



The 5th Program of China-ASEAN Academy on Ocean Law and Governance

Diversity and conservation challenges on marine mammals in Chinese waters and the South China Sea

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**Institute of Deep-sea Science and Engineering,
Chinese Academy of Sciences**

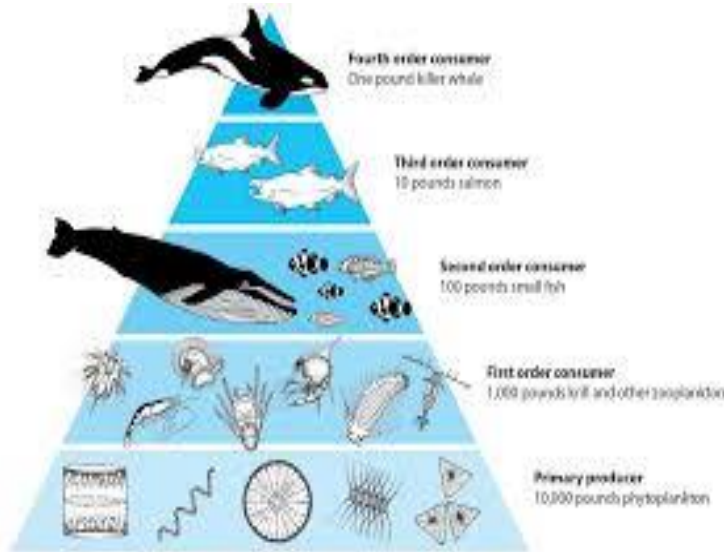
15 Nov. 2019, Sanya





Marine Mammals

- Are protected under the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**;
- Most marine mammals are at the top of the food chain in the ocean ecosystem;
- A lot of marine mammals in our region.





Marine Mammals

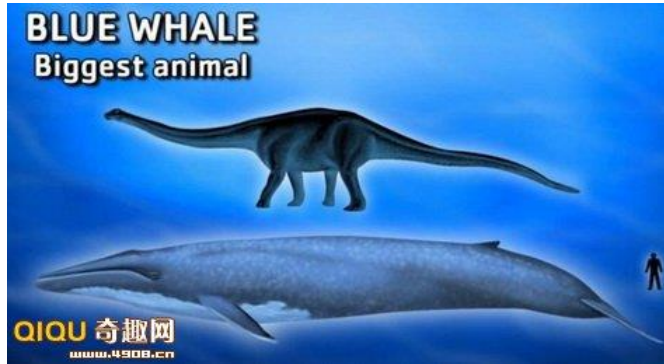
- Charismatic mammals living in the ocean;
- Marine mammals have the same characteristics as all other mammals:
 - Warm-blooded
 - Having hair or fur
 - Breathing air through lungs
 - Bearing live young
 - nursing their young with milk produced by mammary glands
 - Having adapted to live all or part of their life in the ocean. To keep warm in the ocean, most of them depend on a thick layer of blubber (or fat). They have streamlined bodies to help them swim faster.
- Cetacean, Sirenian, and Carnivora, about 130 species



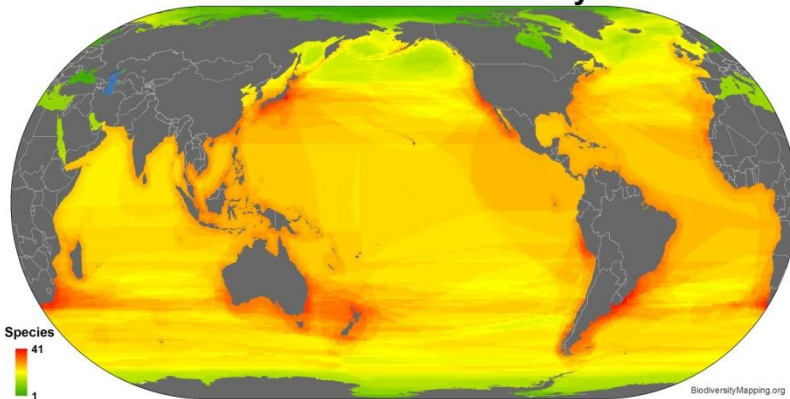


Marine Mammals

- The size range of marine mammals is immense, varying from a sea otter weighing about 20 kilogram (kg) with length of 1.5 m to the largest female blue whale weighing about 180,000 kg with 30 m in length;
- Their habitats are also quite varied; they can be found worldwide, encompassing all seas and numerous coastal areas and shores as well as freshwater lakes and rivers.



Marine Mammal Diversity





Marine Mammal Classification

Order Cetacea includes the whales, dolphins, and porpoises

- 90 species;
- Completely aquatic, and cannot survive on land;
- Two front flippers, and a tail uniquely shaped into two horizontal extensions, called fluke, which provide swimming power.

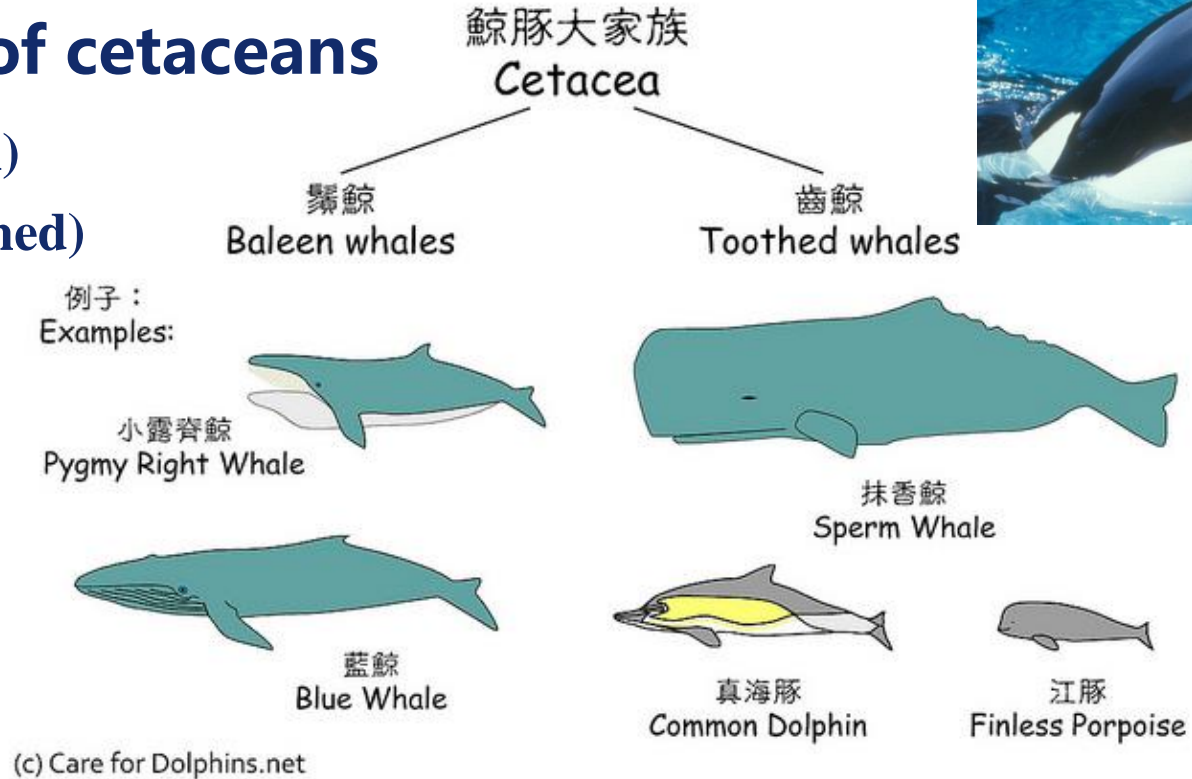




Marine Mammal Classification

Two suborders of cetaceans

- Mysticeti (baleen)
- Odontoceti (toothed)



- Baleen whales include blue, gray, humpback, and bowhead whales. Instead of teeth, baleen whales have rows of strong, closely spaced baleen plates along both sides of their upper jaws. These plates filter out and trap small fish and plankton, which the whale then swallows. Baleen whales breathe through a pair of blowholes;
- Toothed whales are highly variable in body shape and size and include dolphins, porpoises, narwhal, beluga, beaked, and sperm whales. Toothed whales have variable numbers of teeth, or may have no functional teeth at all, and breathe through a single blowhole.



Marine Mammal Classification

Order Sirenia includes the dugongs and manatees

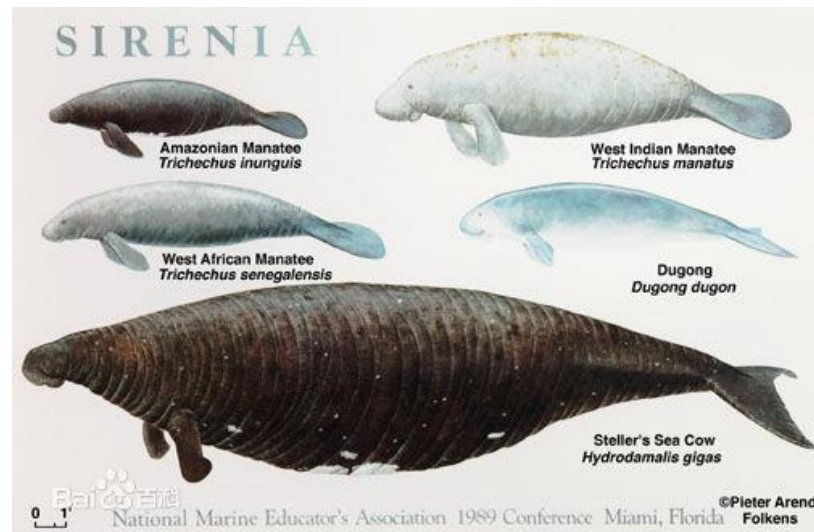
- All species live in warm or tropical waters and feed on plants. Another species of sirenian, called the Steller sea cow, once inhabited Arctic waters, but was hunted to extinction by 1768 within 27 years of its discovery. They are fully aquatic as well and therefore are obligate water dwellers



blog.sina.com.cn/vickichen



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Marine Mammal Classification

Order Carnivora includes five families of marine mammals:

- Otariidae (sea lions and fur seals), Phocidae (true seals), and Odobenidae (walrus), i.e., Pinnipeds. They are semiaquatic and regularly come out on land to rest, breed, and give birth;
- Sea otters and polar bears. Sea otters are the only marine member of the mustelid family; Polar bears are designated as marine mammals because they depend on the ocean for a majority of their food.

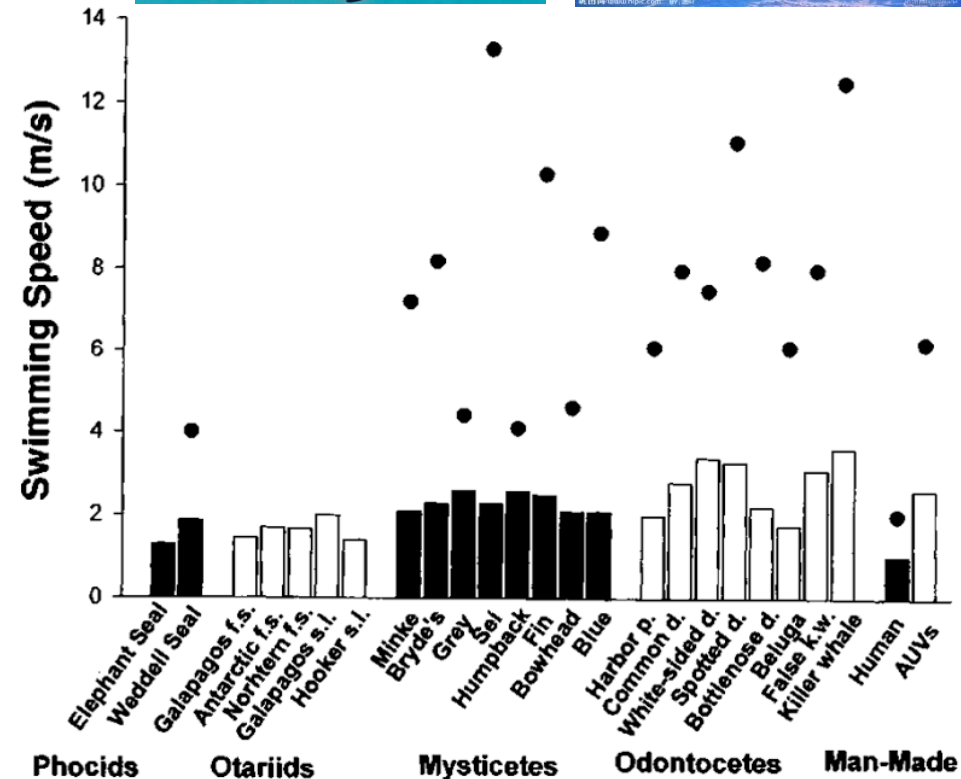




Marine Mammal Locomotion

Swimming is the primary mode of locomotion for marine mammals

- A streamlined body shape with the possible exception of polar bears;
- For cetaceans, it is the only form of locomotion.
- As short as several seconds when moving between prey patches;
- As long as several months during seasonal migrations across entire ocean basins.
- Routine speeds of marine mammals;
- Filled circles are the sprinting speeds recorded for each species;
- Range of routine speeds are similar for the marine mammals regardless of body size.

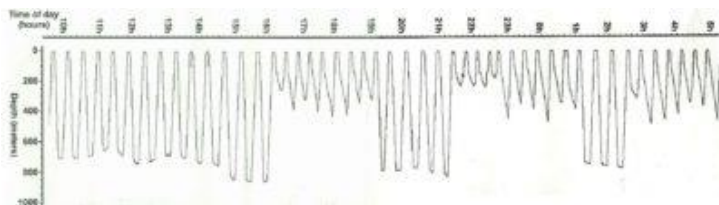




Marine Mammal Diving

- Mammals are warm blooded air breathers, not ideal for the conditions in deep sea;
- Marine mammals have thrived in the ocean, and evolved adaptations to dive to extraordinary depths;
- The sperm whale is the diving champion of marine mammals, and can stay under water for over 2 hours and dive to depths of nearly 3000 m. It has an extraordinary array of adaptations that allow it to dive so deep. All marine mammals can make dives that are deep compared to human beings.

| Species | Body mass (kg) | Routine depth (m) | Maximum depth (m) | Routine duration (min) | Maximum duration (min) |
|--------------------|----------------|-------------------|-------------------|------------------------|------------------------|
| Human | 70 | 5 | 133 | 0.25 | 6 |
| Elephant seal | 400 | 500 | 1500 | 25 | 120 |
| Bottlenose dolphin | 200 | | 535 | | |
| Sperm whale | 10000 | 500 | >3000 | 40 | 132 |



Seal-diving-profile





Marine Mammal Life History

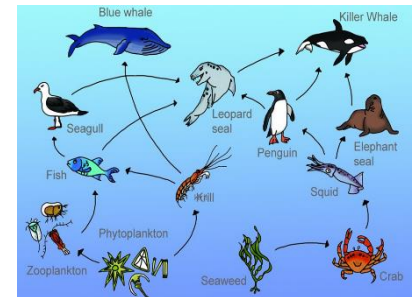
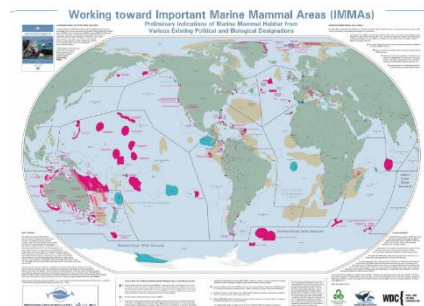
- All species of whales and dolphins, sirenians, and sea otters, without exception, typically give birth to single, large, and precocial young;
- Gestation times are approximately a year;
- The breeding cycle varies from one year to several years;
- Relatively long-lived;
- Age at attainment of sexual maturity is delayed from ages of 3 years to 10 years or more.





Marine Mammal Values

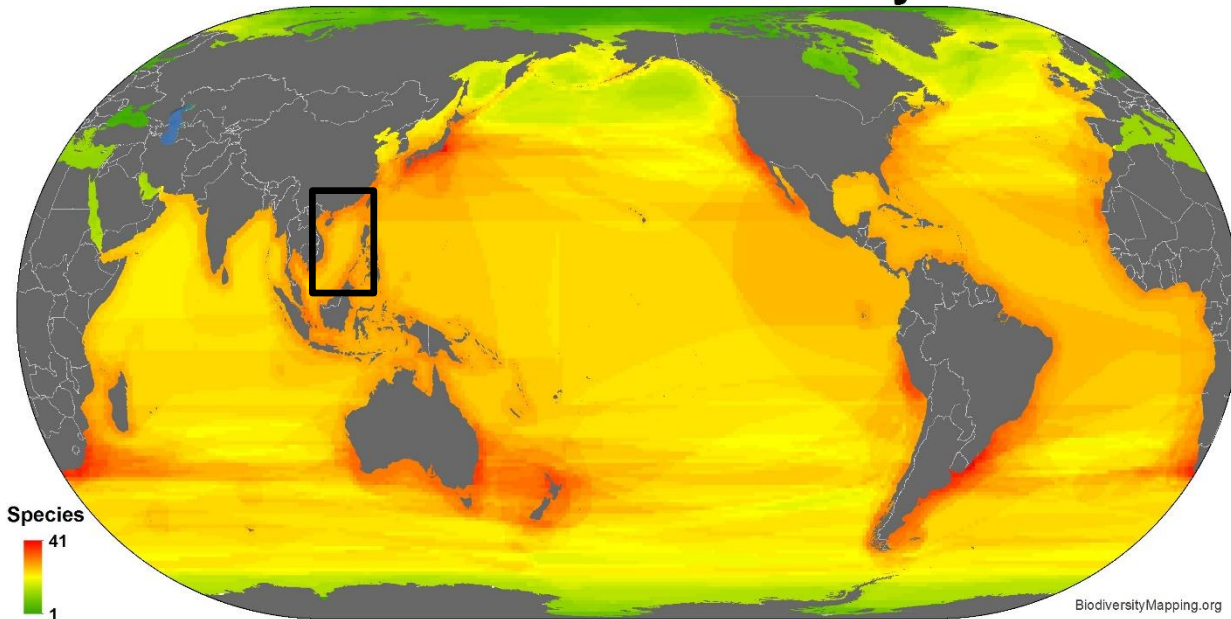
- **Economic values:** Certain species of marine mammals, including whales and dolphins, are increasingly important drivers of economic growth for tourism and related industries.
- **Ecological and conservation values:** Marine mammals play a varied role in marine ecosystems, may act as top level predators feeding on other marine mammals, on fish, or feed at much lower levels on benthic and pelagic invertebrates. They play a very clear role in structuring marine ecosystems.
- **Scientific research values:** Bioacoustics, animal behavior, evolution, bionics...
- **Culture and collaboration values...**





Diversity of marine mammals in Chinese waters and the South China Sea

Marine Mammal Diversity



- Nearly 40 species in the South China Sea (SCS);
- Some of the animals are endemic species in the South China Sea-ASEAN region;
- Concerns on researches and conservation of these animals are rather scarce.



Irrawaddy



Finless



IPHD



Dugong



Sperm whale



Bottlenose



Diversity of marine mammals in Chinese waters and the South China Sea



Stranding Database 1978-2019

Fishermen interview survey

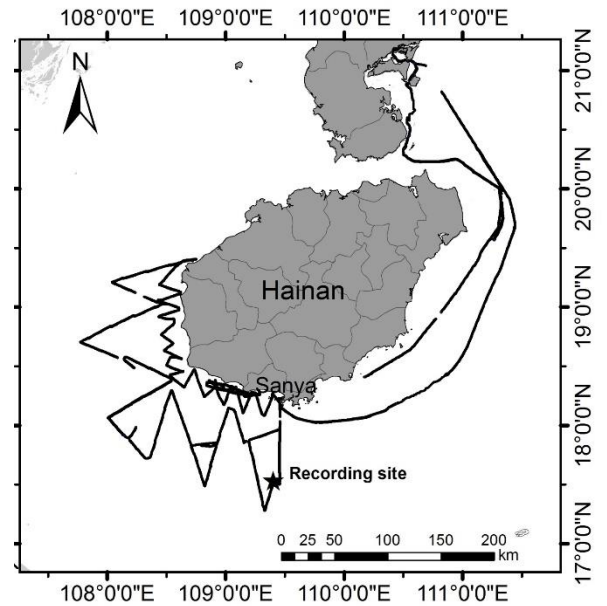
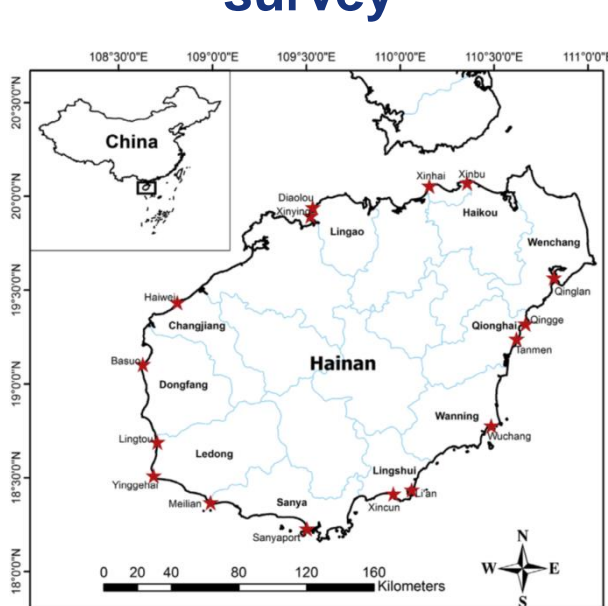
Boat-based survey

中国科学院深海科学与工程研究所
Institute of Deep-sea Science and Engineering, CAS

海南岛鲸类搁浅记录专业数据库

| 种类 (Species) | 学名 (Scientific Name) | 日期 (Time) | 地点 (Site) | 死亡个体数量 (Number) | 详情 (Detail) |
|--------------|--------------------------|---------------------|-----------|-----------------|-------------|
| 未知海豚 | Delphinidae | 2018-09-18 | 后海 | 1 | 查询 |
| 未知海豚 | Delphinidae | 2018-07-03 18:01 | 小东海 | 1 | 查询 |
| 热带瓶海豚 | Stenella attenuata | 2018-05-03 | 崖城 | 1 | 查询 |
| 中华白海豚 | Sousa chinensis | 2018-03-16 11:32 | | 1 | 查询 |
| 未知海豚 | Delphinidae | 2018-03-09 | | 1 | 查询 |
| 印太瓶鼻海豚 | Tursiops aduncus | 2018-01-20 00:00 | | 1 | 查询 |
| 印太江豚 | Neophocaena phocaenoides | 2018-01-03 | 澄迈桥头镇市场 | 1 | 查询 |
| 俾儒抹香鲸 | Kogia breviceps | 2017-12-09 | 大东海 | 1 | 查询 |

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Diversity of marine mammals in Chinese waters and the South China Sea



Indo-Pacific humpback dolphin



Pantropical spotted dolphin



Spinner dolphin



Pygmy sperm whale



Dwarf sperm whale



Indo-Pacific bottlenose dolphin



Indo-Pacific finless porpoise



Risso's dolphin



Short-finned pilot whale



False killer whale



Sperm whale



Cuvier's beaked whale



Pygmy Bryde's whale



Sei whale



Dugong



Fin whale

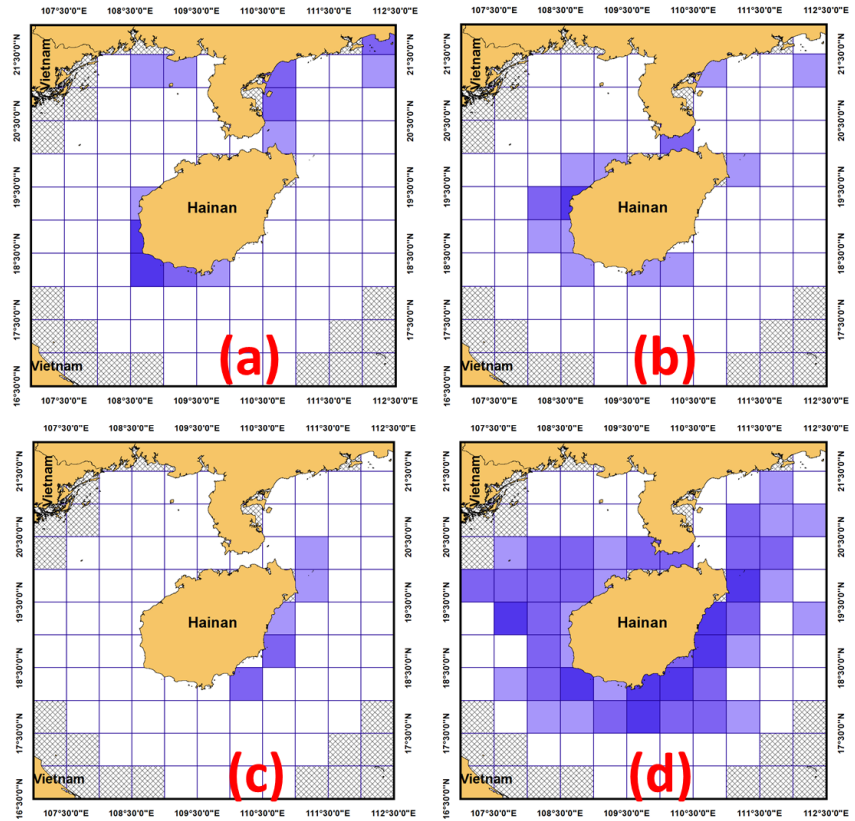
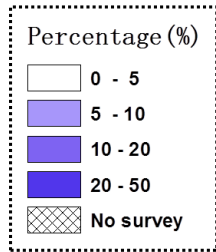


Humpback whale

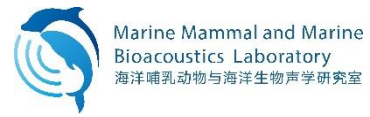


Diversity of marine mammals in Chinese waters and the South China Sea

中国南海海洋哺乳动物物种图鉴 Identification Guide for Marine Mammals In the South China Sea



Distribution maps of marine mammal encounter rate around Hainan Island: (a) Indo-Pacific humpback dolphins; (b) Indo-Pacific finless porpoises; (c) baleen whales; (d) other dolphins.



Diversity of marine mammals in Chinese waters and the South China Sea





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Diversity of marine mammals in Chinese waters and the South China Sea

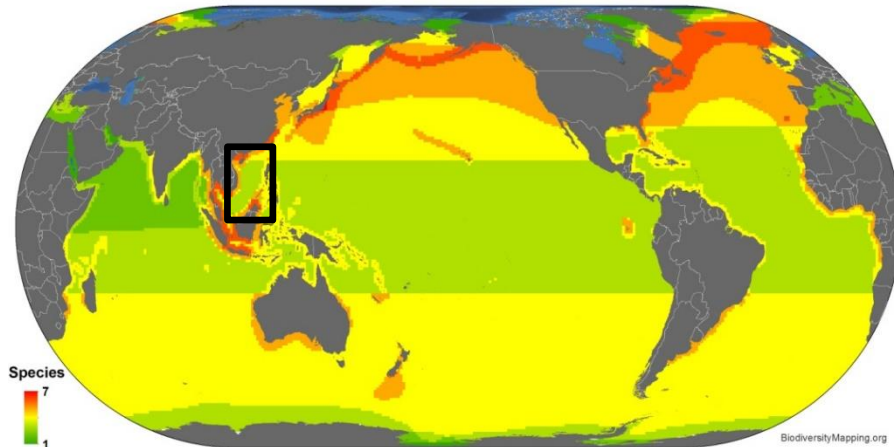




Threats and conservation challenges of marine mammals

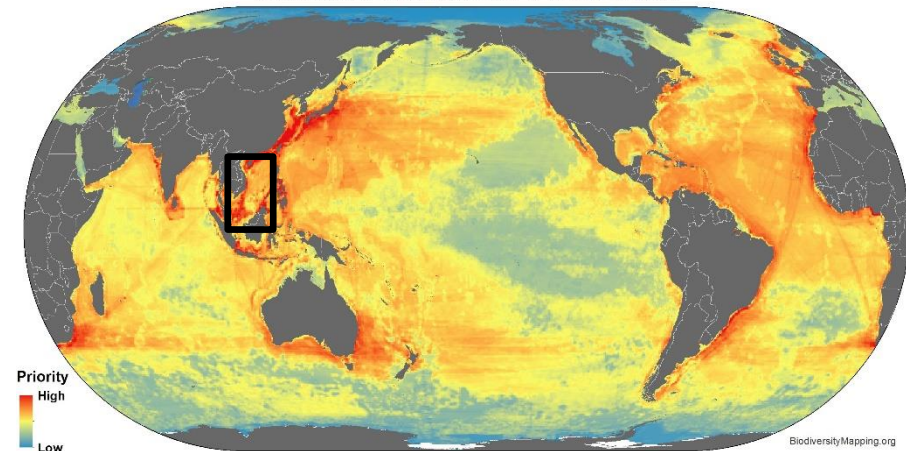
- Life for a marine mammal in today's world is tough. They are facing a lot of issues due to human negligence and interference.

Threatened Marine Mammals



- Ship Strikes
- Acoustic Pollution
- Open Net Fishing
- Oil Spills
- Agricultural Runoff

Marine Mammal Priorities

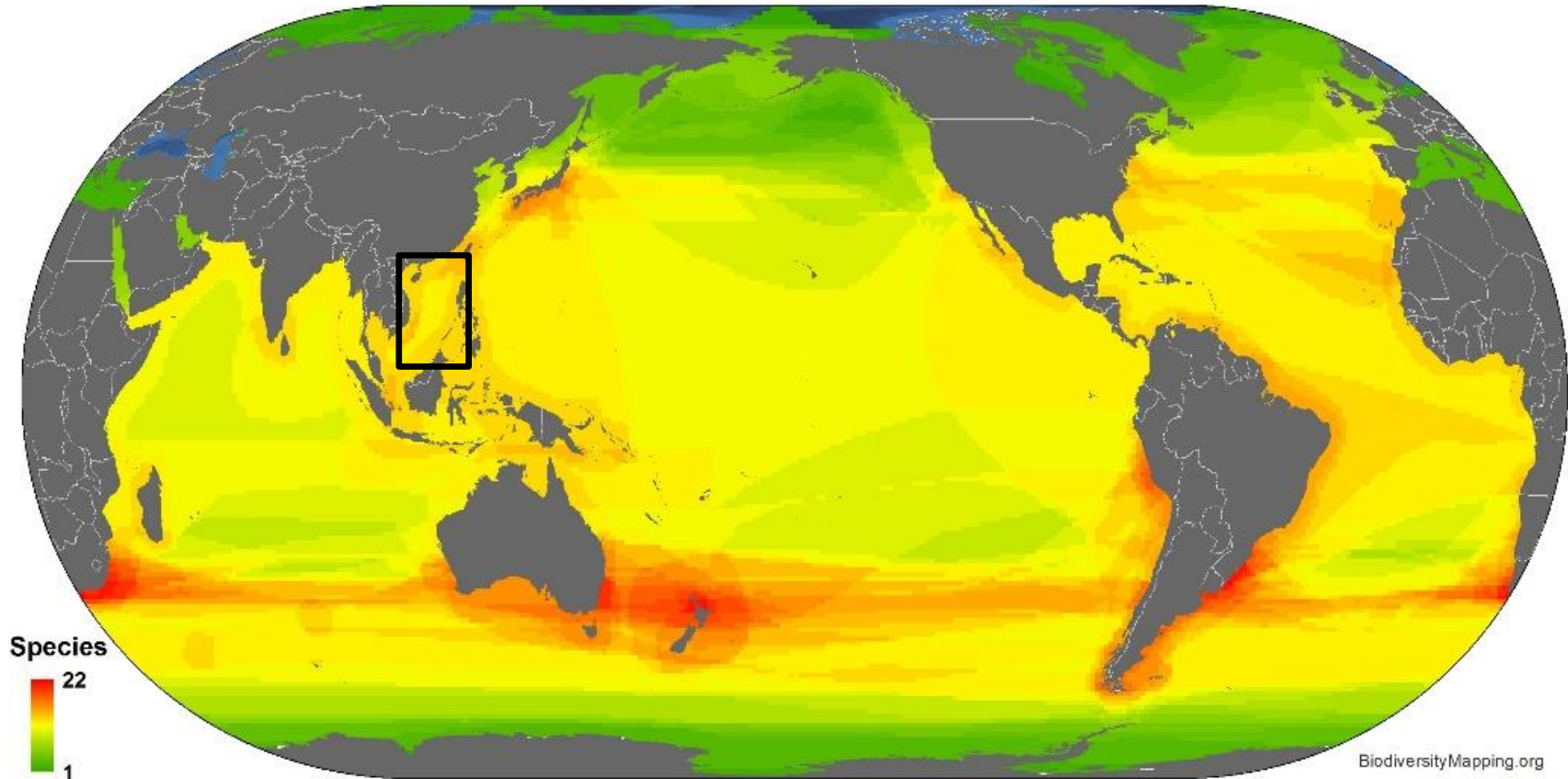


- Commercial Hunting
- Climate Change
- Entertainment and Captivity
- Tourism
- Habitat Loss



Threats and conservation challenges of marine mammals

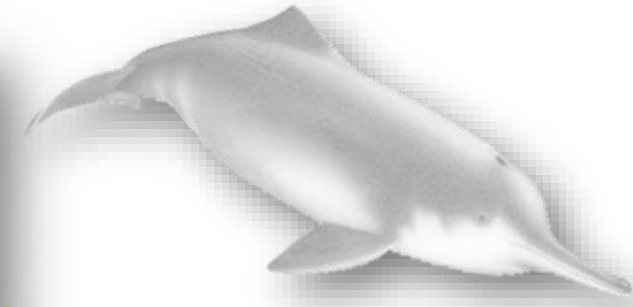
Data Deficient Marine Mammals



- Most marine mammals in the Chinese waters and SCS are data deficient;
- For those we do have data, their status is not optimistic.



Threats and conservation challenges of marine mammals in Chinese waters



Yangtze River dolphin, or Baiji

(*Lipotes vexillifer*)



Yangtze finless porpoise

(*Neophocaena asiaeorientalis a.*)

- **Endemic species of the Yangtze River;**
- **The Yangtze River is the largest and most important river in China with rich and unique biodiversity.**



Threats and conservation challenges of marine mammals in Chinese waters



- **“Yangtze Goddess”, was listed as one of the Grade 1 National Key Protected Animals by China’s Wild Animal Protection Law issued in 1988.**



- **“River Pig”, was listed as one of the Grade 2 National Key Protected Animals by China’s Wild Animal Protection Law issued in 1988, but now revised to Grade 1.**



Threats and conservation challenges of marine mammals in Chinese waters

Yangtze: the Golden Channel

- With the increasing demands of development, various anthropogenic activities have been increasing rapidly, and the habitat of the Yangtze cetaceans has been vastly deteriorated.



Shipping



Fishing



pollution

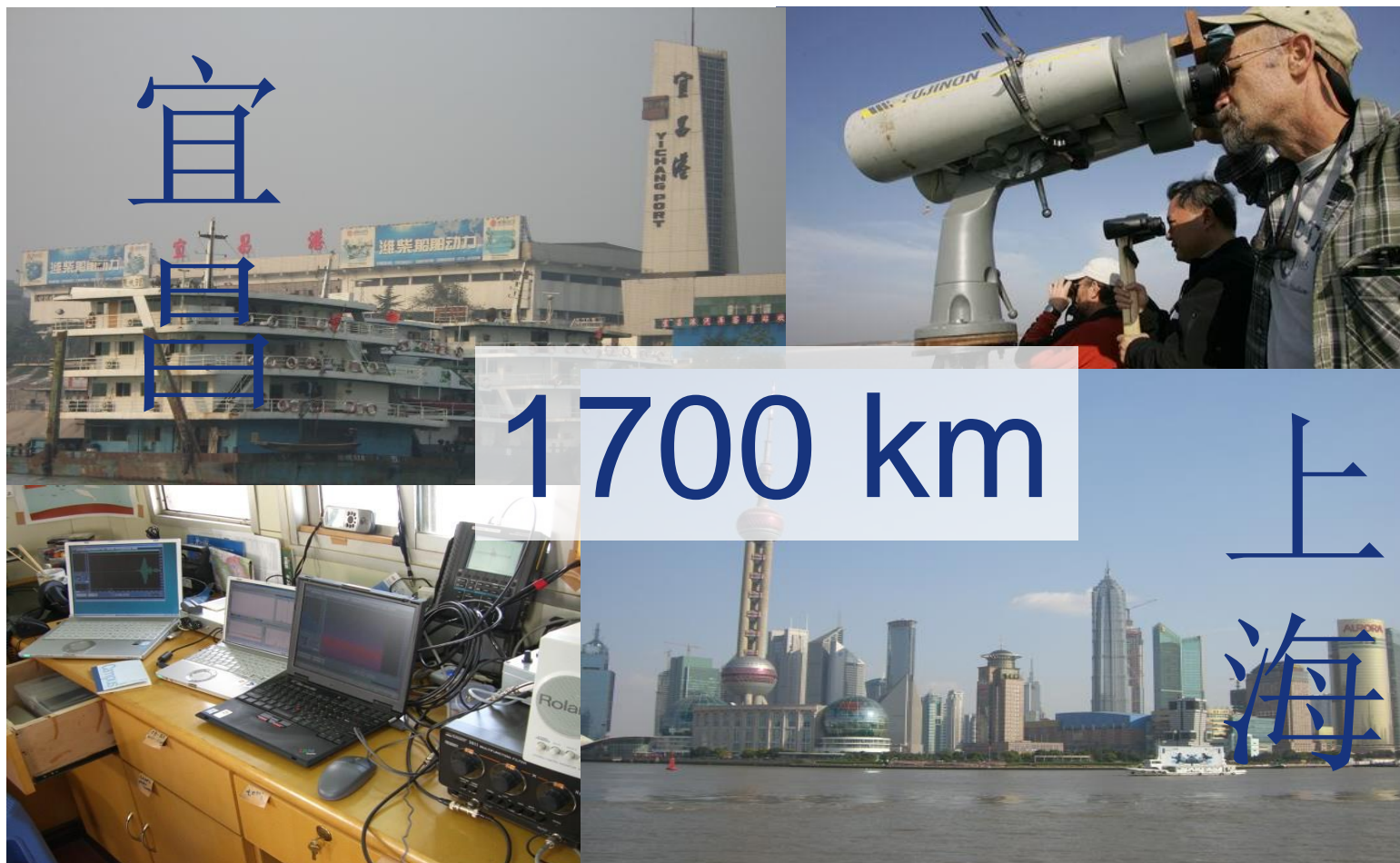


Hydro-projects





Threats and conservation challenges of marine mammals in Chinese waters



- A range-wide visual-acoustic joint survey was conducted in 2006 from Yichang to Shanghai covering the main potential habitat of the Baiji. No baiji was sighted.



Threats and conservation challenges of marine mammals in Chinese waters



Bye-bye baiji

- Then the baiji was announced functionally extinct in 2007, which was actually the first extinct cetacean species caused by human activities.

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biology
letters
Marine biology

Biol. Lett. (2007) 3, 537–540
doi:10.1098/rsbl.2007.0292
Published online 7 August 2007

1. INTRODUCTION

The Yangtze River dolphin or baiji (*Lipotes vexillifer*), an obligate freshwater odontocete known only from the middle-lower Yangtze River system and neighbouring Qiantang River in eastern China (figure 1), has long been recognized as one of the world's rarest and most threatened mammal species (e.g. Chen *et al.* 1980; Chen & Hua 1989; Lin *et al.* 1985; Zhou & Li 1989; Zhou *et al.* 1998; Würsig *et al.* 2000; Zhang *et al.* 2003). Baiji have not been seen in the Qiantang River since the 1950s (Smith *et al.* 2000), and Chinese scientists reported a steady rapid decline in the Yangtze through the 1980s and 1990s from an estimated 400 individuals in 1979–1981 (table 1). Surveys during 1997–1999 provided a minimum estimate of only 13 animals (Zhang *et al.* 2003). The last authenticated baiji records were of a stranded pregnant female found in 2001 and a live animal photographed in 2002, although a few more recent unverifiable sightings have been reported by fishermen to reserve managers in National and Provincial Baiji Reserves along the Yangtze (see electronic supplementary material).

A range of anthropogenic extinction drivers (e.g. boat collisions, dam construction), which also threaten freshwater cetaceans in other river systems (e.g.

First human-caused extinction of a cetacean species?

Samuel T. Turvey¹, Robert L. Pitman², Barbara L. Taylor², Jay Barlow², Tomonari Akamatsu³, Leigh A. Barrett⁴, Xiujiang Zhao^{5,6}, Randall R. Reeves⁷, Brent S. Stewart⁸, Kexiong Wang⁵, Zhuo Wei⁵, Xianfeng Zhang⁹, L. T. Pusser², Michael Richlen¹⁰, John R. Brandon¹¹ and Ding Wang^{5,*}

¹Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, UK

²NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, CA 92037, USA

³NRIFE, Fisheries Research Agency, Haasaki, Kamisu, Ibaraki 314-0408, Japan

⁴Rosli and Foundation, Klostersstrasse 116, 8032 Zurich, Switzerland



Threats and conservation challenges of marine mammals in Chinese waters

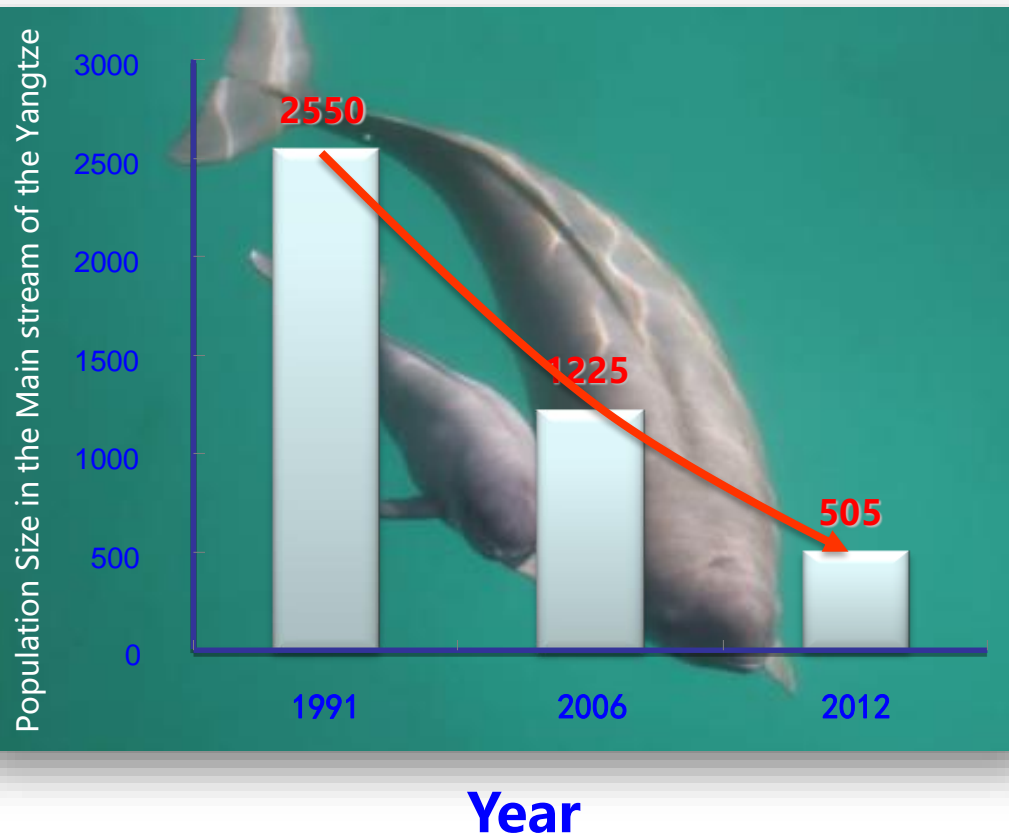


- Yangtze finless porpoise is a subspecies of genus of finless porpoise;
- Narrow-ridged finless porpoise: Japanese coastal waters, Yellow Sea, Yangtze River...
- Indo-Pacific finless porpoise: India Ocean, Bengal Bay, SouthEast Asia, Southeast China.



Threats and conservation challenges of marine mammals in Chinese waters

- The Yangtze finless porpoise is also facing significant population decline due to similar threats



Decline rate

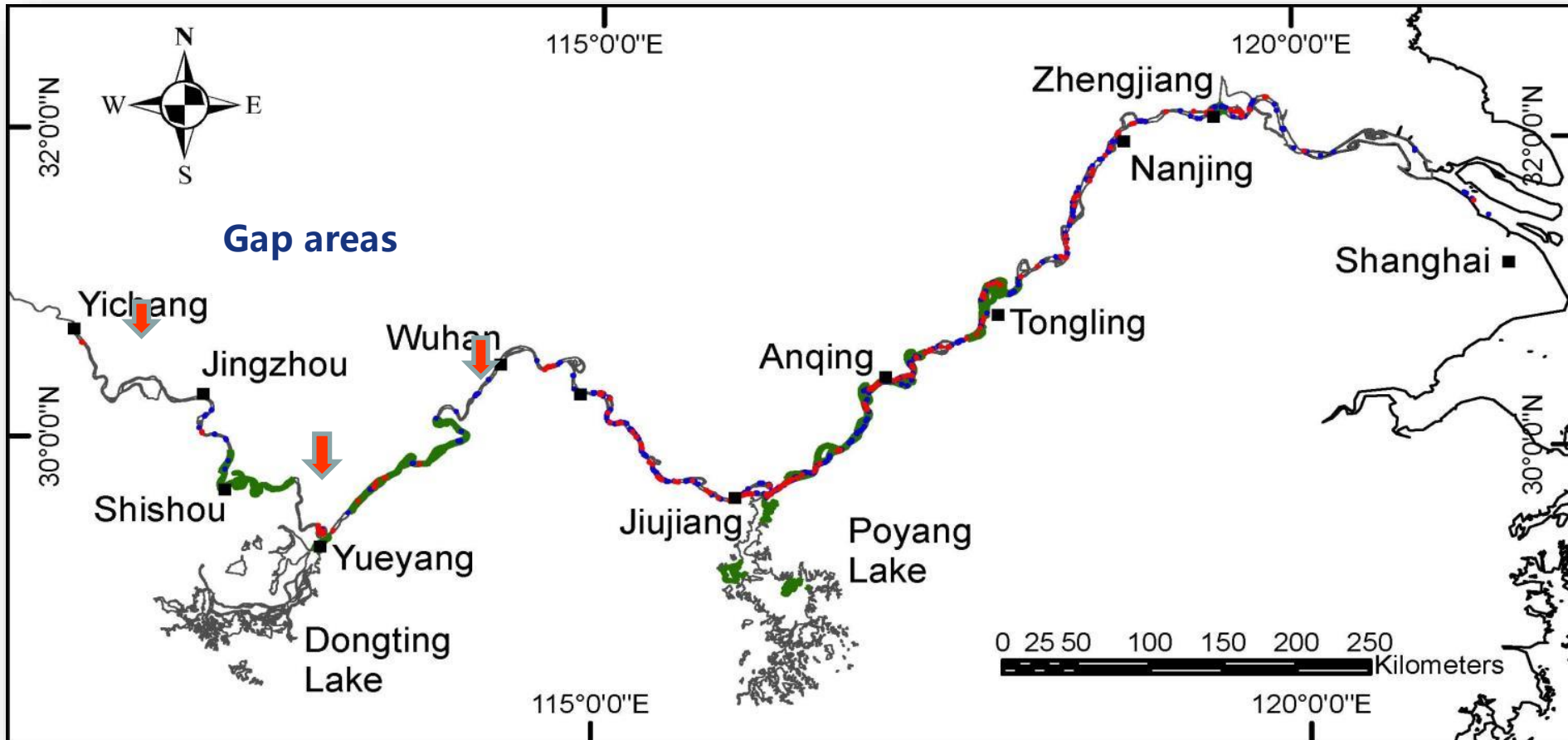
- Pre -1993: 1.58%
- 1993-2006: 6.06%
- 2006-2012: 13.73%

Present: around 1000



Threats and conservation challenges of marine mammals in Chinese waters

● Distribution in the main stream: discrete



● Sightings in 2006

● Sightings in 2012

■ Protected area



Threats and conservation challenges of marine mammals in Chinese waters

The IUCN Red List of Threatened Species™ 2014.1

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Home > *Neophocaena asiaeorientalis* ssp. *asiaeorientalis* (Yangtze Finless Porpoise)

Neophocaena asiaeorientalis ssp. *asiaeorientalis*

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VIEW MAP

Summary Classification Schemes Images & External Links Bibliography Full Account

Taxonomy [top]

| Kingdom | Phylum | Class | Order | Family |
|----------|----------|----------|-----------------|-------------|
| ANIMALIA | CHORDATA | MAMMALIA | CETARTIODACTYLA | PHOCOENIDAE |

Scientific Name: *Neophocaena asiaeorientalis* ssp. *asiaeorientalis*
Species Authority: (Pilleri & Gühr, 1972)
Parent Species: See *Neophocaena asiaeorientalis*
Common Name(s): English – Yangtze Finless Porpoise

[Taxonomy](#)
[Assessment Information](#)
[Geographic Range](#)
[Population](#)
[Habitat and Ecology](#)
[Use and Trade](#)
[Threats](#)
[Conservation Actions](#)

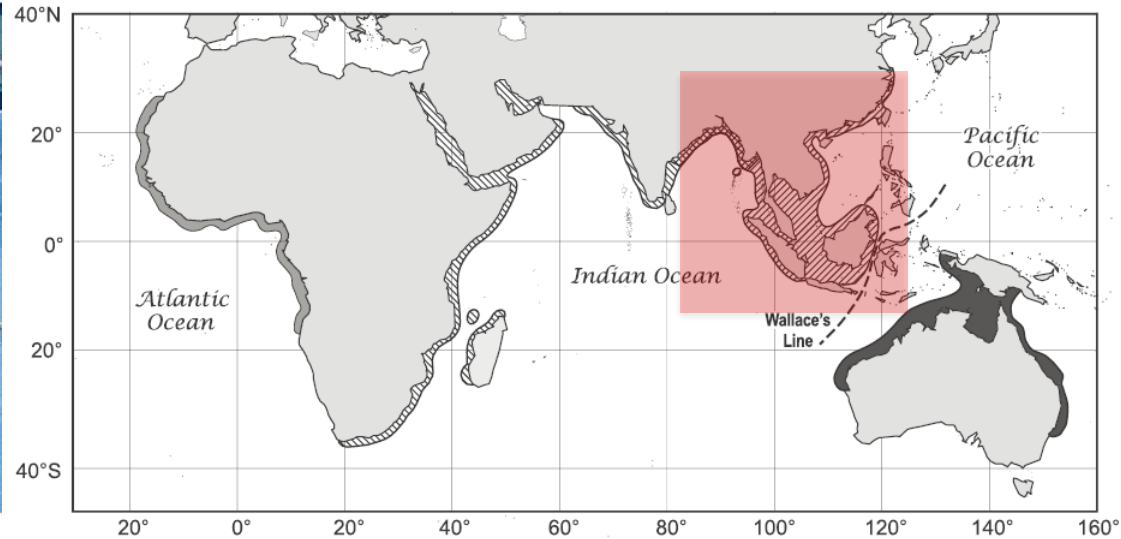
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CRITICALLY ENDANGERED

- The Yangtze finless porpoise was identified as **Critically Endangered** by IUCN

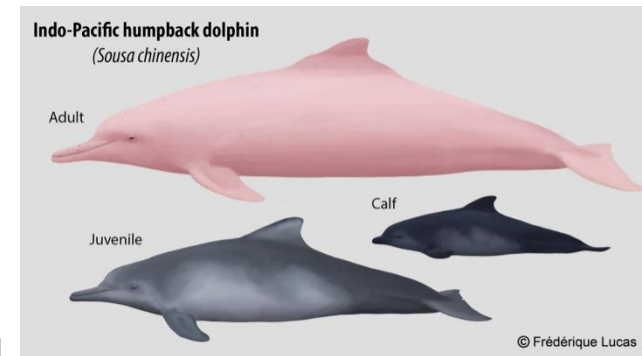


Threats and conservation challenges of marine mammals in Chinese waters



[Jefferson and Rosenbaum, 2014](#)

- One of the four species in humpback dolphin;
- Nearshore small odontocete;
- Tropical coastal waters of Southeast Asia Region;
- Coastal waters of southeast China;
- Called as Chinese White Dolphin in China, “Panda”;
- Was listed as one of the Grade 1 National Key Protected Animals by China’s Wild Animal Protection Law issued in 1988, and received the same priority of protection as the Baiji.





Threats and conservation challenges of marine mammals in Chinese waters

Aquatic Mammals 2004, 30(1), 149-158, DOI 10.1578/AM.30.1.2004.149

A Review of the Status of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in Chinese Waters

Thomas A. Jefferson¹ and Samuel K. Hung²

¹ Southwest Fisheries Science Center, NOAA, NMFS, 8604 La Jolla Shores Drive, La Jolla, CA 92037 USA

² Hong Kong Cetacean Research Project, 12 Kak Tin Kung Miu Village, Tai Wai, New Territories, Hong Kong

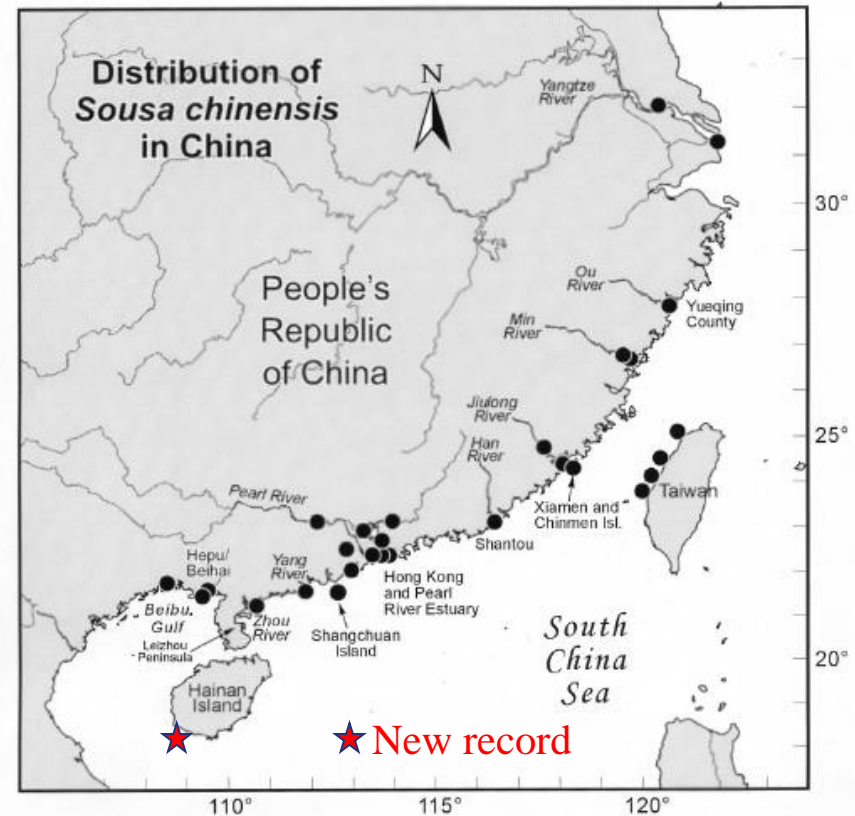


Figure 1. Reliable records of occurrence of *Sousa chinensis* in Chinese waters; updated from Jefferson (2000).

[Jefferson and Hung, 2004](#)

- Sporadically distributed in the coastal waters of Southeast China from Beibu Gulf, near the border of Vietnam, to the mouth of the Yangtze River;
- It was thought there is no Indo-Pacific humpback dolphin in the waters around Hainan.



Threats and conservation challenges of marine mammals in Chinese waters

● A new population was recorded Southwest of Hainan Island in 2014

RESEARCH

Open Access

First record of the Indo-Pacific humpback dolphins (*Sousa chinensis*) southwest of Hainan Island, China



Songhai Li^{1*}, Mingli Lin¹, Xiao Xu^{1,2}, Luru Xing¹, Peijun Zhang¹, Rodolphe E. Gozlan³, Shiang-Lin Huang¹ and Ding Wang⁴

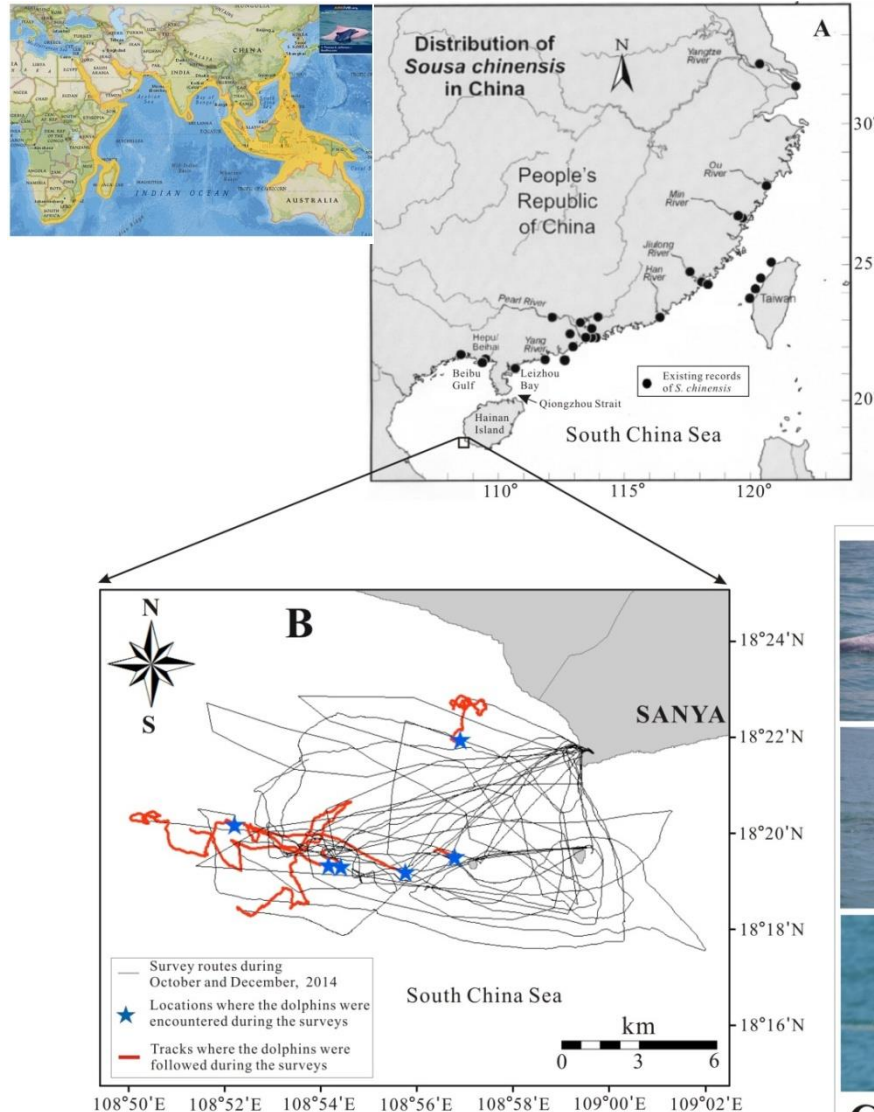
Abstract

Background: Populations of Indo-Pacific humpback dolphins (*Sousa chinensis*) in China were known to be distributed from the Beibu Gulf near the border with Vietnam to the mouth of the Yangtze River. According to existing studies, the waters around Hainan Island, China, were not considered to be part of the humpback dolphins' distribution.

Results: In 2014, for the first time, we recorded humpback dolphins in waters southwest of Hainan Island.

Conclusions: This record expands the known southern distribution range of this dolphin in Chinese waters by more than 300 km.

Keywords: Chinese white dolphin, Marine mammals, Conservation, Distribution





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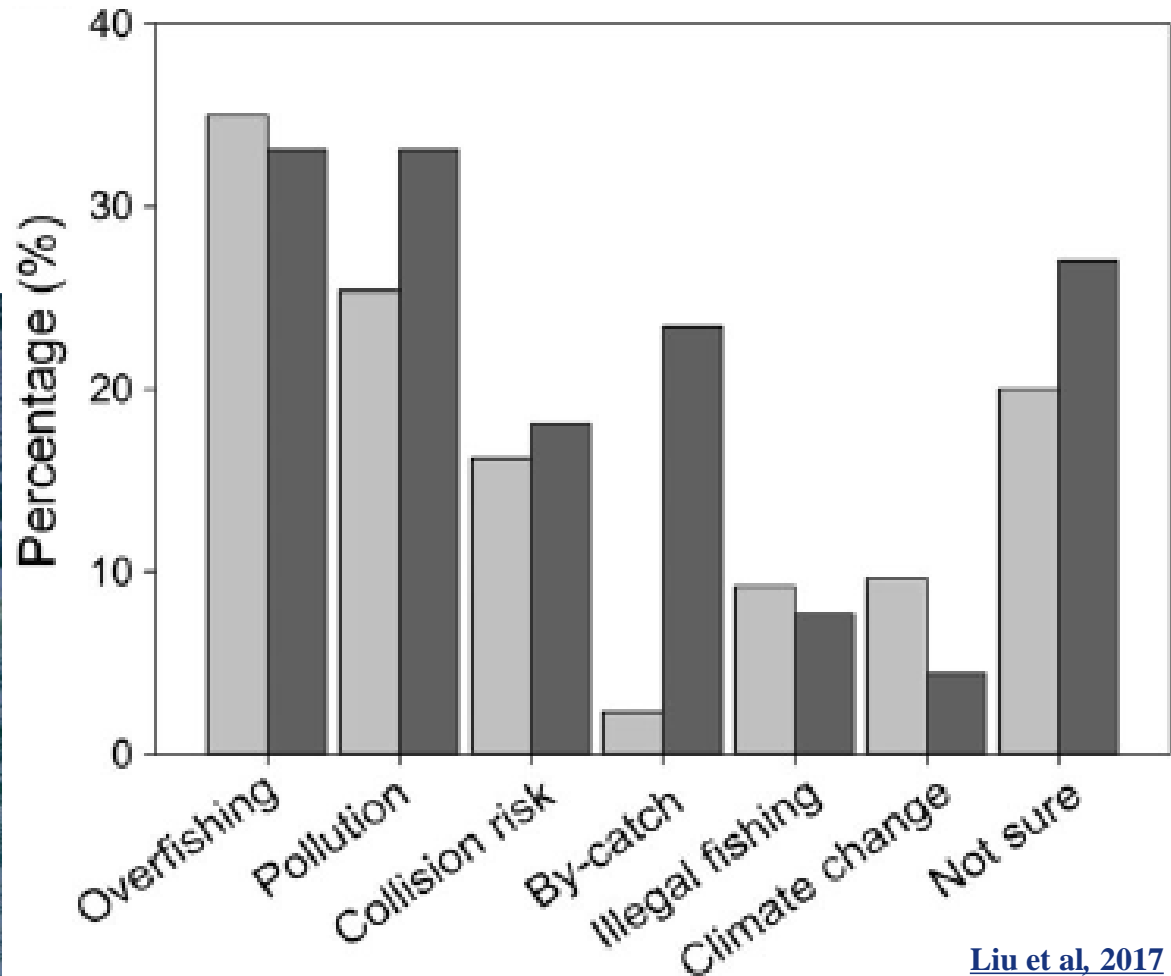
Threats and conservation challenges of marine mammals in Chinese waters





Threats and conservation challenges of marine mammals in Chinese waters

- It's suffering from...
- Population is decreasing quickly, less than 13000 individuals;
- “Vulnerable” by the IUCN.





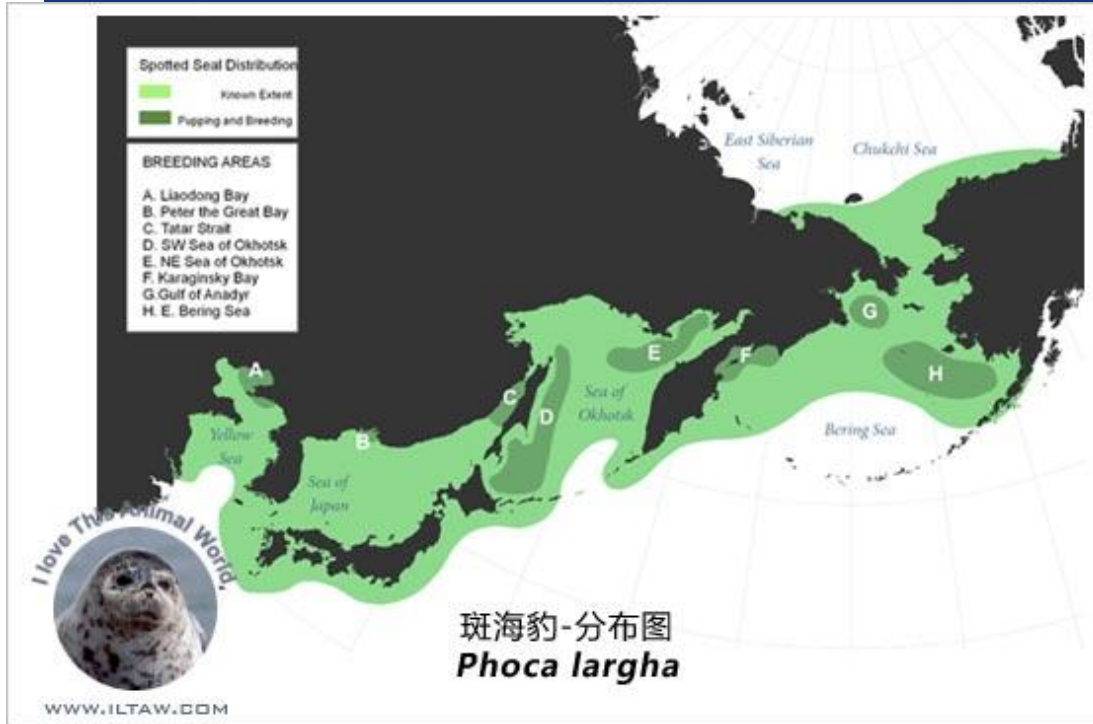
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- Dugong can be found in warm coastal waters from East Africa to Australia, including the Red Sea, Indian Ocean, and Pacific;
- Graze on underwater grasses day and night;
- It distributed in Chinese waters around Hainan Island and in the Beibu Gulf;
- Was listed as one of the Grade 1 National Key Protected Animals by China's Wild Animal Protection Law issued in 1988; Extinct in Chinese waters.



Threats and conservation challenges of marine mammals in Chinese waters



- It's a “true seal”;
- Primarily found along the continental shelf of the Beaufort, Chukchi, Bering and Okhotsk Seas and south to the northern Yellow Sea;
- The only Pinnipeds could breed in Chinese waters;
- Was also listed as one of the Grade 2 National Key Protected Animals by China's Wild Animal Protection Law.



Threats and conservation challenges of marine mammals in Chinese waters

- **Increasing threats**



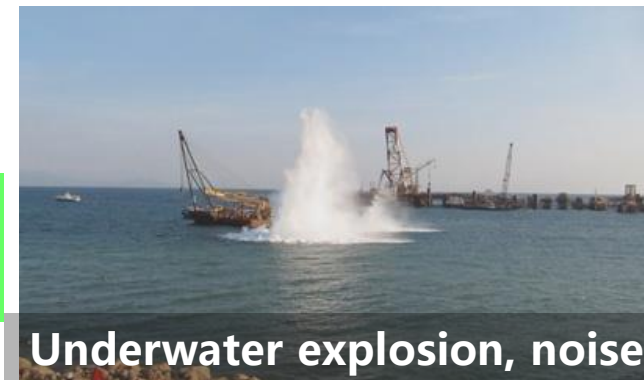
Decreasing in food



Habitat destruction

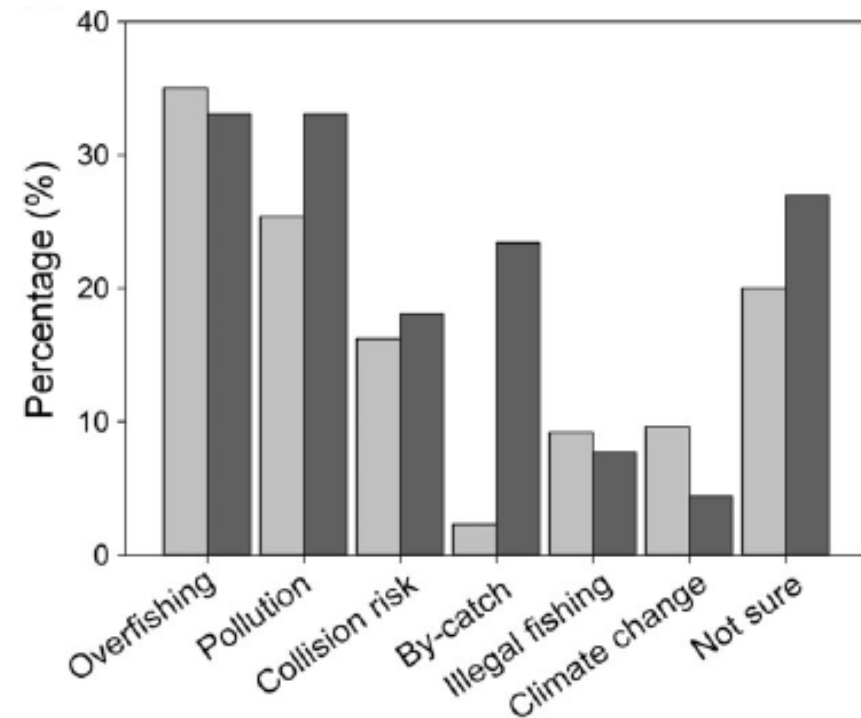
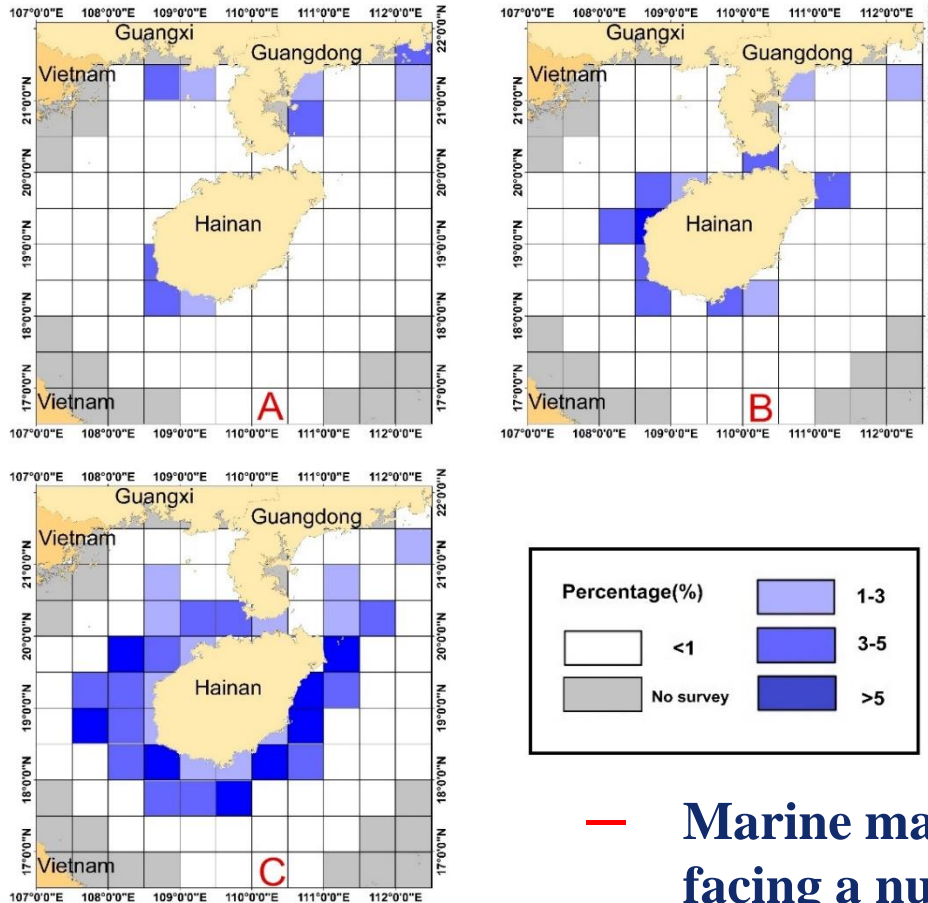


**Direct injury by
Human activities**



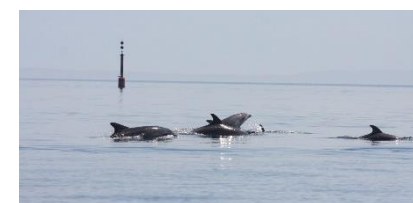


Threats and conservation challenges of marine mammals in South China Sea



Liu et al., 2017

— Marine mammals in the South China Sea are facing a number of threats;





Threats and conservation challenges of marine mammals in South China Sea



- **Overfishing or illegal fishing from the neighboring countries**



Threats and conservation challenges of marine mammals in South China Sea



— All kinds of pollutants from everywhere all around





Threats and conservation challenges of marine mammals in South China Sea



- Underwater noises from the drilling platform, warship, military exercise, and other human activities



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Bioacoustics Laboratory
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Threats and conservation challenges of marine mammals in South China Sea





Threats and conservation challenges of marine mammals in South China Sea



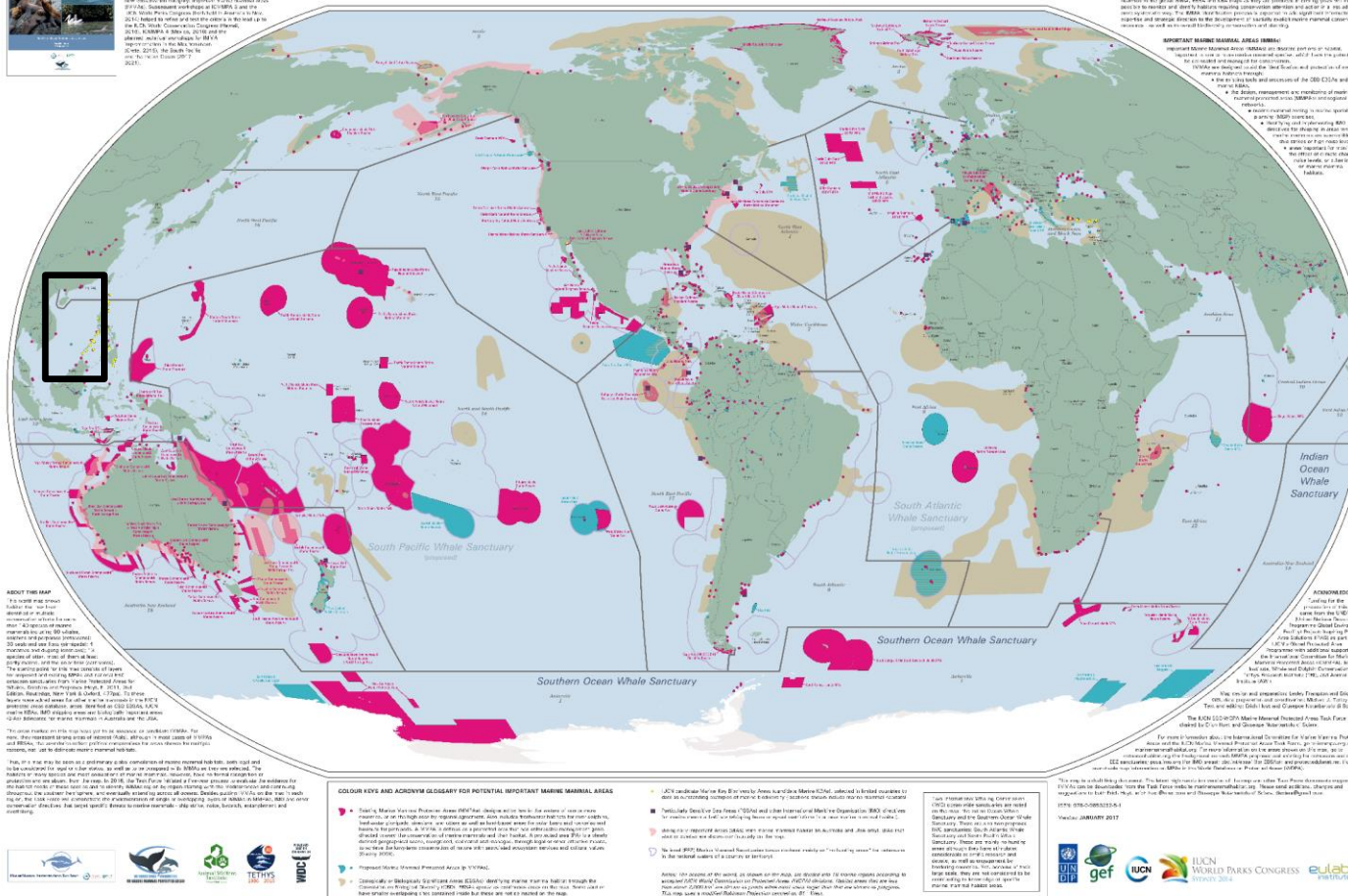
— A lot of marine mammals being stranded every year



Threats and conservation challenges of marine mammals in South China Sea



Working Towards Important Marine Mammal Areas (IMMAs): Ground Zero



— Nothing happened to protect this important Marine Mammal Area



Threats and conservation challenges of marine mammals in South China Sea

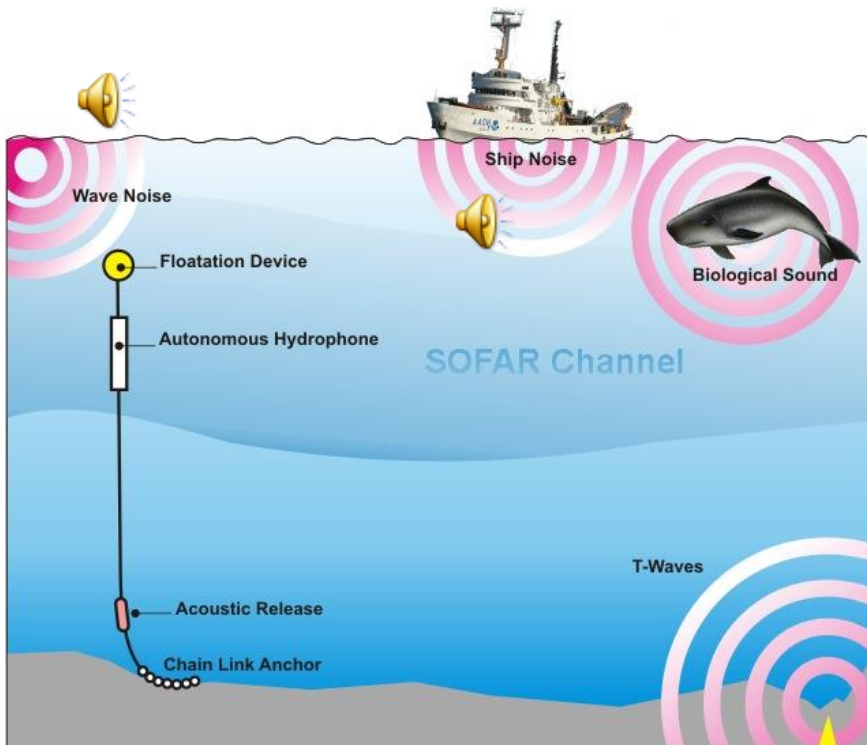


- In order to change or mitigate this tendency, and make a better world for marine mammals in the South China Sea, it's crucial to perform intra-regional or even inter-regional collaboration on joint research and conservation actions on marine mammals within both science and conservation communities.



Bioacoustics of Marine Mammals

- Sound travels far greater distances than light under water;
- The ocean is filled with sound;
- Underwater sound is generated by a variety of natural and man-made sources.



Deep-sea fish



Deep-sea shrimps

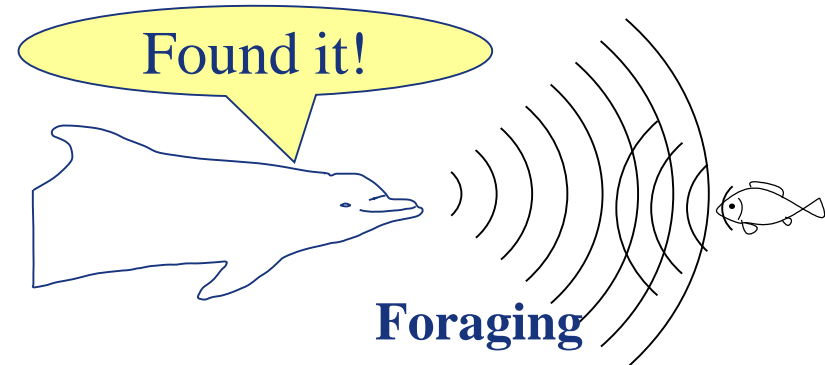
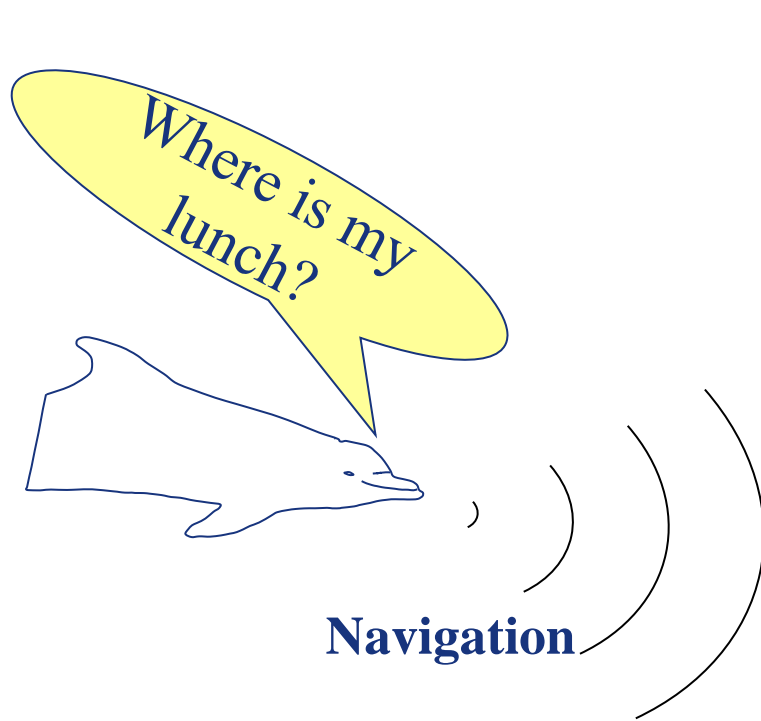


Undersea sounds made by natural and man-made sources



Bioacoustics of Marine Mammals

- All marine mammals rely on sound for survival (communication, mating, foraging, and migration);
- Developed unique adaptations that enable them to communicate, protect themselves, locate food, navigate underwater, and/or understand their environment by sounds;
- Produce sounds and listen to the sounds around them.





Bioacoustics of Marine Mammals



What can I do when I lost my mom in the turbid and muddy waters?

Looking for by vision? **No!**

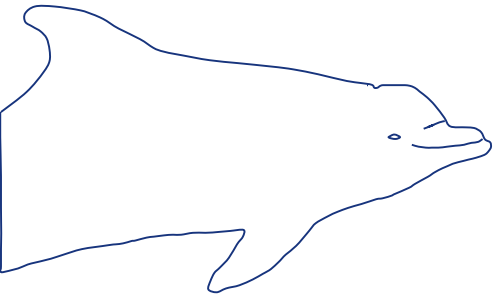
It is by sound!



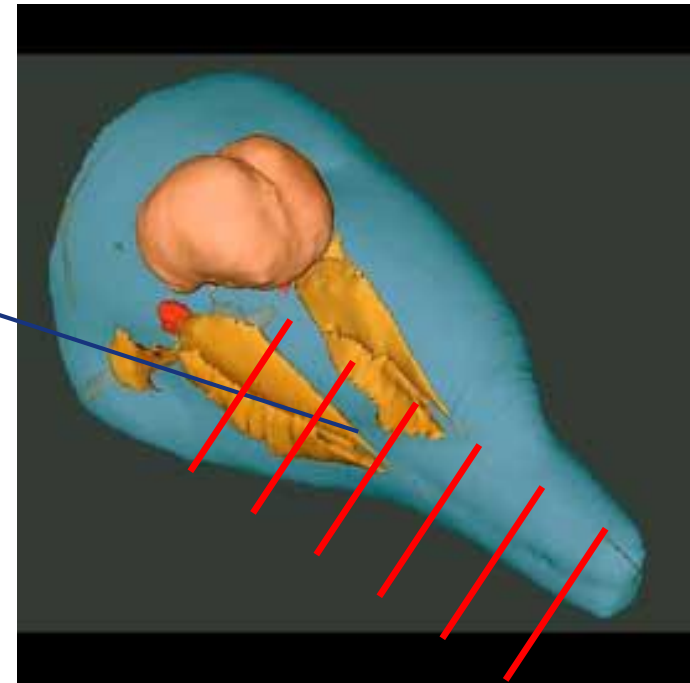
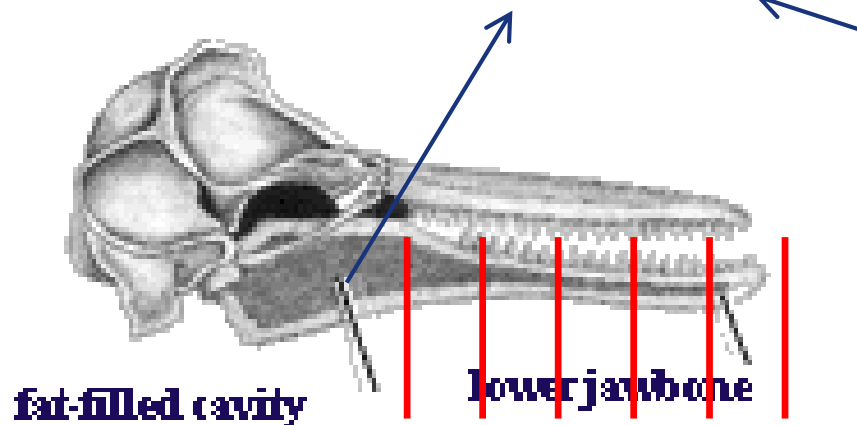


Bioacoustics of Marine Mammals

Echolocation (Biosonar) in Toothed whales



Receiving sound through pan bone
in the lower jaw





Bioacoustics of Marine Mammals

Sounds of several cetacean species

Baleen whales



Humpback whale
Megaptera novaeangliae



Whistles of odontocetes



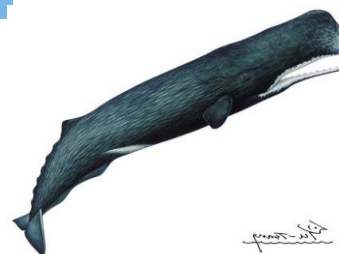
Baiji
Lipotes vexillifer



High-frequency clicks of odontocetes



YFP
*Neophocaena asiaeorientalis
asiaeorientalis*



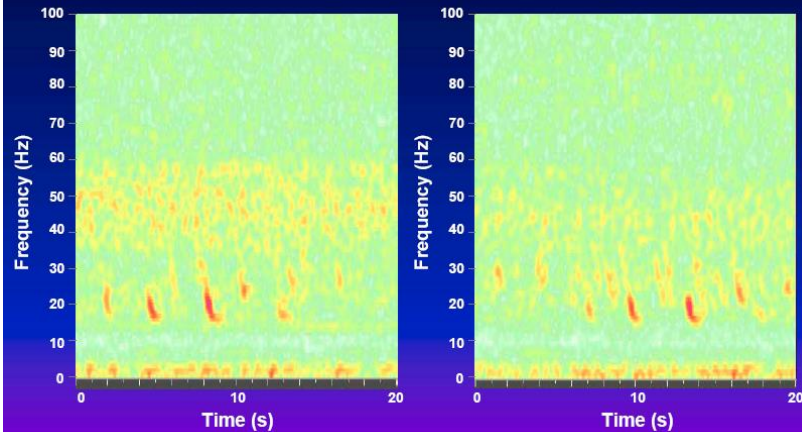
Sperm whale
Physeter macrocephalus



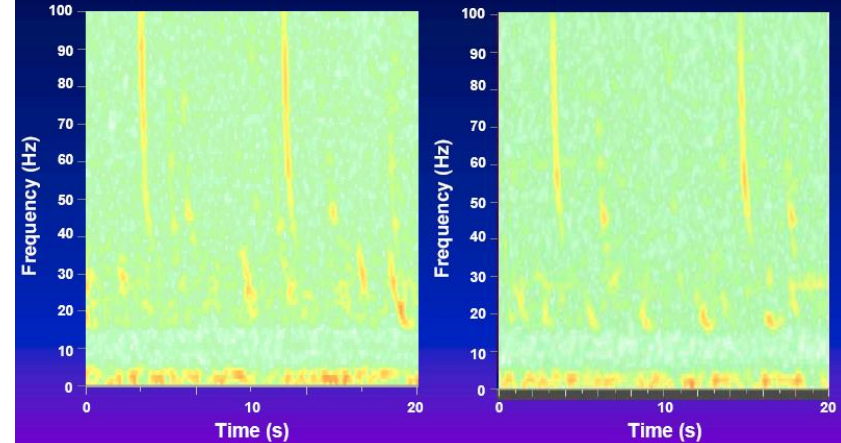


Bioacoustics of Marine Mammals

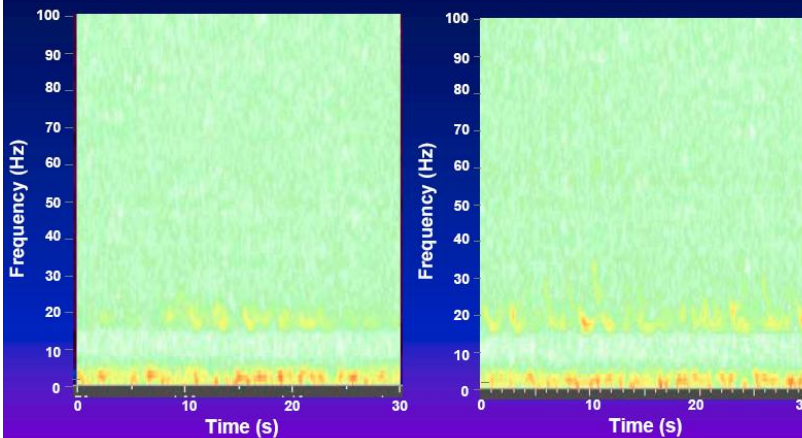
Examples of fin whale calls



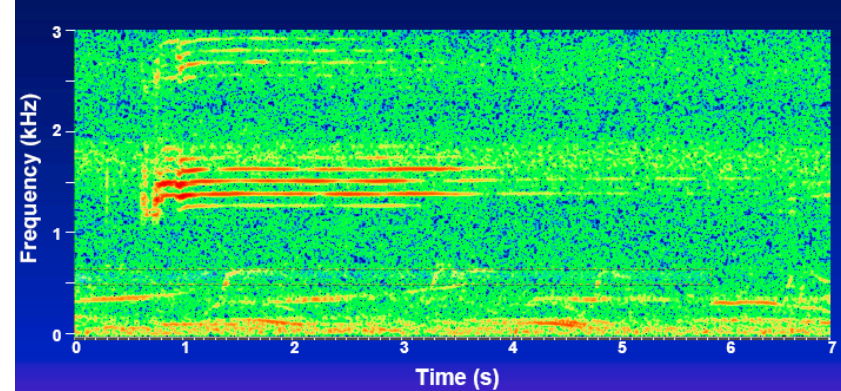
Examples of sei whale calls



Examples of blue whale calls



Examples of minke whale calls (boing)





Bioacoustics of Marine Mammals

Frequency range of sounds from several baleen whale species

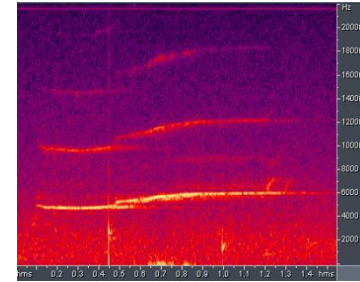
| Species | Frequency range(kHz) | References |
|---|----------------------|--|
| bowhead whale (<i>Balaena mysticetus</i>) | 0.02-3.5 | Thompson <i>et al.</i> 1979; Ljungblad <i>et al.</i> 1980, 1982; Norris and Leatherwood 1981; Clark and Johnston 1984; Wursig <i>et al.</i> 1985. |
| common minke whale (<i>Balaenoptera acutorostrata</i>) | 0.06-6 | Schevill and Watkins 1972; Winn and Perkins 1976. |
| sei whale (<i>Balaenoptera borealis</i>) | 1.5-3.5 | Thompson <i>et al.</i> 1979; Knowlton <i>et al.</i> 1991. |
| blue whale (<i>Balaenoptera musculus</i>) | 0.012-0.4 | Cummings and Thompson 1971, 1994; Edds 1982; Stafford <i>et al.</i> 1988. |
| fin whale (<i>Balaenoptera physalus</i>) | 0.01-28 | Thompson <i>et al.</i> 1979; Watkins 1981; Cummings <i>et al.</i> 1986; Watkins <i>et al.</i> 1987; Edds 1988; Clark 1990; Cummings and Thompson 1994. |
| southern right whale (<i>Eubalaena australis</i>) | 0.03-2.2 | Cummings <i>et al.</i> 1972; Clark 1982, 1983. |
| North Atlantic right whale (<i>Eubalaena glacialis</i>) | <0.4 | Watkins and Schevill 1972; Thompson <i>et al.</i> 1979; Spero 1981; Clark 1990. |
| gray whale (<i>Eschrichtius robustus</i>) | 0.02-20 | Cummings <i>et al.</i> 1968; Fish <i>et al.</i> 1974; Norris <i>et al.</i> 1977; Swartz and Cummings 1978; Dahlheim <i>et al.</i> 1984; Moore and Ljungblad 1984; Dahlheim and Ljungblad 1990. |
| humpback whale (<i>Megaptera novaeangliae</i>) | 0.02-10 | Thompson <i>et al.</i> 1979; Watkins 1981; Edds 1982, 1988; K. Payne <i>et al.</i> 1983; Payne and Payne 1985; Silber 1986; Thompson <i>et al.</i> 1986. |



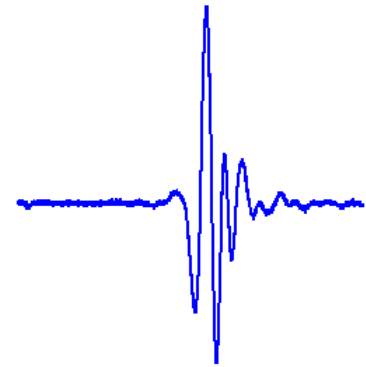
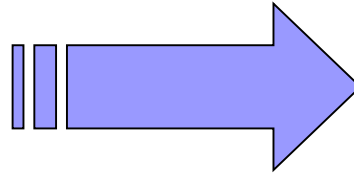
Bioacoustics of Marine Mammals



Baiji / Yangtze River dolphin



Whistle



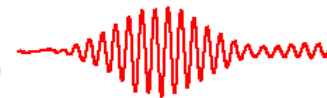
Click



Finless porpoises

Transmit path via 'Melon'

Echo reception via lower jaw



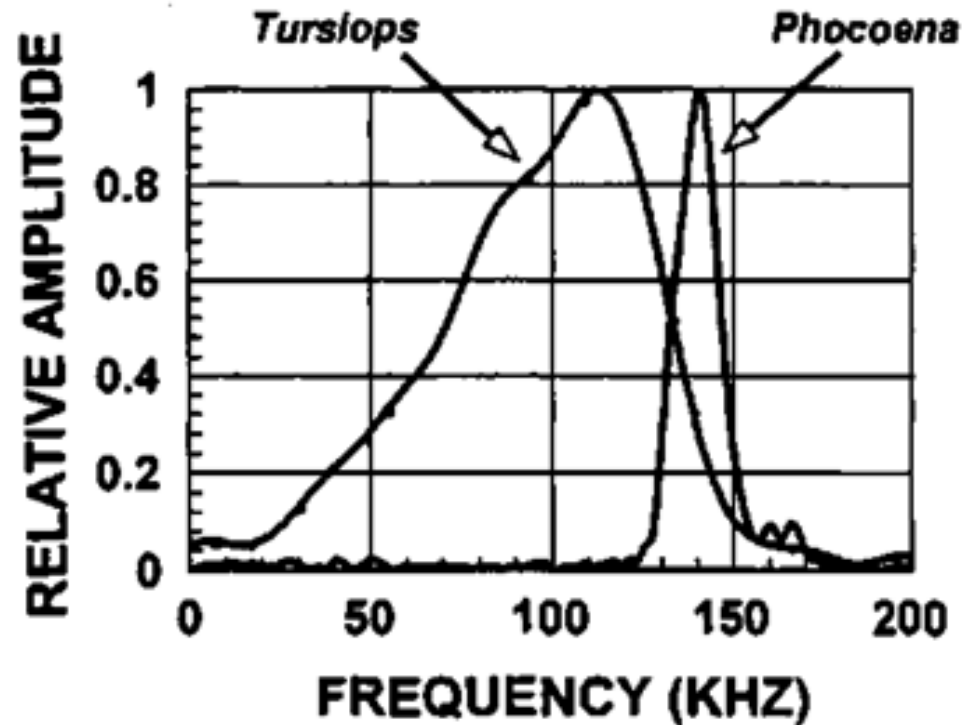
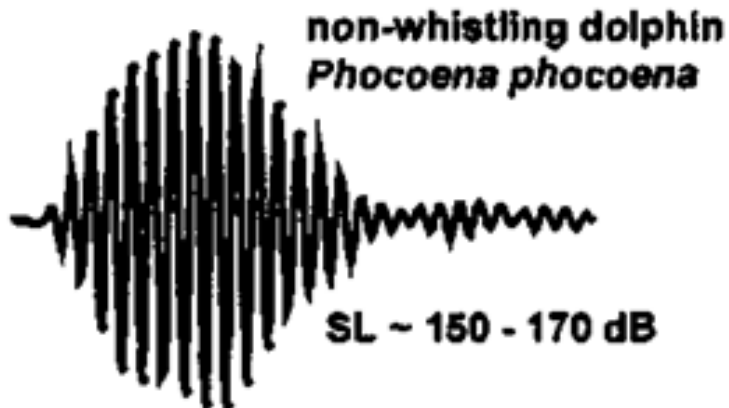
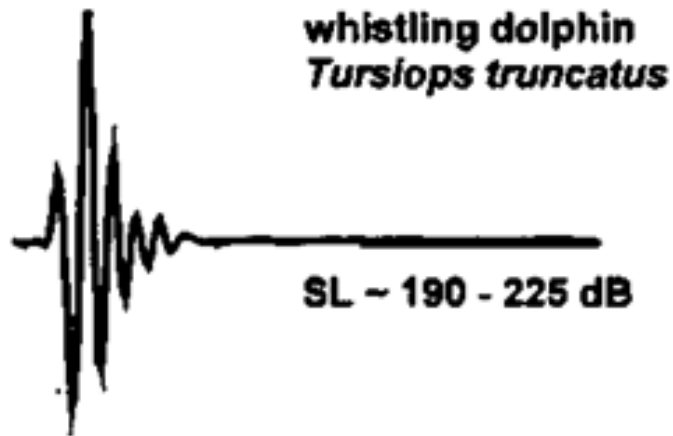
Click

50μs



Bioacoustics of Marine Mammals

Two categories of echolocation clicks



Waveform and spectrum of the two click categories



Bioacoustics of Marine Mammals

Frequency range of whistles from several odontocete species

| Species | Frequency range (kHz) | References |
|--|-----------------------|---|
| dusky dolphin (<i>Lagenorhynchus obscurus</i>) | 1.04-27.3 | Wang <i>et al.</i> 1995a. |
| Beluga (<i>Delphinapterus leucas</i>) | 0.2-19.6 | Karlsen <i>et al.</i> 2002; Matthews <i>et al.</i> 1999. |
| Baiji (<i>Lipotes vexillifer</i>) | 3.8-6.8 | Wang <i>et al.</i> 1999; Wang <i>et al.</i> 2006. |
| spinner dolphin (<i>Stenella longirostris</i>) | 0.85-25 | Barzua-Duran and Au 2002, 2004; Wang <i>et al.</i> 1995a. |
| Atlantic spotted dolphin (<i>Stenella frontalis</i>) | 5-19.8 | Wang <i>et al.</i> 1995a. |
| bottlenose dolphin (<i>Tursiops truncatus</i>) | 0.94-41 | Boisseau 2005; Wang <i>et al.</i> 1995a, b. |
| Amazon River dolphin (<i>Inia geoffrensis</i>) | 0.22-64.63 | May-Collado and Wartzok in prep.; Wang <i>et al.</i> 1995b, 2001. |
| tucuxi (<i>Sotalia fluviatilis</i>) | 0.5-38.25 | Azevedo and Simao 2002; Erber and Simao 2004; Podos <i>et al.</i> 2002; Wang <i>et al.</i> 1995a, 2001. |
| Indo-Pacific humpback dolphin (<i>Sousa chinensis</i>) | 0.9-22 | Van Parijs and Corkeron 2001; Zbinden <i>et al.</i> 1977. |



Bioacoustics of Marine Mammals

| Species | Peak frequency (kHz) | 3-dB bandwidth (kHz) | Source level (dB) | Time duration (us) | Location | References |
|---|----------------------|----------------------|-------------------|--------------------|------------------------|--|
| Commerson's dolphin <i>Cephalorhynchus commersonii</i> | 120-134 | 17-22 | 160 | 180-600 | Pool | Kamminga and Wiersma (1982); Evans <i>et al.</i> (1988) |
| Beluga <i>Delphinapterus leucas</i> | 100-115 | 30-60 | 225 | 50-80 | Bay | Au <i>et al.</i> (1985); Au <i>et al.</i> (1987) |
| short-beaked common dolphin <i>Delphinus delphis</i> | 23-67 | 17-45 | - | 50-150 | Ocean | Dziedzic (1978) |
| long-finned pilot whale <i>Globicephala melaena</i> | 30-60 | - | 180 | - | Pool | Evans (1973) |
| Amazon River dolphin <i>Inia geoffrensis</i> | 95-105 | - | - | 200-250 | River | Kamminga <i>et al.</i> (1989) |
| Baiji <i>Lipotes vexillifer</i> | 50-100 | 37 | 156 | - | Pool | Xiao and Jing (1989) |
| Finless porpoise <i>Neophocaena phocaenoides</i> | 128 125 | 11 20 | - 164-186 | 127 68 | Pool, wild, wild | Kamminga (1988) Li <i>et al.</i> (2005a) Li <i>et al.</i> (2006) |
| Irrawaddy dolphin <i>Orcaella brevirostris</i> | 50-60 | ~22 | - | 150-170 | Pool | Kamminga <i>et al.</i> (1983) |
| killer whale <i>Orcinus Orca</i> | 14-20 | ~4 | 178 | 210 | Pool | Evans (1973) |
| harbor porpoise <i>Phocoena phocoena</i> | 120-140 | 10-15 | 162 | 130-260 | Pool | Møhl and Andersen (1973); Kamminga and Wiersma (1981); Hatakeyama <i>et al.</i> (1988) |
| false killer whale <i>Pseudorca crassidens</i> | 100-130 | 15-40 | 228 | 100-120 | Bay | Thomas and Turl (1990) |
| tucuxi <i>Sotalia fluviatilis</i> | 95-100 | ~40 | - | 120-200 | Pool and River | Wiersma (1982); Kamminga <i>et al.</i> (1989) |
| common bottlenose dolphin <i>Tursiops Truncatus</i> | 110-130 | 30-60 | 228 | 50-80 | Bay | Au (1980) |



Bioacoustics of Marine Mammals

Day 1



Day 22



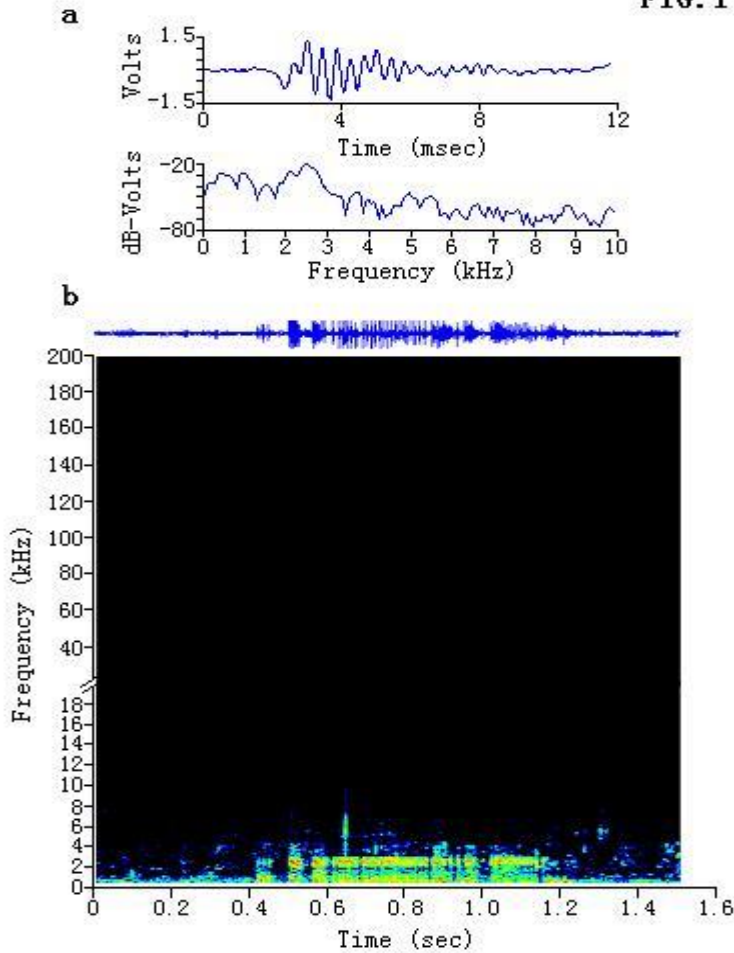
Mature porpoise





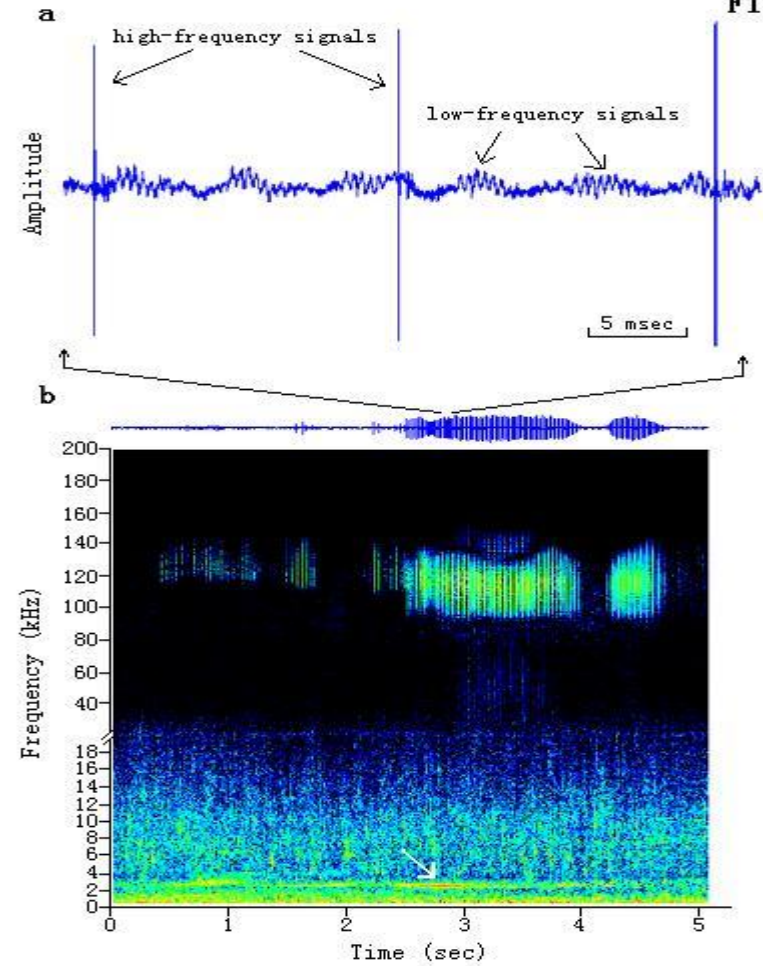
Bioacoustics of Marine Mammals

FIG. 1



Day 1

FIG. 2

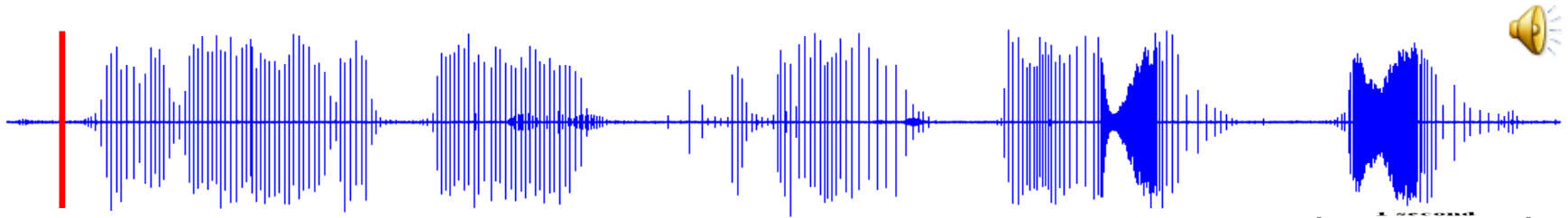


Day 22



Bioacoustics of Marine Mammals

Characteristics of echolocation click train of odontocetes

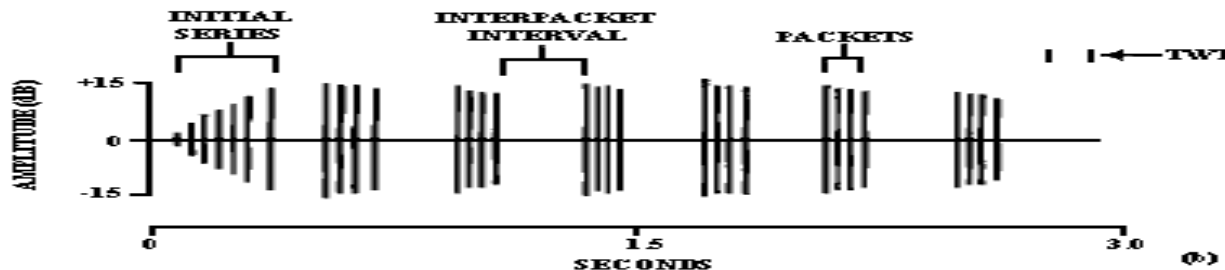


Click train of YFP



(a)

Typical click train pattern of beluga during target detection



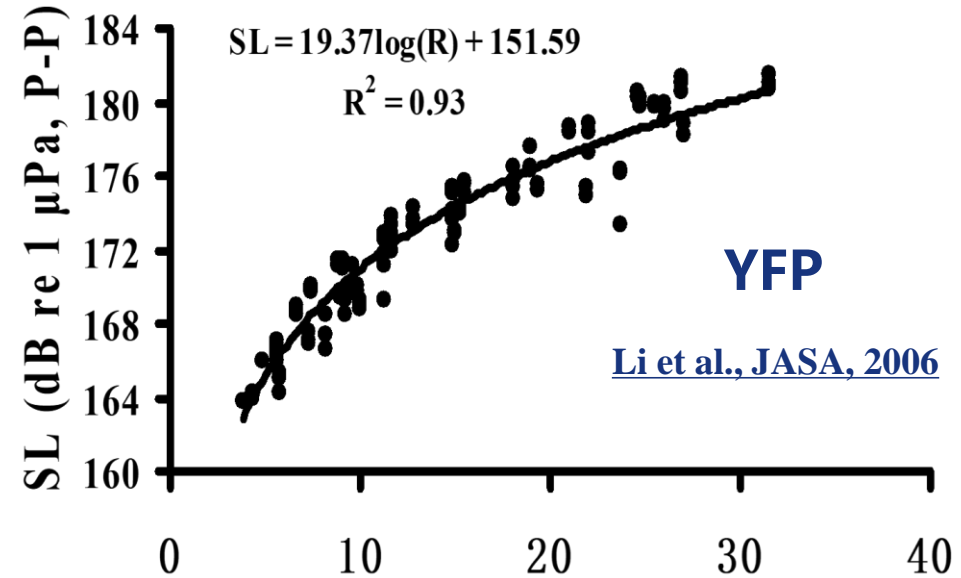
(b)

(From Turl and Penner, 1989)

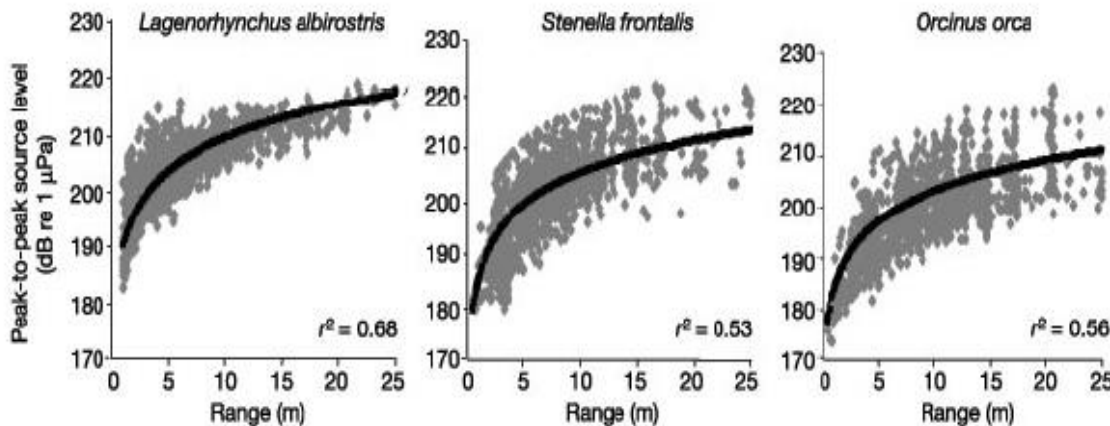


Bioacoustics of Marine Mammals

Sonar gain control



6 dB/dh transmitting AGC



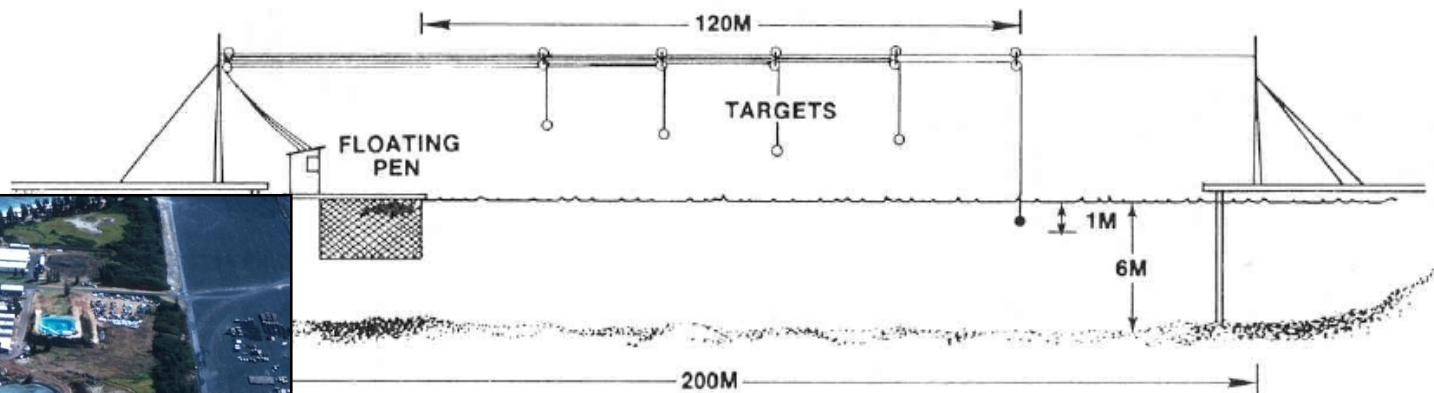
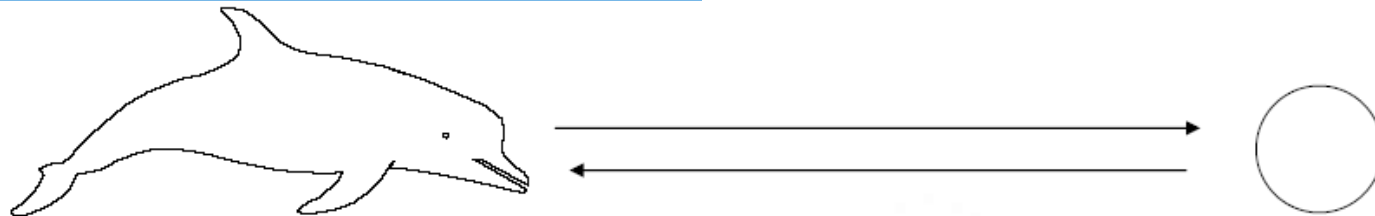
[Au and Benoit-Bird, Nature, 2003](#)

- RANGE (m)
- Sound source levels of echolocation clicks increase with target distance;
- The source level increases 6 dB in each distance doubling



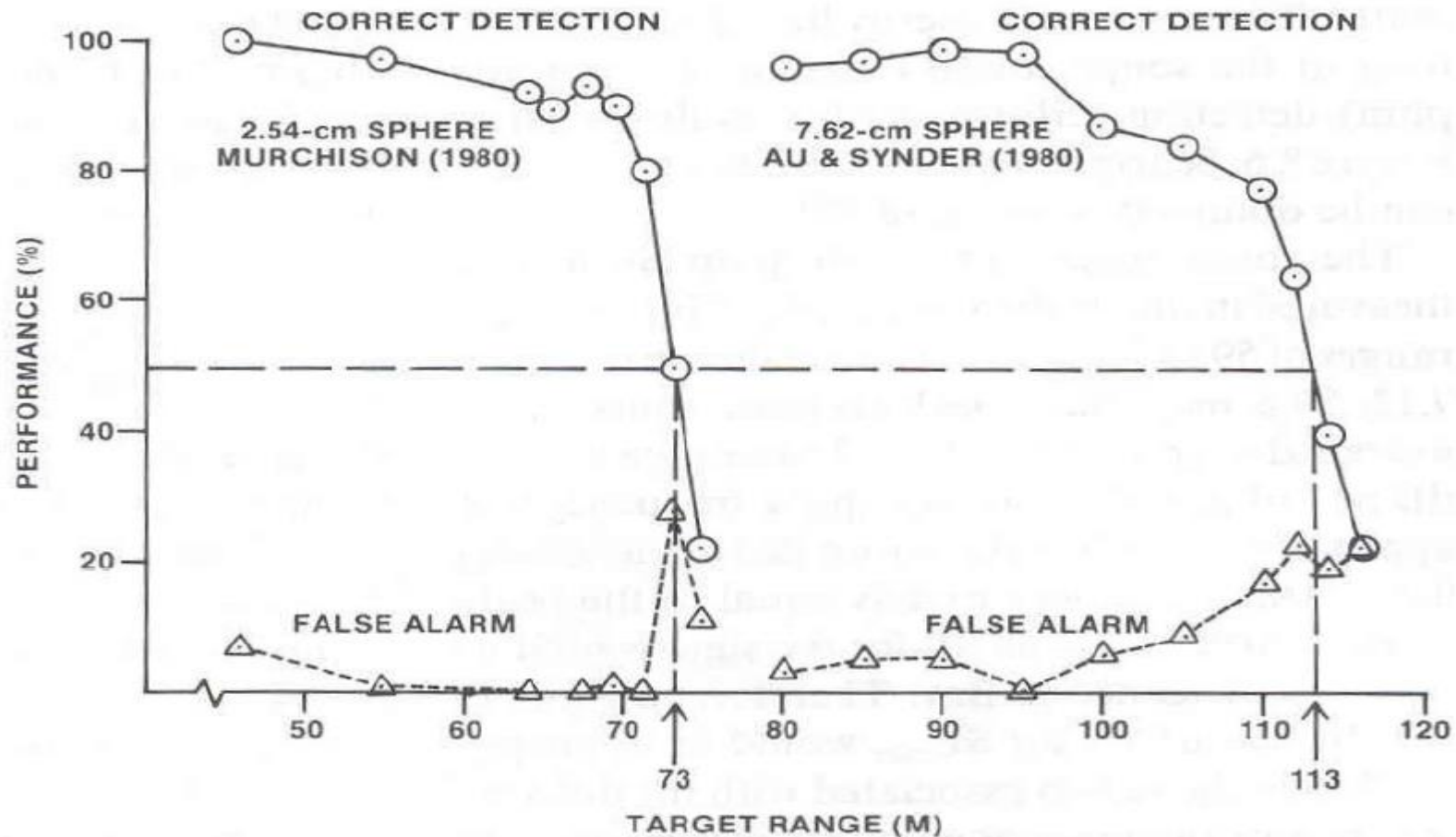
Bioacoustics of Marine Mammals

Biosonar detection capabilities





Bioacoustics of Marine Mammals



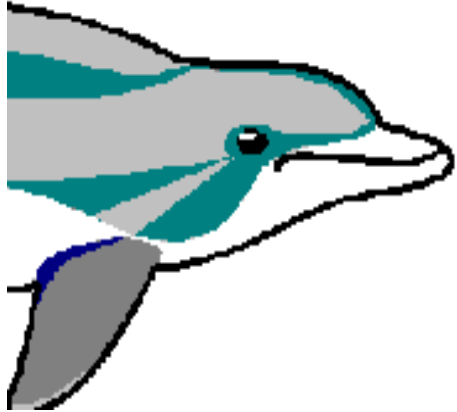
(Au, 1993)

- Bottlenose dolphin is able to detect a 2.54-cm steel sphere up to 73 m, and 7.62-cm steel sphere up to 113 m

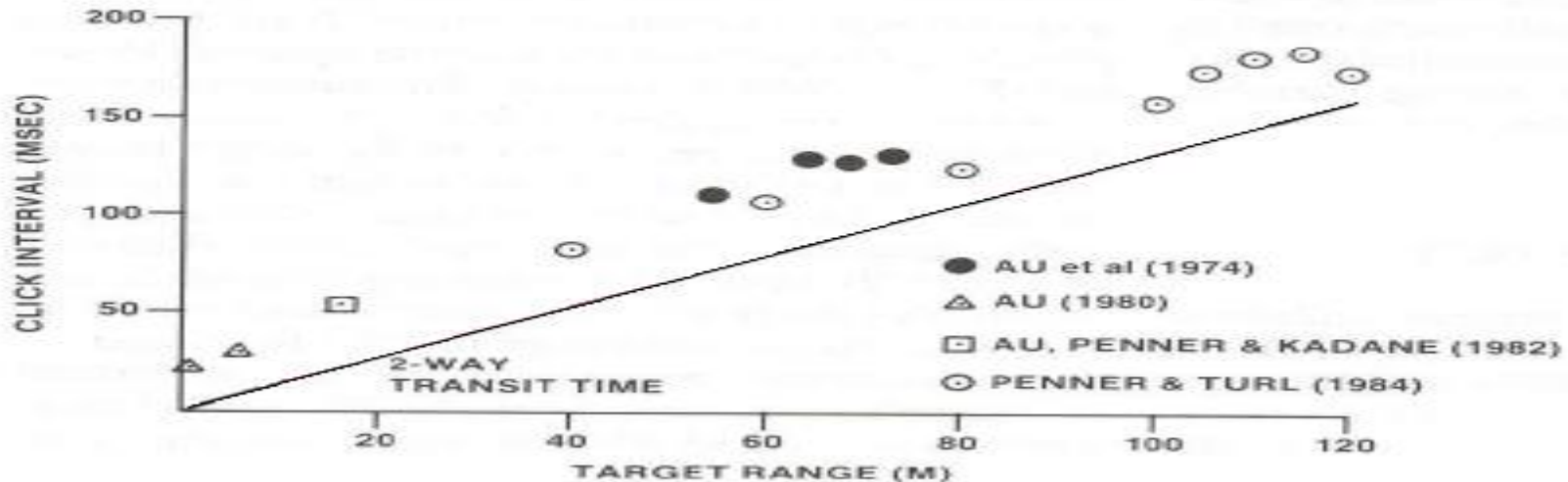


Bioacoustics of Marine Mammals

Biosonar range is also observable



$$\text{ICI} = \text{TWT} + 20 \text{ msec lag time}$$





Bioacoustics of Marine Mammals

2003/10/17

Date & time

16:11:00

16:11:10

16:11:20

Time

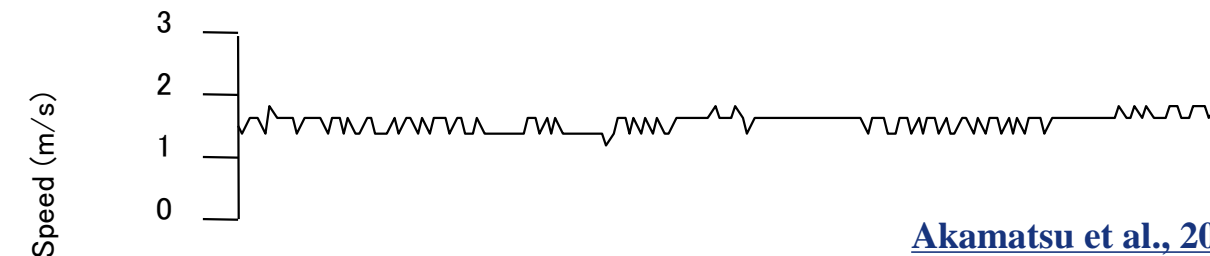
Silent



SLs and Silent phase



Inter-click interval

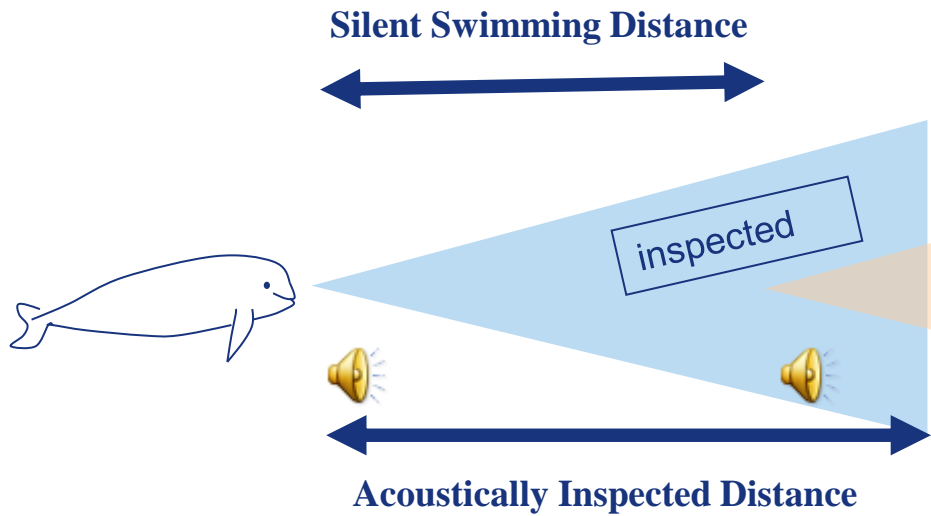


Swimming speed

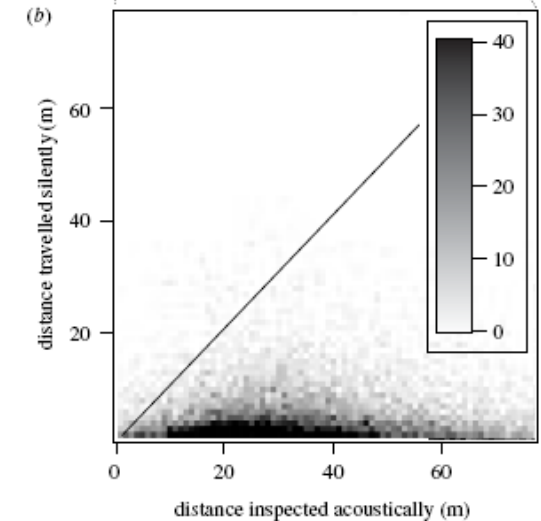
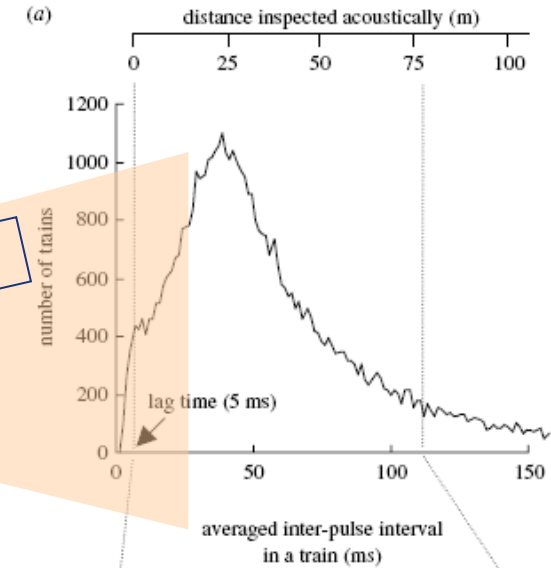
Akamatsu et al., 2005



Bioacoustics of Marine Mammals

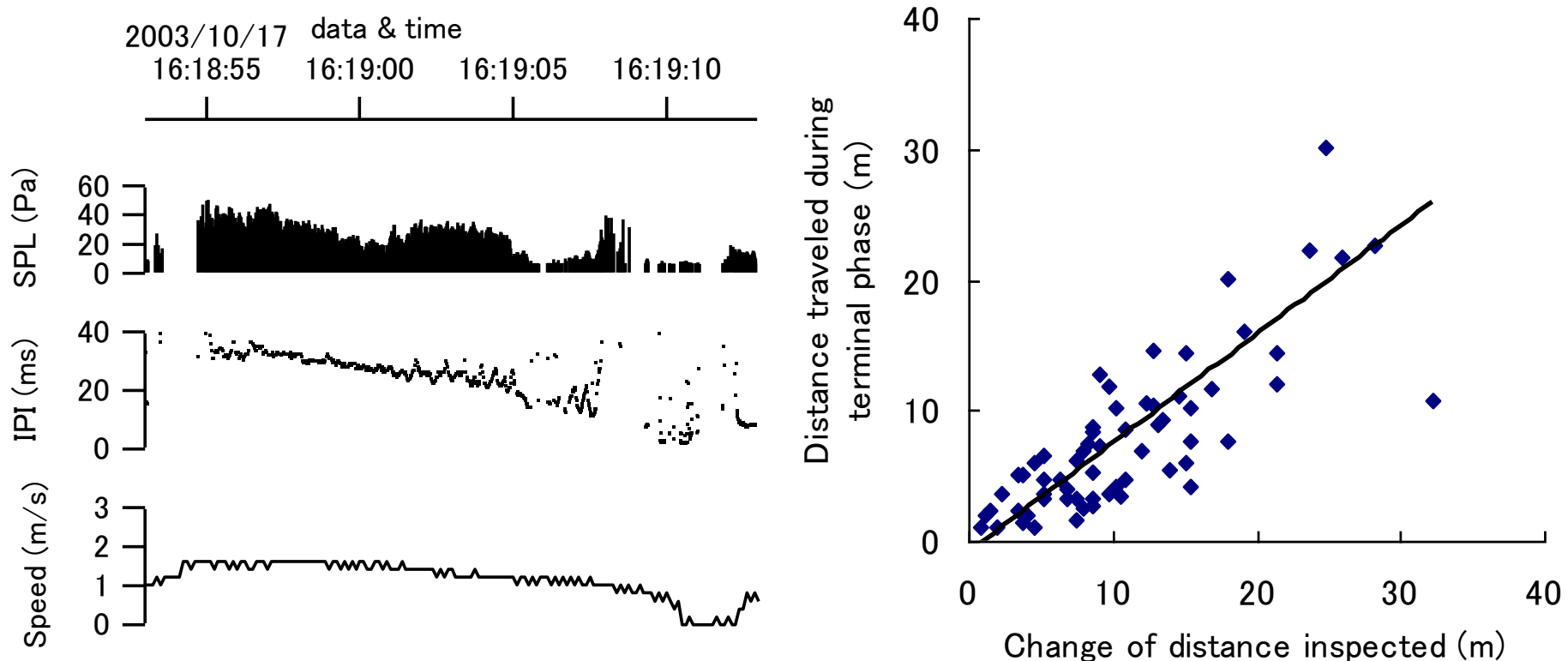


— **Silent Swimming Distance < Acoustically Inspected Distance**





Bioacoustics of Marine Mammals

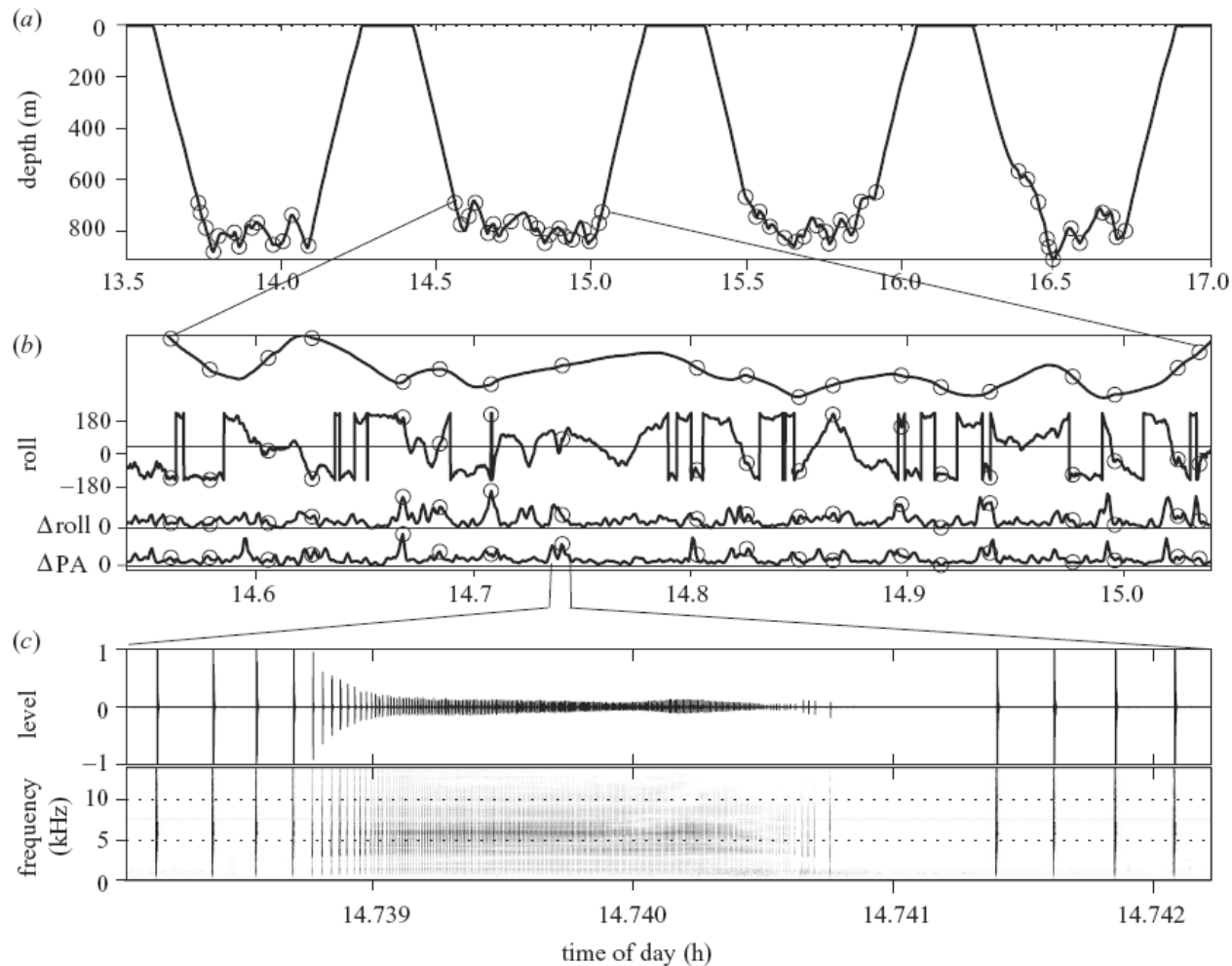


- The distance traveled during terminal phase (approaching phase) correlated to the change of distance inspected acoustically, that means the porpoises do focus their target by sonar.

Akamatsu et al., 2005



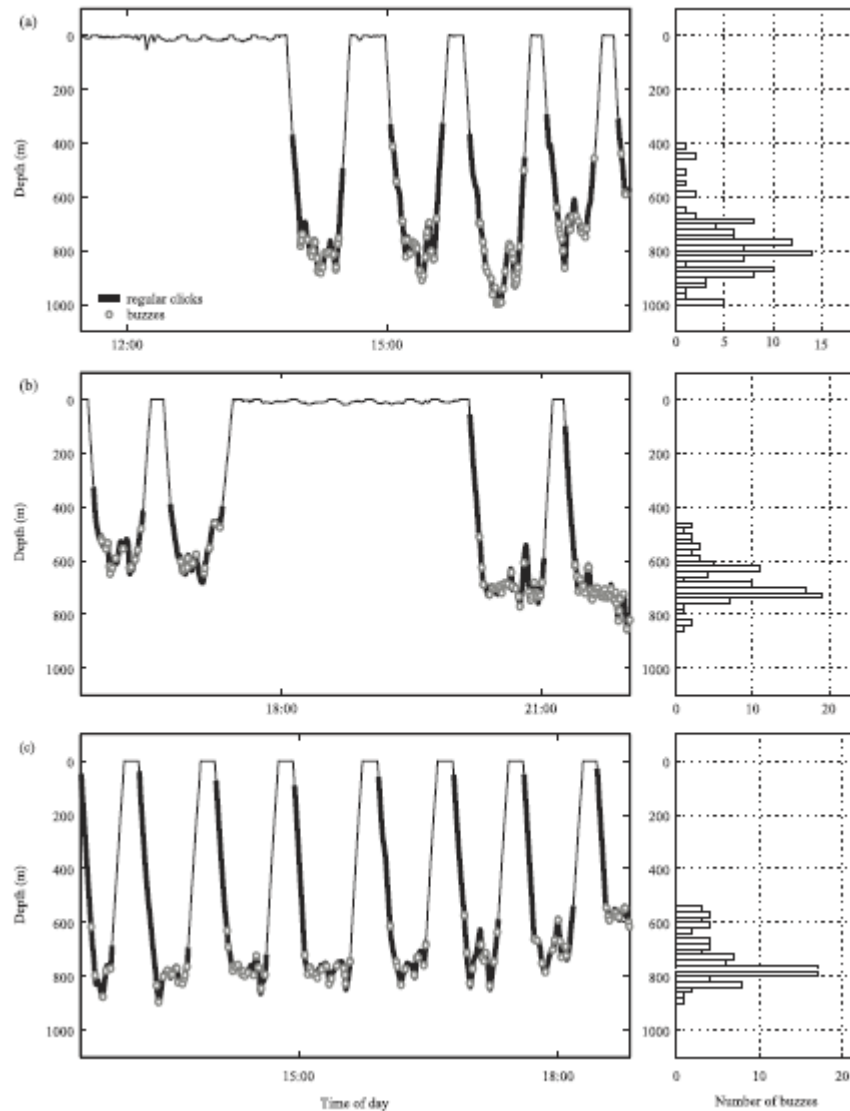
Bioacoustics of Marine Mammals



- Sperm whales were also observed to produce the terminal phase (approaching phase) click trains



Bioacoustics of Marine Mammals



- Sperm whale only produces the terminal phase click trains at depth over 400 m.;
- May be related to its foraging behavior at the bottom.



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Institute of Deep-sea Science and Engineering, CAS



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Bioacoustics of Marine Mammals

SEARCH and DESTROY

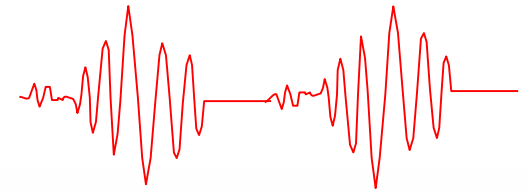


Bioacoustics of Marine Mammals

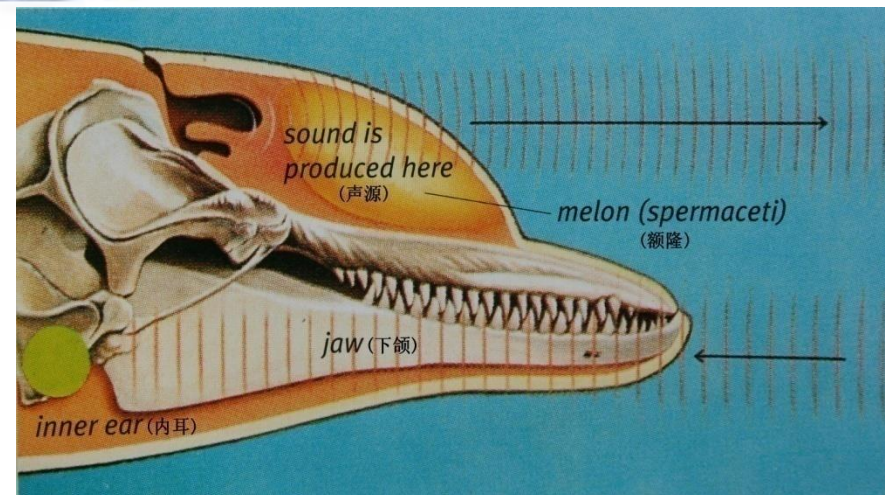
声音从鼻囊和“猴唇”复合体发出

经由额隆聚焦向水中发射

回声进入下颌的脂肪腔



The biosonar system consists of both sound production and receiving parts





Bioacoustics of Marine Mammals

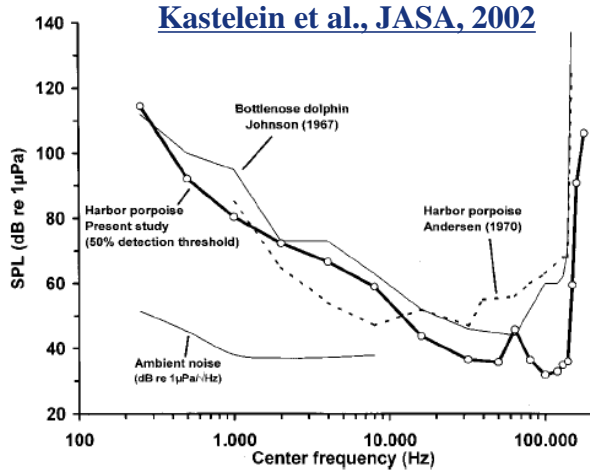


FIG. 4. The mean 50% detection thresholds in dB *re* 1 μ Pa (rms) for the tested narrow-band FM signals in the present study ($n=12-15$ mean session threshold per frequency, for details see Table I). Also shown is the audiogram determined by Andersen (1970) for one harbor porpoise (sample size per frequency threshold unknown, and definition of the threshold unknown), and the audiogram of an Atlantic bottlenose dolphin (Johnson, 1967). The spectral level (dB *re* 1 μ Pa/ $\sqrt{\text{Hz}}$; note that this is a different unit than the one along the Y axis) of the ambient noise in the pool is shown up to 8 kHz.



Harbor porpoise



Finless porpoise

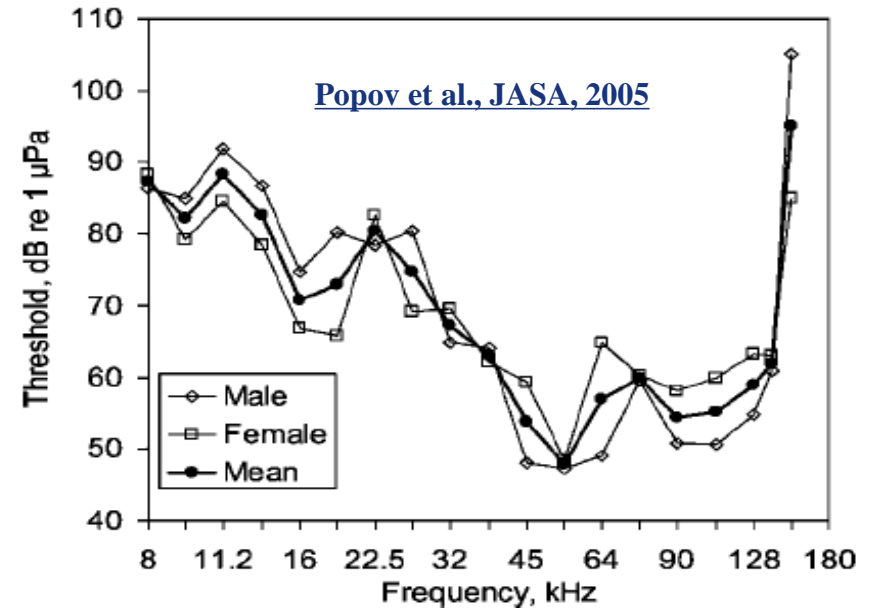
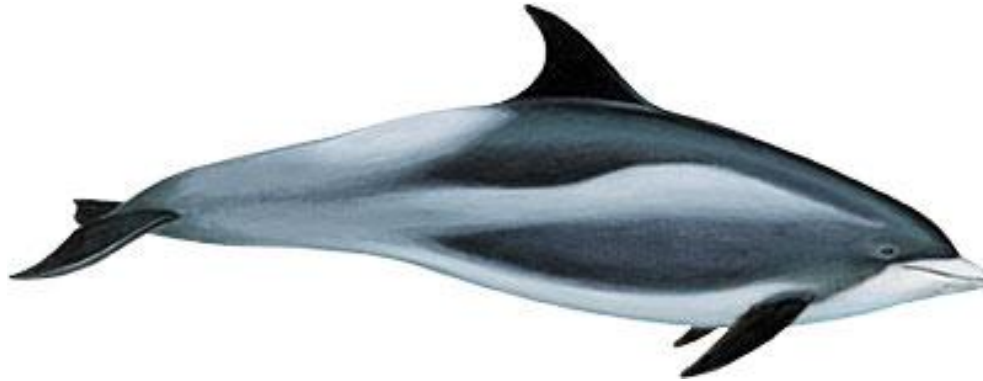


FIG. 3. Audiograms of the two subjects and the mean of two.



Bioacoustics of Marine Mammals



White-beaked dolphin

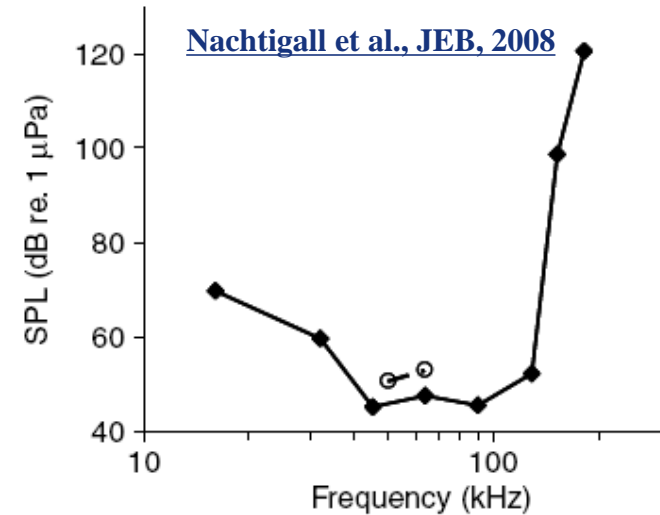
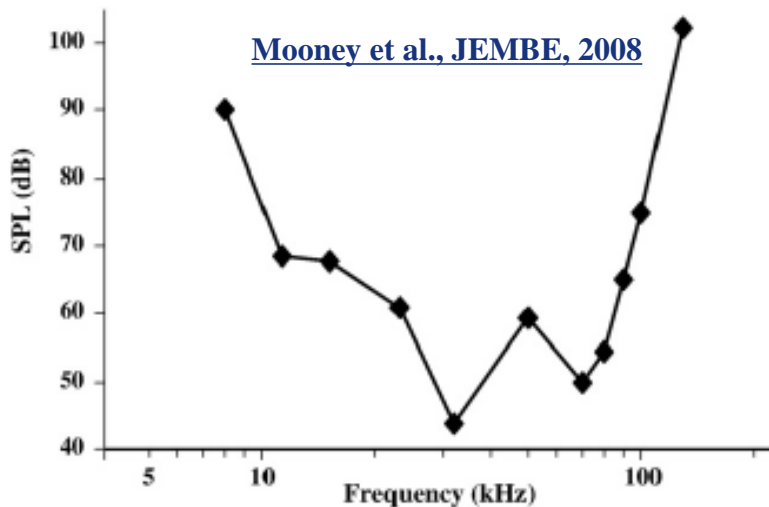


Fig. 9. Partial and entire evoked potential audiogram of two white beaked dolphins, *Lagenorhynchus albirostris*. Female dolphin: broken line with open circles; male dolphin: solid line with black diamonds. The values above 100 kHz are 128 kHz, 152 kHz and 181 kHz.

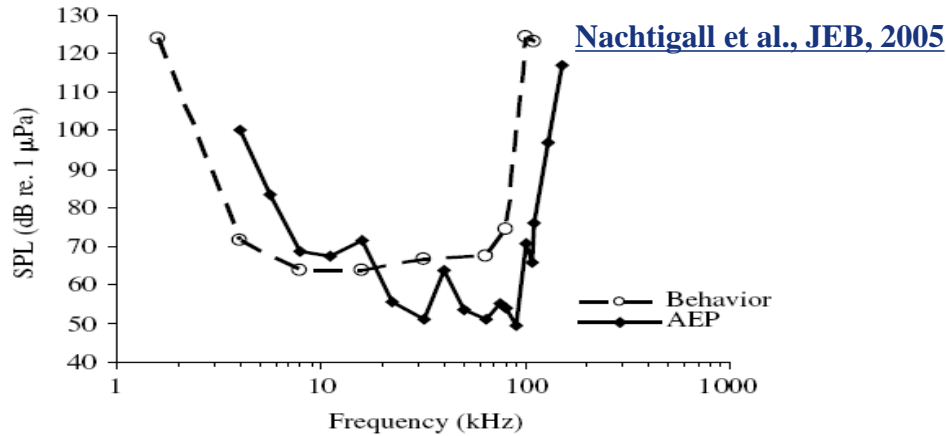


Beluga whale

Fig. 3. AEP audiogram of the beluga whale subject stationed at the surface. Thresholds in dB (re: 1 μPa) were measured from 8 to 128 kHz using SAM tones.



Bioacoustics of Marine Mammals

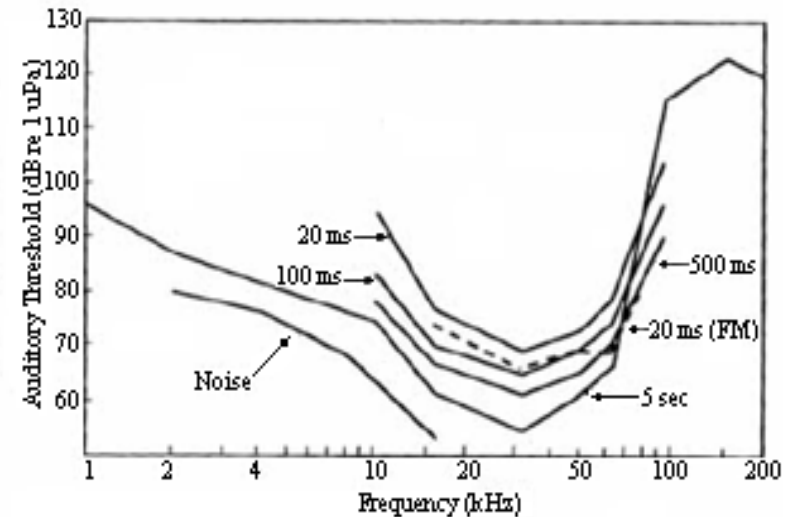


Risso's dolphin

Fig. 7. Comparison of an auditory evoked potential (AEP) and behavioral audiogram of two Risso's dolphins. The behavioral threshold was published by Nachtigall et al. (1995). The y-axis is intensity of stimulus, or sound pressure level (SPL) in dB. Nachtigall et al. (1995) used a pure-tone, 3 s stimulus; the present study used a 20 ms SAM.



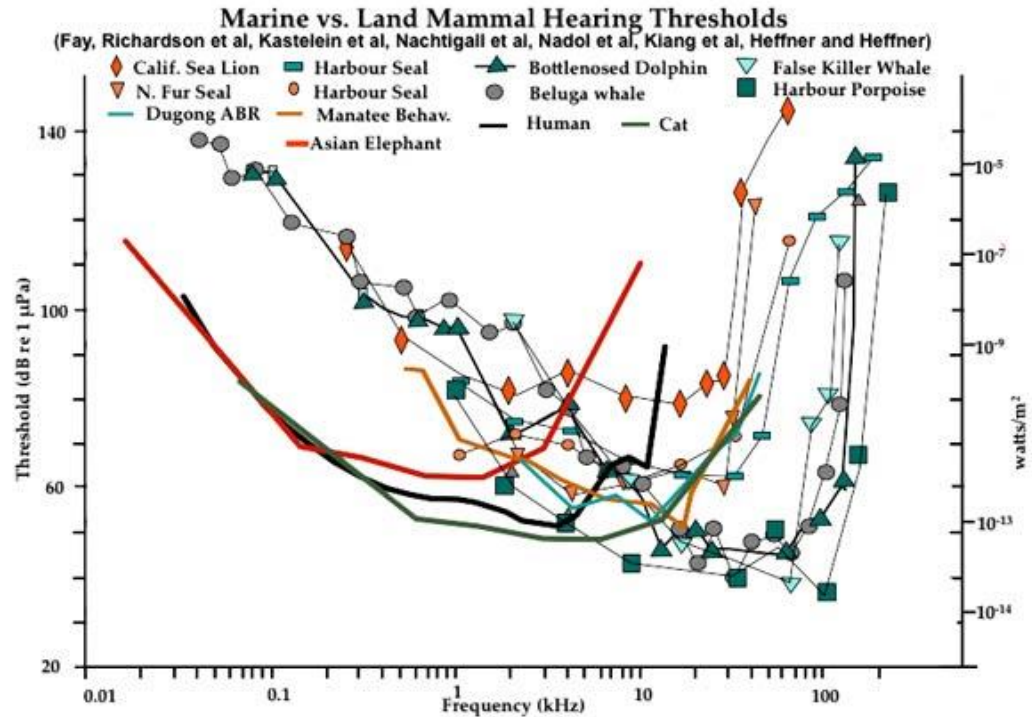
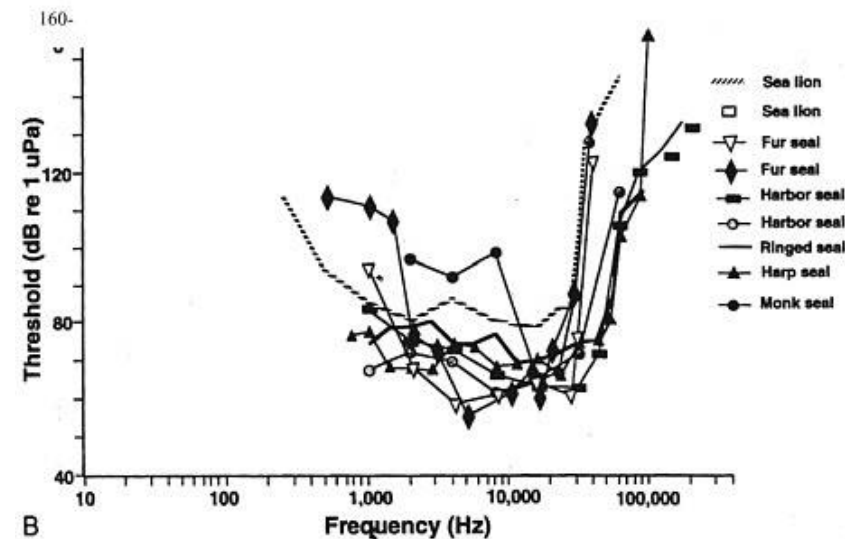
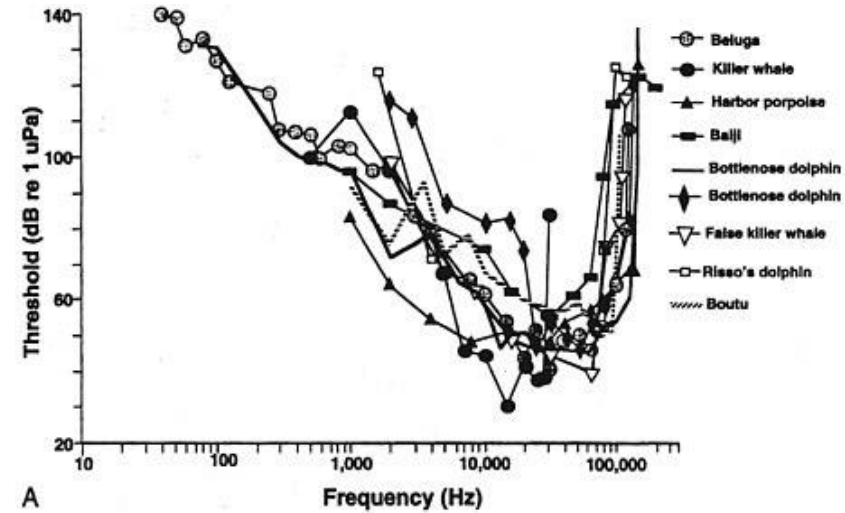
Baiji



Wang et al., 1992



Bioacoustics of Marine Mammals



● Audiograms of odontocetes and pinnipeds, and comparison of audiograms between marine and land mammals including human being



Bioacoustics of Marine Mammals

Frequency range of hearing and best sensitivity of odontocete species

| Species | n | Hearing range (kHz) | Best sensitivity (kHz) | Method | References |
|----------------------------------|----------------|----------------------|------------------------|------------|---------------------------------|
| <i>T. truncatus</i> | 1 | 0.75–150 | 7–130 | Behaviour | Johnson (1966, 1967) |
| | 42 | 10–150 | 10–80 ^a | Physiology | Houser and Finneran (2006b) |
| <i>P. phocoena</i> | 1 | 1–150 | 2–140 | Behaviour | Andersen (1970) |
| | 1 | 0.250–180 | 4–150 | Behaviour | Kastelein <i>et al.</i> (2002) |
| <i>O. orca</i> | 1 | 0.5–31 | 5–30 | Behaviour | Hall and Johnson (1972) |
| | 2 | 4–100 | 12–52 | Behaviour | Szymanski <i>et al.</i> (1999) |
| | 2 ^b | 1–100 | 16–45 | Physiology | Szymanski <i>et al.</i> (1999) |
| <i>I. geoffrensis</i> | 1 | 1–105 | 10–50 | Behaviour | Jacobs and Hall (1972) |
| <i>D. leucas</i> | 2 | 1–130 | 15–110 | Behaviour | White <i>et al.</i> (1978) |
| | 4 | 0.125–8 ^c | 4–8 | Behaviour | Awbrey <i>et al.</i> (1988) |
| | 1 | 8–128 | 27–107 | Physiology | Klishin <i>et al.</i> (2000) |
| | 2 | 2–130 | 14–90 | Behaviour | Finneran <i>et al.</i> (2005) |
| | 1 | 8–128 | 22–90 | Physiology | Mooney <i>et al.</i> (2008) |
| <i>T. truncatus gilli</i> | 1 | 2–135 | 25–110 | Behaviour | Ljungblad <i>et al.</i> (1982) |
| | 13 | 10–150 | 20–130 ^a | Physiology | Houser <i>et al.</i> (2008) |
| <i>P. crassidens</i> | 1 | 2–115 | 16–64 | Behaviour | Thomas <i>et al.</i> (1988) |
| | 1 | 4–45 | 7–27 | Behaviour | Yuen <i>et al.</i> (2005) |
| | 1 ^b | 4–45 | 6.7–27 | Physiology | Yuen <i>et al.</i> (2005) |
| <i>L. vexillifer</i> | 1 | 1–200 | 10–65 | Behaviour | Wang <i>et al.</i> (1992) |
| <i>G. griseus</i> | 1 | 1.6–110 | 4–80 | Behaviour | Nachtigall <i>et al.</i> (1995) |
| | 1 | 4–150 | 8–108 | Physiology | Nachtigall <i>et al.</i> (2005) |
| <i>S. fluviatilis guianensis</i> | 1 | 4–135 | 16–105 | Behaviour | Sauerland and Dehnhardt (1998) |
| <i>S. coeruleoalba</i> | 1 | 32–120 | 0.5–160 | Behaviour | Kastelein <i>et al.</i> (2003) |
| <i>N. phocaenoides</i> | 2 | 8–152 | 32–139 | Physiology | Popov <i>et al.</i> (2005) |
| <i>M. europaeus</i> | 1 | 10–80 | 40–80 | Physiology | Cook <i>et al.</i> (2006) |
| | 1 | 20–90 | 20–80 | Physiology | Finneran <i>et al.</i> (2009) |
| <i>L. albirostris</i> | 2 | 16–181 | 32–128 | Physiology | Nachtigall <i>et al.</i> (2008) |
| <i>G. melas</i> | 1 | 22.5–50 | 4–100 | Physiology | Pacini <i>et al.</i> (2010) |
| <i>S. bredanensis</i> | 14 | 10–120 | Unclear | Physiology | Mann <i>et al.</i> (2010) |
| <i>M. densirostris</i> | 1 | 5.6–160 | 40–50 | Physiology | Pacini <i>et al.</i> (2011) |
| <i>F. attenuata</i> | 2 | 5–120 | 20–60 | Physiology | Montie <i>et al.</i> (2011) |

Note: Bullock *et al.* (1968) published hearing ranges and relative responses, but not calibrated audiograms.

^a Greatly varied depending on sex and age.

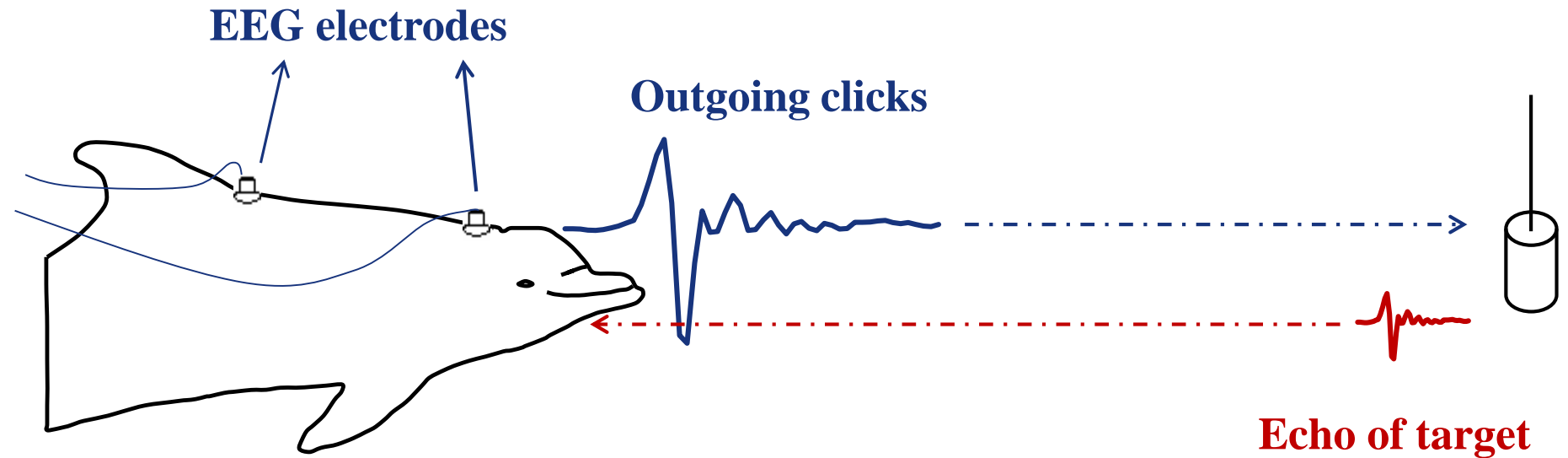
^b Same animal tested as preceding study.

^c Did not establish upper limit.



Bioacoustics of Marine Mammals

Hearing and its mechanism during echolocation of odontocetes

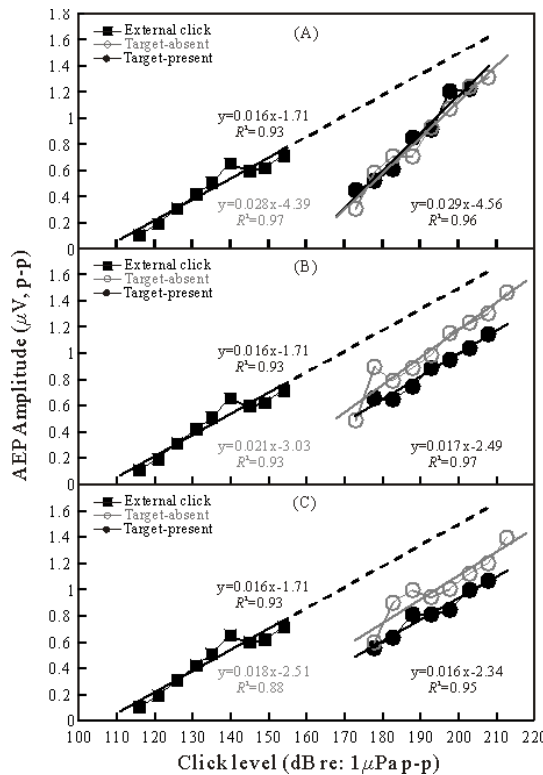




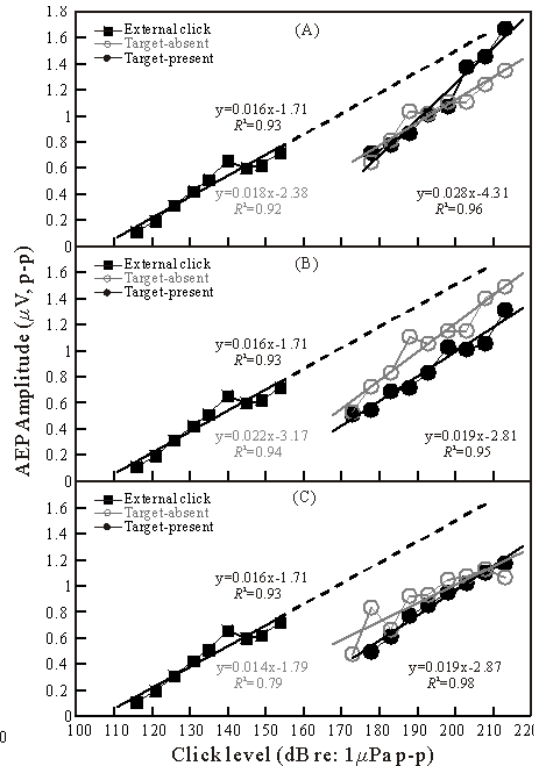
Bioacoustics of Marine Mammals

● Hearing protection

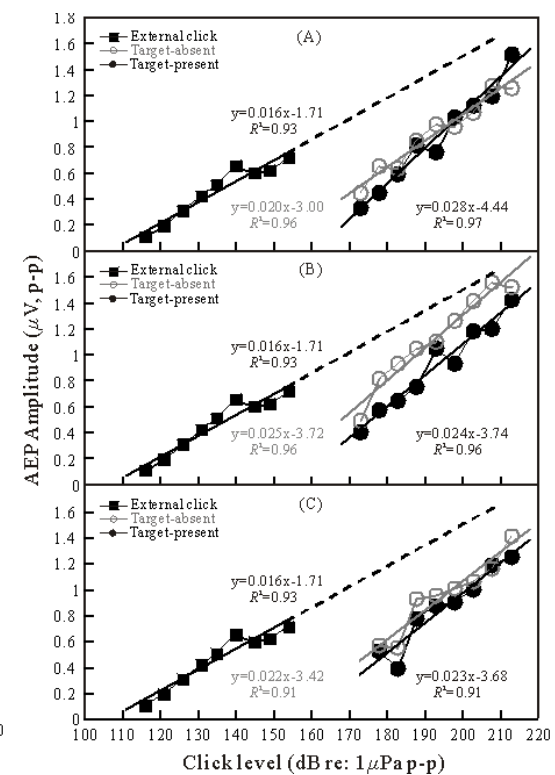
Li et al., PlosONE, 2012



-22 dB target



-28 dB target



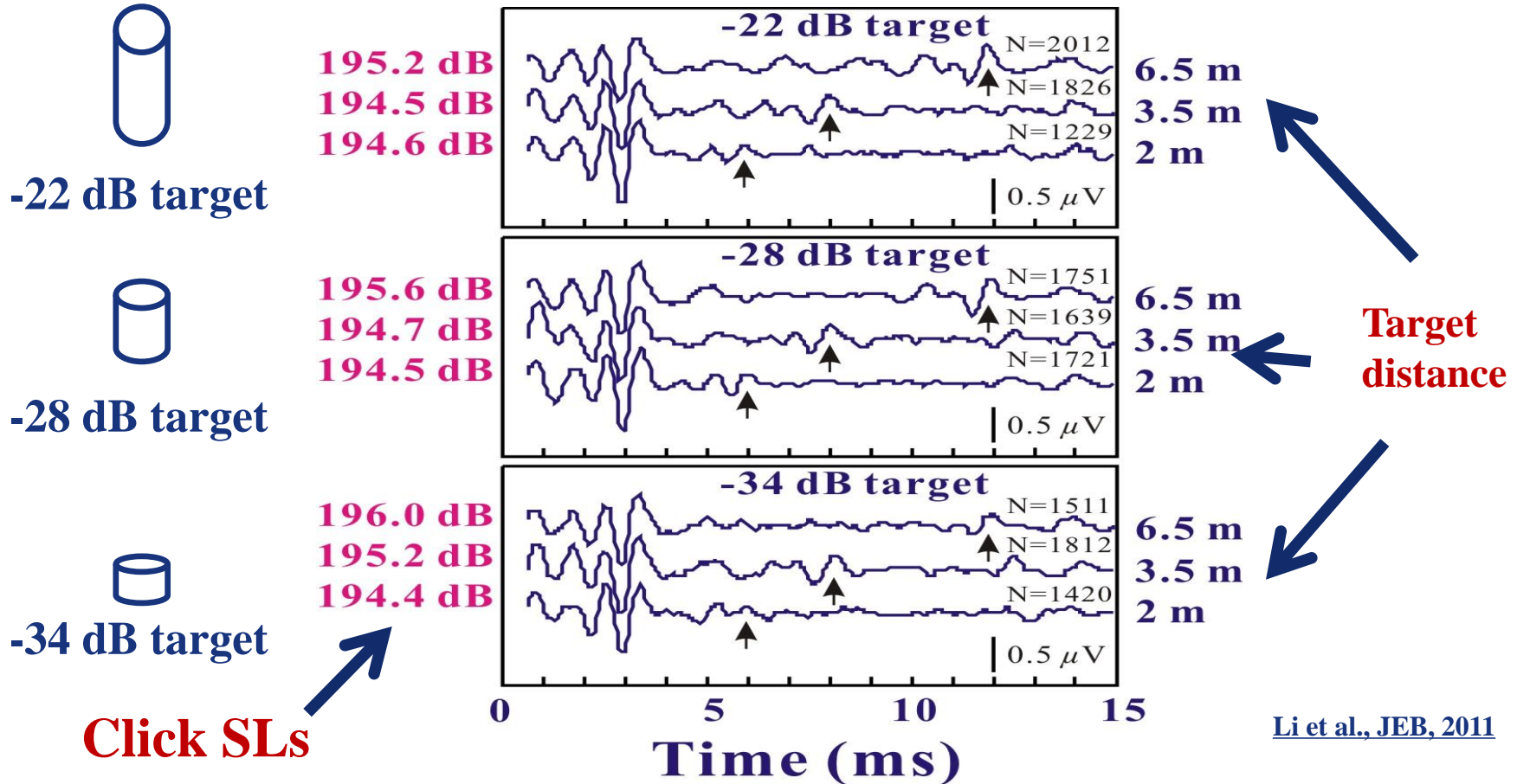
-34 dB target

- Dolphin's hearing sensation levels of her own biosonar clicks were 16 to 36 dB lower than the biosonar click source levels;
- Indicating that the dolphin possesses an effective protection system to isolate the self-produced loud biosonar clicks from the animal's ears



Bioacoustics of Marine Mammals

● Biosonar control



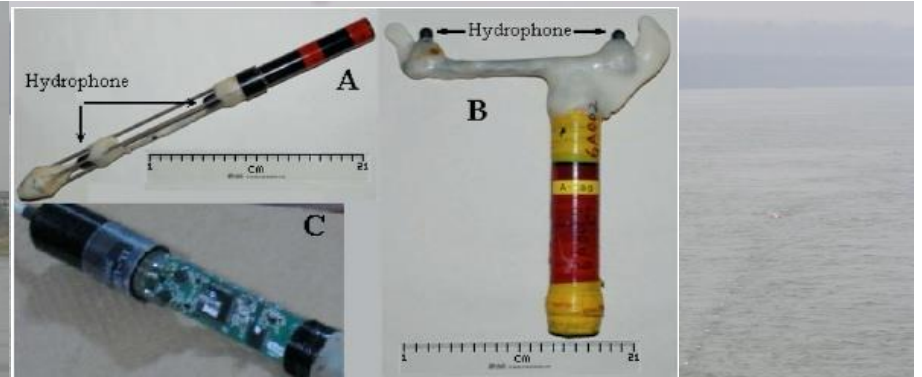
Li et al., JEB, 2011

- The echo-related AEP response amplitudes increased at further target distances, demonstrating an overcompensation of echo attenuation with target distance



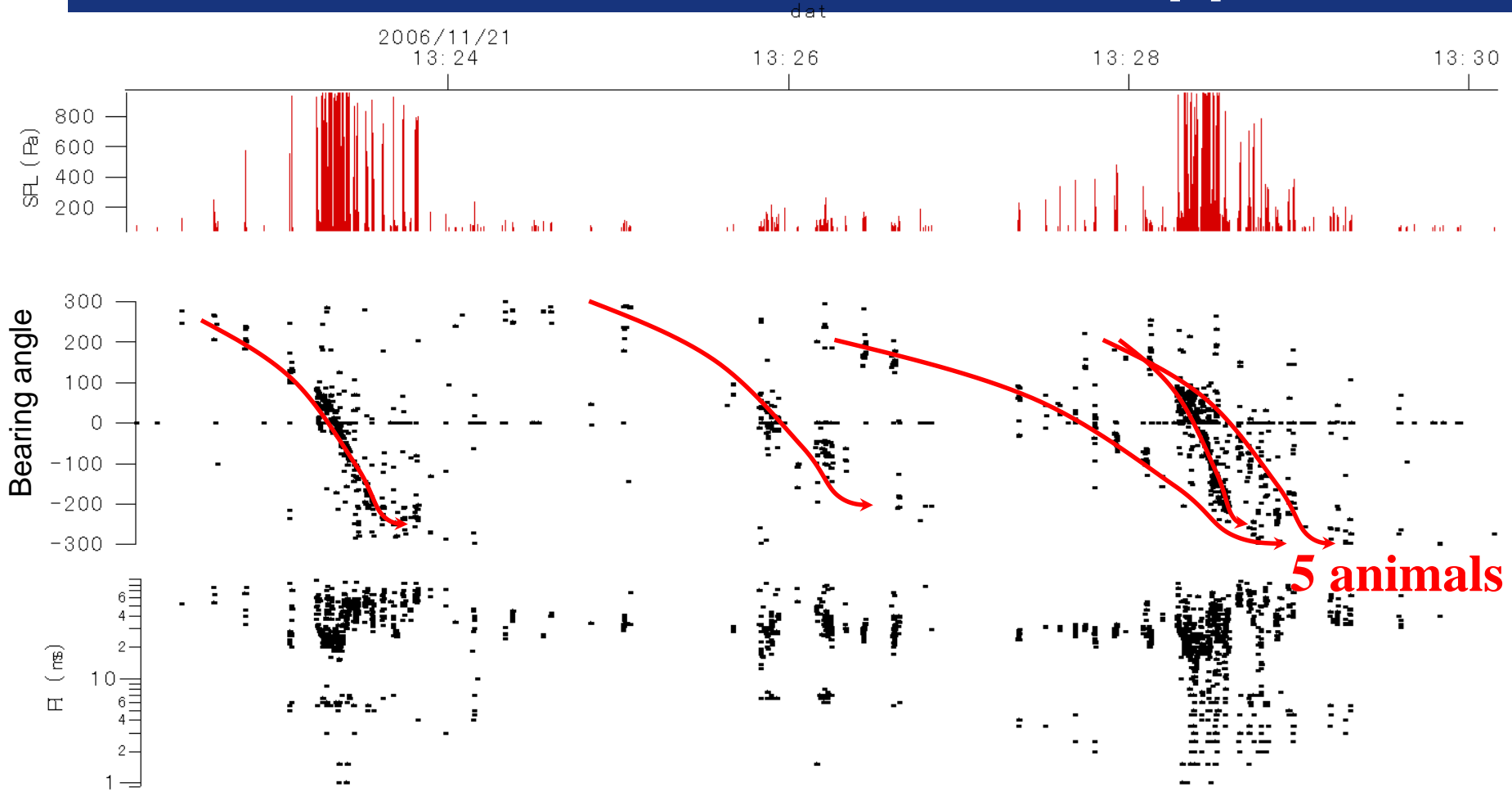
Bioacoustics of Marine Mammals-applications

□ Survey boat





Bioacoustics of Marine Mammals-applications

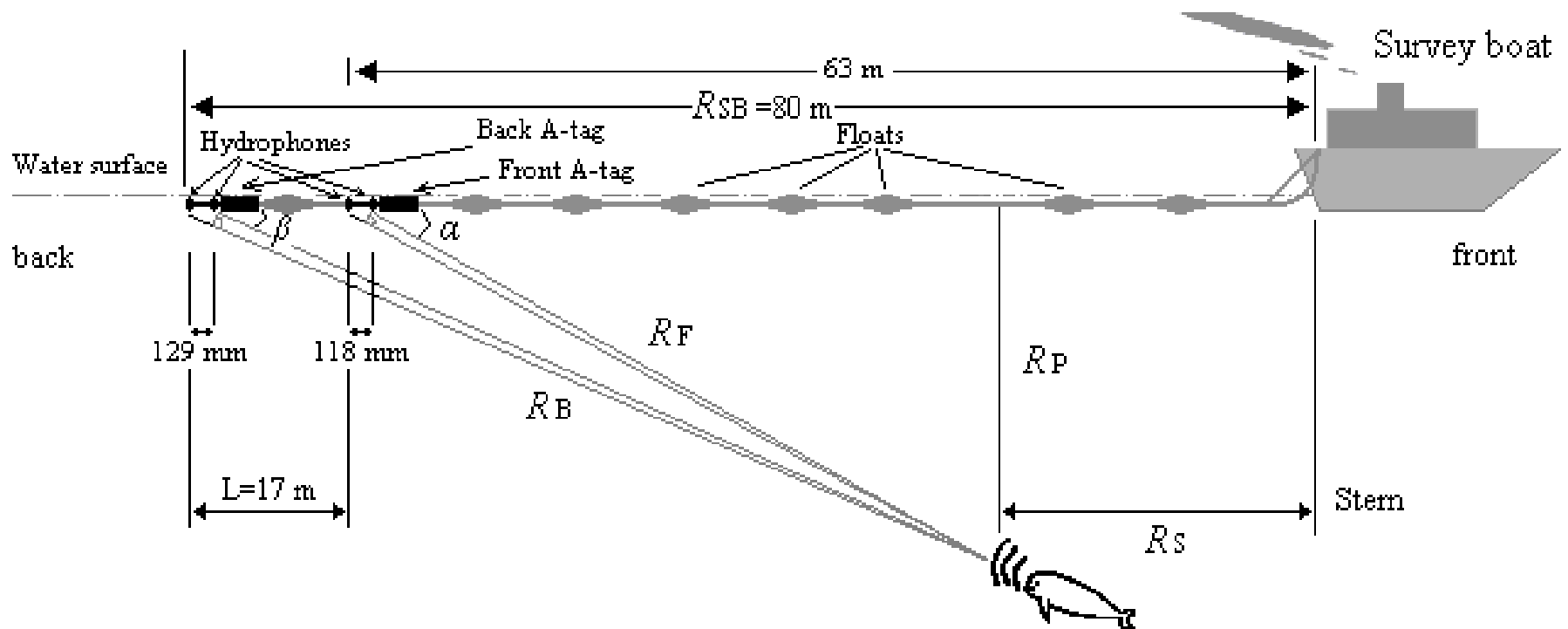


5 animals

— Detect the presence, species, individual number



Bioacoustics of Marine Mammals-applications



— Localization and tracking

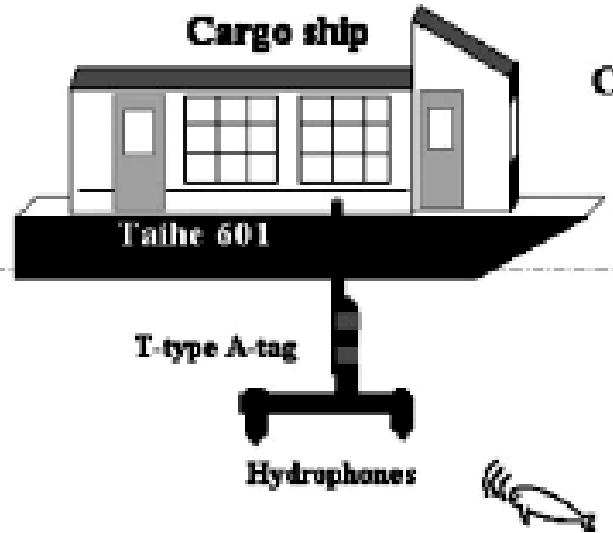
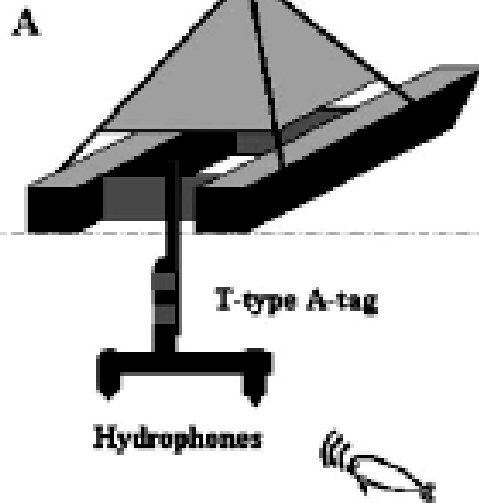


Bioacoustics of Marine Mammals-applications

Fixed platform

Cargoship

Buoy or anchored fishing boat



— Except the survey boat, fixed platform, cargoship can be also applied as passive acoustic monitoring platforms to monitor marine mammals in long-term

B

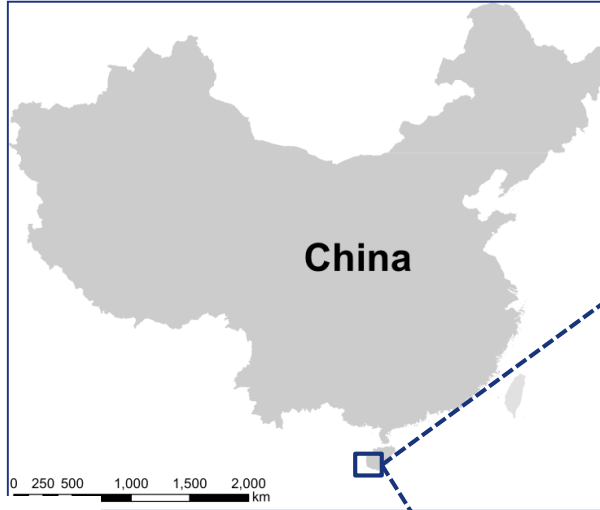
Customizing survey boat or fishing-boat



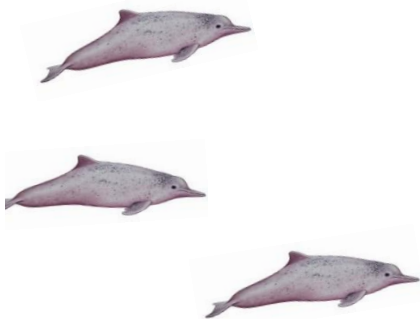
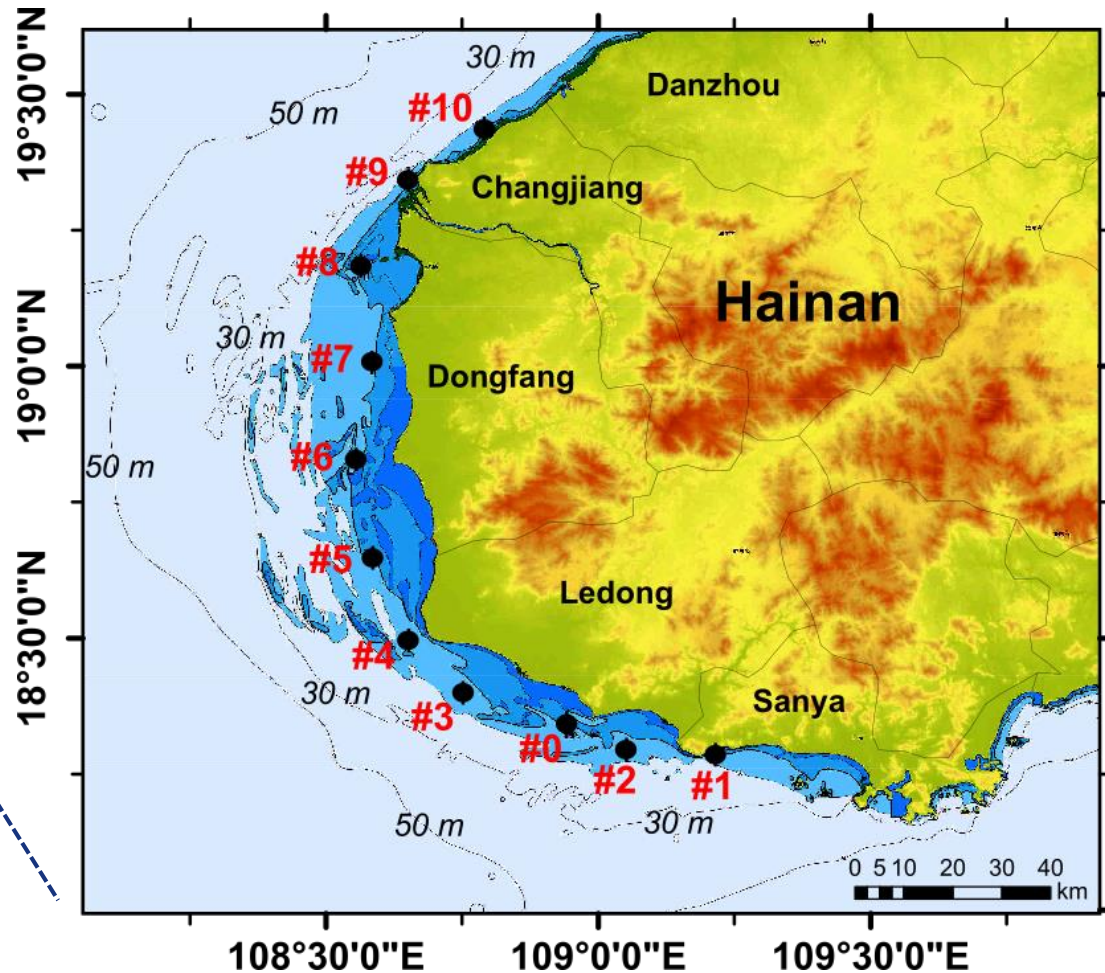
Survey boat



Bioacoustics of Marine Mammals-applications

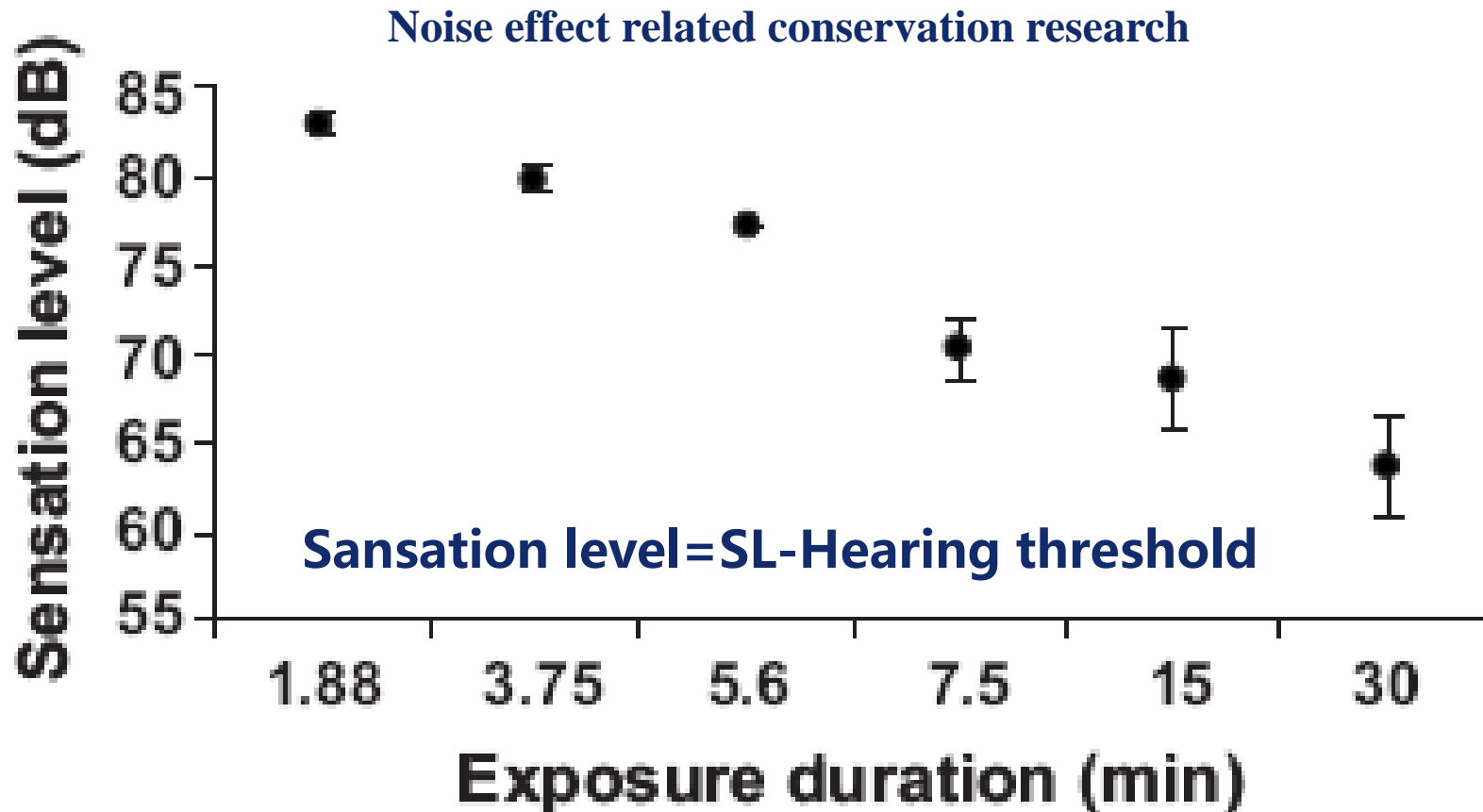


South-western coast of *Hainan* *Island*





Bioacoustics of Marine Mammals-applications

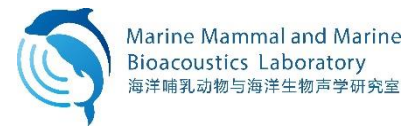


- Higher sensation level, higher effect of noise on the animals



Marine mammal and marine bioacoustics Lab

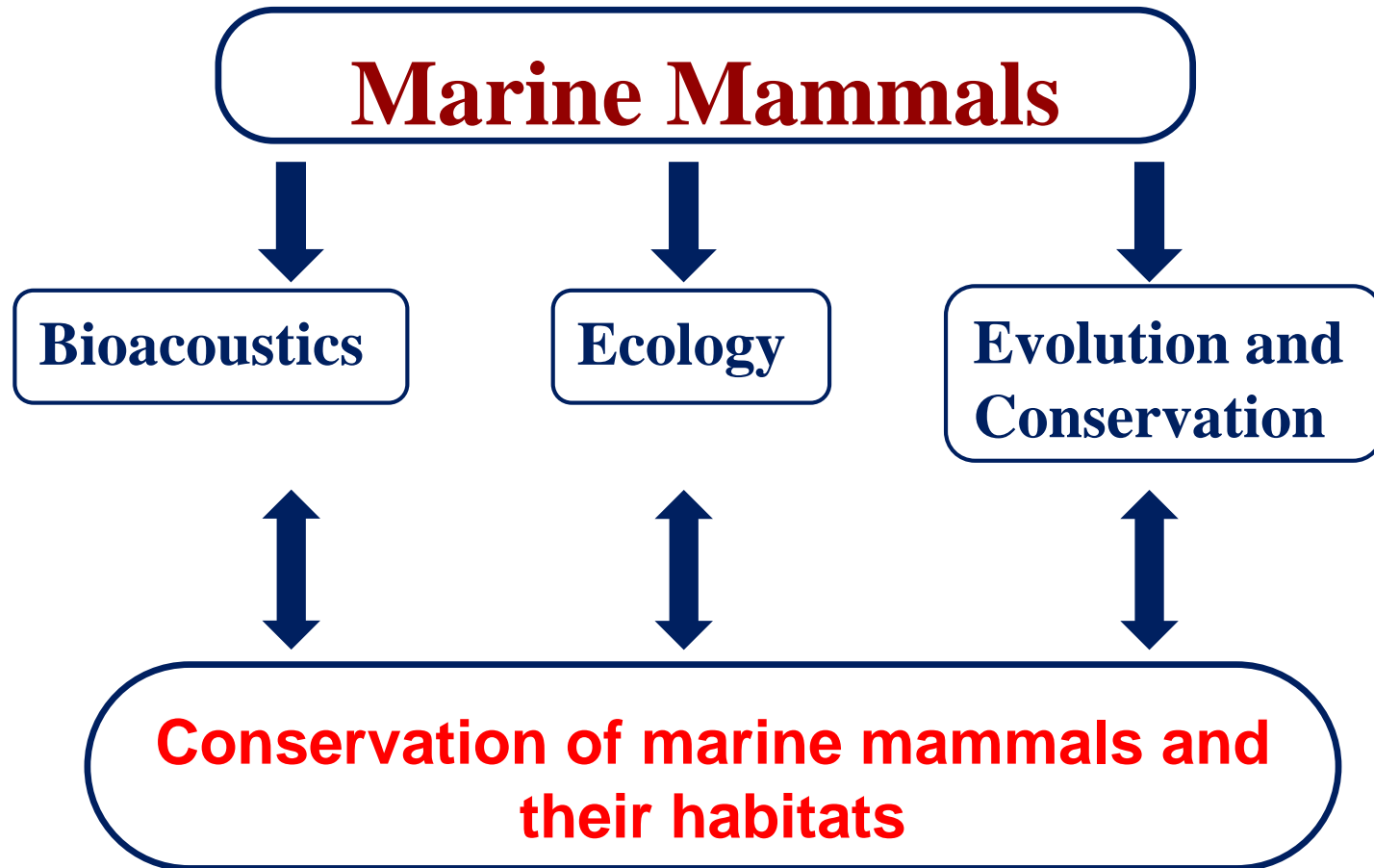
Marine Mammal Research Team



— A research team focusing on marine mammals in the South China Sea and ASEAN region.



Marine mammal and marine bioacoustics Lab





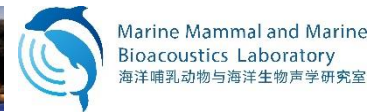
中国科学院深海科学与工程研究所
Institute of Deep-sea Science and Engineering, CAS



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