Historical experience of False Killer Whale depredation NW Coral Sea from 1986

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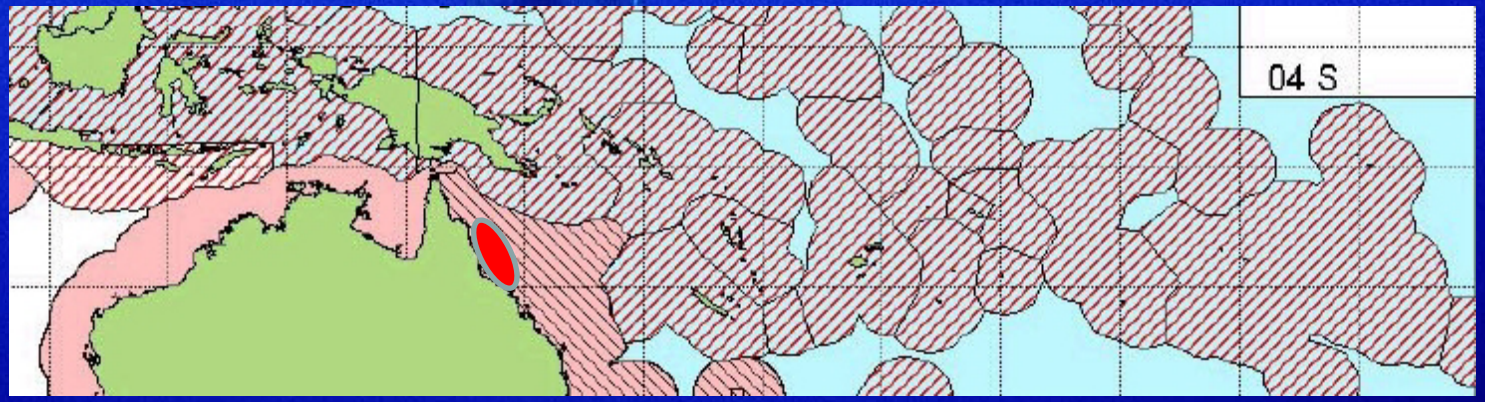
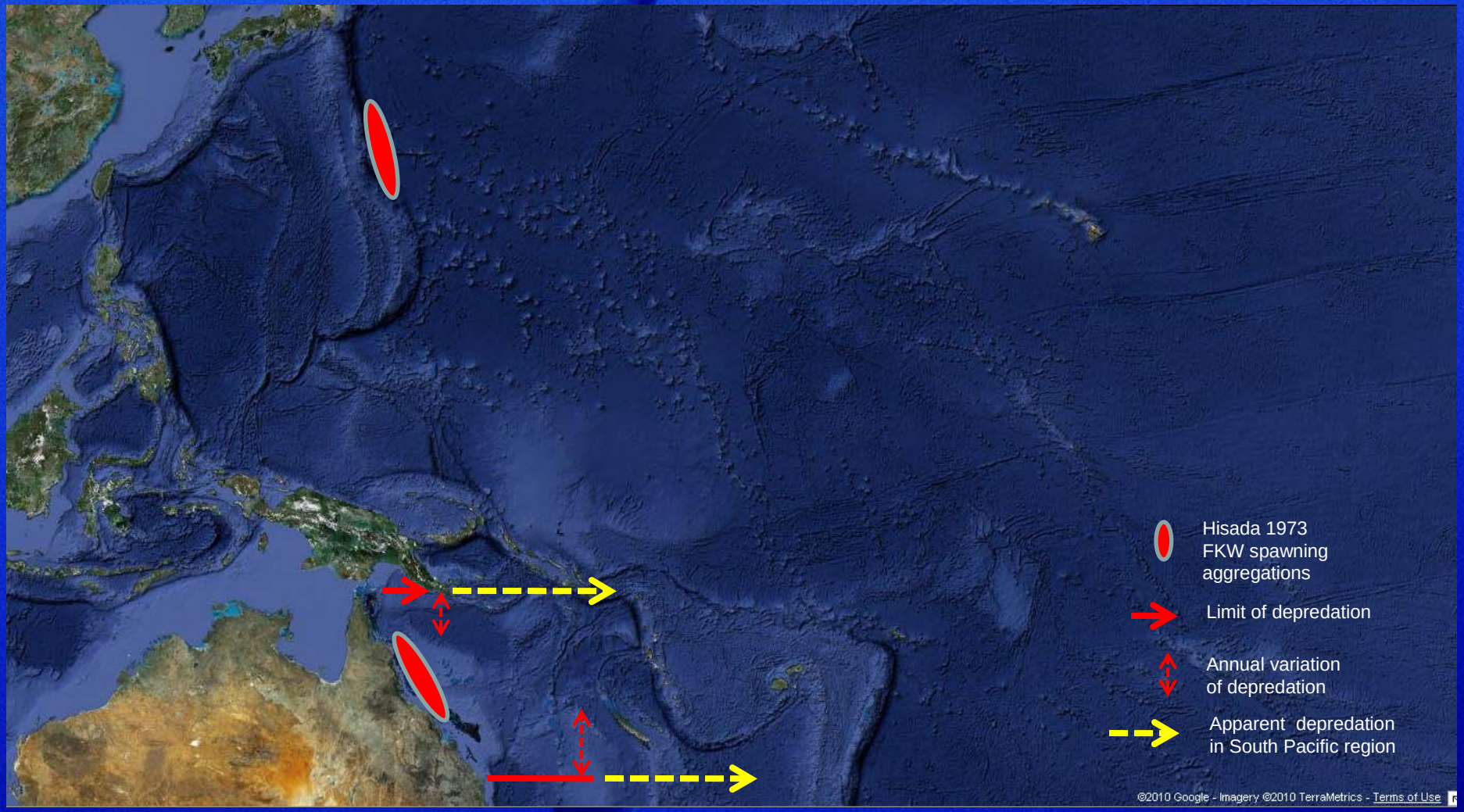
Supported by
Fisheries Research and Development Corporation Australia

Western Pacific Regional Fishery Management Council US NMFS

1. **Japanese handline fishery developed in the NW Coral Sea in the 1960's using longline vessels**
   - **False killer whales and short fin pilot whales were listed.**
   - **Depredation in HL by FKW would terminate fishing**
   - **Described as *worst blackfish depredation in the Indo-Pacific***
   - **No descriptions of depredation events**




Hisada 1973
FKW spawning
aggregations
Limit of depredation
Annual variation
of depredation
Apparent depredation
in South Pacific region
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2. 1985 Australian project to examine the YF and BE tuna aggregations

- Length at maturity
- Frequency of spawning and fecundity
- Mechanism for the aggregation

Japanese LL vessels in Coral Sea 1985

whale sharks

spawning myctophids

up to 8 LL vessels
all on schools of tuna

Thanks to:
Fishing Master and crew
of Fukuichi Maru No.81

using pole and line

using branchlines
as handlines

3. Depredation on handline fishing gear

- FKW depredation
  - Losses in 100's of tuna each fishing session
  - Sometimes 0% of the catch was landed, fishing terminated
  - Whales RARELY OBSERVED around vessels
  - Depredation occurred in day and night periods
  - Depredation occurred at very fast swim speeds
  - Depredation
    - started with a rear approach, to a parallel position
    - was an extremely rapid event, never properly resolved
  - Depredation unlike shark depredation
    - there is <u>no</u> line strain associated with the strike

4. Domestic LL depredation experience since the Japanese HL fishery

- Images of hooked FKW from Hawaii
- Manual release system used by Australian fishermen in the Coral Sea

Conclusions

- **Japanese handline Coral Sea 1985**
  - **Depredation by FKW can be an extremely rapid process.**
  - **Depredation highly seasonal when tuna catches highest**
  - **Japanese LL at the time noticed that fish entangled in wire gear could be spared depredation.**

Mitigation of depredation behaviour by toothed whales on tuna longlines.

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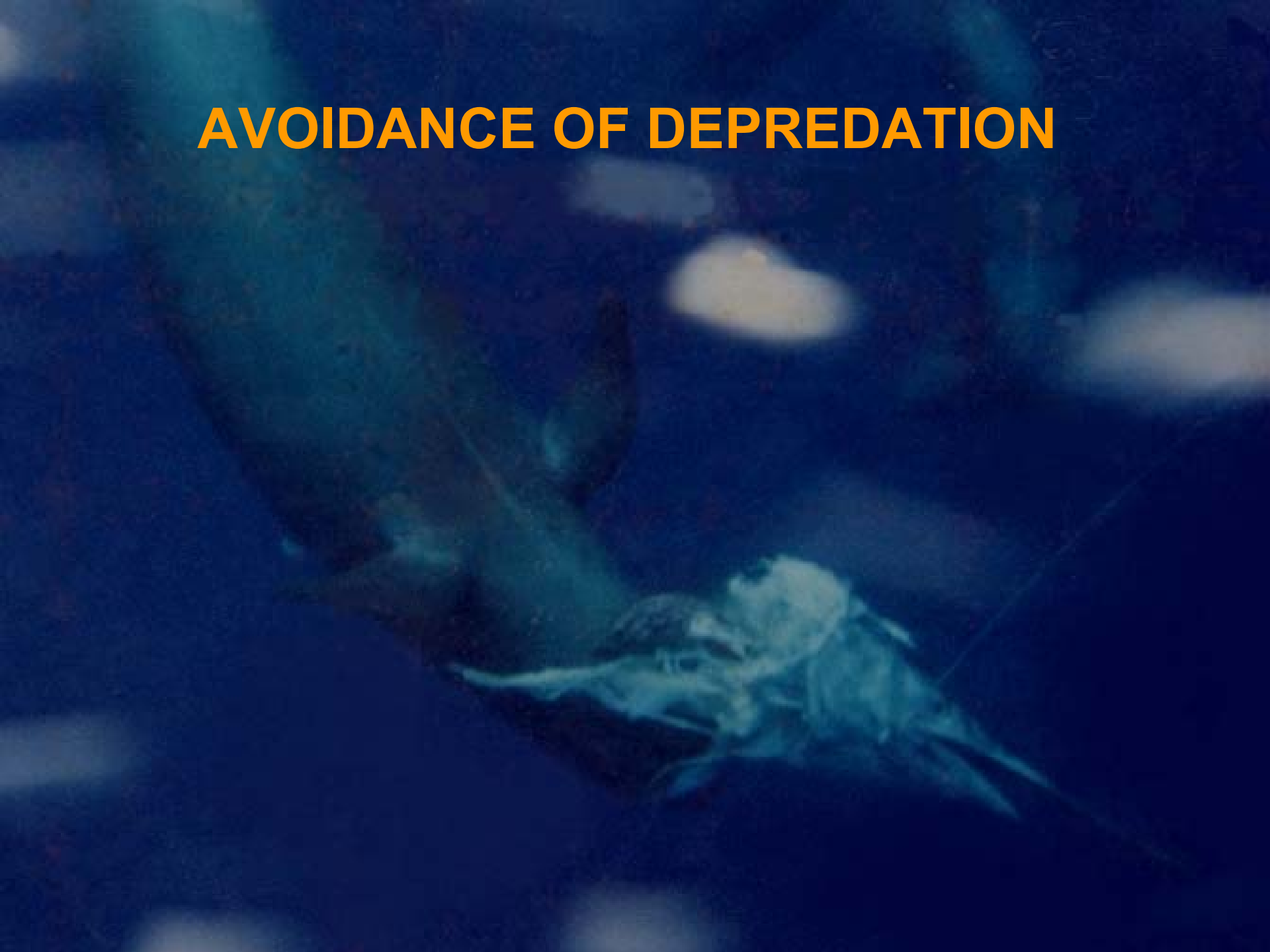
SUMMARY

- **AVOIDANCE of depredation (Australia and elsewhere)**
  - **Long range detection of whistles**
  - **Long range detection of echolocation clicks**
- **MINIMISATION of depredation (Japan, Seychelles)**
  - **Active acoustics – recent progress on pingers**
  - **Passive acoustics – progress on sonar reflective systems**

AVOIDANCE OF DEPREDATION



Elements of the AVOIDANCE approach

a) Depredation may occur at any part of a LL and fishing masters would not be aware

b) Knowledge of depredation occurring would permit fishing masters to take steps to reduce further loss.

c) Avoidance at its most basic included Australian operators in the NW Coral Sea tuna aggregations in 2009
   - Crew placed as high lookouts
   - Hauling started if whales were seen coming.

d) With support from HLA and Japan Fisheries
   - Australia has supported development of a whale depredation proximity buoy

Detecting depredating toothed whales around radio buoys

1. Project funded by Australia Industry.
   - Request for GDS to apply for additional funding
2. Modification of existing RDF receivers to provide 'proximity' information
   - Hydrophone
   - Depredation sounds yes/no processor on buoy
   - Vessel response likely as
     - ✓ GPS buoy location
     - ✓ Indicator light
     - ✓ Sound envelope of signal

Modified GPS capable NewStar RDF buoy
- with 2 rewired Navy sonobuoy hydrophones

ASM SYSTEMS

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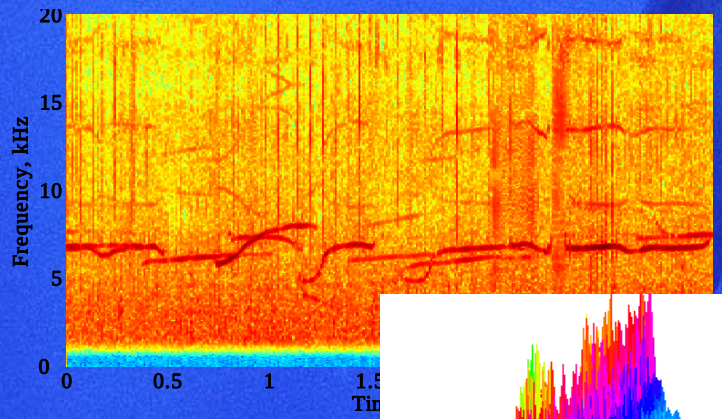
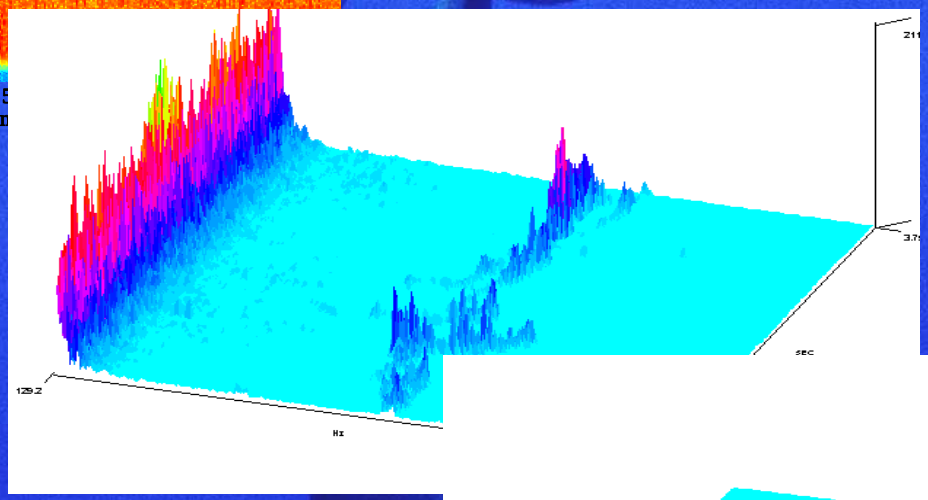
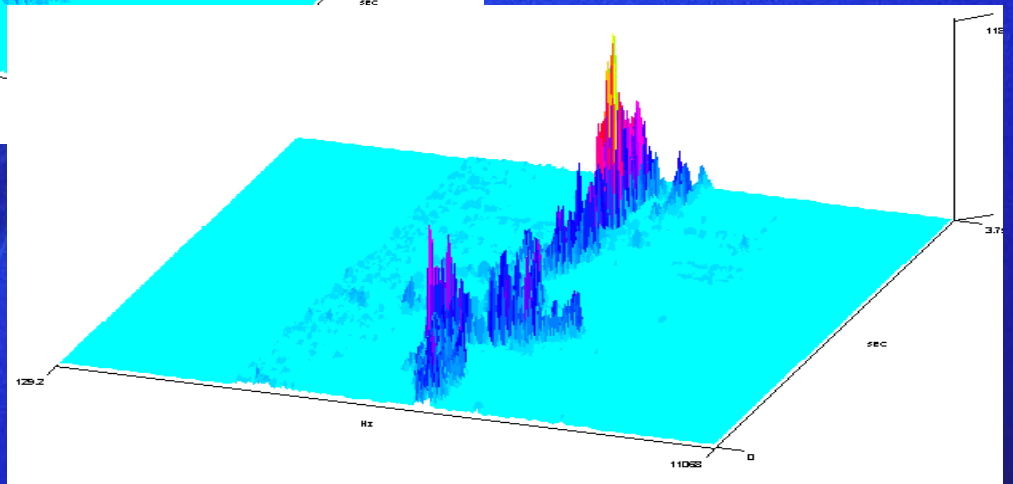
3. Sounds associated with toothed whale depredation

- likely to be broadly species specific,



False killer whales
whistles and clicks

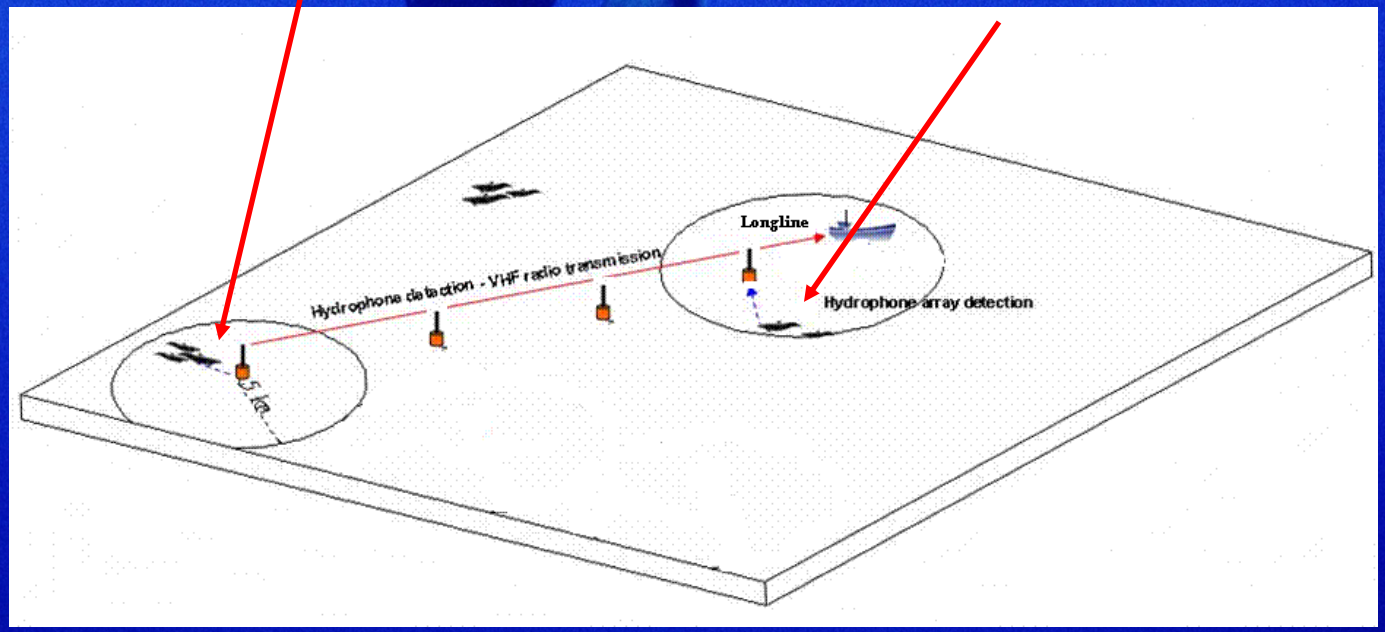




Detecting depredating toothed whales around radio buoys

Detecting toothed whales around radio buoys
'whale proximity detector'

Detecting toothed whales around vessels



RSM SYSTEMS

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Detecting depredating toothed whales around radio buoys

4. Detection methods
   - Sounds of depredation distinct
   - Species differences in many fishery areas not relevant
   - Sounds = ‘teeth’ (on baits or tuna)
   - Thesis work on detection algorithm commenced

5. Assessment operations.
   - Australia
   - Hawaii
   - Seychelles

ASM SYSTEMS

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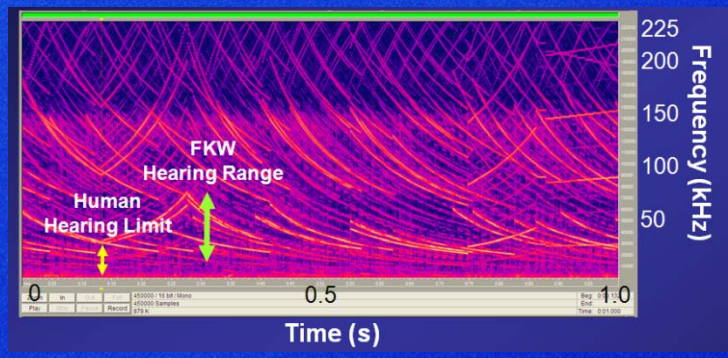
MINIMISATION OF DEPREDATION
Further pinger development

1. Pingers utilised to date

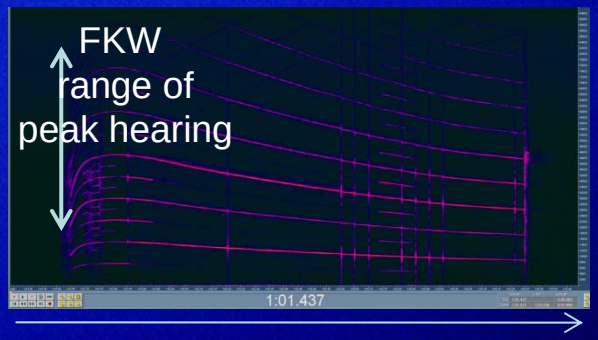
SaveWave ORCA pinger

- tested by Mooney *et al.* (2009)
- DID significantly interfere with
  - echolocation at < 8 m range
  - decision making ≈ 5 secs
- DID NOT interfere with
  - decision making about targets at 30 m
- DID interfere with aspects of late stage depredation <0.5 secs



Seamaster PROTECTOR pinger

- 16 different continuous FM tones.
- in effect, a cost-effective version of SaveWave.
- Asian fishing industry acceptance suggests real success with smaller delphinids



2. Pingers for the future

DDD pinger

- 1.5 kg.
- max. SL 176 dB (rms) at 30-80 kHz
- erratic FM tones + variable ICI broadband clicks.
- Interactive version under test.
- early versions demonstrated success with common dolphin in trawls / purse seines.
- 2010 versions better suited to sonar interference with >1 octave bandwidth clicks.
- DDD (version to be finalised) to be used with Japan Fishery Research Agency project south of Hawaii, late 2010

MINIMISATION OF DEPREDATION

Passive acoustic, biosonar interference

1. **Fishery observations of depredation**
   a) **Fish entangled in fishing gear are usually NOT depredated upon by toothed whales**
      - **Major differences exist between whale species behaviour.**
   b) **Tom Nishida (Japan Fisheries Agency) developed this idea through the 1980's**
   c) **Hawaiian gamefishermen developed the same idea in the 1980's**

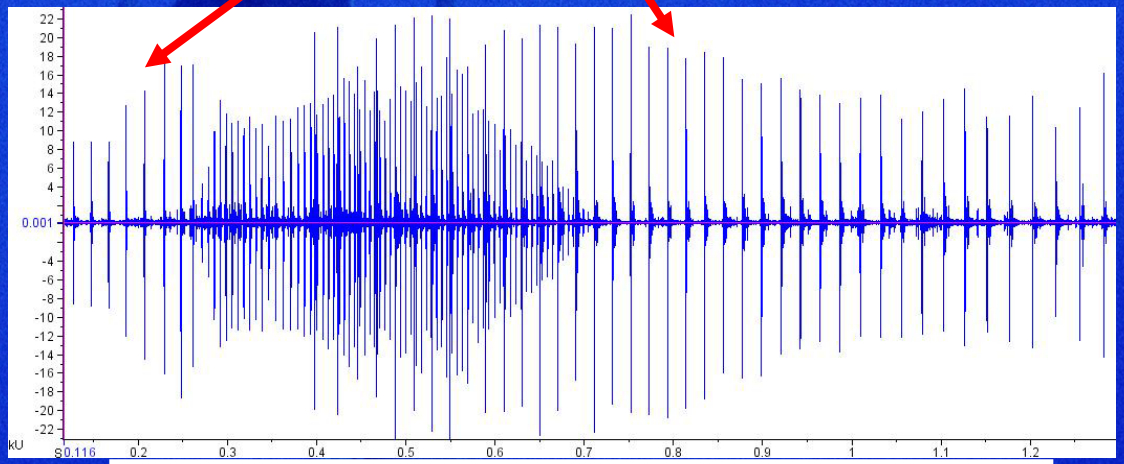
2. Toothed whales echolocate on targets

a) The feeding buzz from sonar of whales approaching targets has been studied
   - Using hydrophones directed toward approaching whales.
   - Using attached acoustic recorders (later presentations).

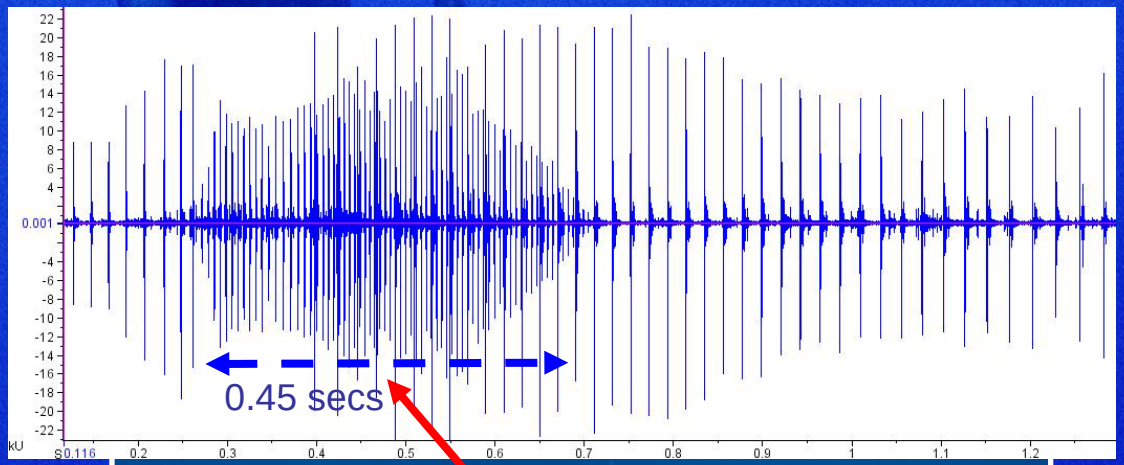
b) There were no matching data for depredation behaviour, just assumed (not unreasonable).

c) Industry experience is most instructive.
   - When depredation occurs social calls may be heard through boat hulls by fishermen.
   - Also echo click trains as the whales target the fish immediately before fish removal.
   - A European study using click detectors did not conclude FKW clicked on targets – there were sufficient caveats to explain anything.

Spatial orientation echo clicks of nearby FKW



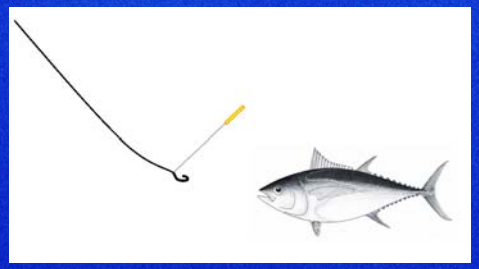
Example FKW echolocating on diver

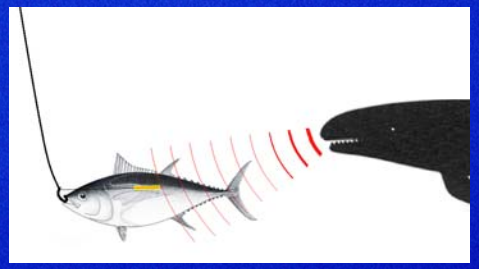


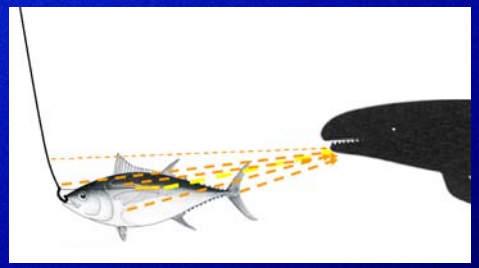
Echo clicks on diver

3. The biosonar basis for depredation mitigation is developed on the sonar aspects of entangling gear

Interfering with the whales' perception of targets from their on sonar is a potential option for mitigation

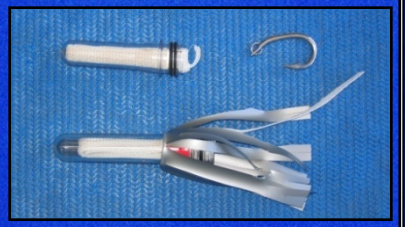


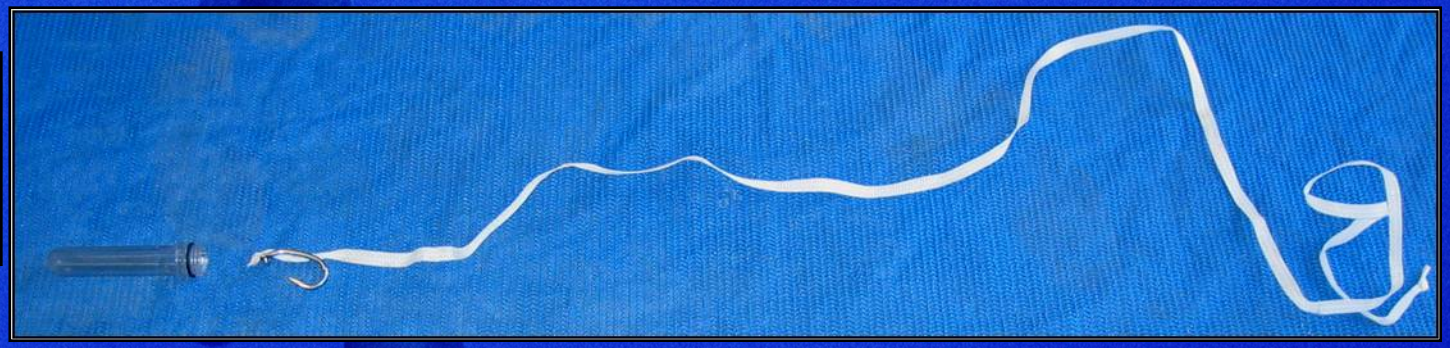


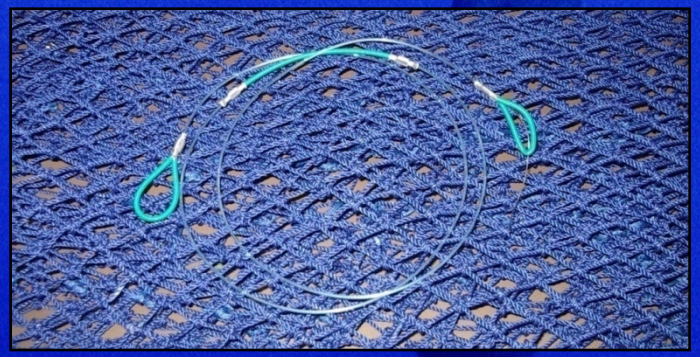


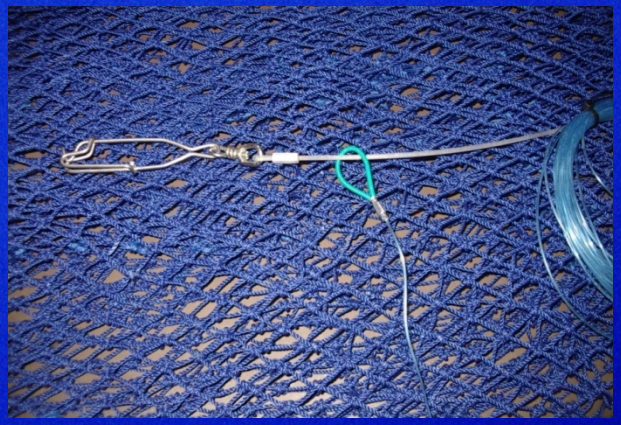
Acoustic reflector examples

- Streamers with known acoustic reflection



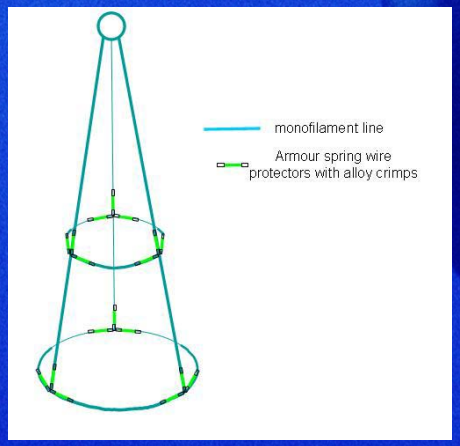




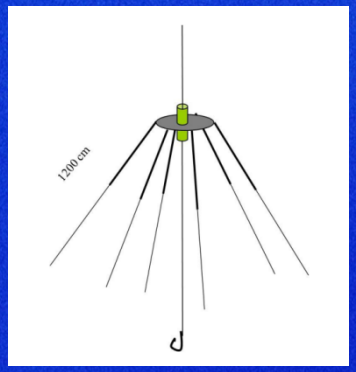


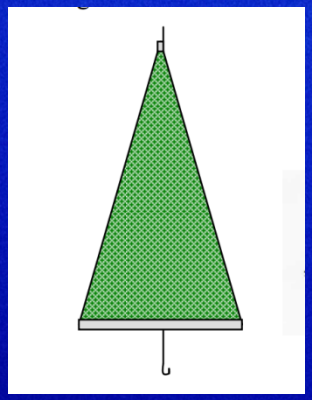
Acoustic reflector examples

- Streamers with known acoustic reflection
- Streamer made from fishing gear components (drop down hoop / sock of fishing gear)

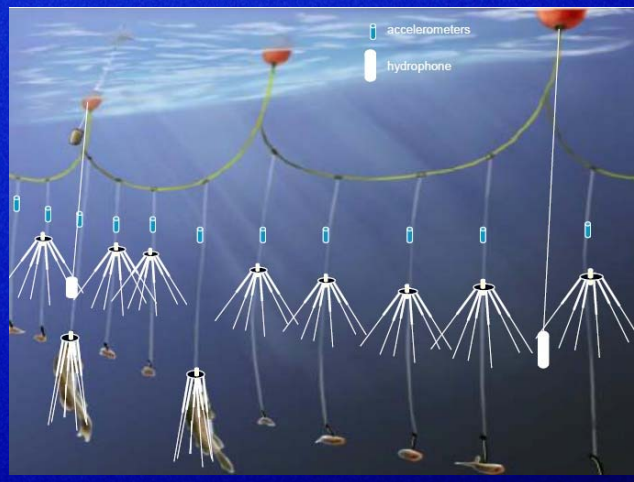


Coral Sea





Seychelles



Acoustic reflector examples

- Streamers with known acoustic reflection
- Streamer made from fishing gear components (drop down hoop / sock of fishing gear)
- **Reflectors based on maximising sonar reflectivity**
  - **(TS of reflection is based on *ka* (= *wavenumber*) parameter : using sound wavelength and object size parameters).**

radius of reflector

$$ka = \frac{(2 * \pi) * a}{\lambda}$$

wavelength of whales' sonar

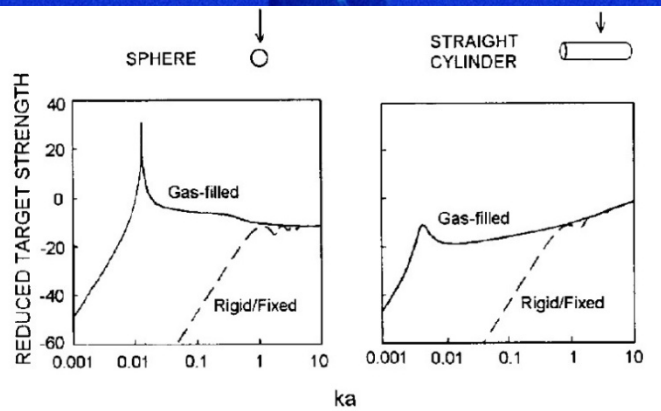
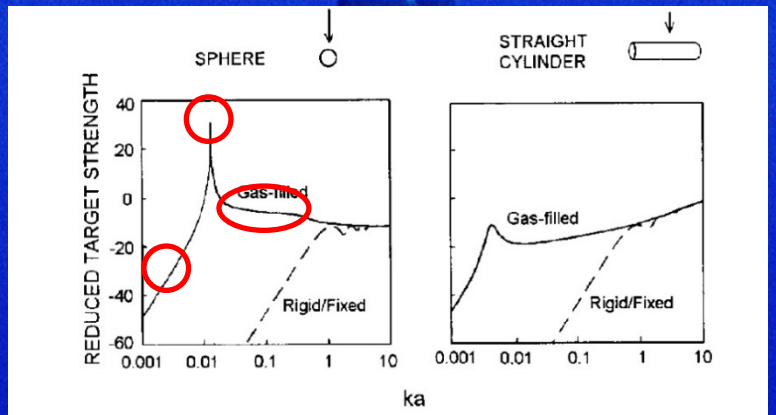


Fig. 5. Target strength versus ka for spherical and long cylindrical reflectors ($L \gg a$) (from Stanton [7]). The target strength is reduced (normalized) by $10 \log_{10}(\pi a^2)$ for the sphere and by $20 \log_{10}(L)$ for the cylinder; normal incidence, backscatter geometry is assumed.

Target Strength of reflections from AIR BUBBLES



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SONAR TERMINATION in FKW STRANDINGS IN AUSTRALIA

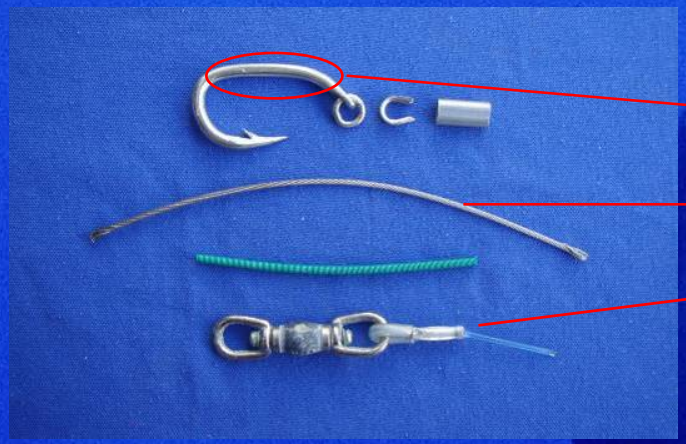
- 30-60 micron air bubbles free in water
- 0.1-3.0 m depth
- 50-70 kHz greatest sonar dampener.

MICROBUBBLES *circa 2005*

- 3M micro-spheres
- mean radius to 150 microns
- resonant at 200 kHz
- as soon as radius stiffens the TS drops dramatically
- air has natural TS highlights, not like junk !

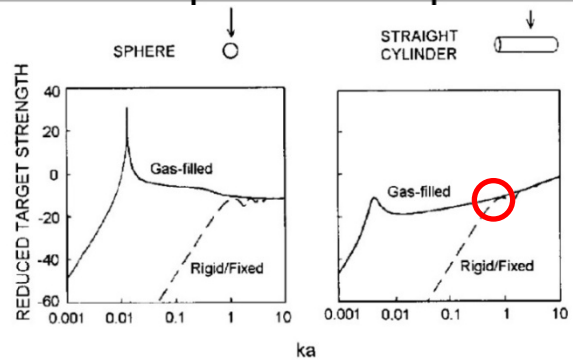
Target Strength of reflections from FISHING GEAR

Fishing gear



Target Strength of gear

Component	Conditions for calculation (radius in mm)	Target Strength dB (*ka*) at 20 kHz	Target Strength dB (*ka*) at 40 kHz
Isolated			
Hook shaft	perp. axis	-55 (0.33)	-50 (0.67)
Hook curved	aspect independent	-40 (0.33)	-35 (0.67
Alloy crimp D size	perp. axis	-61 (0.25)	-55 (0.05)
Wire trace 2.0mm 60cm	perp. axis	-66 (0.17)	-61 (0.20)
Armour spring 2.2mm	perp. axis	-66 (0.17)	-60 ((0.34)
Leaded swivel	perp. axis	-45 (0.67)	-35 (1.34)
Monofilament 4.0m	perp. axis	-62 (0.8)	-56 (0.16)
In combination			
Hook-wire-swivel	mean 4 mm	-40 to -67 to -52	-35 to -62 to -46
Trace to swivel	1 mm and 8 mm	-67 to -45	-61 to -35
Swivel and crimps	mean 2 mm to 4 mm	-55 to -45	-48 to -35
Streamers			
mono alone	perp. axis	-68 (0.08)	-62 (0.17)
bead chain 200mm	2 mm solid beads	-63 (0.17)	-56 (0.34)
alloy spheres*			
3.1mm solid		-75 (0.25)	-63 (0.50)
3.1mm air-filled		-55 (0.25)	-43 (0.50)
4.6mm solid		-65 (0.38)	-52 (0.80)
4.6mm air-filled		-45 (0.38)	-42 (0.80)
6.0mm solid		-57 (0.50)	-45 (1.00)
6.0mm air-filled		-37 (0.50)	-42 (1.00)
9.0mm solid		-47 (0.75)	-46 (1.50)
9.0mm air-filled		-37 (0.75)	-46 (1.50)
16.0mm solid		-42 (1.30)	-42 (2.70)
16.0mm air-filled		-42 (1.30)	-42 (2.70)
			-35
			-25
			-31 (2.50)
			-23 (5.80)
			-40 to -50



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Target Strength of reflections from SPHERES

Target Strength of gear

Component	Conditions for calculation (radius in mm)	Target Strength dB (*ka*) at 20 kHz	Target Strength dB (*ka*) at 40 kHz
Isolated			
Hook shaft	perp. axis	-55 (0.33)	-50 (0.67)
Hook curved	aspect independent	-40 (0.33)	-35 (0.67
Alloy crimp D size	perp. axis	-61 (0.25)	-55 (0.05)
Wire trace 2.0mm 60cm	perp. axis	-66 (0.17)	-61 (0.20)
Armour spring 2.2mm	perp. axis	-66 (0.17)	-60 ((0.34)
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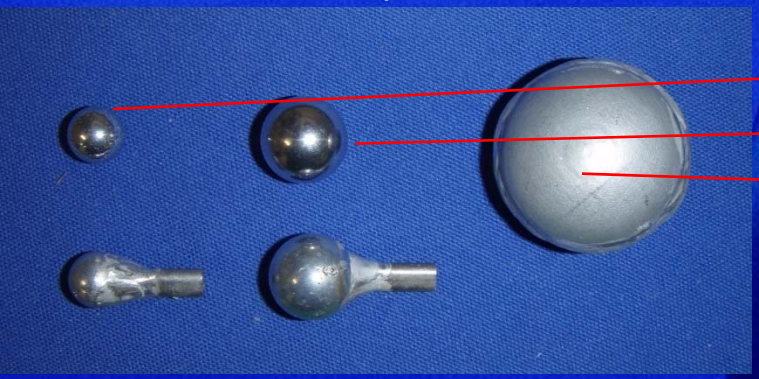
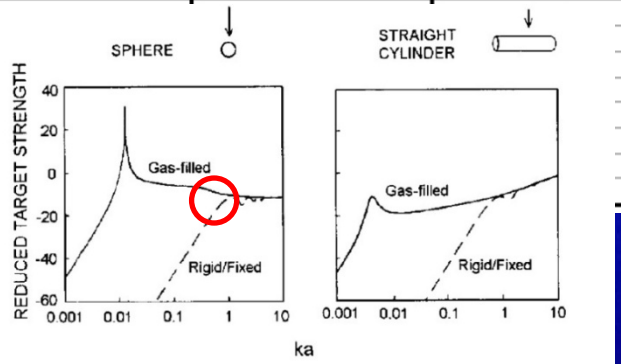
16.0mm air-filled		-42 (1.30)	-42 (2.70)
			-35
			-25
			-31 (2.50)
			-23 (5.80)
			-40 to -50

air-filled spheres



Spheres on short streamers



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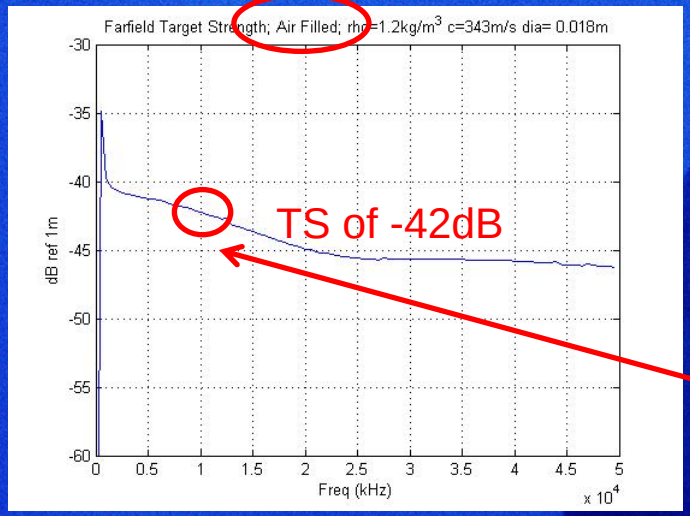
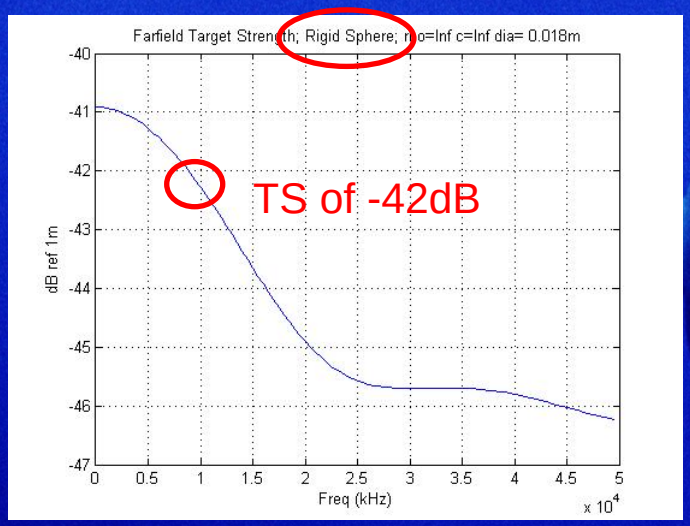
air filled
0-10dB
better ?



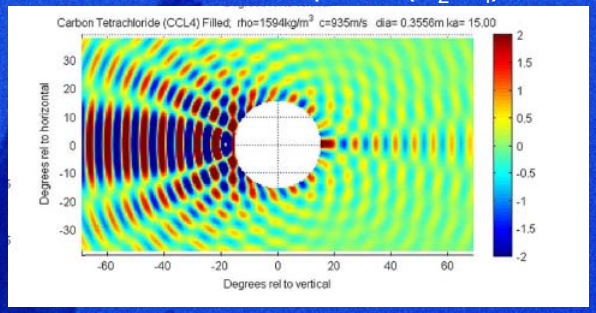


Thank you
Dave Deveau

UNDERSEA NAVAL WARFARE

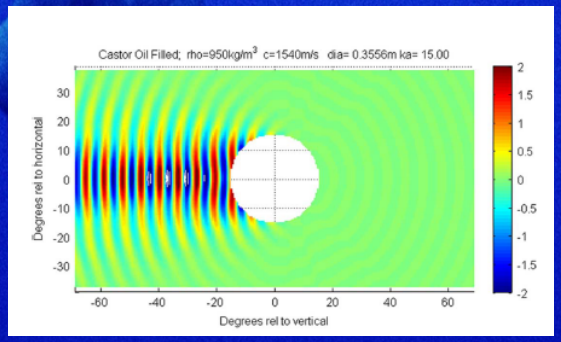
air-filled spheres

Sonar backscatter
on a fluid-filled sphere (C_2Cl_4)



Nature of the reflection from the spheres

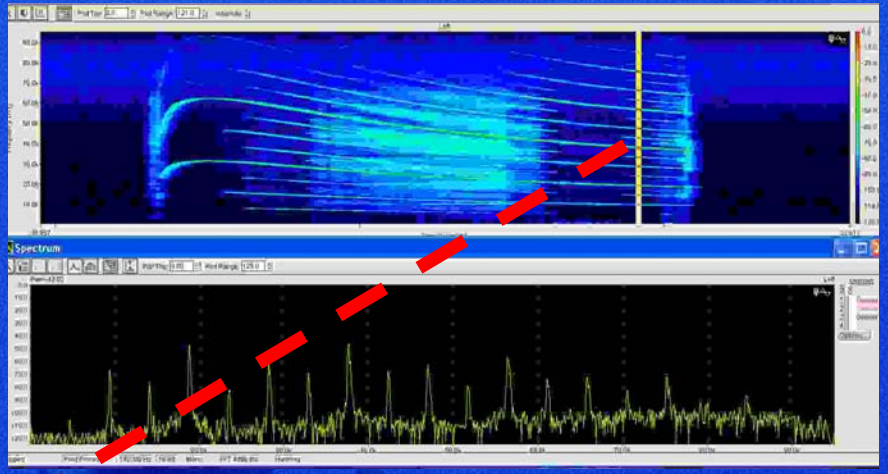
Sonar backscatter
on a fluid-filled sphere (similar to water)



Target Strength of reflections from AIR TUBES

Air filled light stick

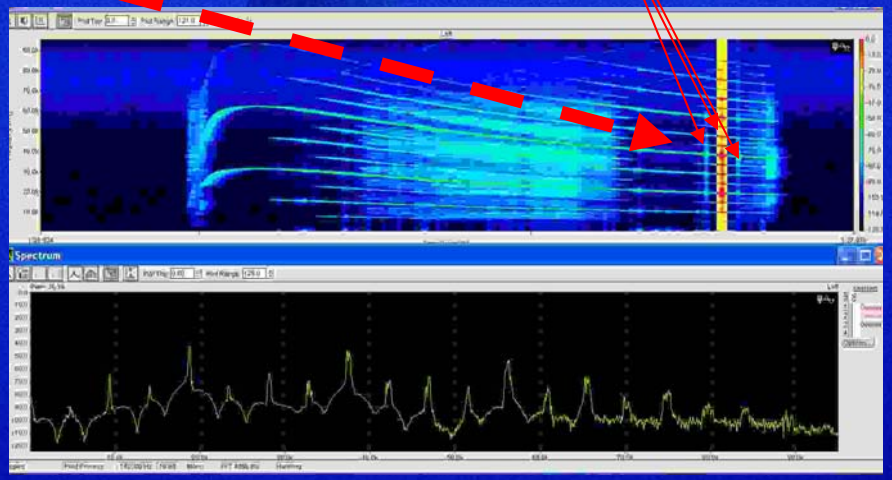
Air filled PVC tube with glass beads



Acoustic reflector examples

- Reflectors **using air filled tubes**
  - air-filled cylinders generate reflections
  - however based on a perpendicular aspect to target

reflected highlights



Spectral analysis of echoes

Outgoing clicks

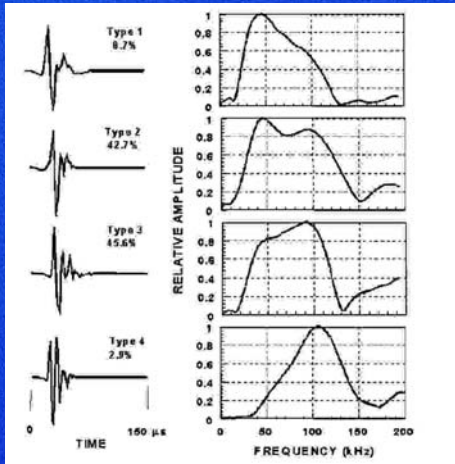
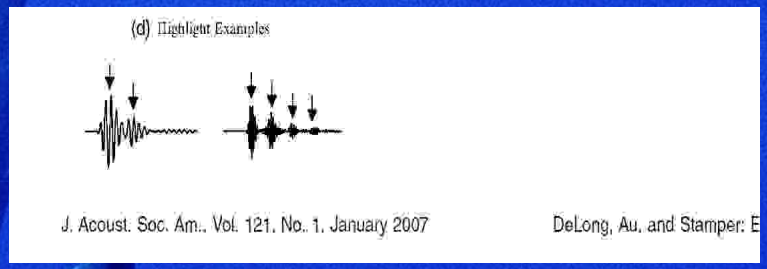
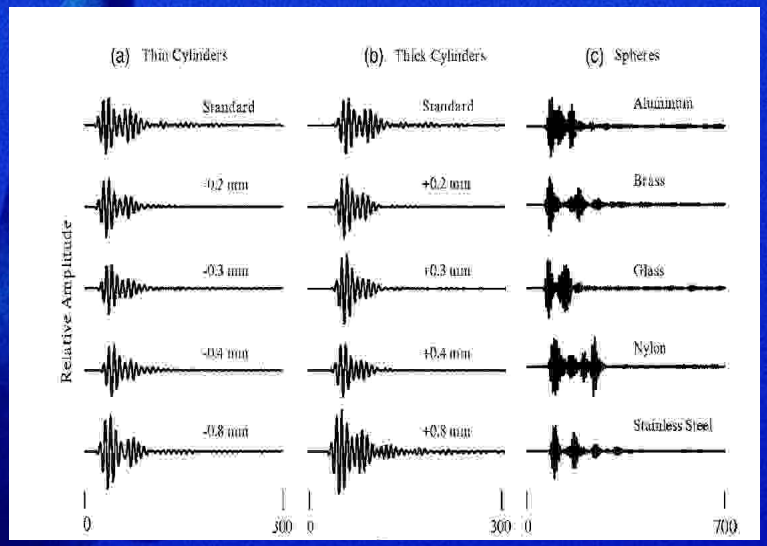


FIG. 2. Examples of some representative echolocation signal waveforms and spectra emitted by the dusky dolphin in Kaikoura. Type 1 and 2 signals have low peak frequencies (<64 kHz) with type 1 being unimodal and type

Returning clicks





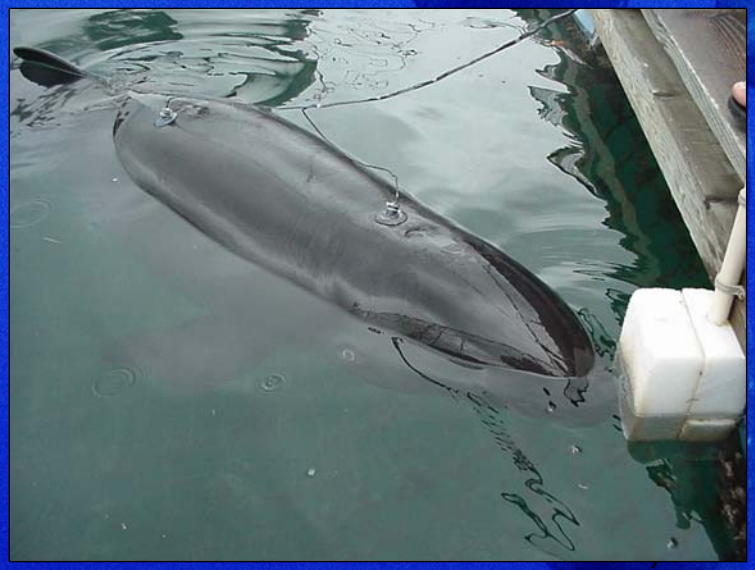
4. Toothed whale sonar signals

a) Tuna target strengths

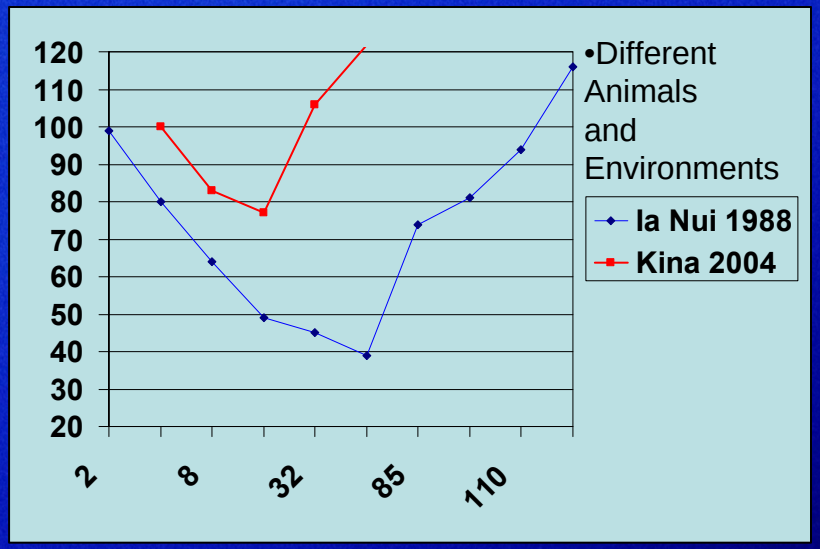
- Target strengths vary - 25dB for 130cm tuna perpendicular
  - 35dB for 60cm tuna perpendicular
- Swimbladder accounts for 95% of echo and will be the primary highlight (Foote 1981)
- Target Strength ≈ 15 dB lower with >15° off perpendicular (Au & Benoit-Bird 2003) with a tail-first approach
- Braincase is probably a secondary echo
- No detection when secondary echo <7dB than primary echo (Muller *et al*. 2007)
- Highly likely that an air OR water filled sphere would dominate all return echoes other than swimbladder, or any other fishing gear

4. Toothed whale sonar signals

b) Change in toothed whale hearing capability



AEP Audiogram



Kina developed presbycusis

- **Conclusions**

Toothed whale sonar signals

1. Toothed whales utilise sonar in depredation to within close range of the target
2. With false killer whales – after the swimbladder, the brain case is probably a major target in depredation
3. The returning echoes, from the braincase could be overwhelmed by adding sonar reflectors
4. #2 and #3 are speculation and would require conformation by dolphin sonar specialists.
5. The challenge – to add cheap reflectors to reduce the quality of returning echoes.
6. The reflectors would unlikely be 100% effective
7. The dimensions of reflectors would need to vary with species, and animal age.

Directions for depredation mitigation

1. AVOIDANCE using a modified radio direction finding buoy
   - Under development and construction
   - Ready for testing September
3. MINIMISATION utilising newly developed and evolving pingers
   - Japan Fisheries Agency (Dr Tom Nishida) project for late 2010 with the appropriate pinger available at that time
4. MINIMISATION utilising sonar reflective equipment.
   - Larger acoustic streamers are proving to be logistically extremely difficult.
   - Potential Project - To acoustically highlight the location of the hook to mitigate hooking at least.

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  FRA and Tom Nishida

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  Fisheries Research & Development Corporation

- **NOAA's**

  Western Pacific Regional Fisheries Management Council, Hawaii

  Marine Mammal Advisory Committee, Hawaii

- **Australia's**

  James Cook Uni, School of Engineering & Physical Sciences

- ***Kina* at HIMB, Coconut Island, Hawaii**

and Paul Nachtigall,
Aran Mooney and Whitlow Au.