Potential effects of noise on fish

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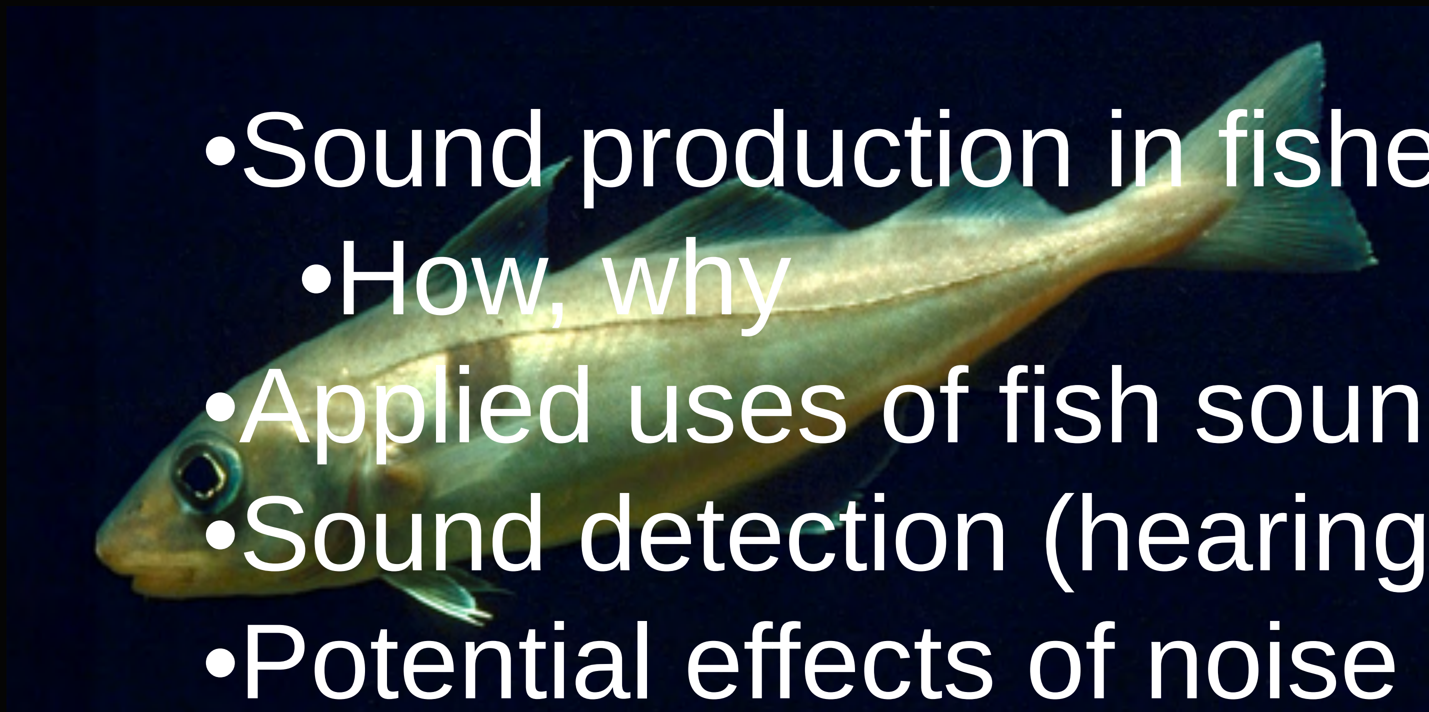
Potential effects of noise on fish

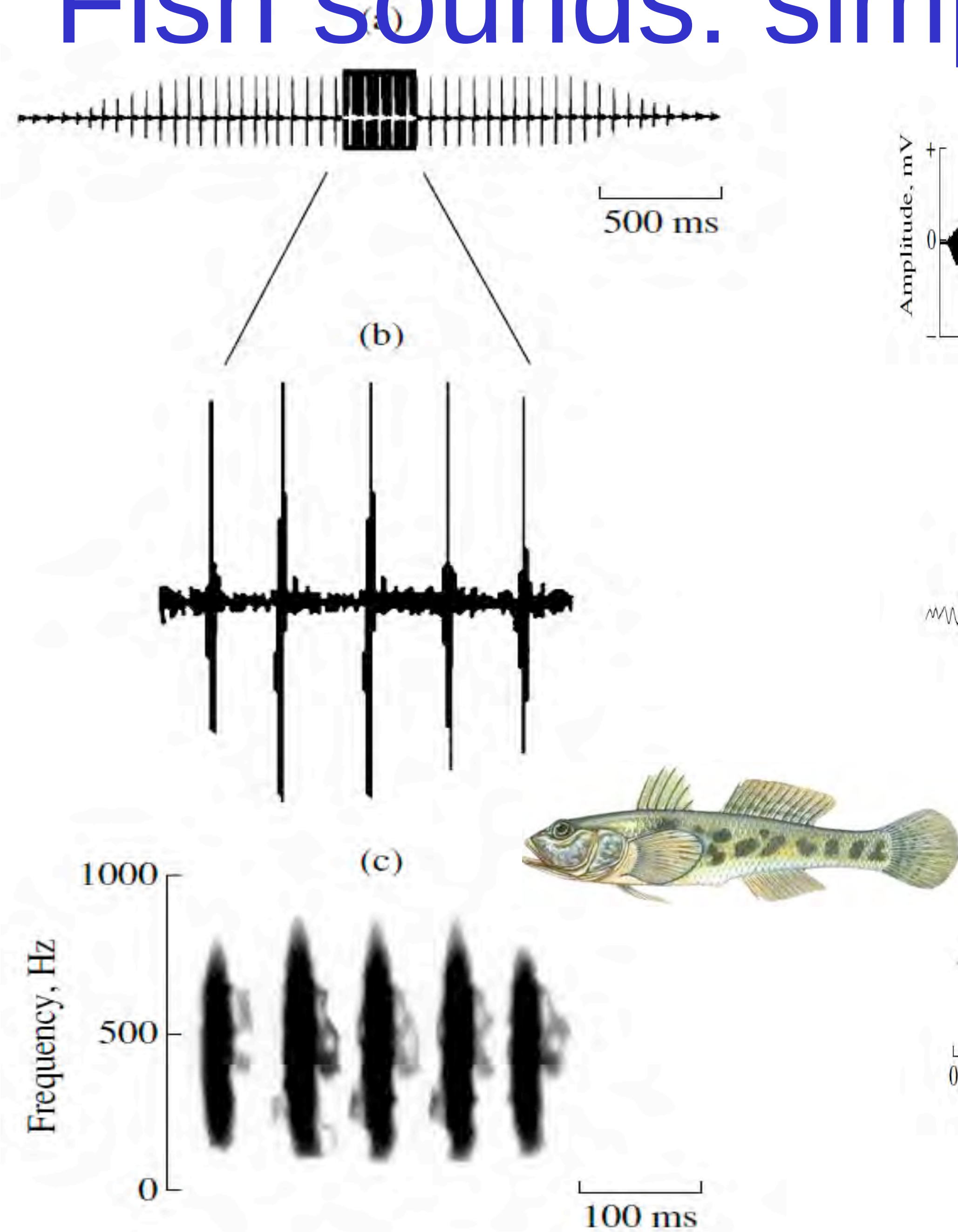


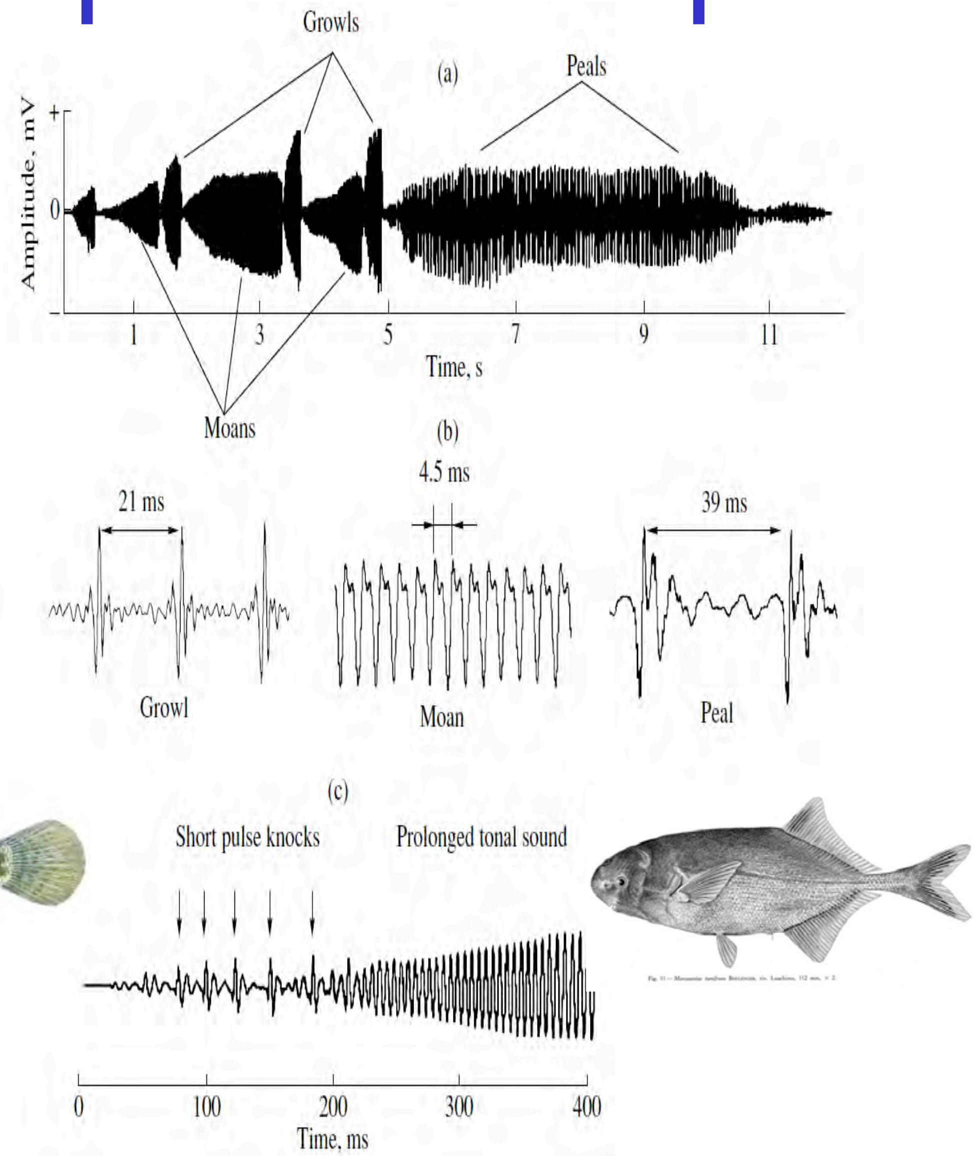
- Sound production in fishes?
  - How, why
- Applied uses of fish sounds
- Sound detection (hearing)
- Potential effects of noise

Fish produce sounds?

- So far >700 vocal species worldwide

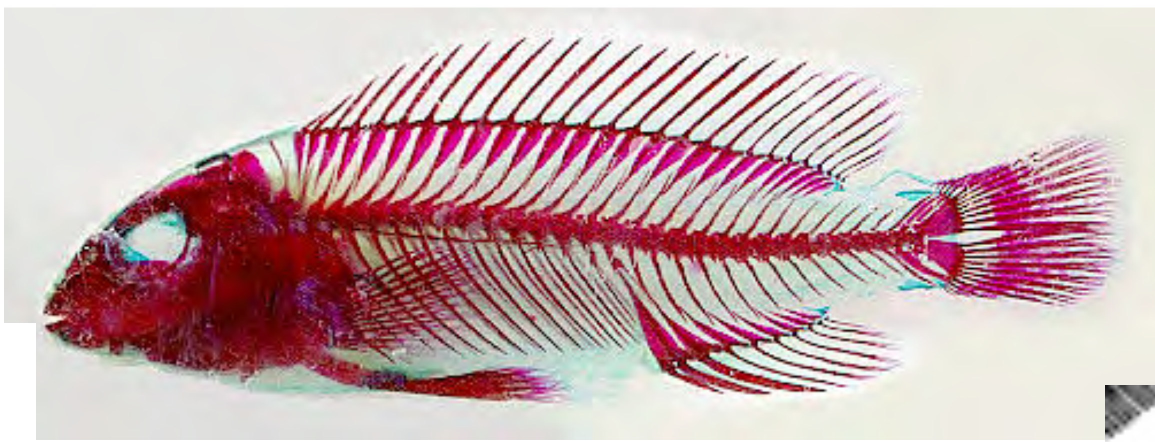
Fish sounds: simple vs complex

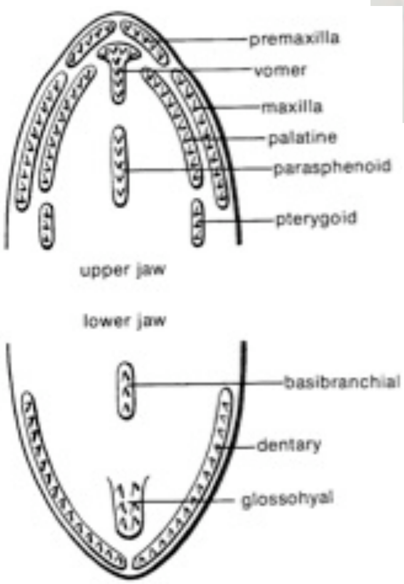


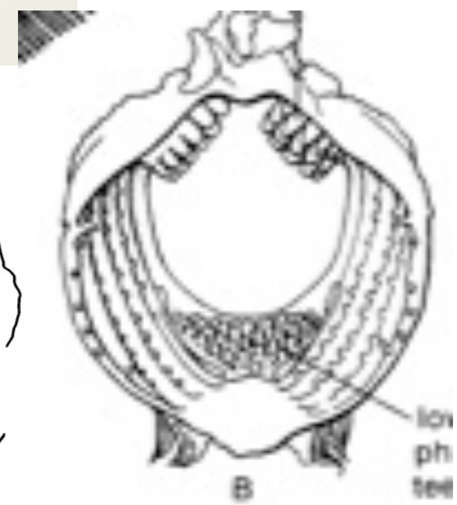


How do fish make sound?

- Stridulation – rubbing or scrapping together of fins, bones, or teeth

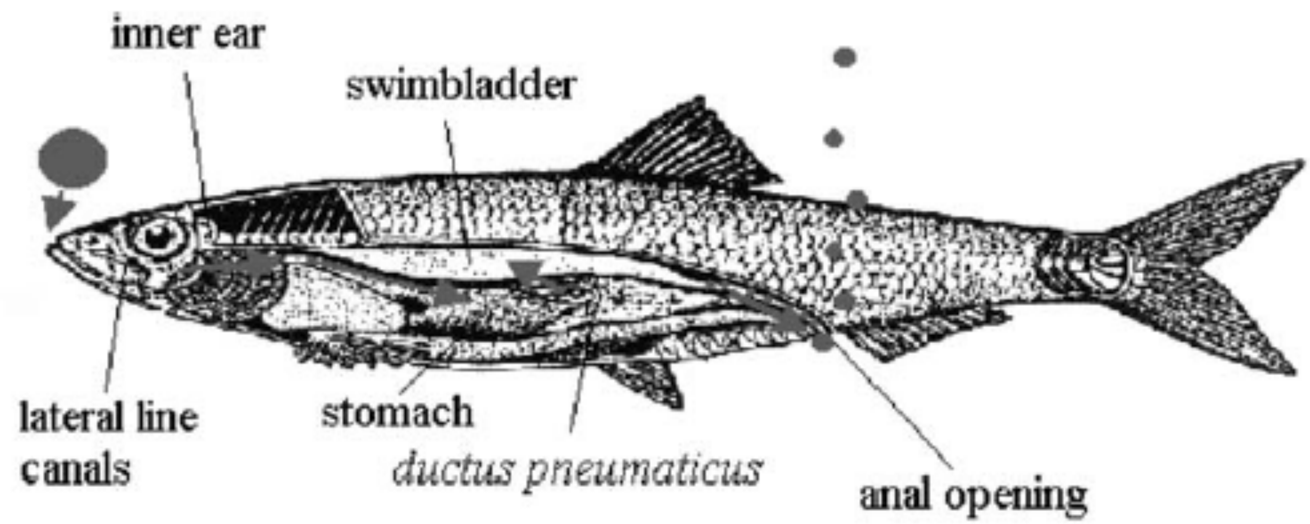






How do fish make sound?

- Air passage – little understood internal movement of air, or escape of air through mouth, gills, or anus



How do fish make sound?

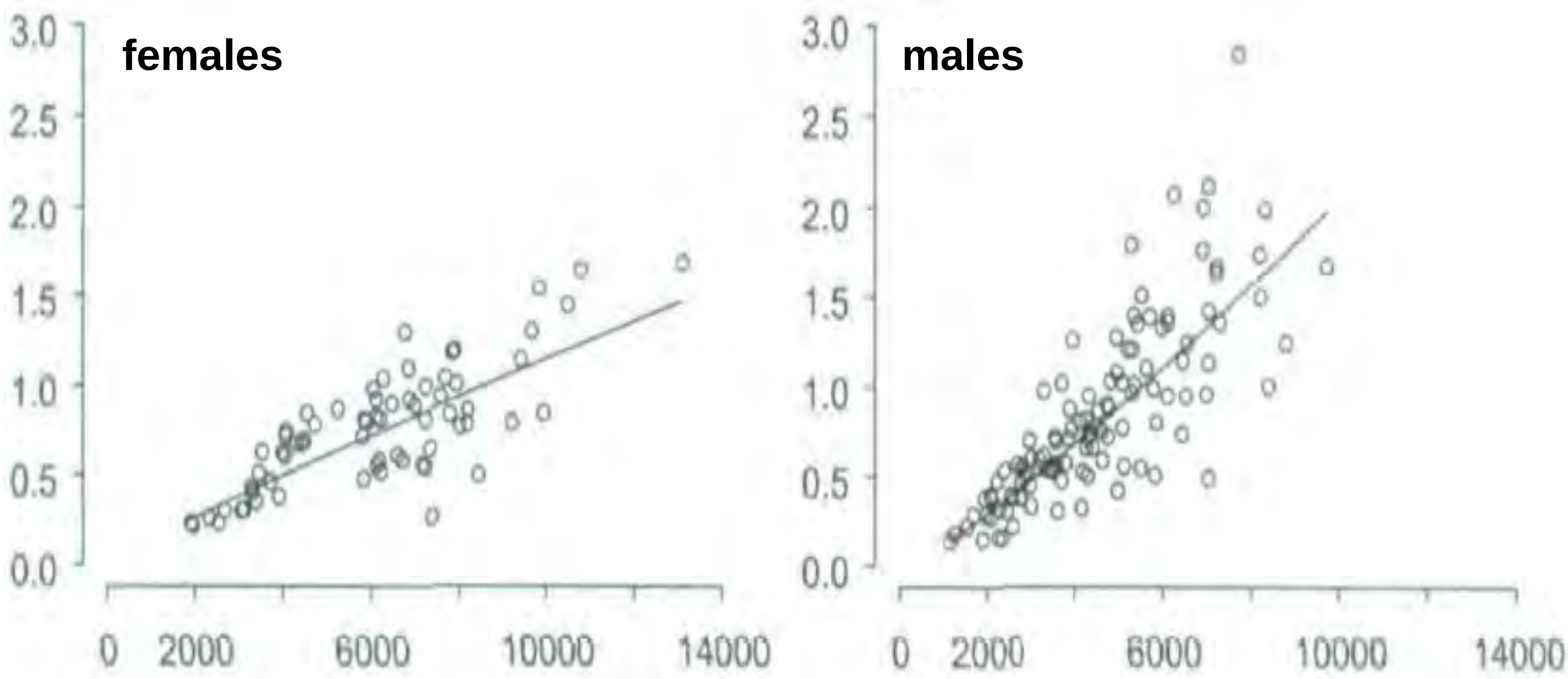
- Drumming – special muscles pushing/ pulling on the internal air/swim bladder (called sonic muscles)

Why/when are fish vocal?

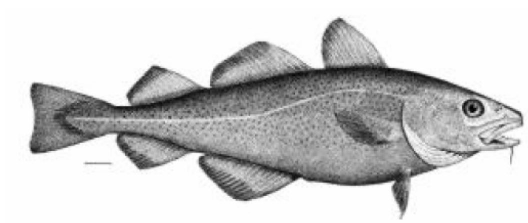
- Spawning and courtship behaviour
- Aggression and territorial behaviour
- Distress
- Predator/prey behaviour?

Male cod display larger drumming muscles

Drumming muscle mass (g)

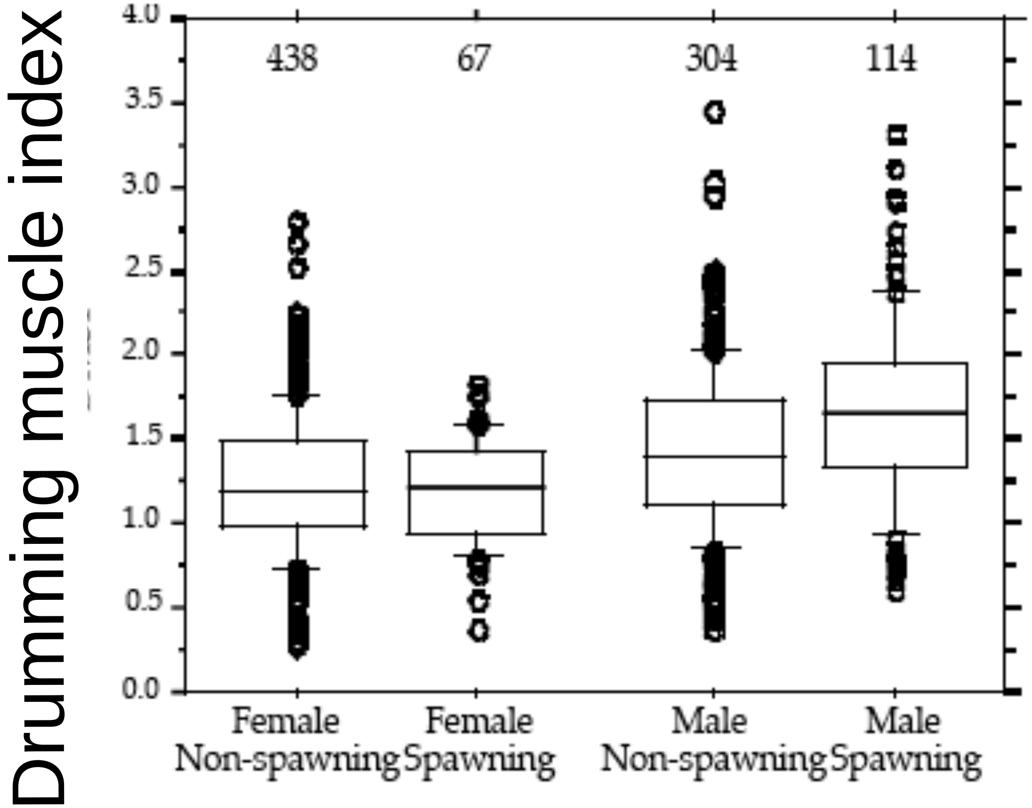


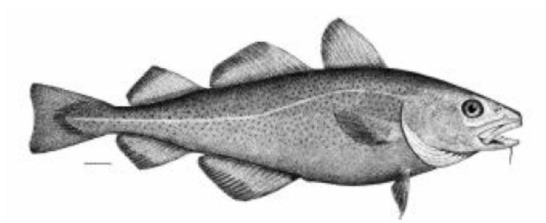
Somatic mass (g)



Rowe & Hutchings 04

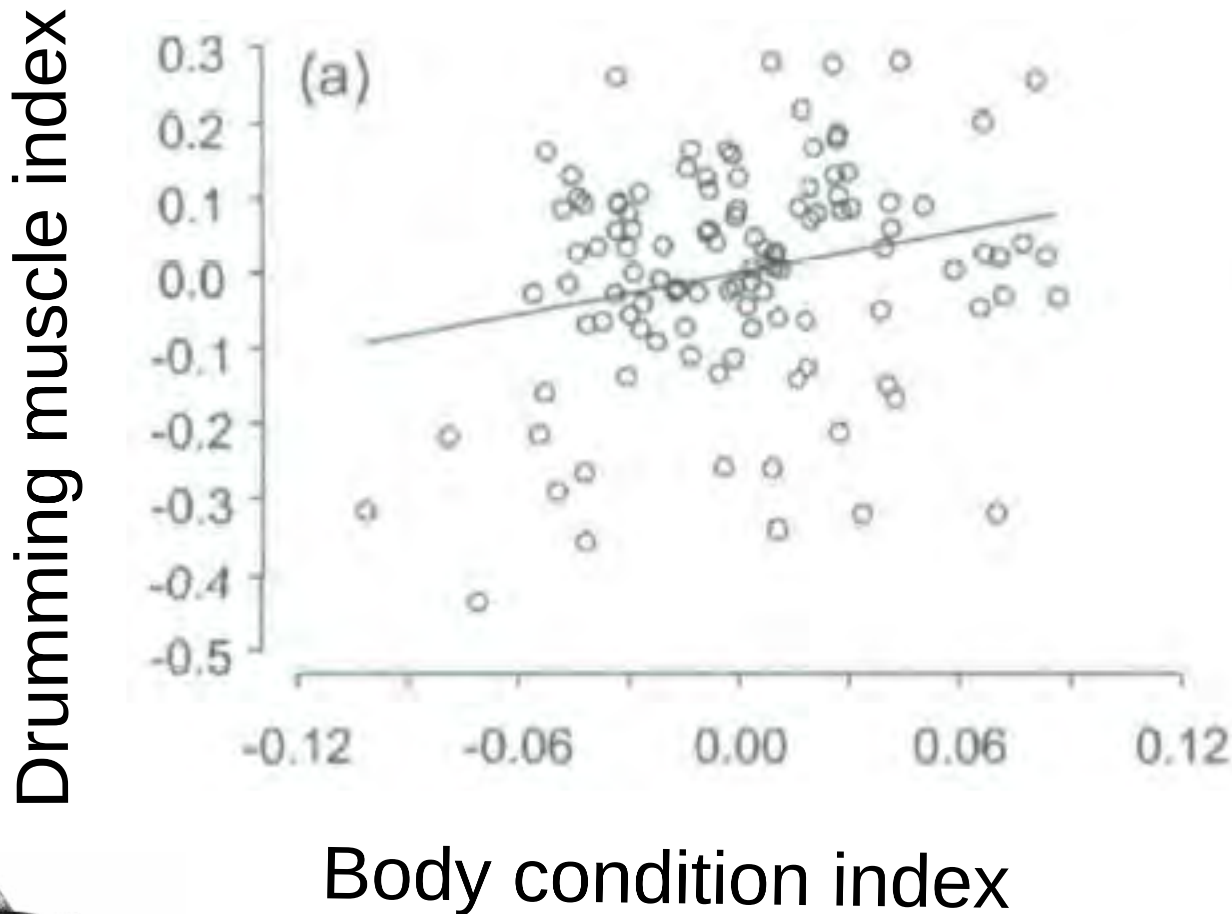
Male cod display larger drumming muscles at spawning time

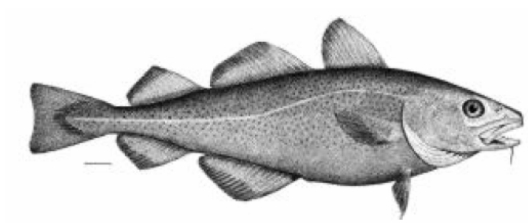




Rowe & Hutchings 03

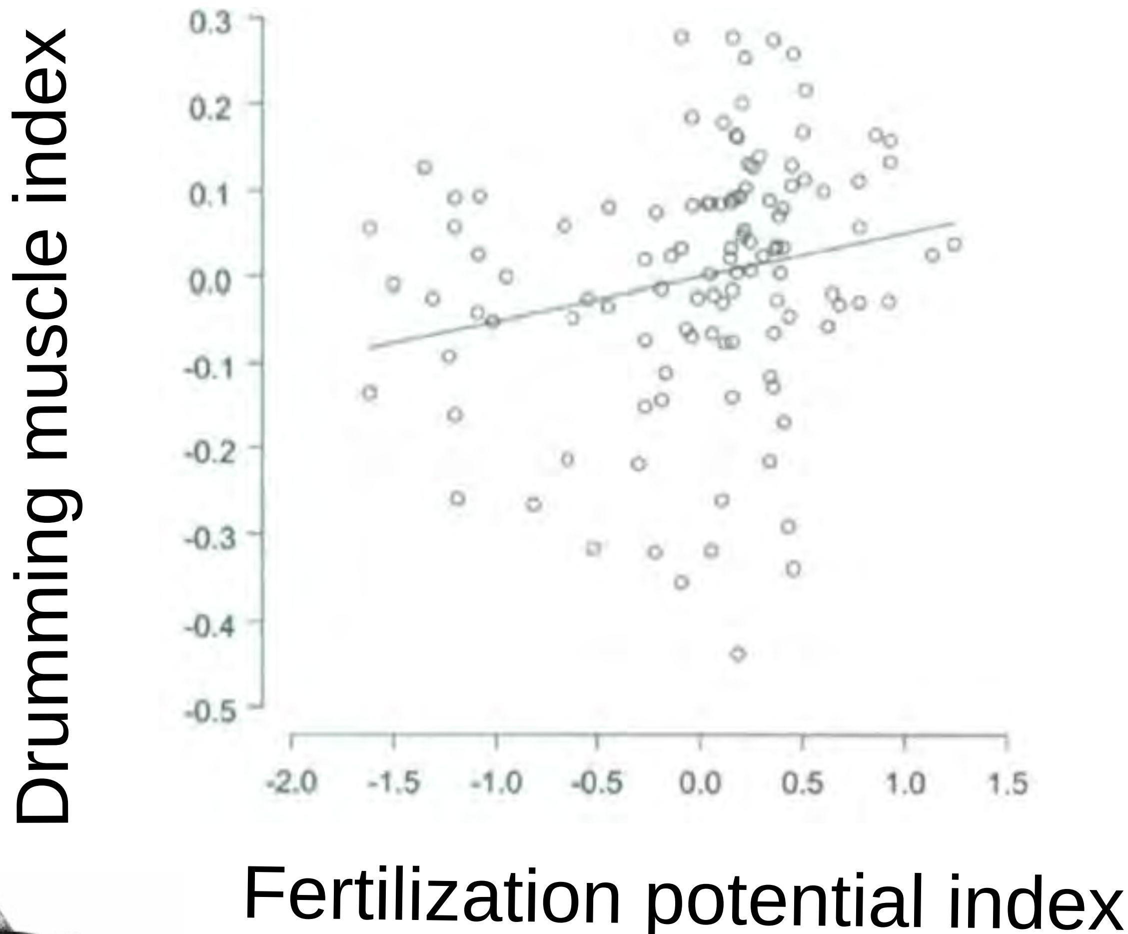
Male cod drumming muscles are correlated with body condition

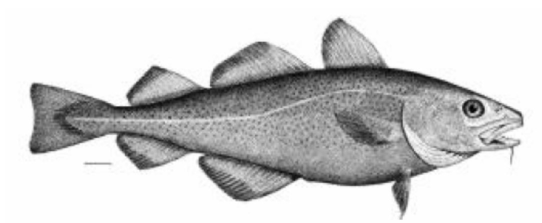




Rowe & Hutchings 03

Male cod drumming muscles are correlated with fertilization potential

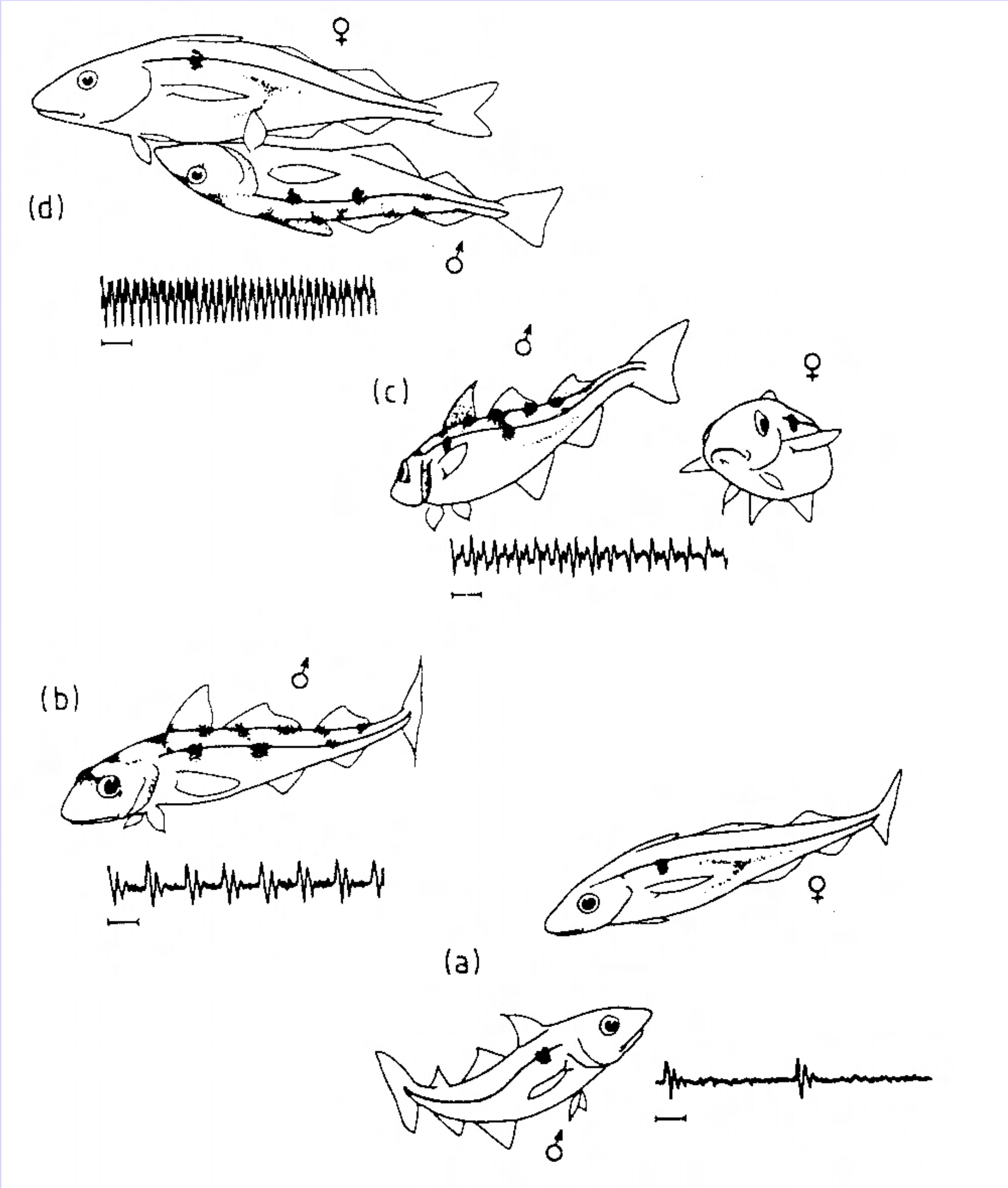




Rowe & Hutchings 03

Haddock Courtship Behaviour

Pulse Repetition rate changes at each stage of courtship

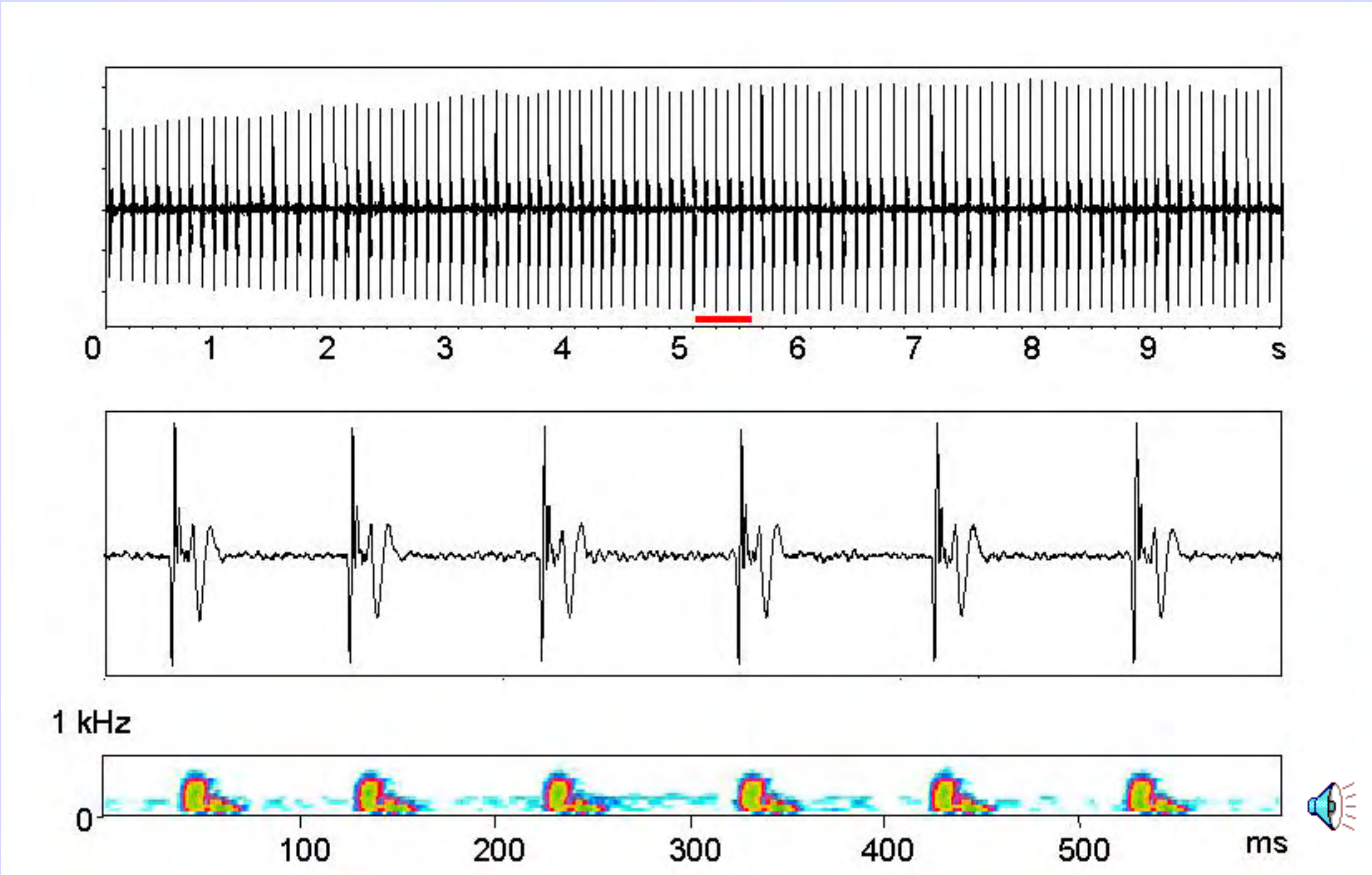


Hawkins

Male Solitary Display

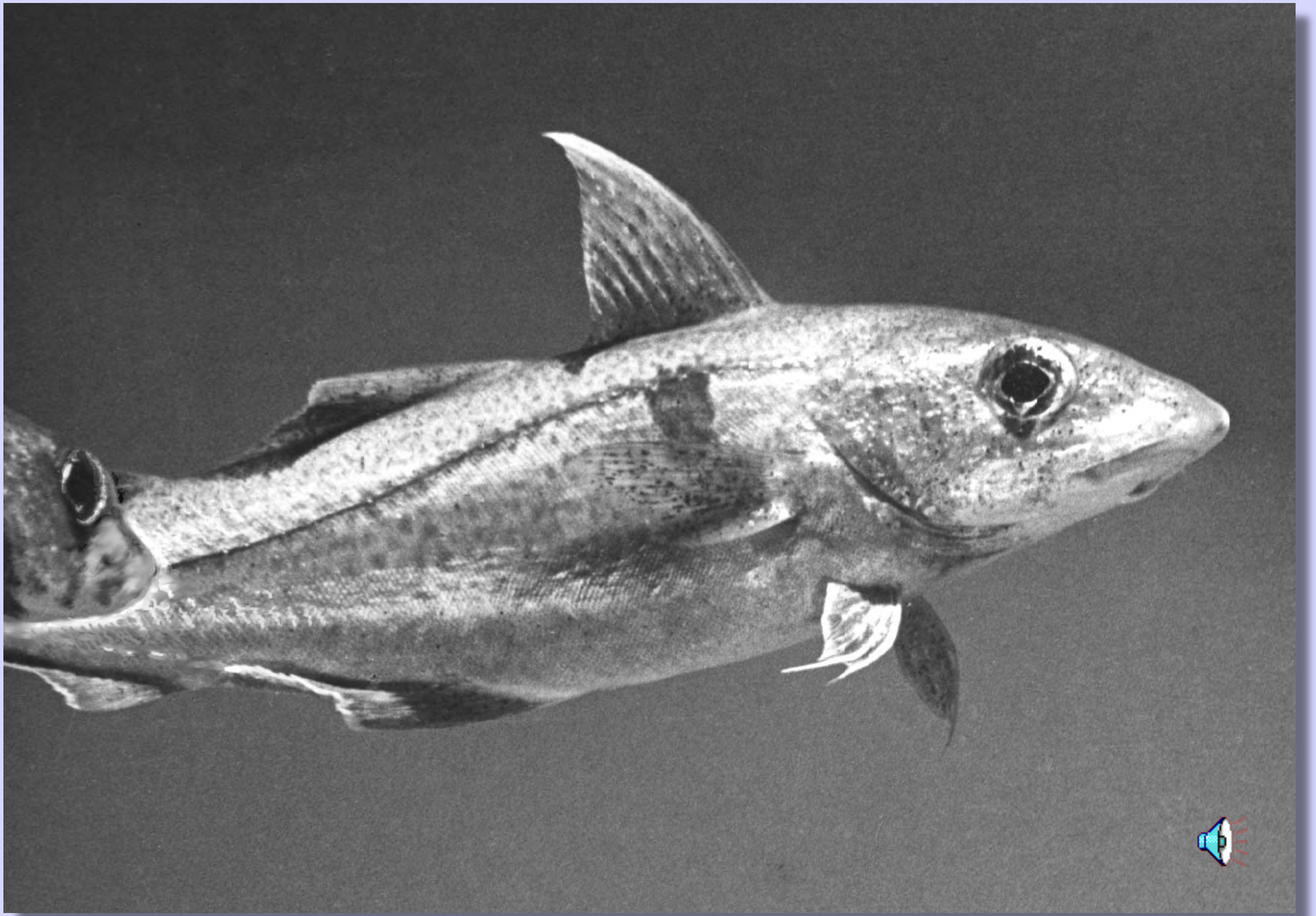
Hawkins

Sounds During Solitary Display



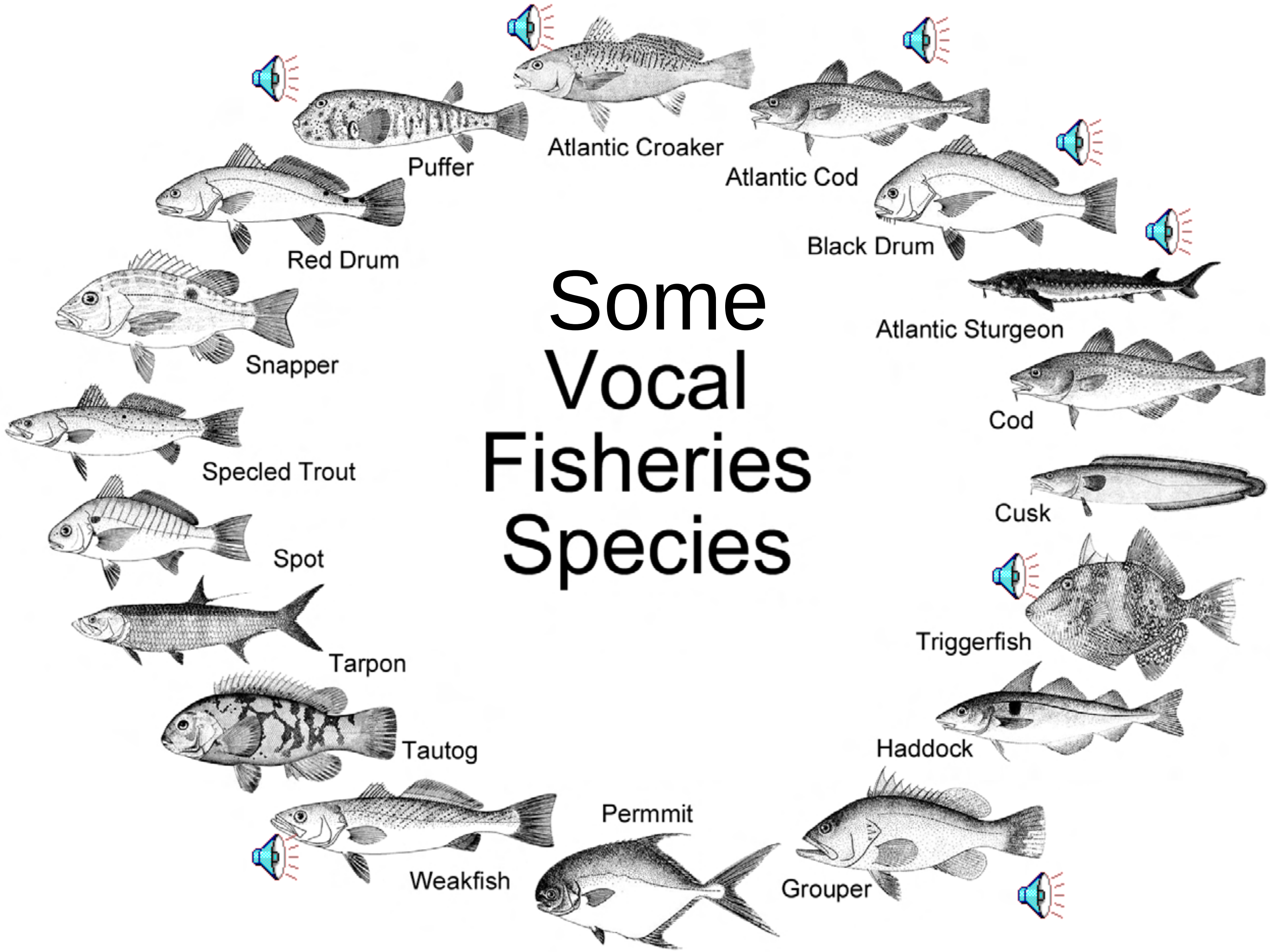
Hawkins

Male Flaunting to Female

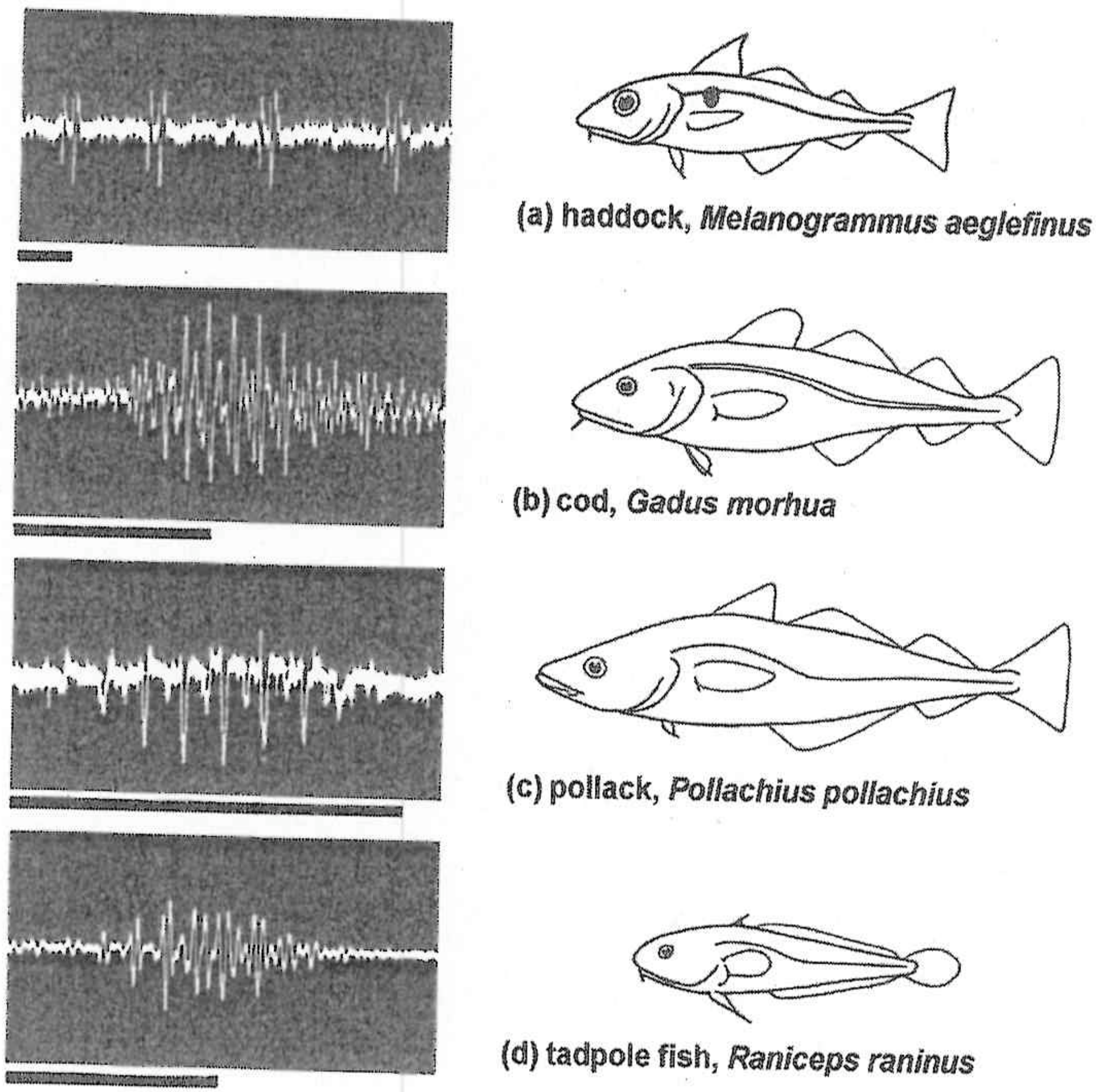


Hawkins

Some Vocal Fisheries Species



Aggressive behaviour: gadids



How do we study fish sounds?

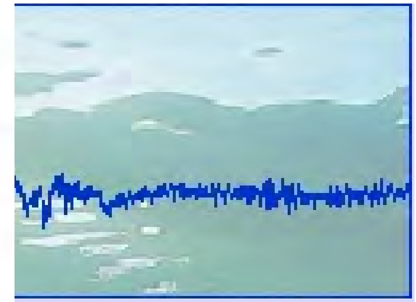
- Passive acoustics
- Technologies that enable us to listen to and record ambient underwater sounds
- Only recently used as a tool for the census and exploration of marine life

Advantages of passive acoustics

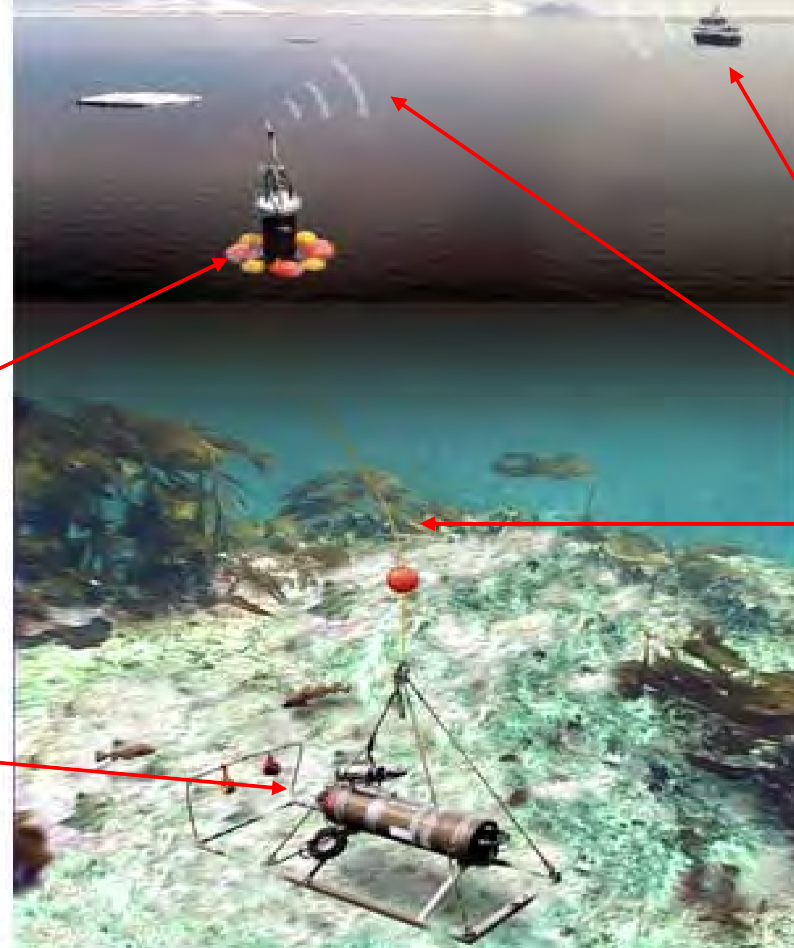
- Non-invasive
- Non-visual (light not needed)
- Continuous remote monitoring
- Provides detailed behavioral information

In situ underwater recording

Phil Lobel, BUMP



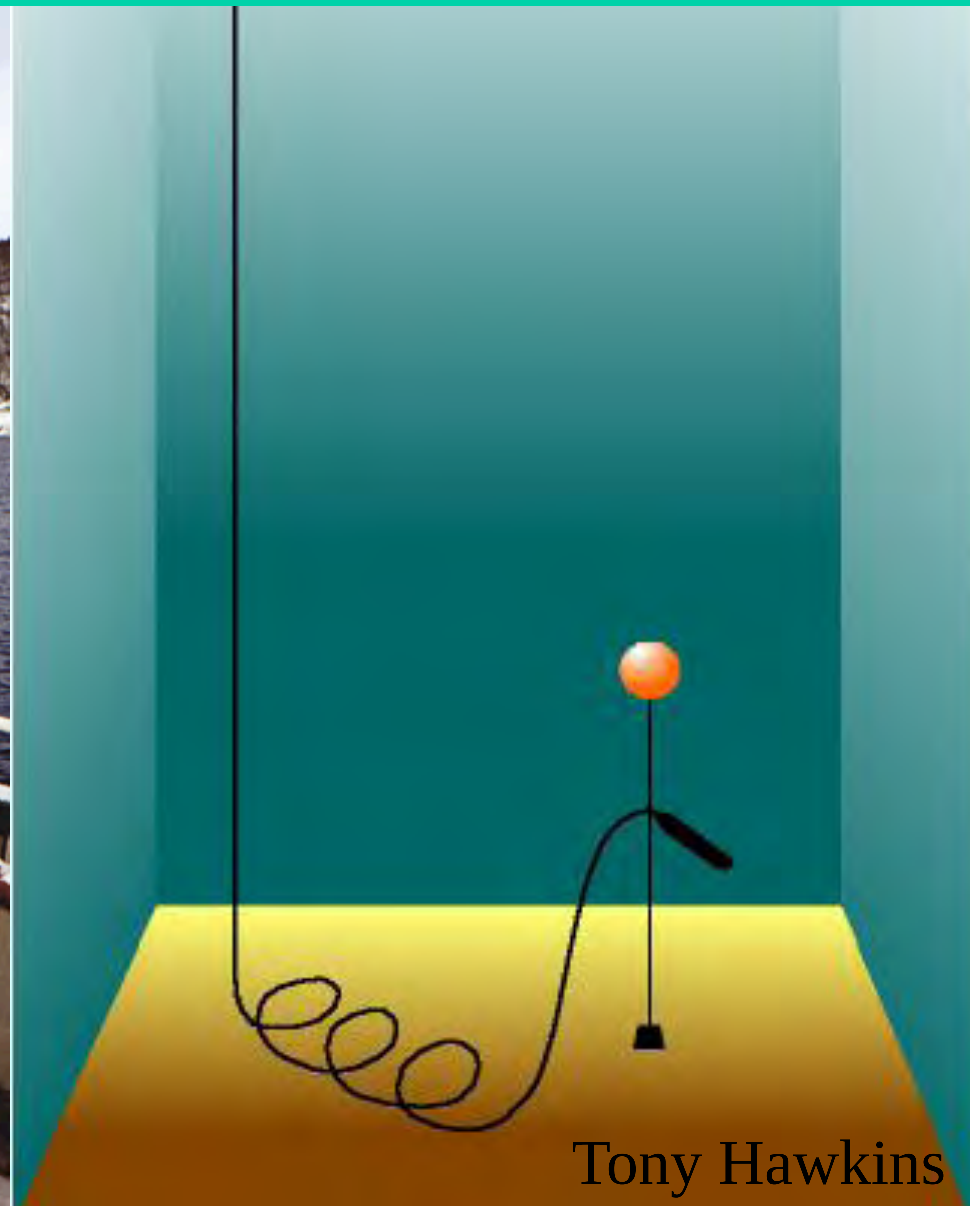
Remote-controlled instrument platform for synchronous recording of behaviour specific fish sound and video observations



Remote recording

Jan Tore Øvredal, Inst. Of Marine Res., Norway

At Sea Sampling in Norway



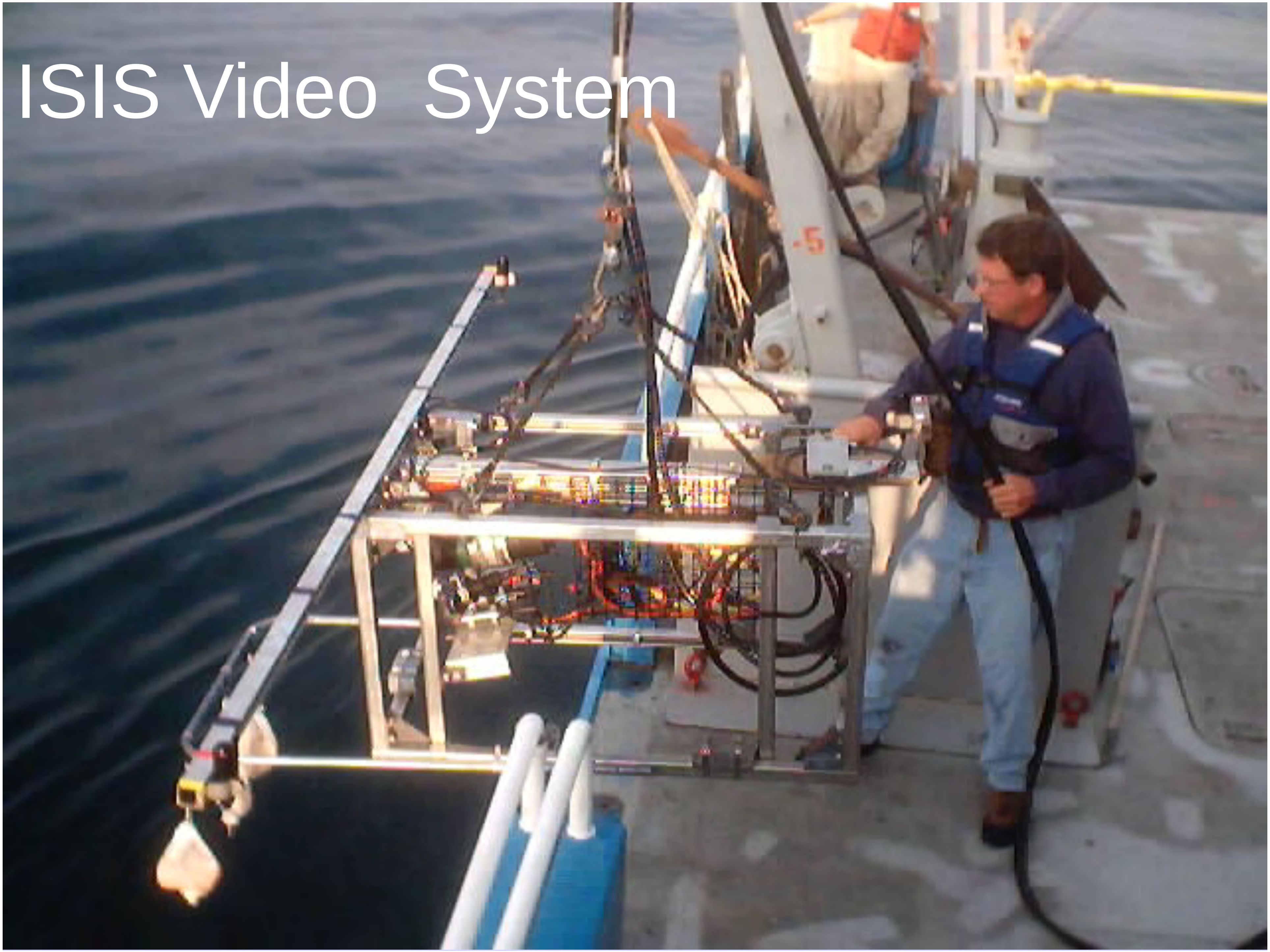
Tony Hawkins

Portable hydrophone unit

AULS (Autonomous underwater listening stations)


ROVs

ISIS Video System



Ecological uses of fish sounds

Locate vocal fishes

- Identify essential fish habitat (EFH)
- Locate spawning habitats/locations
- Exploration of the seas/Census of marine life

Determine when fish are vocal

- Spawning behavior
- Predator/prey interactions
- Foraging
- Territorial defense

Season
and
Time of day

Study of Underwater Noise Effects

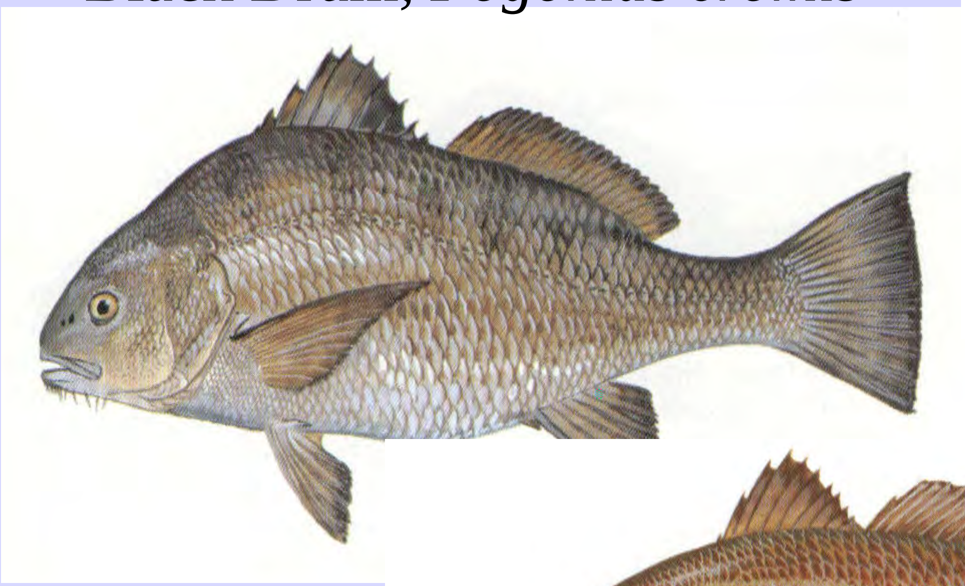
- Identify noise source and levels
- Quantify temporal and spatial patterns in noise
- Quantify noise impact on fish behavior

Examine fish interactions with fishing gear

Rountree & Juanes

Case Studies: Sciaenid (drum fishes) Research

Black Drum, *Pogonias cromis*



Weakfish, *Cynoscion regalis*

Red Drum, *Sciaenops ocellata*

Grant Gilmore

Mapping estuarine spawning areas

Grant Gilmore

Mapping spawning seasons

SILVER PERCH

WEAKFISH

SEATROUT

BLACK DRUM

O N D J F M A M J J A S

RED DRUM

MONTH

Grant Gilmore

Case study: Cusk-eels

Ophidion marginatum, (Ophidiidae)

Range extension

Discovery of striped cusk-eel in Cape Cod waters, where they were formally unknown despite a long history of biological sampling, demonstrates the usefulness of even low-budget, low-tech passive acoustic methods as a survey and exploration tool.

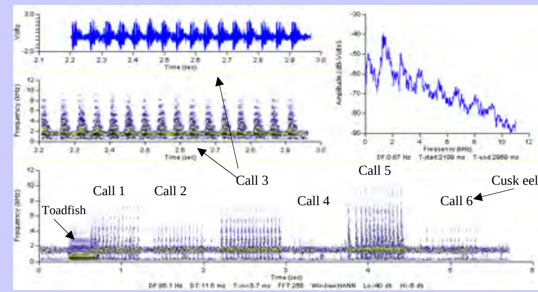
Reproductive Ecology

Striped cusk-eels call in a chorus just after sunset. The chorus time closely tracks the time of sunset through the summer.

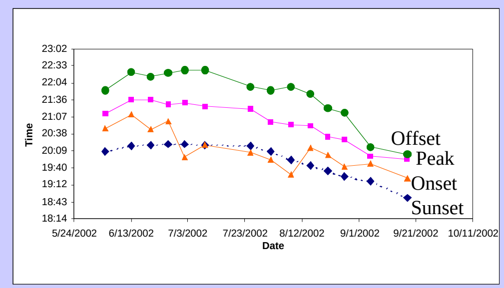
Noise Pollution

The impact of boat noise on spawning chorus behavior needs further st

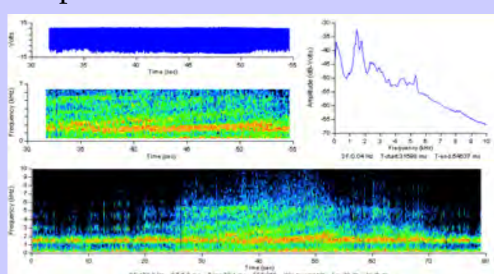
Cusk-eel calls



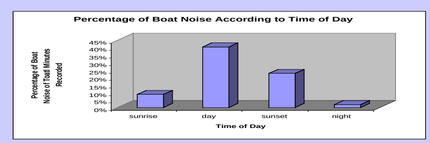
Seasonal pattern of chorus time



Response of cusk-eel to boat noise



Prevalence of boat noise by time of day



Case study: Haddock

Offshore Technology

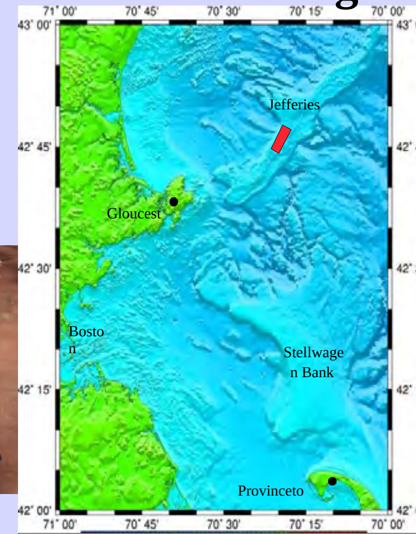
Cooperative Fisheries:

Cliff Goudey (MIT Sea Grant) Francis Juanes and Rodney Rountree (UMASS) have developed low-cost Autonomous Underwater Listening Stations (AULS) suitable for deployment from commercial fishing vessels. Collaborating fishermen deploy the AULS on the fishing grounds during normal fishing operations to obtain acoustic data needed to identify spawning sites and times for haddock, cod and other groundfishes.

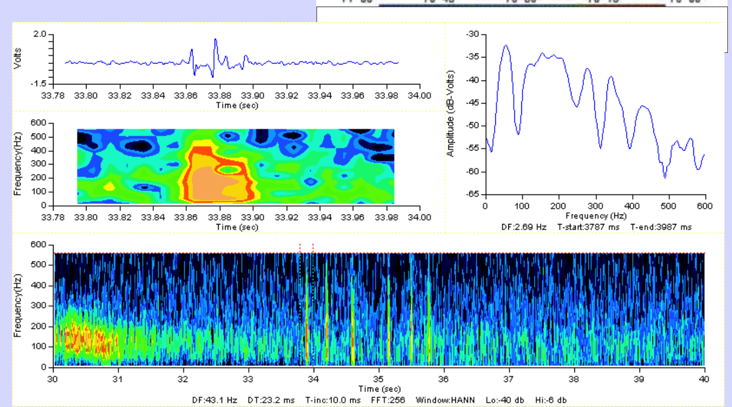
Deployments to 1000 m depths began in 2004

AULS

Jefferies Ledge



First *in situ* recording of haddock in North America



First *in situ* recording of daily vocal activity (i.e. spawning) patterns

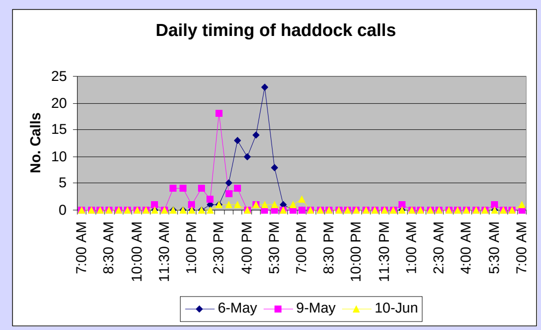
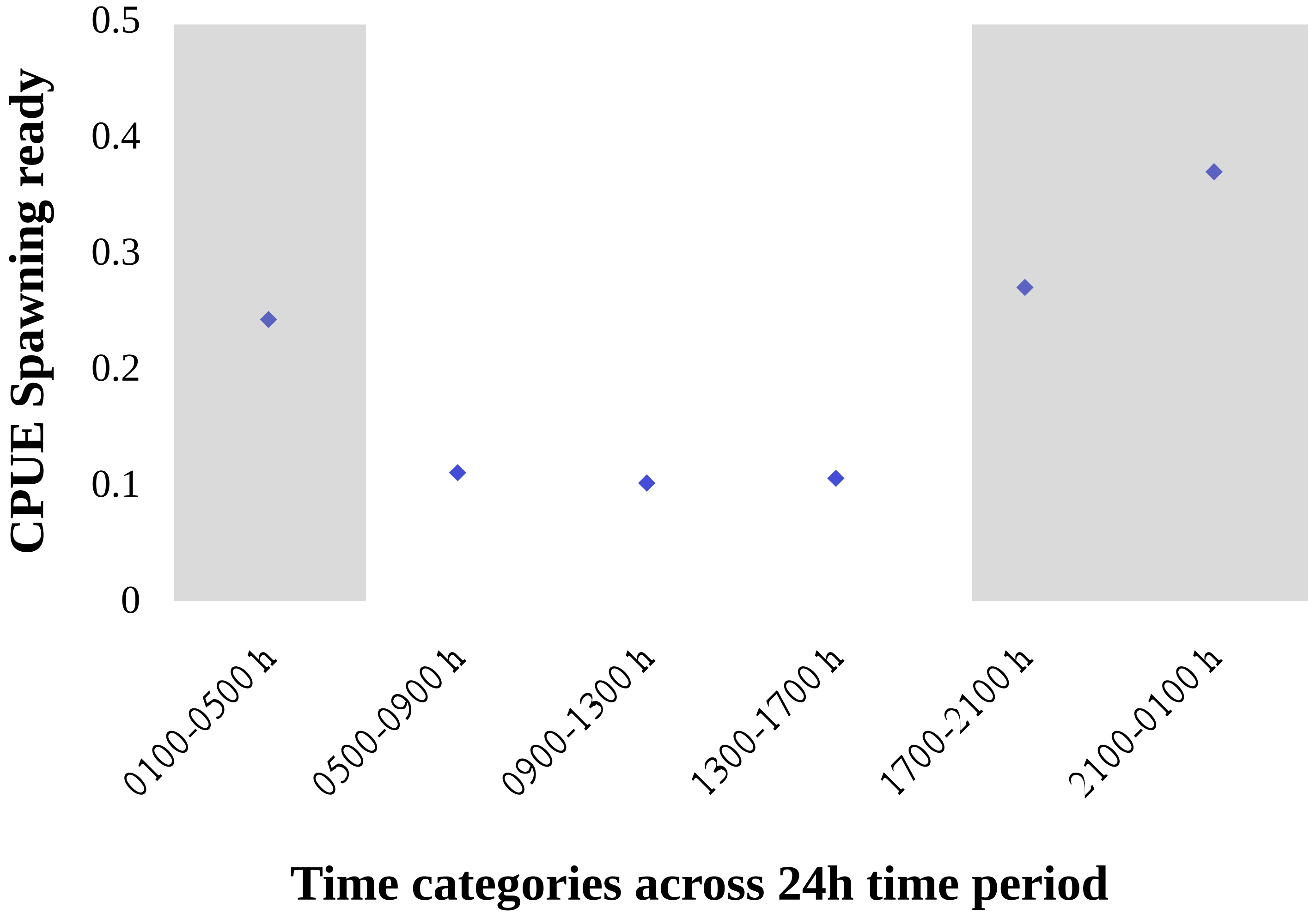


Figure 6. Daily pattern of vocal activity recorded on Jefferies Ledge on three separate dates.

Haddock spawn primarily at night



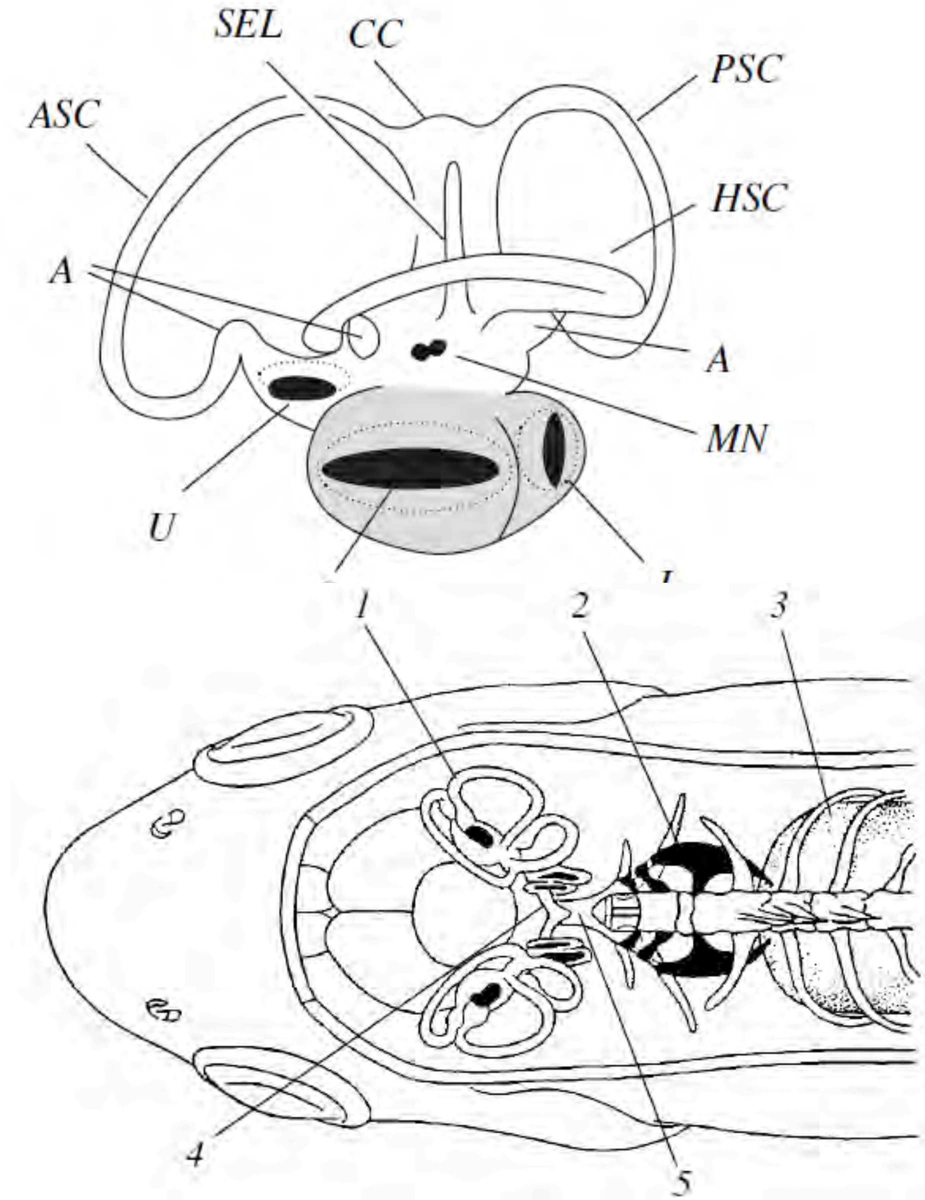
Night hours

Potential of passive acoustics to monitor the invasion of the Hudson River by the freshwater drum, *Aplodinotus grunniens*

Francis Juanes (Univ. Victoria) and Rodney Rountree (Univ. Mass)

How are sounds detected?

- Fishes have 2 inner ears but no middle or external ear
- Inner ear structure similar to other vertebrates
- Sensory hair cells responsible for converting sound to electrical signals



REVIEW PAPER

The effects of anthropogenic sources of sound on fishes

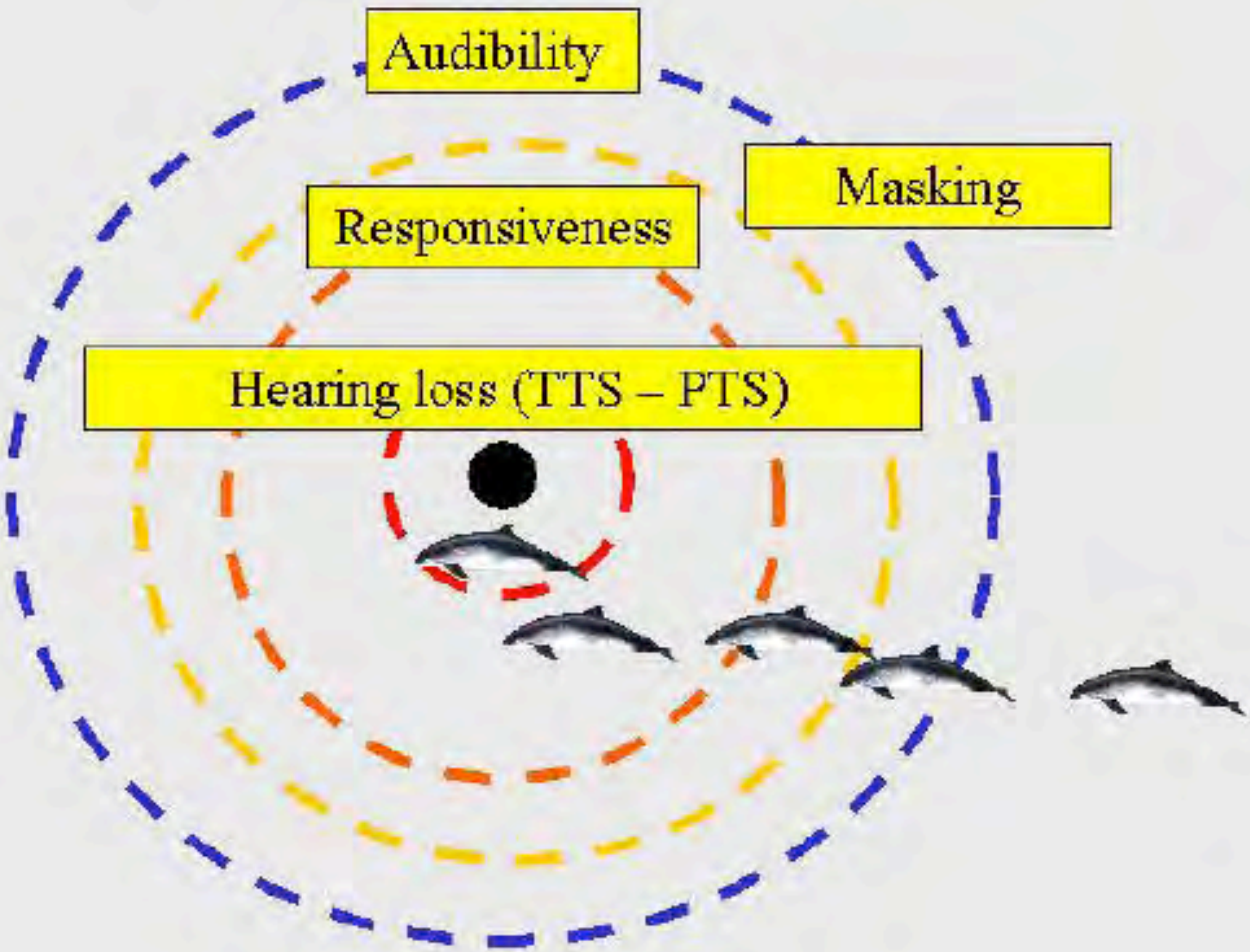
A. N. Popper*† and M. C. Hastings‡

Despite the concerns raised by the increased presence of anthropogenic sound in the aquatic environment, very little is known about the effects of exposure to such sounds on marine mammals, **and far less is known about the effects on fishes**

One must always be cautious when extrapolating outside the bounds of empirical data, and because data available for the **effects of sound on fishes are so few**, extra caution is advised when attempting to extrapolate between fish species, even for identical stimuli. Moreover, one must also be cautious with any attempt to extrapolate results between stimuli because the **characteristics of the sources** (e.g. air guns, sonars, ships, pile driving) **differ significantly from one another**.

Journal of Fish Biology (2009) **75**, 455–489

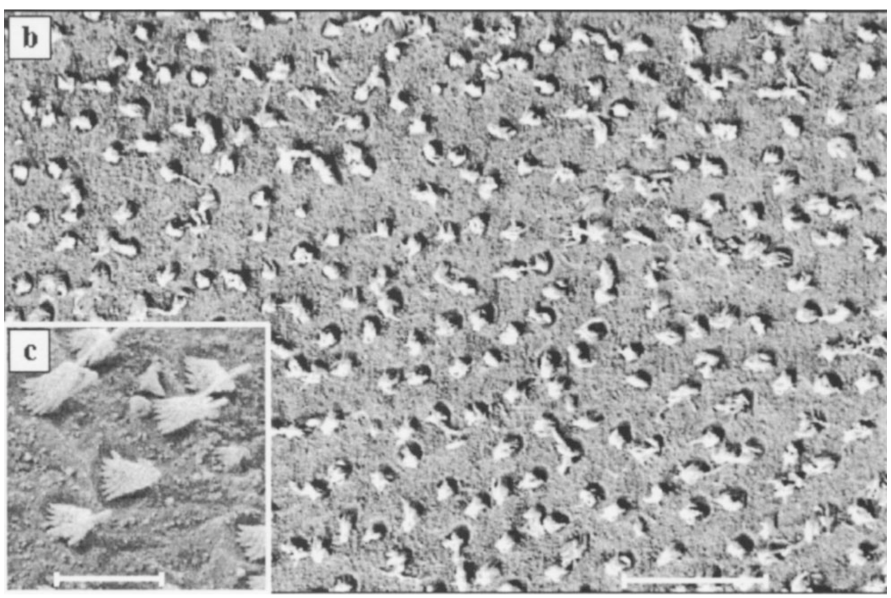
Zones of noise influence

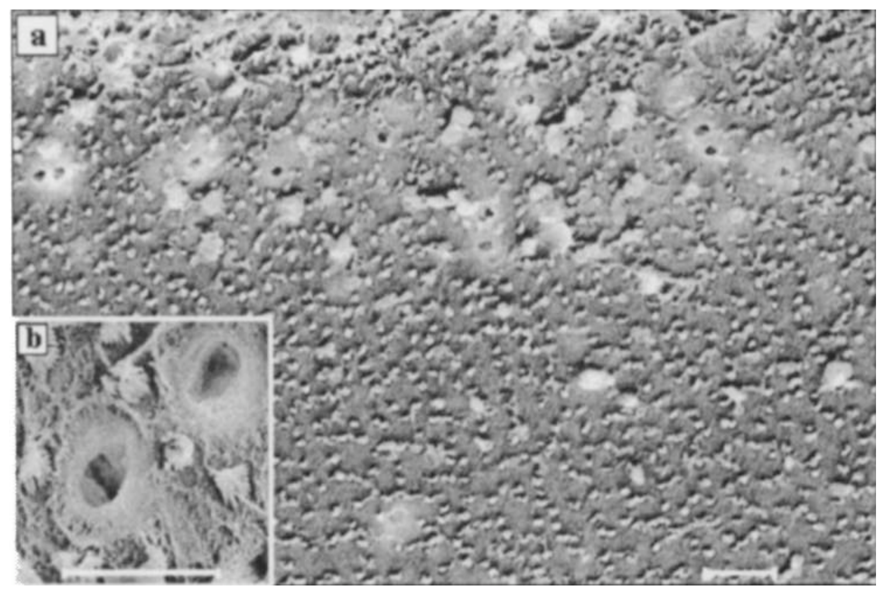


Thomsen et al. 06

Potential effects on hearing?

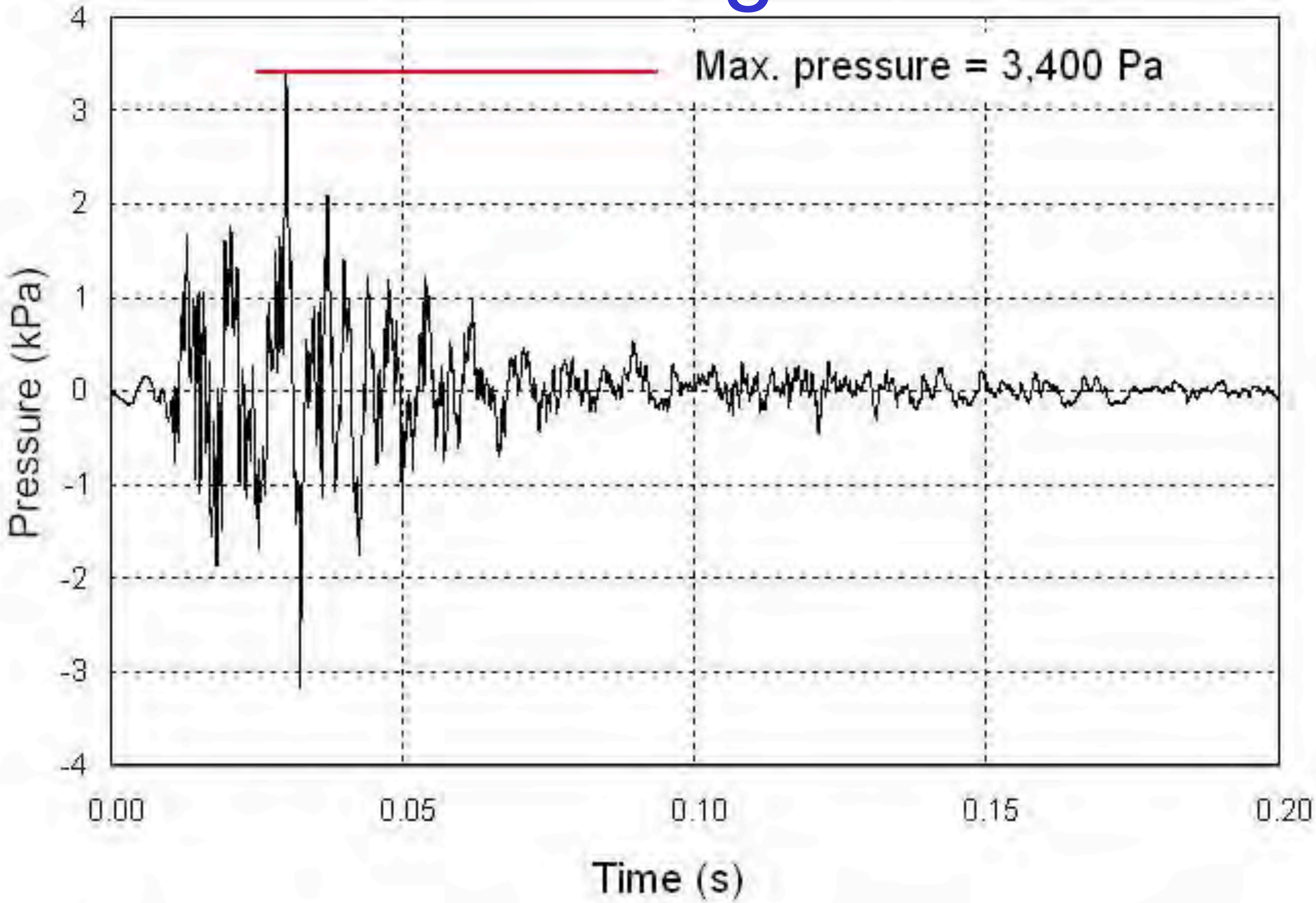
- High intensity (relatively transient) sounds can fatigue, damage or kill sensory hair cells
- Unlike mammals, fish can replace or repair damaged sensory cells





McCauley et al. 03

Pile driving sound



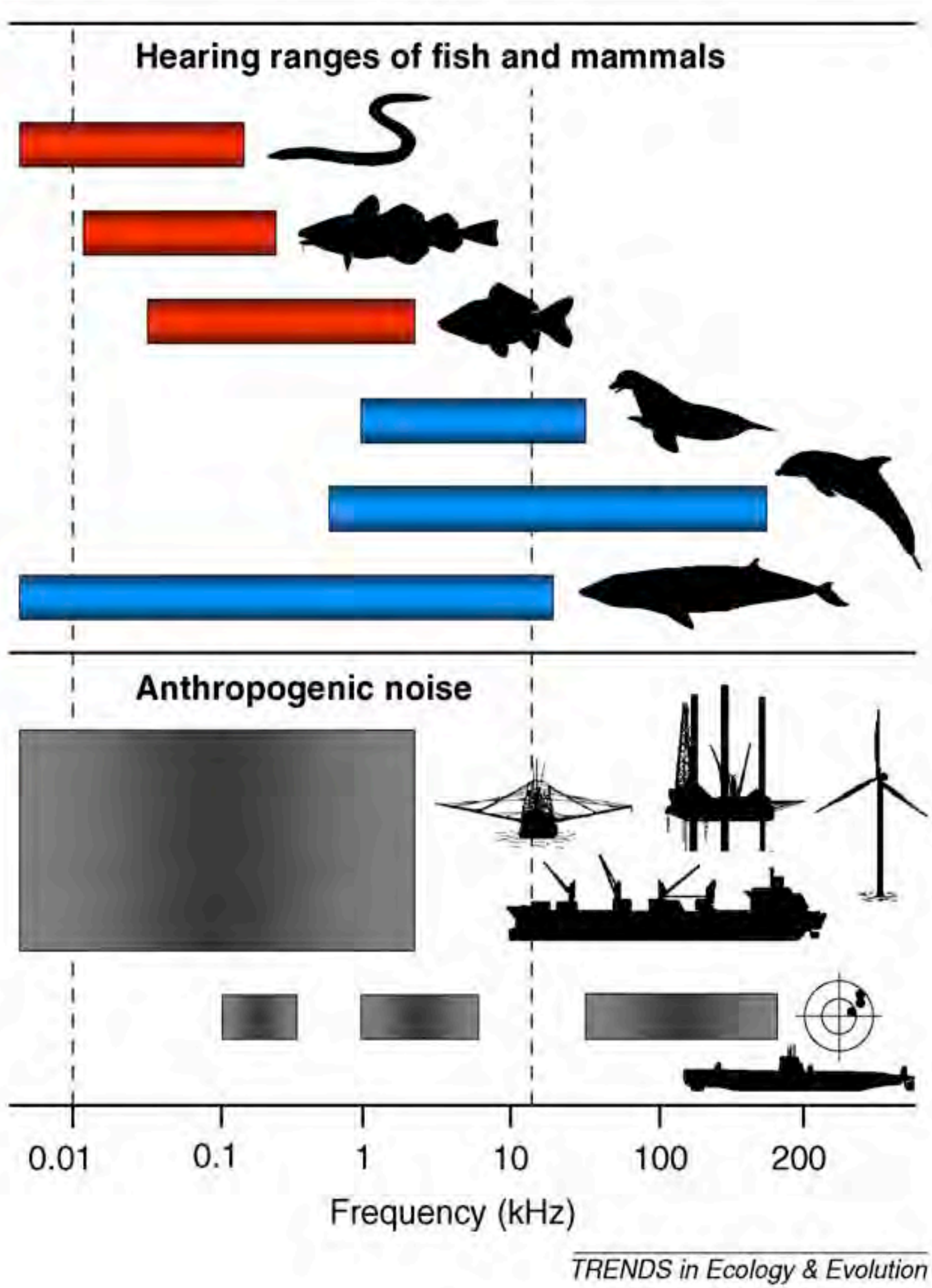
Thomsen et al. 06

Behavioural effects of pile driving noise

- Direct mortality in surfperches
  - Extent of damage and mortality greater closer to the source
- Startle and alarm responses when exposed to an air gun (rockfish)
  - Tighter schools
  - Schools collapsed to the bottom
  - Became motionless on bottom

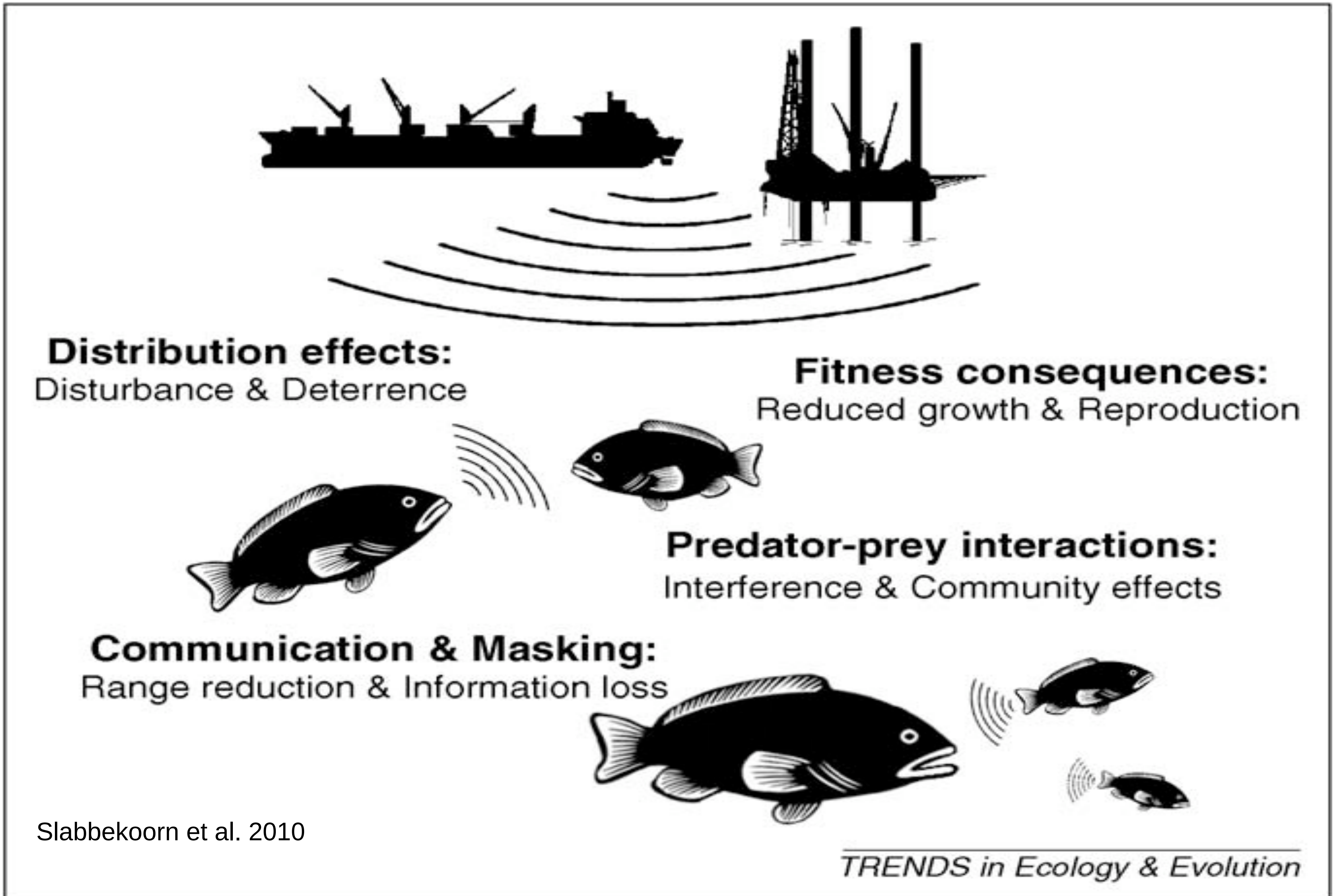
Potential effects on hearing?

- High intensity (relatively transient) sounds can fatigue, damage or kill sensory hair cells
- Unlike mammals, fish can replace or repair damaged sensory cells
- Lower intensity (but longer term) may have more behavioural and physiological effects and perhaps highest impact
  - Low frequency noise from shipping
  - Higher frequency underwater measurement sounds



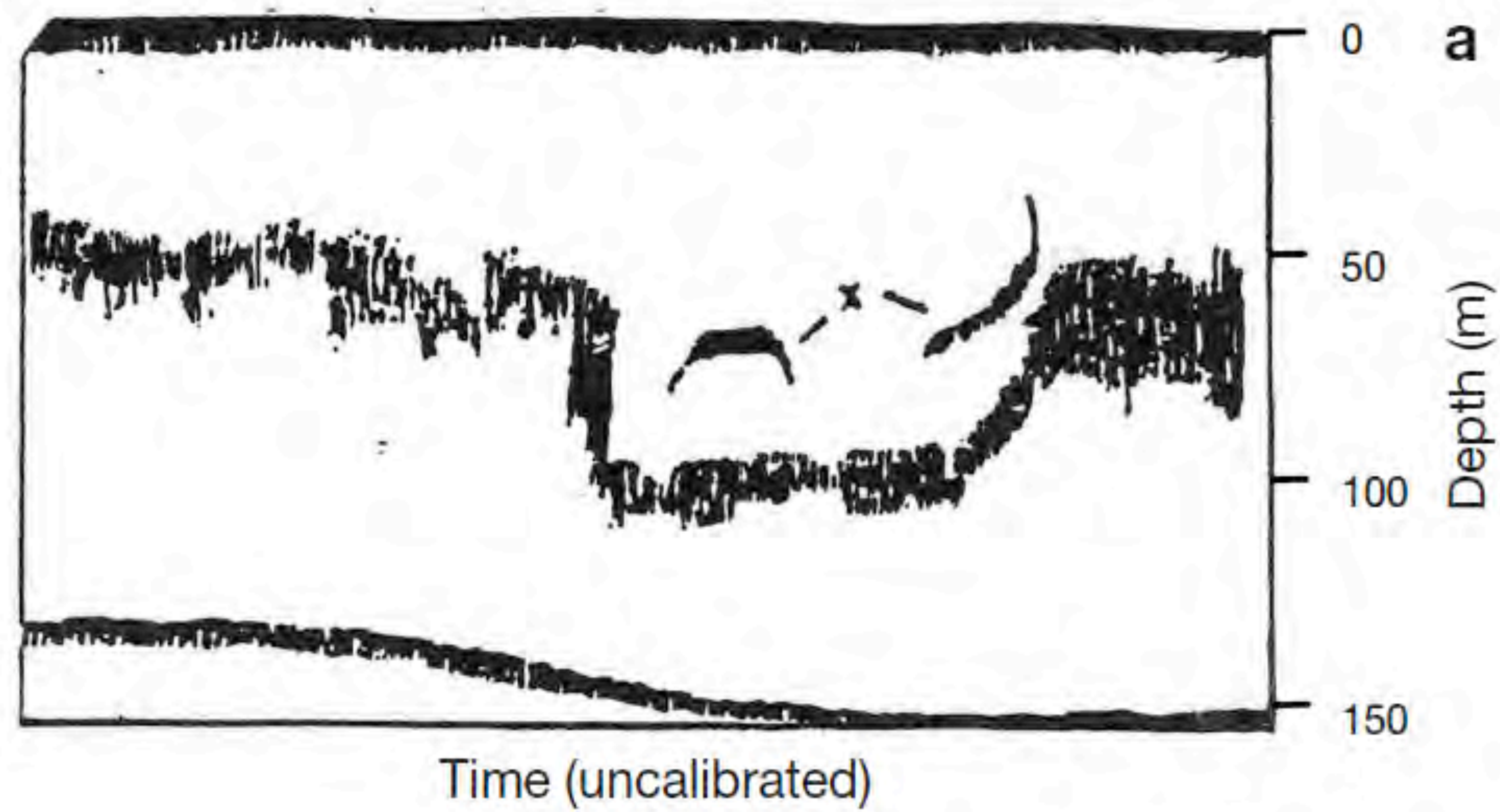
Slabbekoorn et al. 2010

Behavioural effects of noise?



Slabbekoorn et al. 2010

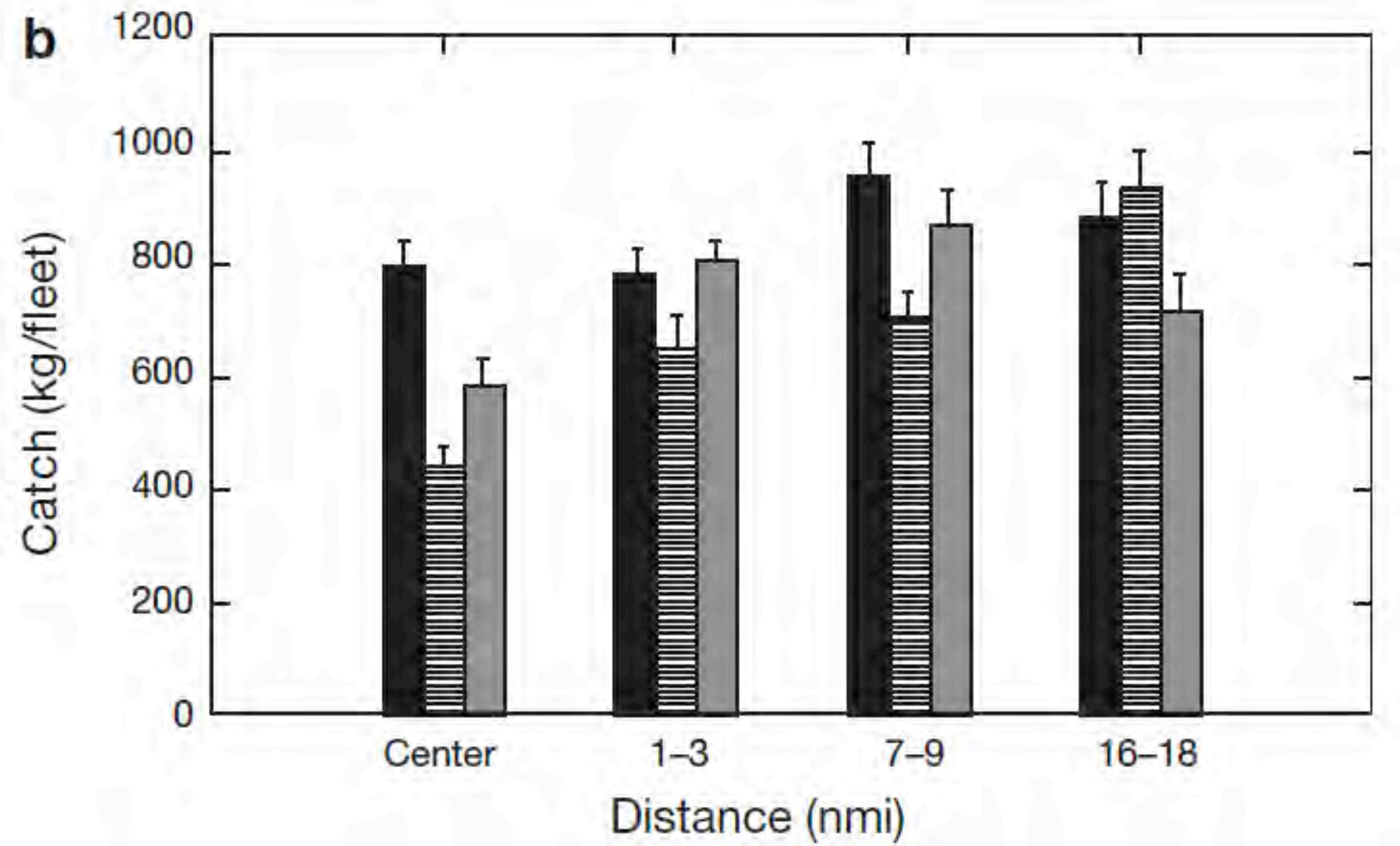
Behavioural effects of noise?



Diving herring school after being approached by a trawl

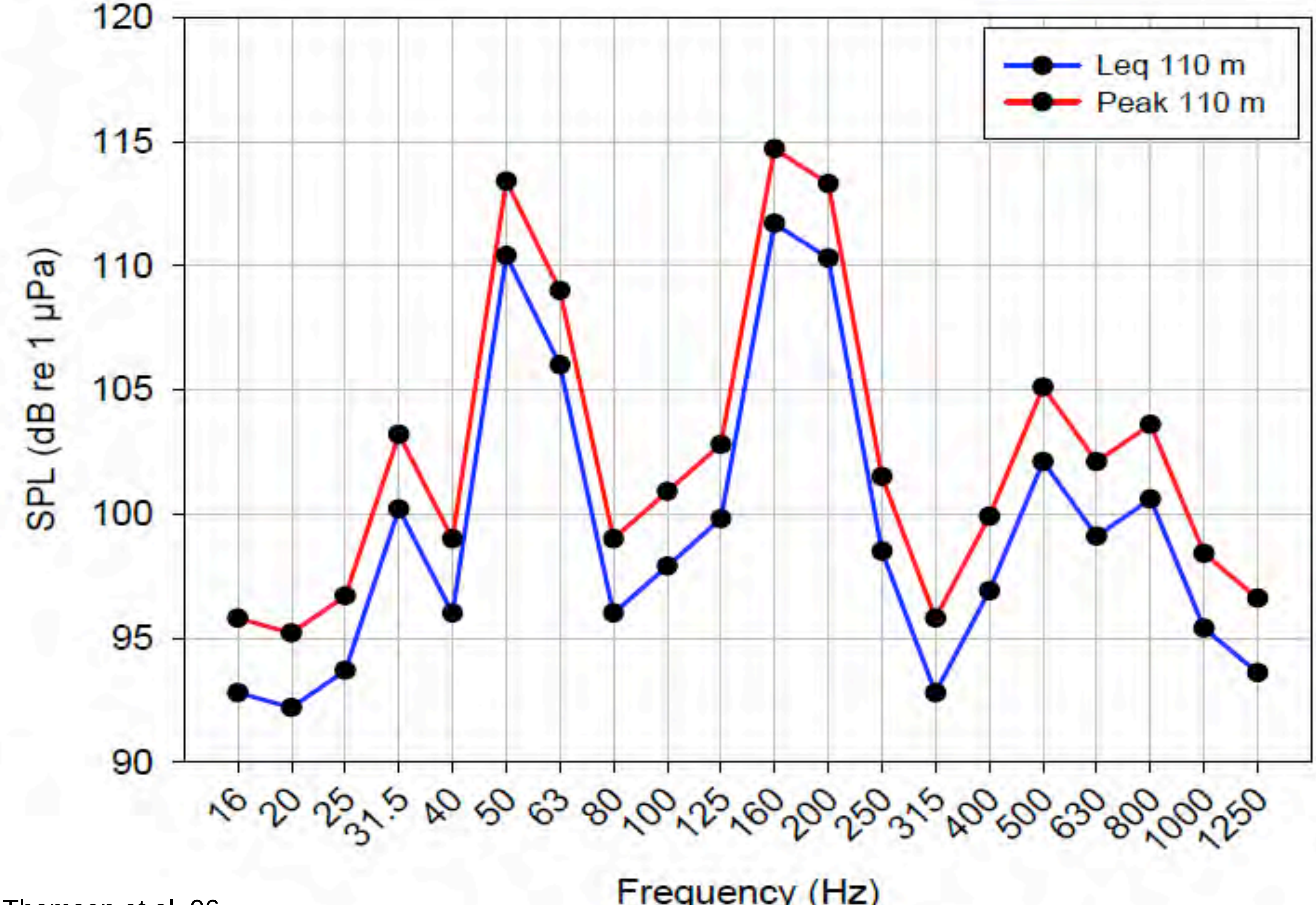
Wahlberg and Westerberg 05

Behavioural effects of noise?



Cod catch before, during and after a seismic survey using an air gun

Offshore wind turbine sound

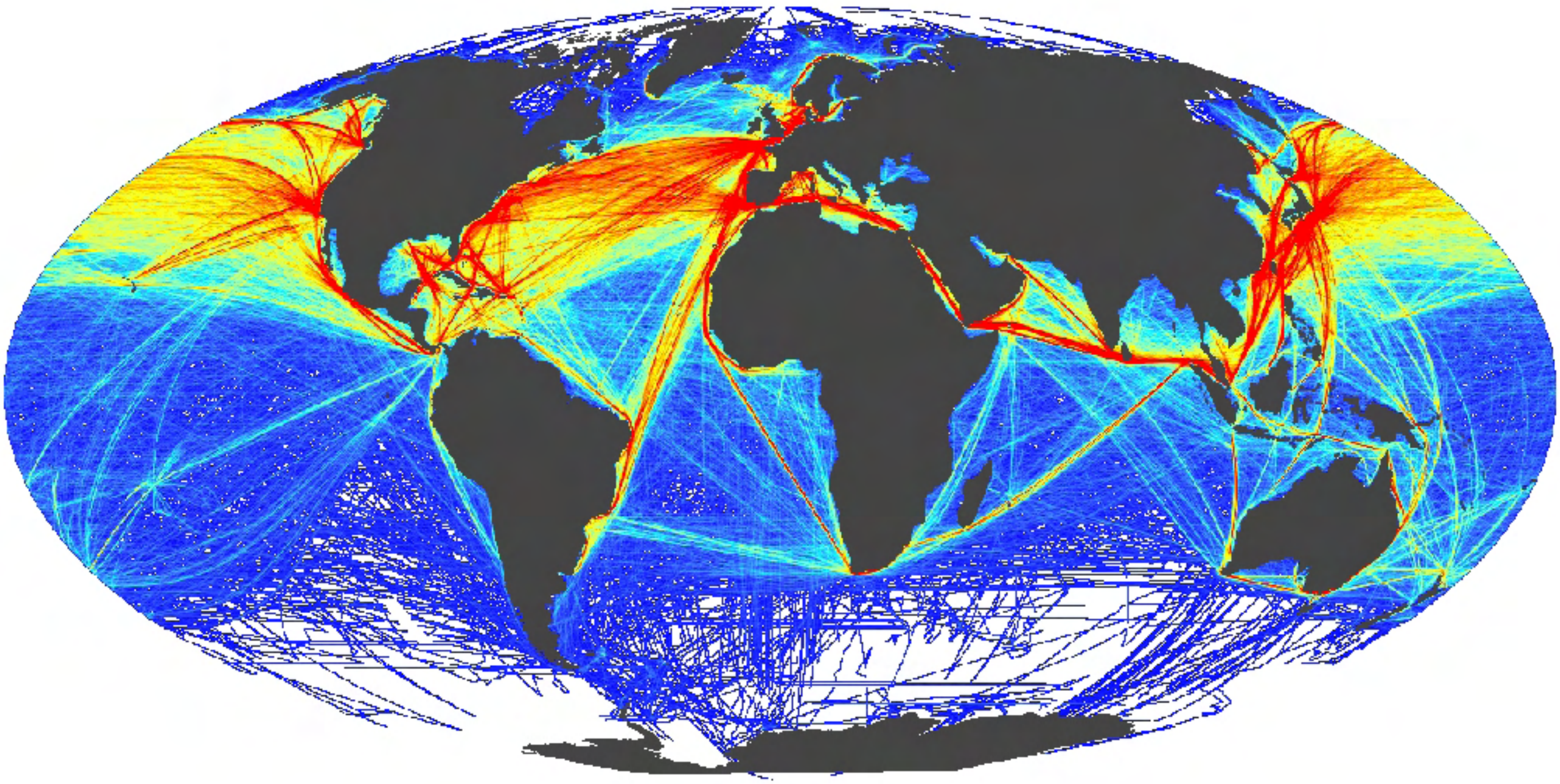


Thomsen et al. 06

Effects of wind farm noise

- Salmon and cod likely detect wind farm sounds at maximum distance of 25km
  - Distance depends on wind speed, type and number of windmills, water depth and bottom substrate
- Little evidence that windmills can cause temporal or permanent hearing damage
  - But may cause avoidance, physiological stress
  - And will have an effect on maximum acoustic signaling distance (masking)
- Wind farm construction may have much higher impacts than operations
  - Pile driving may be heard up to 80 km

Volume of world shipping traffic

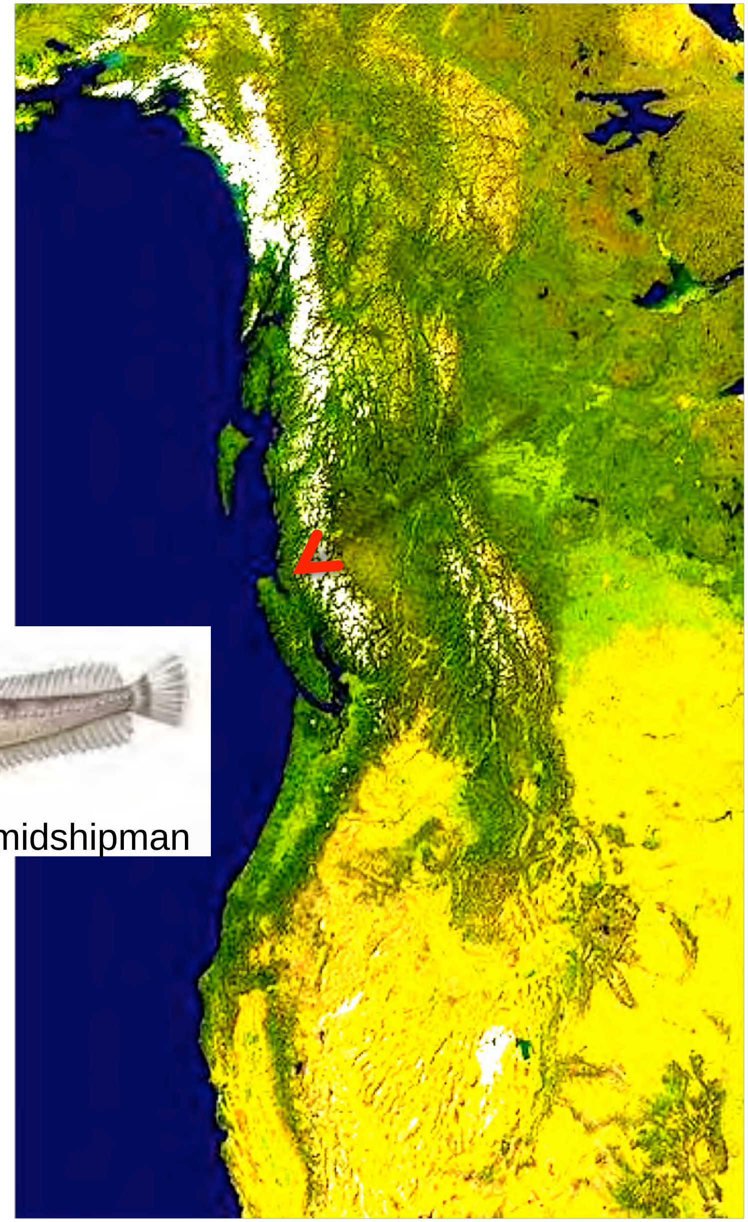


Halpern et al. NCEAS

Effects of shipping noise?

"Shipping is probably the most extensive source of noise in the oceans, especially along the major shipping channels (e.g., from Alaska to California for supertankers carrying oil)."

-Popper, 2003



Plainfin midshipman

Ecological implications?

Noise dependent fish distributions

- Are there differences in how fish are distributed in quiet and noisy environments, and how might these distributions vary depending on sound source, species, fish age, and other physical and biological factors?
- How does noise affect orientation (larvae/juveniles)?

Reproductive consequences of noisy conditions

- Is there a negative influence of anthropogenic noise on reproductive success, by causing physiological stress, by restricting mate finding, or by keeping fish from preferred spawning sites?

Ecological implications?

Masking effects on communicative sounds

- Does the presence of masking sounds of different types and intensities impact the ability of fish to communicate acoustically or use the acoustic ‘soundscape’ to learn about the environment?

Masking effects on predator-prey relationships

- Does the presence of masking noise affect the ability of fish to find prey (get food) or detect the presence of predators (become food)?

Thanks!