]

Heavy winds, fog, or rough weather reduce the likelihood of detecting cetaceans

Typically, scientific cetacean surveys are not conducted in conditions stronger than a fresh breeze (5 on the Beaufort scale), as rough weather negates the ability to reliably detect cetaceans in the area

Sighting cetaceans at night is also next to impossible - even light-intensifying goggles are limited to ~100m visibility for cetaceans



An effective mitigation measure is simple avoidance (temporal or spatial) of sensitive whales

e.g. known important habitat for beaked whales include canyons, shelf edges and sea mounts. Beaked whales tend to concentrate in relatively small areas (e.g. a specific canyon).

Unfortunately canyons are areas where the Navy focuses exercises

But data on beaked whale abundance, distribution and seasonal patterns of habitat use are unknown – research is needed.

A new species of beaked whale was recently identified off the Californian coast (Perrin's beaked whale) – but nothing is known about it's behavior, ecology or numbers.

Its possible that this species could be made extinct before we've even had a chance to study it.

The Navy argues that no cetaceans have died in the CA area coincident with military exercises over the several decades they have been conducting exercises

The likelihood of animals washing up on the shore is, however, very low (only a fraction of dead animals wash up on shores – *only a few species float on death*)

BUT – a dead cetacean was reported during one of the SOCAL exercises – but was not collected and arbitrarily dismissed as not being caused by the exercise

Also the nature of anti-submarine exercises has recently changed – they are now coastal (littoral), whereas previous anti-submarine exercises were typically open water and offshore, with a low likelihood of detection

Also no one has been systematically looking for evidence of exercise linked strandings until recently

Only in the past few years have suspicious strandings been analysed for evidence of acoustic trauma

absence of evidence \neq evidence of absence





Occasionally—and especially thrilling for the visitors from the Midwest—a sub would come close enough to have its nose scratched.

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