Geraint West
UK Ocean Research Services

Mitigation Measures for Acoustic Effects on Marine Life

Airguns, sonars and other things that go bump in the sea

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Horror Stories...

news

Nature **428**, 681 (15 April 2004); doi:10.1038/428681a

Push to protect whales leaves seafloor research high and dry

REX DALTON

[SAN DIEGO] A prestigious US research ship's schedule is in disarray after geophysicists were forced to abandon two recent projects because of concerns that they would harm marine mammals.

All at sea: whales demolish the *Maurice Ewing's* cruise schedule.

The *Maurice Ewing* — a 2,000-tonne vessel operated by Lamont-Doherty Earth Observatory at Columbia University, New York state — has been docked in Mobile, Alabama, for the past two months after the cruises were blocked.

Conservation officials turned the *Ewing* away from Bermuda last November and from Mexico in February. A cruise off Venezuela, originally planned for January, has also been delayed for three months, to avoid the seasonal migration of humpback whales there. The Bermudan and Mexican cruises had been planned for several years, involved several institutions and dozens of scientists, and their cost was expected to total about $2.6 million.

Researchers on the *Ewing* use airguns that discharge a sharp burst of compressed air into the ocean to generate sound waves. Geophysicists monitor the reflections from these waves to map
biologists are becoming increasingly concerned
mammals.

In 2000, for example, three beaked whales were
km of a *Ewing* cruise, and in 2002, two more we
coast of Mexico. Some marine biologists have a
noise from the devices (see *Nature* **425**, 549; 20

The 30-day Bermudan cruise was to study the v
cruise off Mexico's Yucatan Peninsula would ha
been formed by the impact of a metorite 65 mill

A senior official from the National Science Four
work programme, described the cancellations as
preparation. "We were not on top of this," says J
agency. "We need to review everything we are d

But officials at Lamont-Doherty deny lax planni
activities damaging to global ecology," says Mic
director.

Bermuda's environment ministry says that it did
about a month before the ship arrived off the isl
applications should be made a year in advance.
Ward, director of Bermuda's conservation servic
crazy. It was easy to say no." Bermuda's 200-mi

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INTERNATIONAL

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U.S. Research Ship Faces Mexican Fines

Controversial U.S. Research Ship Runs Aground on Coral Reef in Mexico, Faces Heavy Fines

By MARK STEVENSON Associated Press Writer

AP Associated Press

MEXICO CITY Feb 18, 2005 — In a significant embarrassment for American scientists, a U.S. research vessel conducting controversial sound-wave research off Mexico's Gulf coast faces heavy fines for running aground on a coral reef.

Mexican authorities announced on Thursday that the U.S. National Science Foundation ship Maurice Ewing hit a reef about 30 miles off the Yucatan peninsula on Monday, even though the reef was clearly marked on maps.

Mexico's Attorney General for Environmental Protection, Jose Luis Luege, said the ship could be seized temporarily to ensure the fine is paid.

EUROPEAN PARLIAMENT

2004 2009

Session document

31 August 2004 B6-xxx/2004

DRAFT MOTION FOR A RESOLUTION

further to Oral Question B6-000/2004

pursuant to Rule 108 (5) of the Rules of Procedure

by Karl-Heinz Florenz

on behalf of the Committee on the Environment, Public Health and Food Safety

on the environmental effects of high-intensity active naval sonars

)103EN.doc PE 347.036

EN

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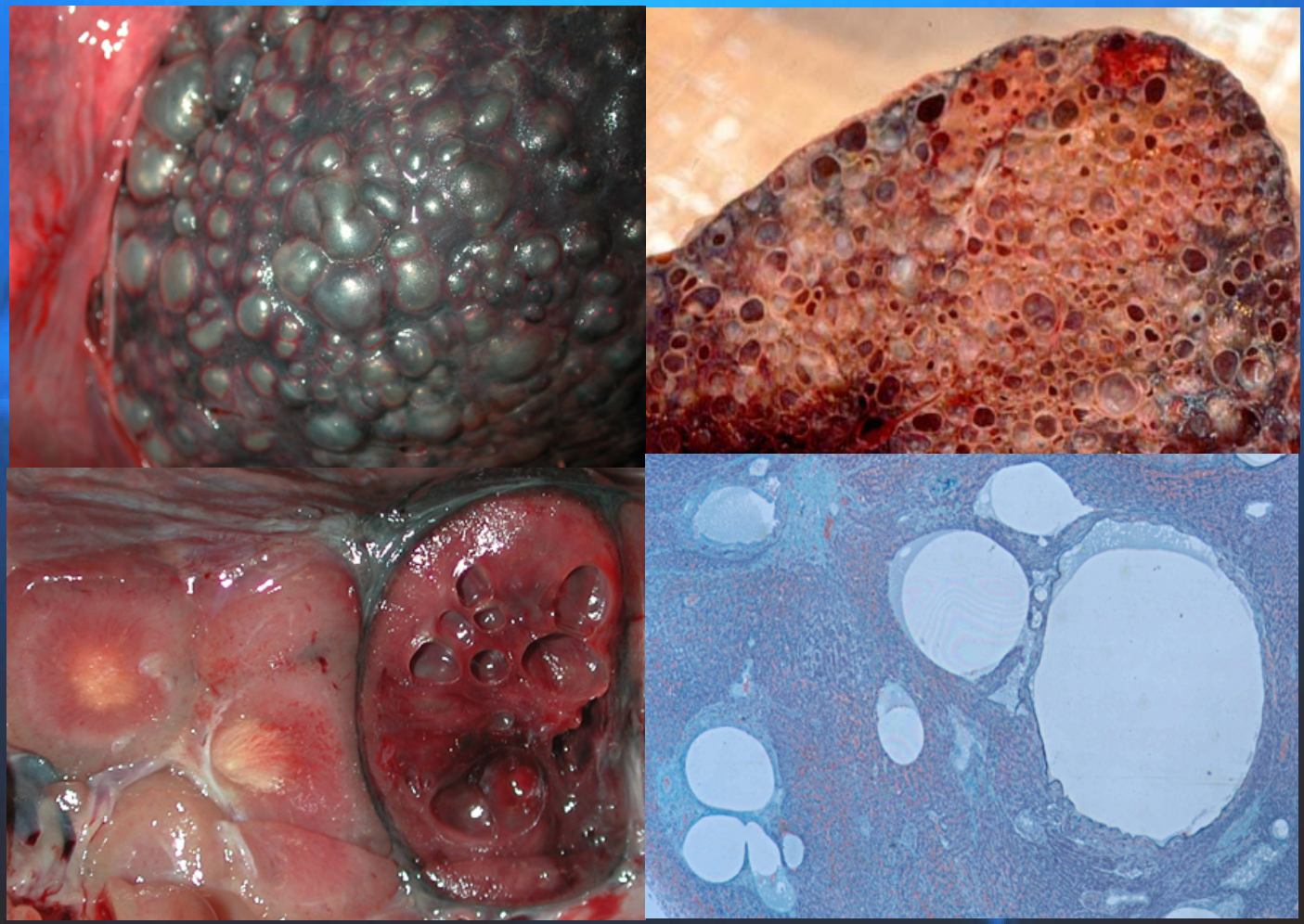
With equally scary small print

- A. whereas scientific and public concerns are increasing after a series of documented mass mortalities of cetaceans (in Greece, 1996; the US Virgin Islands 1998,1999; the Canary Islands 1985, 1986, 1989, 2002; the Bahamas, 2000; Madeira, 2000; and the Northwest coast of the United States, 2003) associated with the use of ***high intensity mid-frequency active sonar*** in coastal environments,
- B. whereas a growing body of research, including evidence published by 18 European scientists in Nature (October 9, 2003), confirm that the very loud sounds produced by naval high intensity active sonars pose a significant threat to marine mammals, fish and other ocean wildlife,
- C. whereas there is a ***potential negative impact of these sonars*** on commercial fishing and the already depleted fish stocks throughout the world's oceans, also evidenced by a study commissioned by the UK Defence Research Agency (FRRI 27/94),
- D. whereas Articles 204-206 of the United Nations Law of the Sea Convention, ***require States to assess the potential effects of their activities on the marine environment and communicate the results of such assessments***,
- E. whereas Article 194 of United Nations Law of the Sea Convention requires ***"States shall take all measures that are necessary to prevent, reduce and control pollution of the marine environment from any source",***
- F. whereas the EU is committed under Decision No 1600/2002/EC(2) laying down the Sixth Environmental Action Programme (6EAP) to halt biodiversity loss by the year 2010 in the EU and globally under the Convention on Biological Diversity and the Plan of Implementation adopted at the World Summit on Sustainable Development,
- G. whereas for effective compliance with these obligations ***the nature of the risks involved requires that the precautionary approach, as enshrined in the EC Treaty, be applied; i.e. that in the case of scientific doubt, action which might harm biodiversity and wildlife, must be avoided***,
- H. whereas the European Parliament, in its resolution on 19 June 2003 on the Commission communication: "Towards a strategy to protect and conserve the marine environment" considered that the lack of a complete information base must not be used as a pretext to prevent appropriate precautionary action in particular where there is clear evidence of a significant decline in biodiversity,
- I. whereas in the same resolution, the European Parliament called for the Commission to bring forward, as soon as possible, a thematic strategy on the marine environment, based on the following elements:
  - the ***'precautionary principle', including the evaluation of long-term effects of policies and actions***, in line with Article 6 of the Treaty;
  - the concept of sustainability, including establishing benchmarks for protection and conservation objectives as well as action targets;
  - ***a Strategic Environmental Assessment (SEA), in order to integrate environmental and biodiversity considerations into mainstream decision-making***;
  - ***an integrated approach to address threats caused by all human activities affecting the marine environment*** and a careful assessment of their impact on this environment and the mutual influence and dependency of such impacts;
  - an integrated approach regarding coastal and offshore marine management;
  - a regional approach taking into account regional diversities on ecological characteristics, threats as well as socio-economic aspects;
  - strategic marine spatial planning for the regional seas covering the whole of the EU continental shelf, which would introduce a plan-led approach to the sectoral decision-making systems;

Scary pictures as well...



Gas bubble lesions in organs from a stranded beaked whale (Jepson et al. Nature Vol. 425 Oct 2003)

Is this going to stop me sleeping at night?

- Seismics – costs and complications
  - Environmental Impact Statement/Assessment

    e.g. Incidental Harassment Authorisation (IHA) under the Marine Mammal Protection Act before any seismic cruise. Private consultants normally prepare the document at a cost of $50K to $100K. The document goes to NOAA, who normally require 6 to 9 months to review the document. It now takes approximately 12 months to organise a seismics cruise.
  - Marine Mammal Observers
  - Passive Acoustic Monitoring
  - Post-Cruise Environmental Reports
  - Un-predictability of host nations
  - NGO pressure groups
- Behavioural effects may be most significant
- Some scientists promoting a cumulative dose philosophy
- We don't know how well mitigation measures work.
- Circumstantial evidence that a variety of other acoustic instruments may have effects.

Cetacean Frequent Flyers Club

- Marine Mammal Commission (MMC)
  - Series of Plenary Sessions
  - International Policy Workshop (with UK JNCC)
- Scientific Committee on Antarctic Research (SCAR) Workshop
- US Office Naval Research (ONR) / UK Defence Science Technology Laboratory (DSTL) Workshop
- ESF/NSF Workshop
- UK Inter-Agency Committee on Marine Science & Technology (IACMST) Working Group
- Not to mention, IWC…

International Law / Conventions

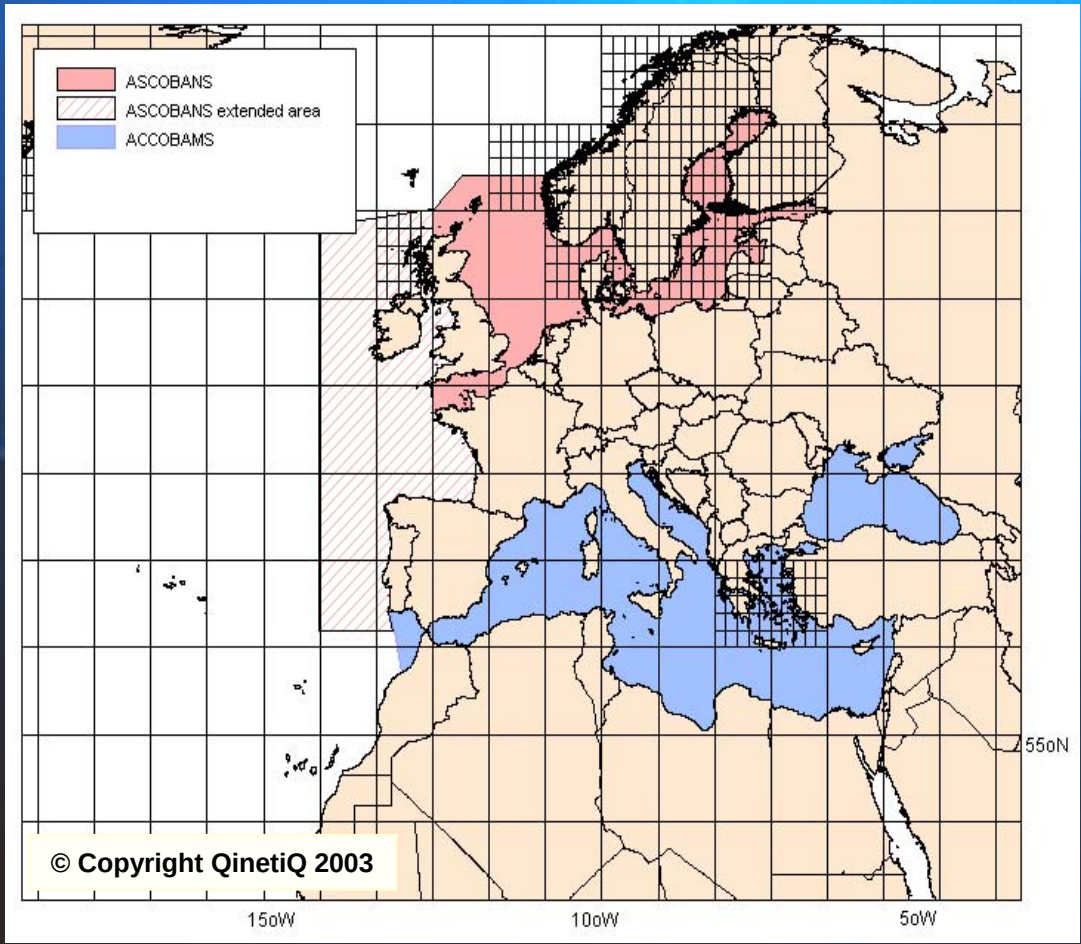
International Laws/Conventions	Aspect
1982 United Nations Convention on the Law of the Sea (UNCLOS).	Provisions relevant to anthropogenic noise in the ocean: Part I – definition of pollution Parts V and VII – conservation and management of marine living resources Part XII – protection of the environment and pollution control Part XIII – Marine Scientific Research (MSR).
1992 UNEP Convention on Biological Diversity (CBD).	Provisions relevant to conservation of marine species, ecosystems and habitats.
1946 International Convention for the Regulation of Whaling (ICRW).	Specifically mentions concern over potentially adverse effects of anthropogenic noise on cetaceans.
1979 Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).	Conservation of marine species, ecosystems and habitats.
UNEP Regional Seas Programme.	Protocols on Specially Protected Areas.
Annex V to the OSPAR Convention.	Ecosystems and biological diversity.
1992 Agreement on Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	Prevention of acoustic disturbance to cetaceans.
Rio Declaration and Agenda 21	Precautionary principle.

General Interpretation

- Part XII of UNCLOS (following Dotinga and Oude Elferink (2000)):
  - States have a general obligation to protect and preserve the marine environment.
  - ***This duty would appear to be unqualified*** and apply to all states and to all activities under their control or jurisdiction, ***including areas outside national jurisdiction***.
  - States are required to take all necessary measures to prevent, reduce and control pollution ***from any source*** using 'the ***best practicable means*** at their disposal and ***in accordance with their capabilities'***.
  - States are obliged to take ***all measures necessary*** to ensure that activities under their control or jurisdiction are conducted so as not to cause damage by pollution to ***other states and their environment***.
  - States have a ***due diligence*** obligation to adopt measures to protect the environment in respect of activities under their jurisdiction or control (e.g. for vessels flying their flag on the high seas), and to avoid harm to the environment or interests of other states, as well as to the environment outside national jurisdiction.
- Rio Declaration and Agenda 21
  - Require states to take measures to protect the environment that are based on ***precautionary and anticipatory*** approaches. Dotinga and Oude Elferink (2000) argue that these principles apply equally to acoustic disturbance as a form of pollution. This is an application of the 'precautionary principle' which states that:

    "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation"
  - The precautionary principle may also be interpreted as putting the burden of proof on the state conducting the activity, who have to demonstrate that appropriate measures have been taken to prevent harm to the environment.

ASCOBANS



- Meeting in August 03
- Resolution 4 - Extension of area
- Resolution 5 - Effects of noise & of vessels
- Sonar may have “potentially lethal consequences”
- Mitigation through use of protected areas

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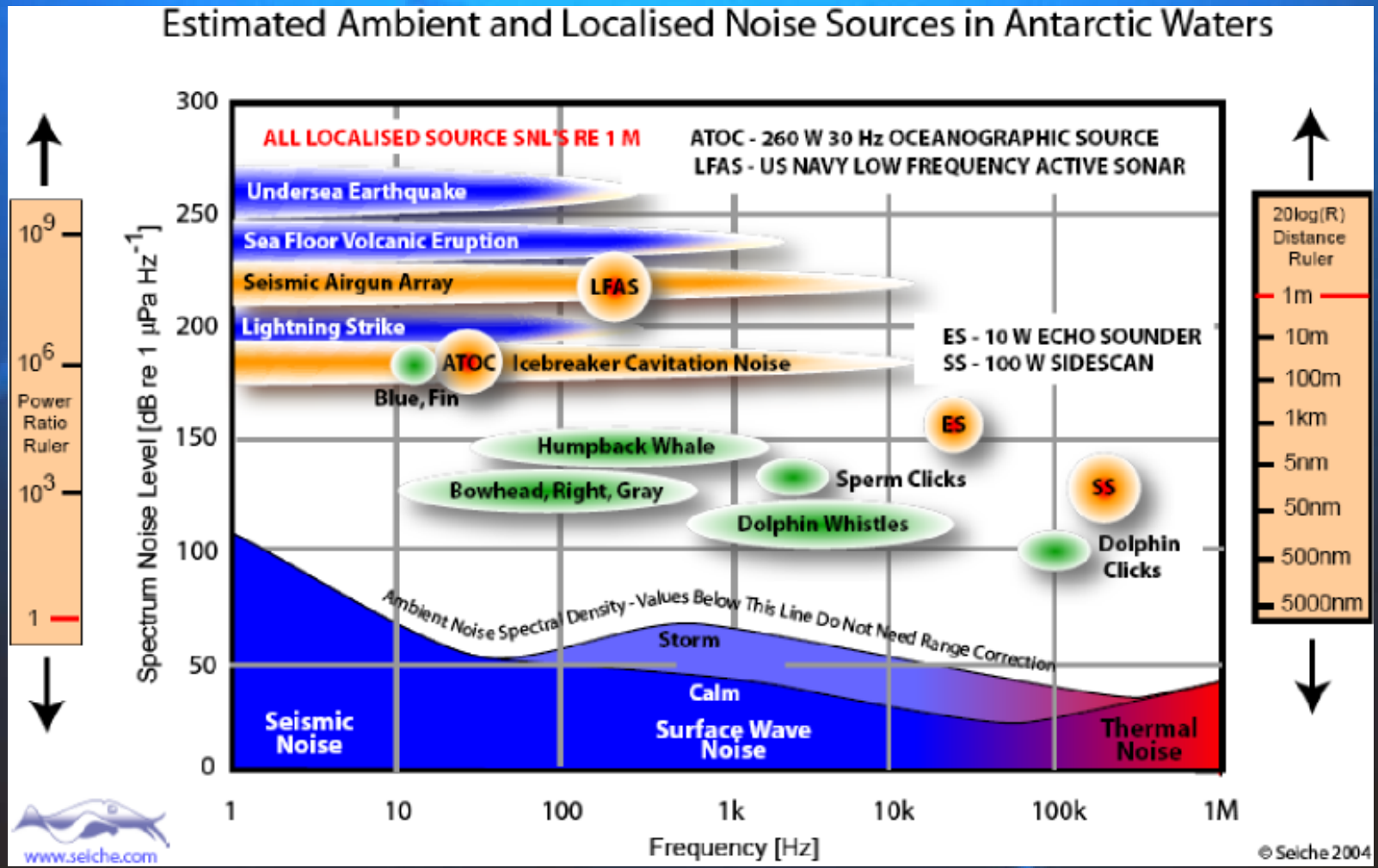
Ocean Noise Sources



SCAR REPORT ON MARINE ACOUSTIC TECHNOLOGY AND THE ANTARCTIC ENVIRONMENT
XXVII ATCM Information Paper

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Comparison of Sources

Sound Source	SPL dBre 1µPa @1m	Ping Energy (dB re 1µPa^2*s)	Ping Duration	Duty Cycle (%)	Peak Frequency (Hz)	Band Width (Hz)	Direct-ionality
Underwater Nuclear Device (30 kilo-ton)	328	?	1000 s	Inter-mittant	Low	Broad	Omni
Ship Shock Trial (10,000 lb TNT)	299	?	100 s	Inter-mittent	Low	Broad	Omni
Military Sonar (SURTASS/LFA)	235	243	6 – 100 s	10	250	30	Horizontal
Airgun Array 2000 psi and 8000 in^3	256	241	30 ms	0.3	50	150	Vertical
Military Sonar (53C)	235	232	0.5 – 2 s	6	2,600-3,300	Narrow	Horizontal
Super Tanker 270 m long	198		CW	100	23	5-100	Omni
Research Sonar (ATOC Source)	195		20 minutes	8	75	37.5	Omni
Acoustic Harrassment Device	185	185	0.5 - 2 s	50	10,000	600	Omni
Multibeam (Echosounder Hull-mounted)	235	218	20 ms	0.4	12,000	Narrow	Vertical
Research Sonar (RAFOS float)	195		120 s	small	250	100	Omni
Fishing Vessel 12 m long (7 knots)	150		CW	100	300	250-1000	Omni
Acoustic Deterrent Device (AquaMark300)	132	127	300 ms	8	10,000	2000	Omni

Hildeband J. Impacts of Anthropogenic Sound on Cetaceans. 56th Meeting of the IWC Scientific Committee. IWC/SC/56/E13

SCAR RISK EVALUATION

		CONSEQUENCES					
		1	2	3	4	5	6
		Individuals show no response, or only a temporary (mins) behaviour change. No change to environment or populations.	Individuals show short-term (hrs) behaviour change. Temporary displacement of a small proportion of a population; small proportion of habitat affected; no impact on ecosystem function.	Longer term (days) simultaneous displacement of a higher proportion of a population; disruption to behaviour; interference with feeding.	Simultaneous displacement and disruption over a period of weeks to behaviour and feeding of a large part of a population, a few injuries, some interference with breeding success.	Long-term displacement (mths) of much of a population, injuries common, substantial interference in a season's breeding success, fatalities rare.	Injuries very common, fatalities, population jeopardized, long-term displacement from a large or important area
LIKELIHOOD							
A	Expected in almost all instances						
B	Will probably occur in most cases						
C	Could occur in some cases						
D	Could occur in a few cases						
E	May occur in exceptional circumstances				I? I	I? I	
F	Cannot see how it could happen				P P P	P/I P P	P

EK60 multi-frequency bio E/S

EM12 Multiberam E/S

12kHz Single beam E/S

3.5kHz Sub-bottom Profiler

Twin Airguns

Large Airgun Array

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General Mitigation

- Use of minimum level to achieve intended scientific result.
- Use of ‘soft starts’ whereby power is increased gradually over periods of >20 mins.
- Care should be taken with line lay-outs to avoid restricting animals’ ability to avoid the source.
- Equipment should be shut down if cetaceans are observed within a potentially harmful distance of the vessel defined by the source power, directionality and power characteristics.
- Surveys should be planned to minimise repeated surveying of areas in consecutive years with high risk equipment.
- Care should be exercised to minimise impacts in known biologically sensitive areas and times.

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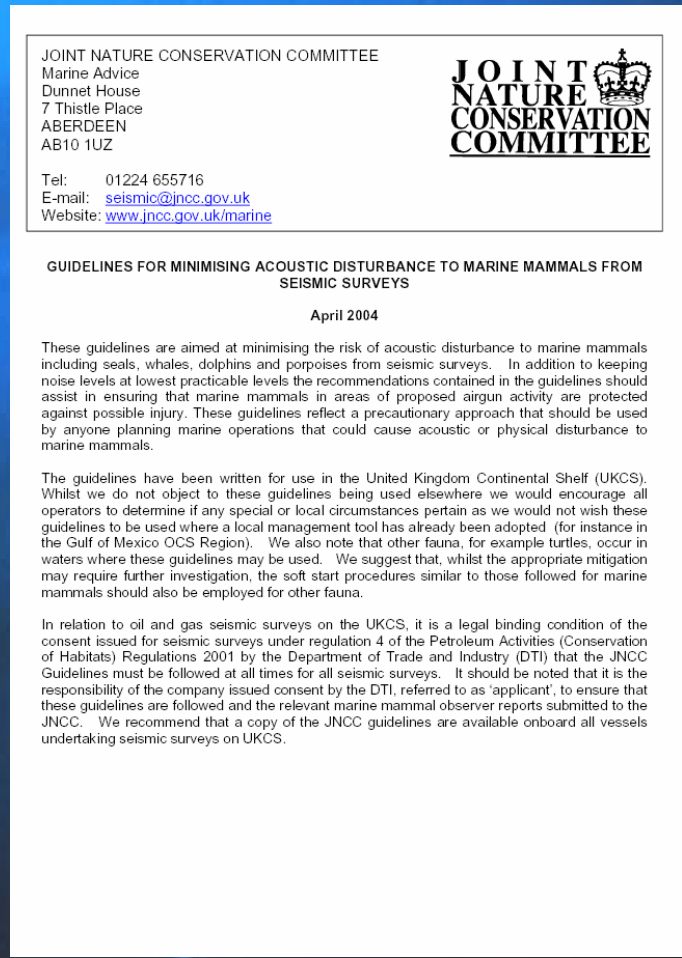
Joint Nature Conservancy Council (JNCC) Guidelines

- Adopted following extensive consultation in 1998.
- Now required under Department of Trade and Industry (DTI) licences under Petroleum Offshore Notification (PON) 14 scheme.
- Adopted voluntarily by UK Offshore Operators Association (UKOOA) and International Association of Geophysical Contractors (IAGC) for all UK shelf operations.
- Guidelines have been endorsed by ASCOBANS.
- Belgium indicated intention to adopt at 2003 ASCOBANS meeting.



JOINT NATURE CONSERVATION COMMITTEE
Marine Advice
Dunnet House
7 Thistle Place
ABERDEEN
AB10 1UZ

JOINT NATURE CONSERVATION COMMITTEE

Tel: 01224 655716
E-mail: seismic@jncc.gov.uk
Website: www.jncc.gov.uk/marine

GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

April 2004

These guidelines are aimed at minimising the risk of acoustic disturbance to marine mammals including seals, whales, dolphins and porpoises from seismic surveys. In addition to keeping noise levels at lowest practicable levels the recommendations contained in the guidelines should assist in ensuring that marine mammals in areas of proposed airgun activity are protected against possible injury. These guidelines reflect a precautionary approach that should be used by anyone planning marine operations that could cause acoustic or physical disturbance to marine mammals.

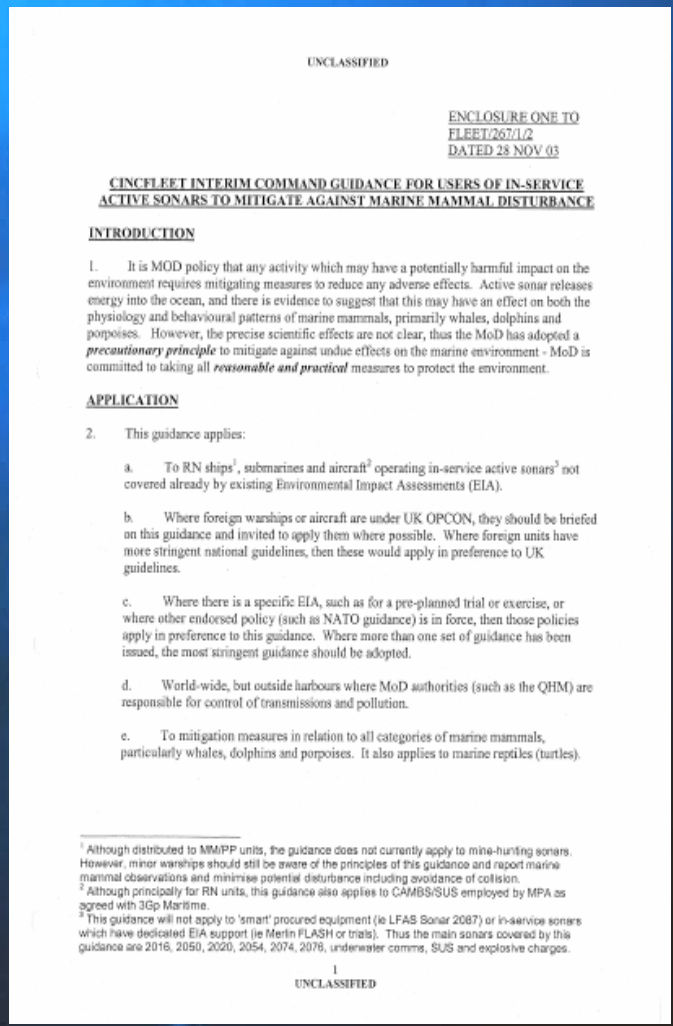
The guidelines have been written for use in the United Kingdom Continental Shelf (UKCS). Whilst we do not object to these guidelines being used elsewhere we would encourage all operators to determine if any special or local circumstances pertain as we would not wish these guidelines to be used where a local management tool has already been adopted (for instance in the Gulf of Mexico OCS Region). We also note that other fauna, for example turtles, occur in waters where these guidelines may be used. We suggest that, whilst the appropriate mitigation may require further investigation, the soft start procedures similar to those followed for marine mammals should also be employed for other fauna.

In relation to oil and gas seismic surveys on the UKCS, it is a legal binding condition of the consent issued for seismic surveys under regulation 4 of the Petroleum Activities (Conservation of Habitats) Regulations 2001 by the Department of Trade and Industry (DTI) that the JNCC Guidelines must be followed at all times for all seismic surveys. It should be noted that it is the responsibility of the company issued consent by the DTI, referred to as 'applicant', to ensure that these guidelines are followed and the relevant marine mammal observer reports submitted to the JNCC. We recommend that a copy of the JNCC guidelines are available onboard all vessels undertaking seismic surveys on UKCS.

General Mitigation

Royal Navy CINCFLEET Interim Command Guidance 28 Nov 03

- Plan
- Look
- Listen
- Act



UNCLASSIFIED

ENCLOSURE ONE TO
FLEET/267/1/2
DATED 28 NOV 03

CINCFLEET INTERIM COMMAND GUIDANCE FOR USERS OF IN-SERVICE ACTIVE SONARS TO MITIGATE AGAINST MARINE MAMMAL DISTURBANCE

INTRODUCTION

1. It is MOD policy that any activity which may have a potentially harmful impact on the environment requires mitigating measures to reduce any adverse effects. Active sonar releases energy into the ocean, and there is evidence to suggest that this may have an effect on both the physiology and behavioural patterns of marine mammals, primarily whales, dolphins and porpoises. However, the precise scientific effects are not clear, thus the MoD has adopted a ***precautionary principle*** to mitigate against undue effects on the marine environment - MoD is committed to taking all ***reasonable and practical*** measures to protect the environment.

APPLICATION

2. This guidance applies:

a. To RN ships[1], submarines and aircraft[2] operating in-service active sonars[3] not covered already by existing Environmental Impact Assessments (EIA).

b. Where foreign warships or aircraft are under UK OPCON, they should be briefed on this guidance and invited to apply them where possible. Where foreign units have more stringent national guidelines, then these would apply in preference to UK guidelines.

c. Where there is a specific EIA, such as for a pre-planned trial or exercise, or where other endorsed policy (such as NATO guidance) is in force, then those policies apply in preference to this guidance. Where more than one set of guidance has been issued, the most stringent guidance should be adopted.

d. World-wide, but outside harbours where MoD authorities (such as the QHM) are responsible for control of transmissions and pollution.

e. To mitigation measures in relation to all categories of marine mammals, particularly whales, dolphins and porpoises. It also applies to marine reptiles (turtles).

[1] Although distributed to MM/PP units, the guidance does not currently apply to mine-hunting sonars. However, minor warships should still be aware of the principles of this guidance and report marine mammal observations and minimise potential disturbance including avoidance of collision.
[2] Although principally for RN units, this guidance also applies to CAMBS/SUS employed by MPA as agreed with 3Gp Maritime.
[3] This guidance will not apply to 'smart' procured equipment (ie LFAS Sonar 2087) or in-service sonars which have dedicated EIA support (ie Merlin FLASH or trials). Thus the main sonars covered by this guidance are 2016, 2050, 2020, 2054, 2074, 2076, underwater comms, SUS and explosive charges.

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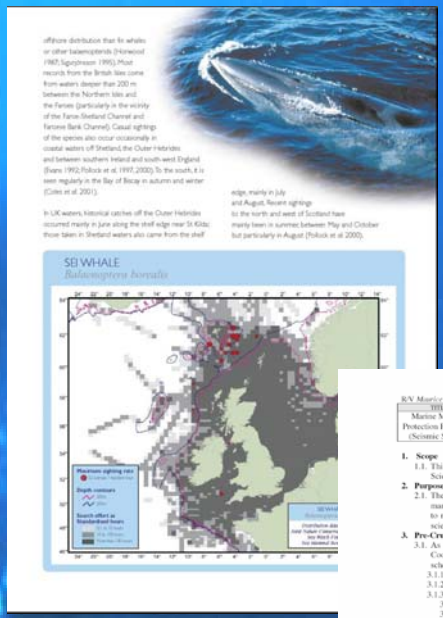
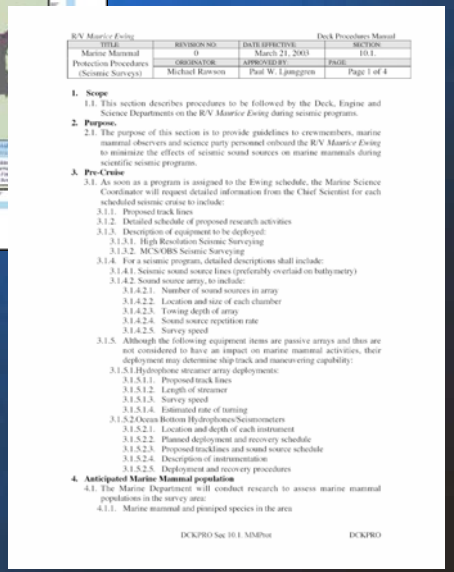
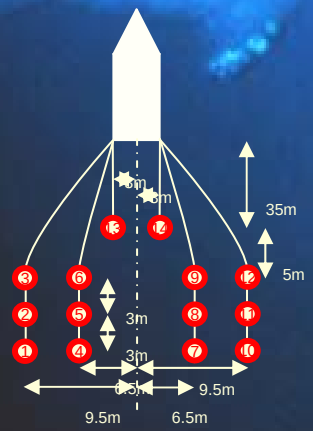
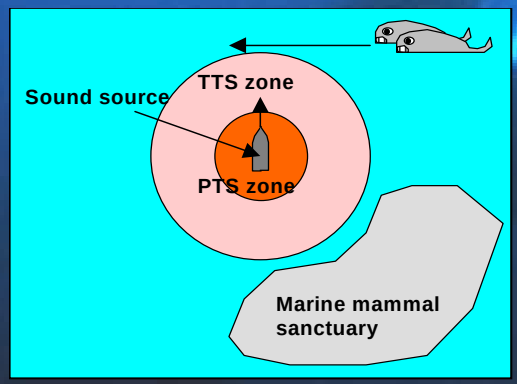
Plan

- Data Sources
- Source Assessment
- Operational Protocol
- PR/NGO Engagement









	Gun Vol. (cu. in)															Cumulative Exposure	PTS (30 min)	TTS (24 hr)
Gun No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total			
MCS	80	300	100	200	400	160	200	250	160	80	100	120	600	-	2750	SL=254 dB re 1 mPa at 1 m	80m	1.2km
OBS	200	300	500	600	700	160	600	700	160	200	300	500	1000	1000	6920	SL=259 dB re 1 mPa at 1 m	80 m	1.5 km

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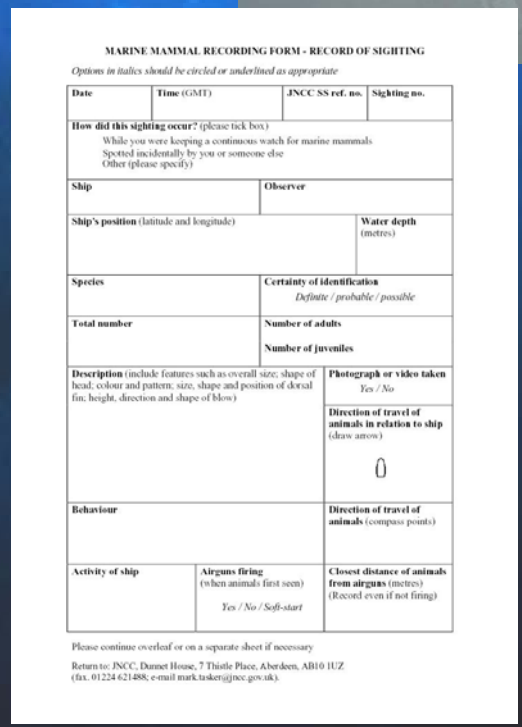
Multibeam Characteristics

System	Freq.	Bw	SL	PL @1m	PL @10m	PL @100m	PL @1000m
	(kHz)		dB re 1µPa @1m	dB re 1µPa			
EM 122	12	0.5°	245	208	202	192	181
EM 120/2	12	1°	242	211	205	195	181
	12	2°	236	211	205	195	171
EM 302	30	0.5°	241	212	212	201	185
EM 300/2	30	1°	237	214	214	203	181
	30	2°	231	214	214	200	175
EM 710	70-100	0.5°	233	209	199	186	142
	70-100	1°	230	212	202	186	139
	70-100	2°	224	212	202	180	133
EM 1002	100	3°	225	210	205	182	135
EM 2000	200	1.5°	218	207	196	173	NA
EM 3002	300	1.5°	216	207	194	167	NA

Look

- Visual
  - Day
    - Binoculars
    - High powered optics
  - Night
    - Night vision goggles (NVG)
- Other sensors
  - Radar
    - Possible to detect the effects of a surfacing animal, the blow and the wake, and give good range information
  - IR
    - Possible to detect the warm air and vapour in the blow, and possibly the body of the animal
  - Electro-optical
    - Should be able to detect the effects of surfacing
- Airborne…
- **Whatever you do, record it!**



MARINE MAMMAL RECORDING FORM - RECORD OF SIGHTING

Options in italics should be circled or underlined as appropriate

Date	**Time** (GMT)	**JNCC SS ref. no.**	**Sighting no.**

How did this sighting occur? (please tick box)
While you were keeping a continuous watch for marine mammals
Spotted incidentally by you or someone else
Other (please specify)

Ship	**Observer**
Ship's position (latitude and longitude)	**Water depth** (metres)
Species	**Certainty of identification** *Definite / probable / possible*
Total number	**Number of adults** **Number of juveniles**
Description (include features such as overall size; shape of head; colour and pattern; size, shape and position of dorsal fin; height, direction and shape of blow)	**Photograph or video taken** *Yes / No* **Direction of travel of animals in relation to ship** (draw arrow) 0
Behaviour	**Direction of travel of animals** (compass points)
Activity of ship	**Airguns firing** (when animals first seen) *Yes / No / Soft-start* **Closest distance of animals from airguns** (metres) (Record even if not firing)

Please continue overleaf or on a separate sheet if necessary

Return to: JNCC, Dunnet House, 7 Thistle Place, Aberdeen, AB10 1UZ
(fax. 01224 621488; e-mail mark.tasker@jncc.gov.uk).

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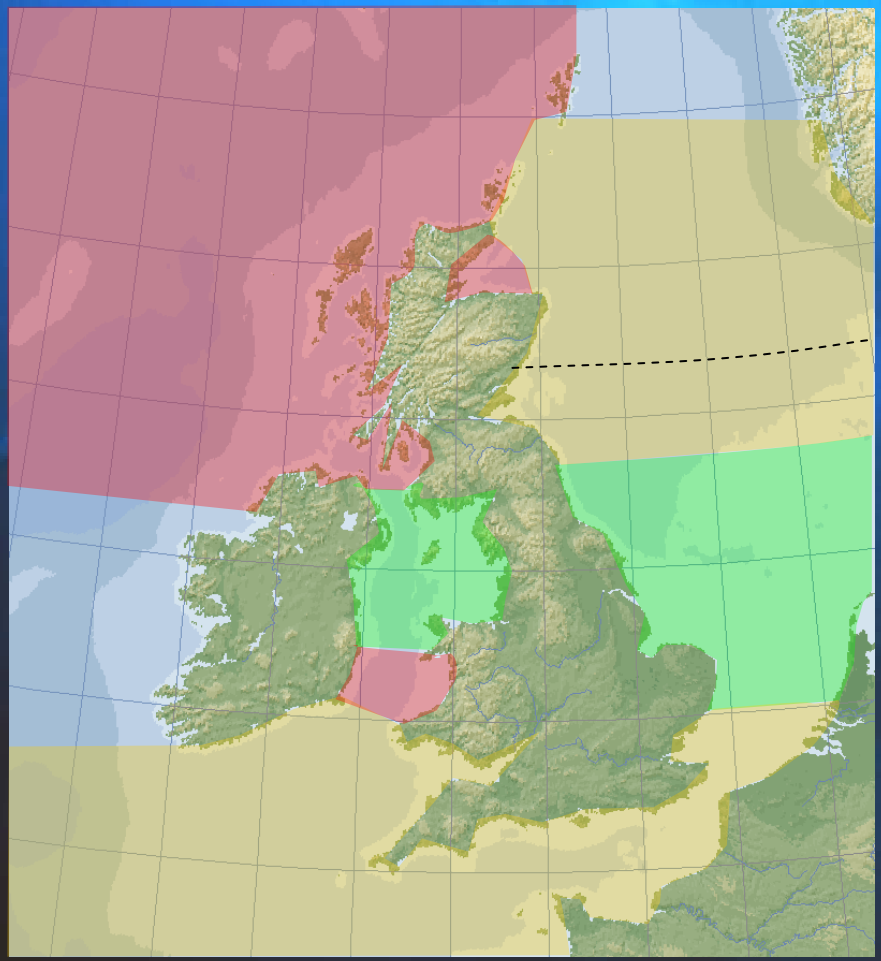
Marine Mammal Observers

- A *prerequisite for an MMO is the attendance on a short course* on implementing the guidelines and recording procedure.
- *For sensitive areas* including West of Britain, Moray Firth and Cardigan Bay, *the MMO must also be an experienced cetacean biologist or similar*.
- When a dedicated MMO is requested, the MMO should be employed solely for the purpose of minimising disturbance to marine mammals during periods of active seismic survey.
- All surveys taking place between 1st April and 1November north of 57º latitude in the NE Atlantic will require the presence of a dedicated MMO. *The use of a crewmember with other onboard responsibilities is not considered an adequate substitute for a dedicated MMO.*
- The MMO should be onboard the source vessel. (i.e. the vessel towing the airguns).
- During the planning phase, all seismic survey operations no matter the geographical area should consult JNCC via RSU Operations as a matter of course.
- The JNCC are able to provide information on the need to embark MMOs.

UK Requirements for MMOs



Cetacean sensitivities are generally low to moderate

- Seismic surveys using large sources such as those for 2D or 3D seismic surveys may require a dedicated MMO.

For all other surveys a dedicated MMO is usually not required however:

- A watch should be kept for marine mammals particularly before and during start up (See B During the Seismic Survey)
- A report should still be submitted to the JNCC containing location, effort and sighting forms (See C Report After the Survey)

Cetacean sensitivities are highly variable

- Requirements for MMOs are varied according to the energy source volume, energy source pressure level, sound frequency and survey location however, the following guidance is available.
- Seismic surveys using large sources such as those for 2D or 3D seismic surveys will require a dedicated MMO.
- All surveys requiring MMOs taking place between 1st April and 1st November north of 57º latitude will require two dedicated MMOs due to the longer daylight hours.

Cetacean sensitivities are high

- Any seismic operation including site surveys will require dedicated experienced, trained cetacean biologists for MMOs.
- All surveys requiring MMOs taking place between 1st April and 1 November north of 57º latitude will require two dedicated MMOs due to the longer daylight hours.

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Look

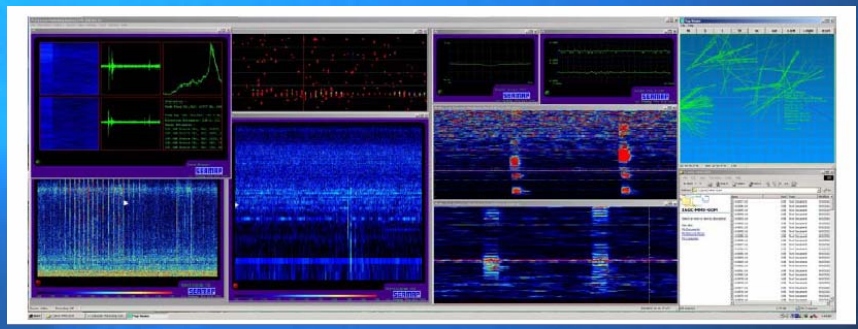
Accounting for both submerged animals and animals that are missed by the observers, only 23% of Cuvier's beaked whales and 45% of mesoplodont beaked whales are estimated to be seen on ship surveys if they are directly on the survey track-line in survey conditions of Beaufort 0-2 (Barlow 1999). The encounter rate of beaked whales decreases by more than an order of magnitude as survey conditions deteriorate from Beaufort 1 to Beaufort 5 (Barlow *et al.* 2004, their Table 1)...

…Experienced observers have beaked-whale sighting rates that are approximately twice as high as less experienced observers (Barlow *et al.* 2004)…

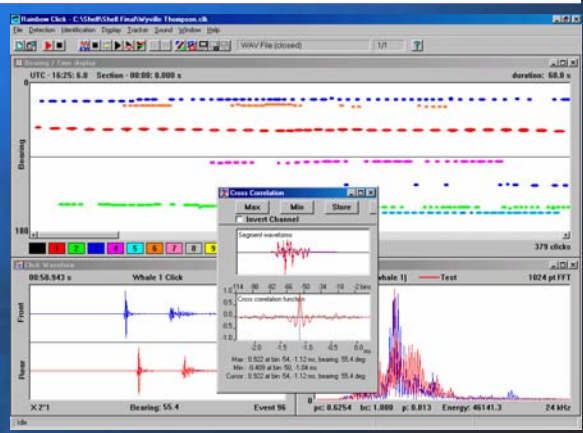
…On aerial line-transect surveys, teams of 2-3 observers typically search by naked eyes from a survey altitude of 600-1000 ft (183-305 m) and at a speed of approximately 100 kts (185 km/hr)…

…Accounting only for animals that are missed because they are diving, only about 7% of Cuvier's beaked whales and 11% of mesoplodont beaked whales would be seen on aerial surveys if they are directly on the survey track-line (Barlow *et al.* 2004). The fraction seen decreases rapidly with distance from the track-line; the effective search width is typically only 250-500 m (on each side of the aircraft) for aerial observers searching by unaided eye in excellent or good sighting conditions (Barlow *et al.* 2004, their Table 2).

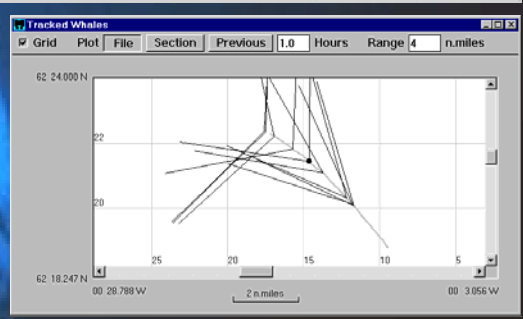
Listen



- Passive acoustic monitoring (PAM)
  - Wide variety of hardware systems:
    - Towed arrays
    - Sonobuoys
    - Ball hydrophones
  - Software
    - Ishmael (total bandwidth)
    - Whistle (for dolphins),
    - Rainbow Click (for sperm whale clicks)
    - Logger (logs location, observations and acoustic detections)
  - Operation
    - Detect
    - Classify
    - Localise
  - Ideally fully automated to eliminate the need for additional manpower
  - Ideally high probability of detection and a low false alarm rate
  - Particularly important during activities after dark
  - Does not detect silent animals transiting the area.
  - Poor for range estimation



- Active acoustic monitoring
  - Fish finding sonars are widely used by the fishing industry to detect shoals
  - US Navy are developing a sonar system designed to detect, locate and track marine mammals (SURTASS, 2001).
  - Enable silent animals to be detected
  - Introduces more sound into the marine environment - potential to pose additional risk
  - Therefore somewhat controversial.



Act

	UK- JNCC	SACLANTCEN	Environment Australia	Gulf of Mexico (MMS)
Surveillance Zone	0.5km	2km Based on 226 dB re 1µPA @ 1m source - 160 dB re 1µPA @ 1m receptor	3km	0.5km 'Exclusion Zone'
Pre-ramp up Obs. Period	30 mins	30 mins	90 mins	30 mins
Ramp-up Period	'at least 20 mins'	Increase from 150 dB re 1µPA @ 1m over 20 mins	20 mins	Start with smallest airgun, then increase by 6 dB re 1µPA per 5 min
Turn/ Interruption Procedure	'continuing to shoot between lines is not encouraged. Firing should stop at the end of the line'	Full ramp up required if transmissions stop for more than 4 hours.	Allows 'continued discharge… during line turns or changes… a limited number of airguns… sufficient in this case'	'May reduce… to output of 160 dB re 1µPA ' without full ramp up procedures.

Outstanding Issues

- Planning
  - Data adequacy
  - Source knowledge – particularly 12kHz MBES and 3.5kHz SBP
  - Response of receptors
- Looking
  - MMO Training
  - Reduced visibility
    - Night
    - Fog
    - Sea-state
- Listening
  - Equipment / Deployment
  - Interpretation
- Acting
  - How do we use the information?
- Effectiveness
  - What works? - how do we know?
  - What is reasonable?

None of the available detection methods have a high probability of detecting and identifying beaked whales. Passive and active acoustic detection must be considered experimental and untested. Because of their long dive times and cryptic surfacing behavior, visual detection will not be effective at detecting more than a small fraction of beaked whales that are in the immediate vicinity of a sound source. **Mitigation plans that depend solely on detecting beaked whales will be similarly ineffective**. (Barlow & Gisiner 2004)

Information Sources

- Joint Nature Conservancy Council
  - Guidelines available in pdf format
  - UK Waters Cetacean Guide
  - http://www.jncc.gov.uk/marine/seismic.htm
- NATO SACLANTCEN – Sound, Ocean and Living Marine Resources (SOLMAR)
  - Policy & Planning Documentation
  - http://solmar.saclantc.nato.int/
- USA Minerals Management Service
  - Environment and Oil industry in Gulf of Mexico
  - http://www.gomr.mms.gov/homepg/regulate/environ/
- Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
  - Records of meetings and resolutions
  - http://www.ascobans.org
- Environment Australia
  - Guidelines available in pdf format
  - http://www.ea.gov.au/coasts

Information Sources

- International Association of Geophysical Contractors (IAGC)
  - Gulf of Mexico MMS Guidelines
  - Information booklet on airguns and marine mammals (the industry view)
  - http://www.iagc.org/public/gom/list.htm
- US Navy SURTASS Low Frequency Active Sonar
  - Military Low frequency sonar
  - http://www.surtass-lfa-eis.com
- USA National Marine Fisheries Service
  - Good coverage of US legislation:
    - Marine Mammals Protection Act (MMPA)
    - Endangered Species act (ESA)
  - http://www.nmfs.noaa.gov/mar_mammals.htm
- British Divers Marine Life Rescue
  - Comprehensive News Archive of worldwide strandings
  - Representative viewpoint of typical public pressure group
  - http://www.bdmlr.org.uk
- Whale & Dolphin Conservation Society
  - http://www.wdcs.org/

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