

# Studies of vessel noise off Southern California

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**Ocean Noise in Canada's Pacific  
Vancouver, BC**

**February 1, 2012**

# Measurements of Radiated Underwater Noise from Modern Merchant Ships

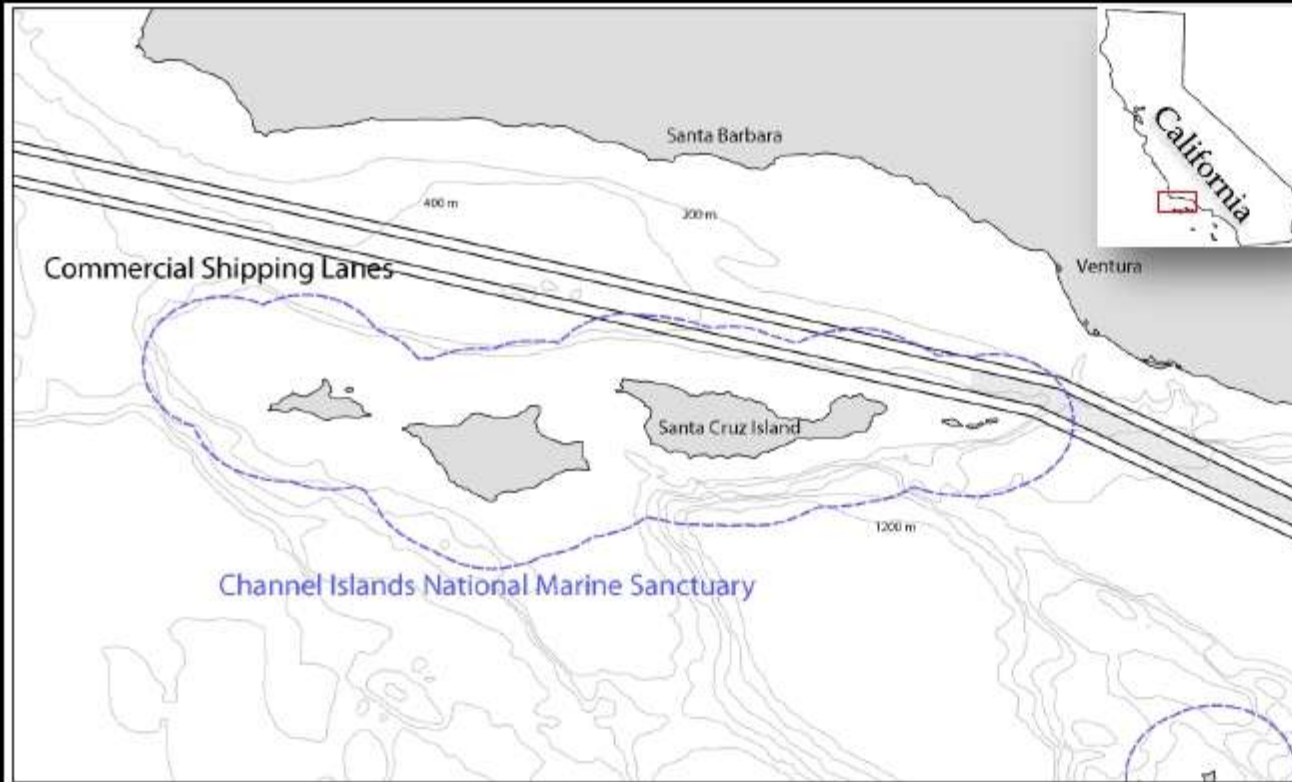
Megan F. McKenna, Donald Ross, Sean M. Wiggins,  
and John A. Hildebrand

Scripps Institution of Oceanography



*Photo credit: CascadiaResearch Collective*

# Santa Barbara Channel



## Port of LA/Long Beach

2<sup>nd</sup> busiest port in the US (6<sup>th</sup> in the world)

90% trade with Asia

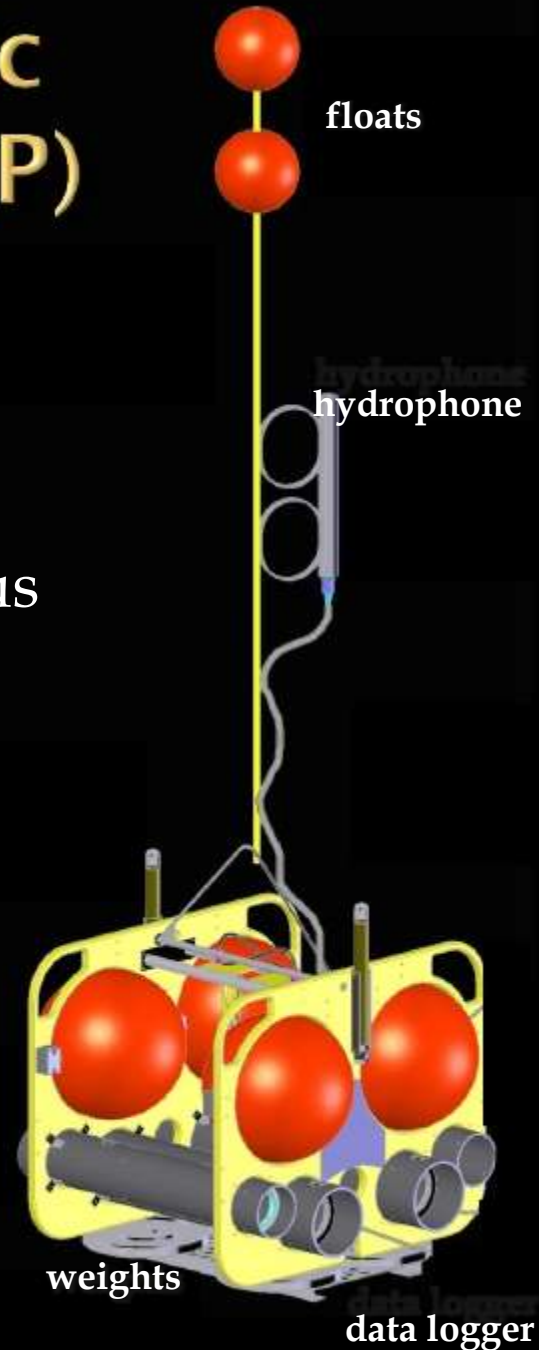
~18 ships per day



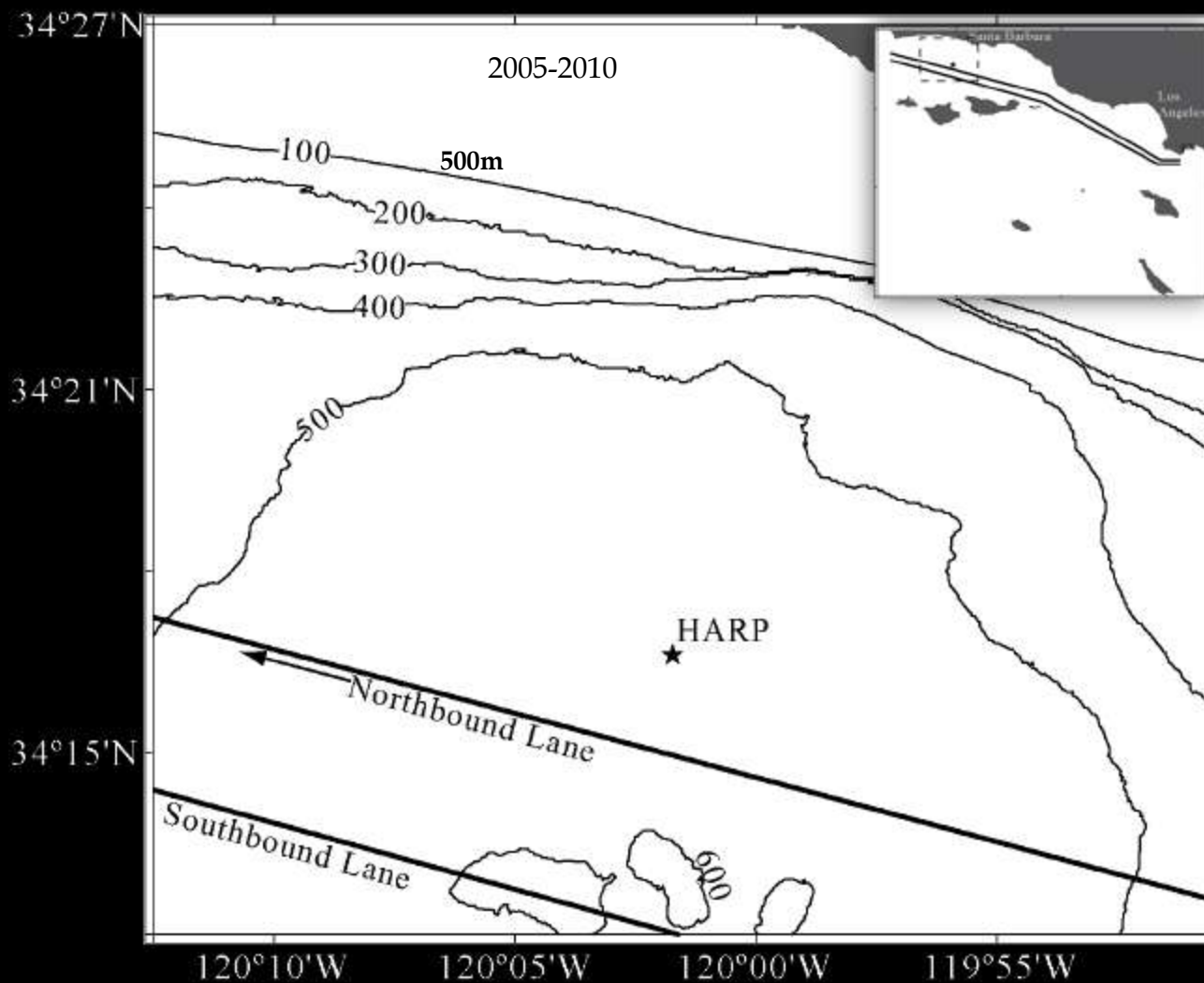
Opportunistic approach- measured radiated ship noise under normal operating conditions.

# High Frequency Acoustic Recording Package (HARP)

- Seafloor packages
- Records sounds from 10 Hz to 100 kHz
- Stores 10 TB of data (300 days of continuous recording at 200 kHz)
- Low drift clock
- Calibrated data



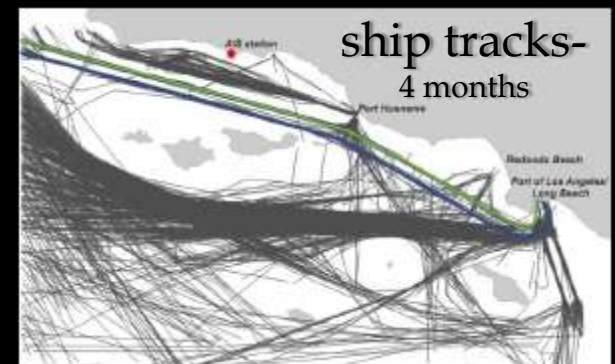
# High Frequency Acoustic Recording Package (HARP)



# Monitoring Ship Traffic

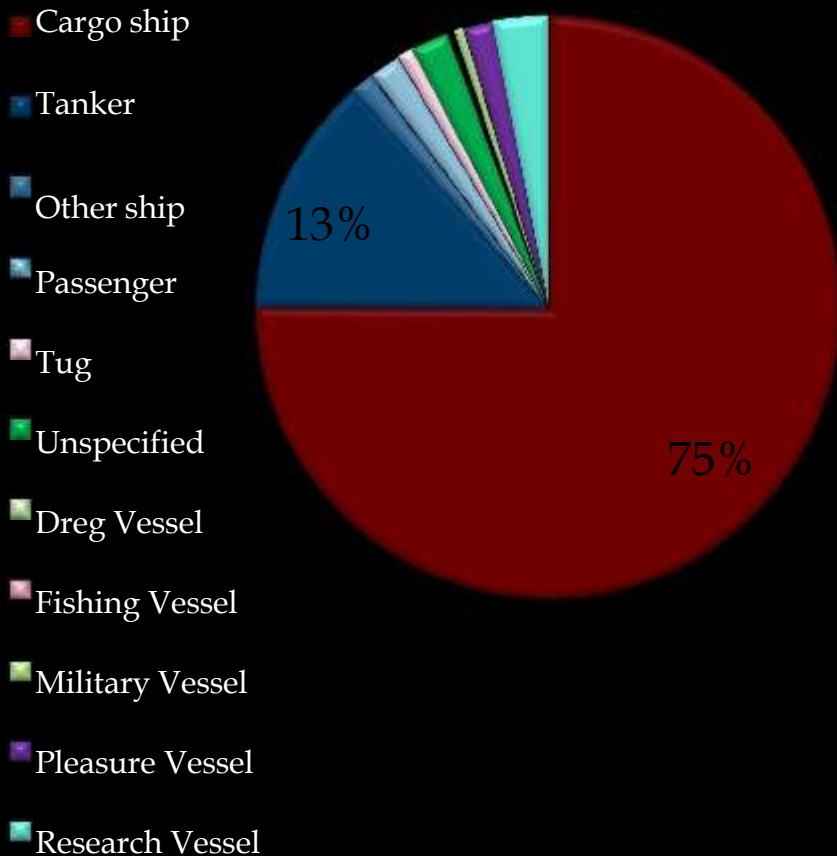
## Automatic Identification System (AIS)

- Designed for vessel collision avoidance and traffic at ports
- VHF signal broadcast from ships 300+ GT
- Information transmitted
  - Every 2-10 seconds  
Ship id, speed, position, course, heading, time stamp
  - Every ~6 minutes  
IMO, call sign, name, type, dimensions-length, draught, destination/ ETA



# Measured Ship Types

Ship Traffic in the Santa Barbara Channel (2008-2009)



CONTAINER SHIPS



BULK CARRIERS



OPEN HATCH CARGO



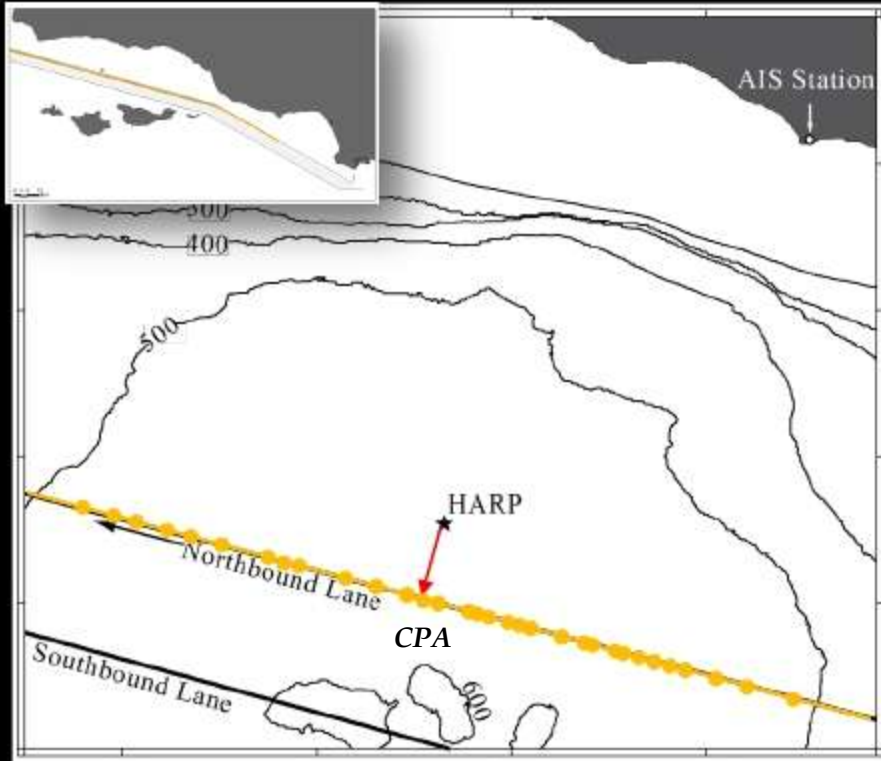
VEHICLE CARRIERS



TANKERS  
(Crude Oil, Product, Chemical)

# Measuring Ship Noise

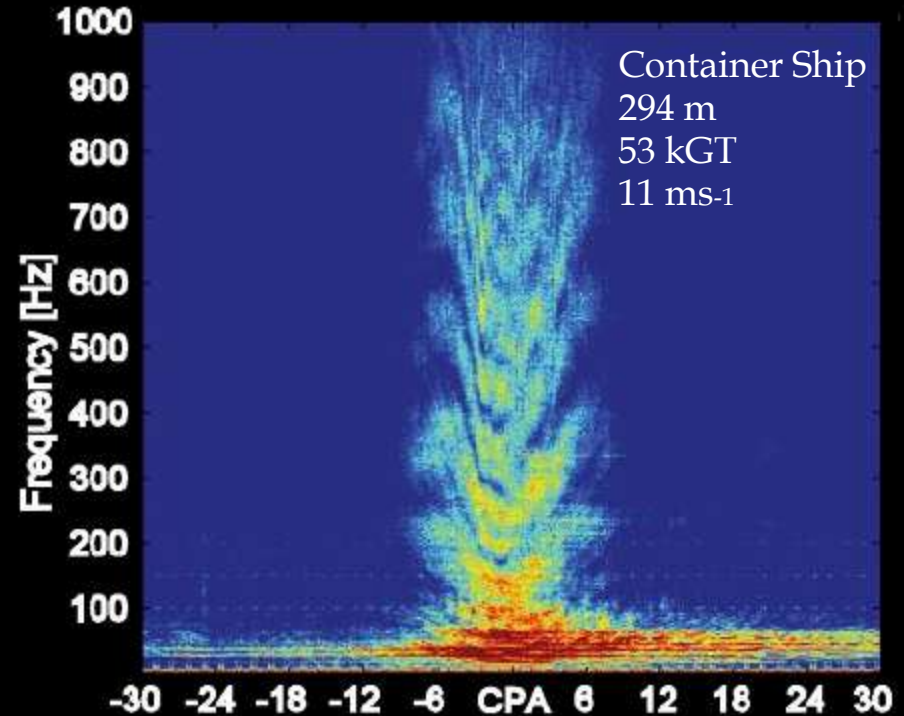
AIS data



- 1) AIS transmission converted to track
- 2) Identify CPA time and distance of ship to HARP

*CPA = Closest Point of Approach*

Acoustic data



- 3) Match CPA time to acoustic data
- 4) Measure received sound levels
- 5) Estimate source level
- 6) Combine with info from Lloyd's Registry of Ships and NOAA buoy

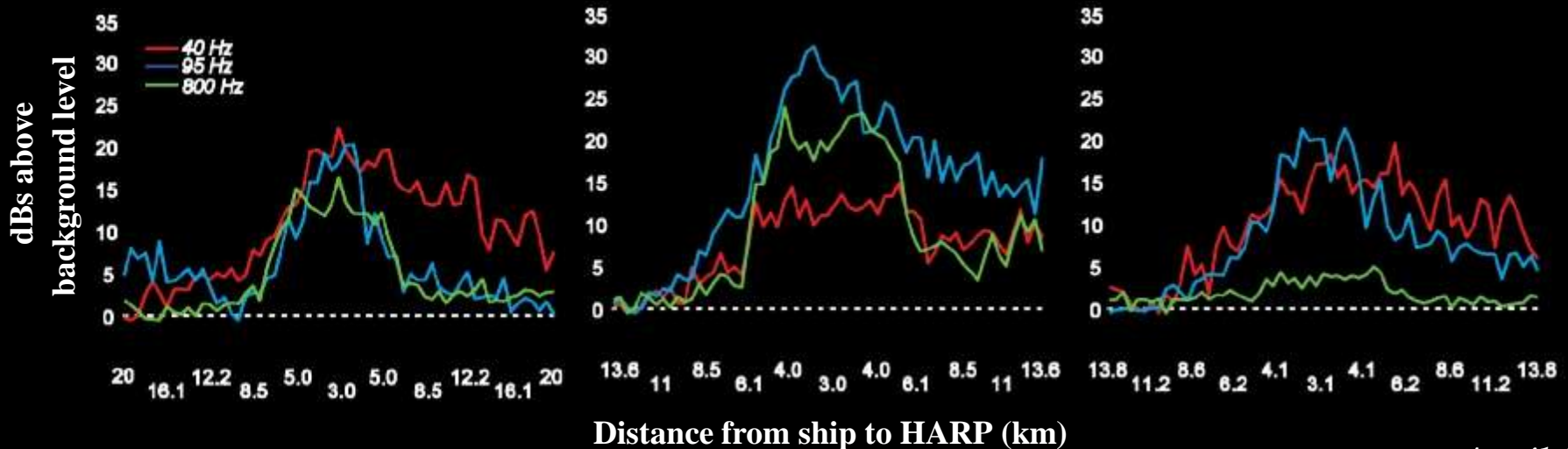
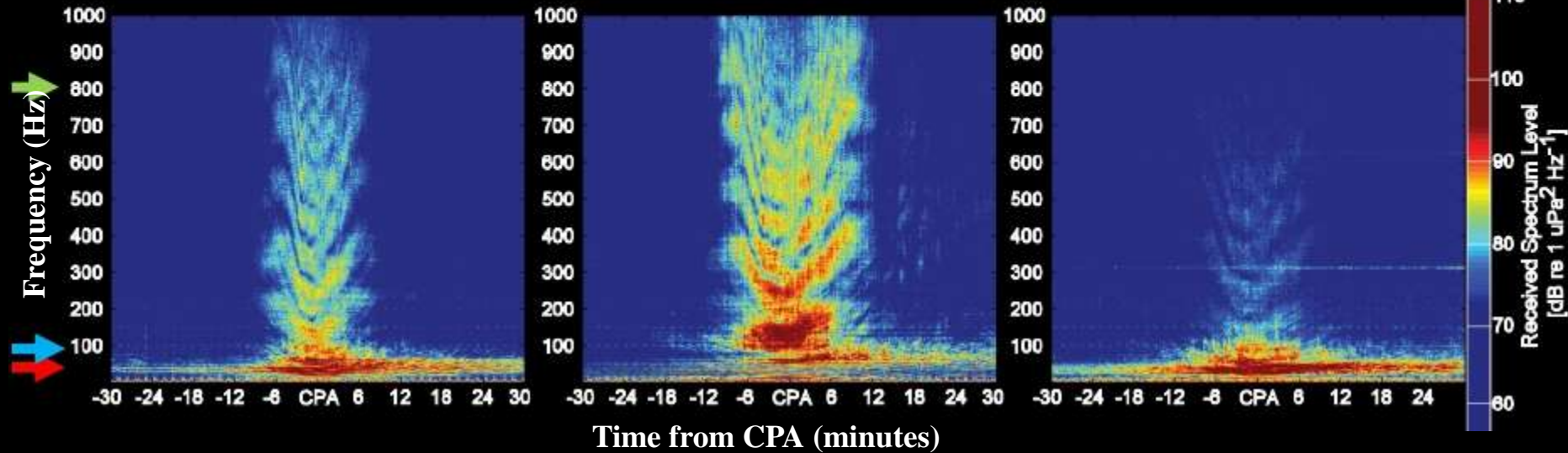
# Radiated Ship Noise

1- Hour Ship Passages at 3 km CPA

Container Ship

Bulk Carrier

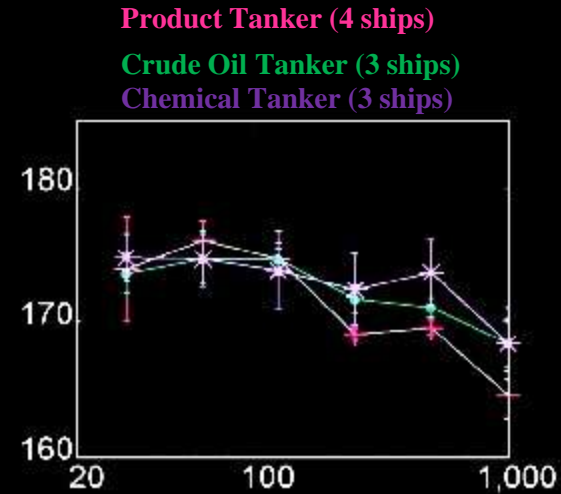
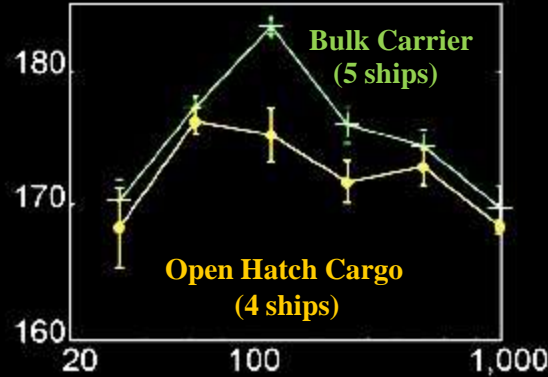
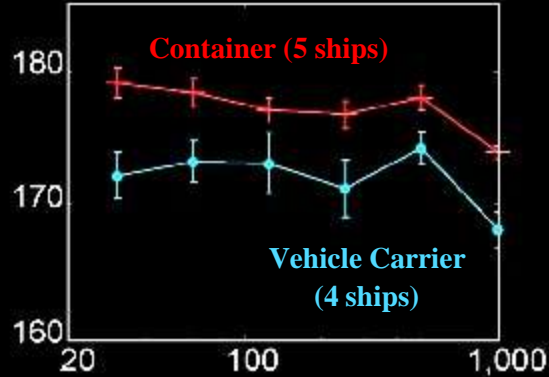
Product Tanker



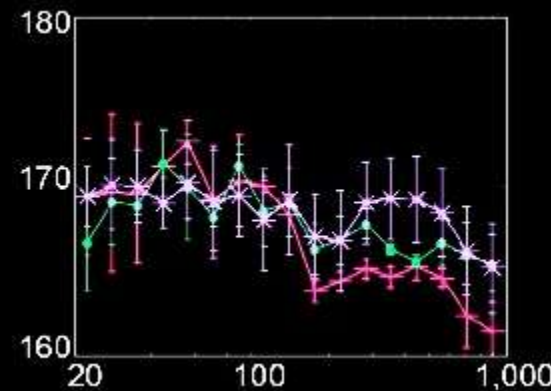
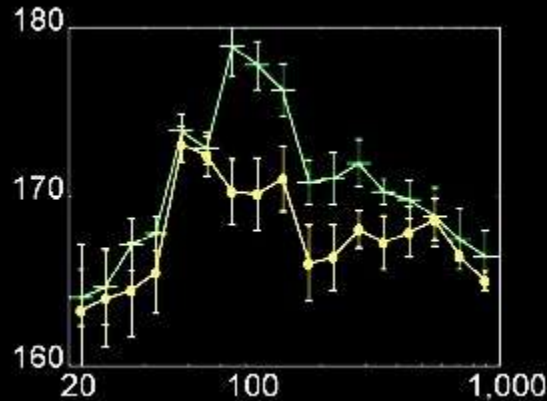
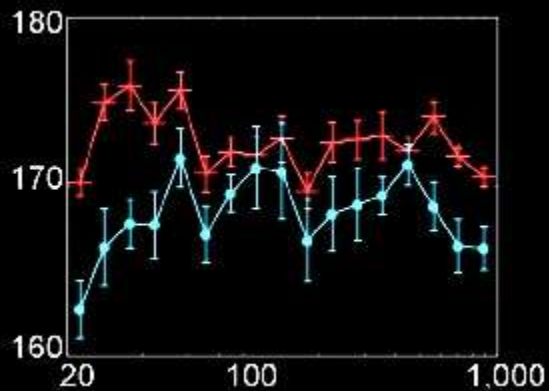
# Ship Source Levels

$SL = RL + 20 \cdot \log(\text{range})$   
 Source Level dB re  $1 \mu\text{Pa}_2$  @ 1 m

*Octave Bands*

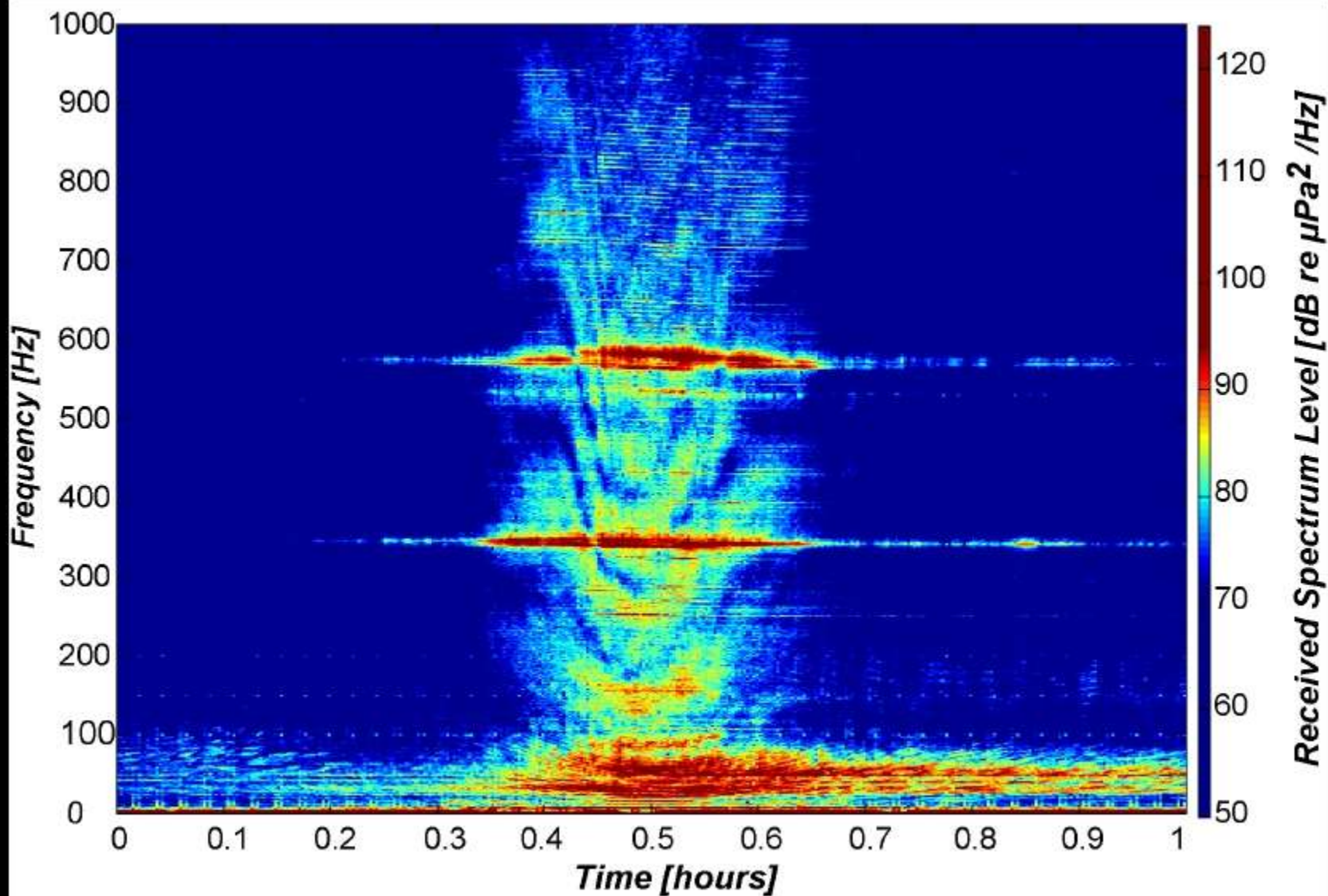


*1/3 Octave Bands*

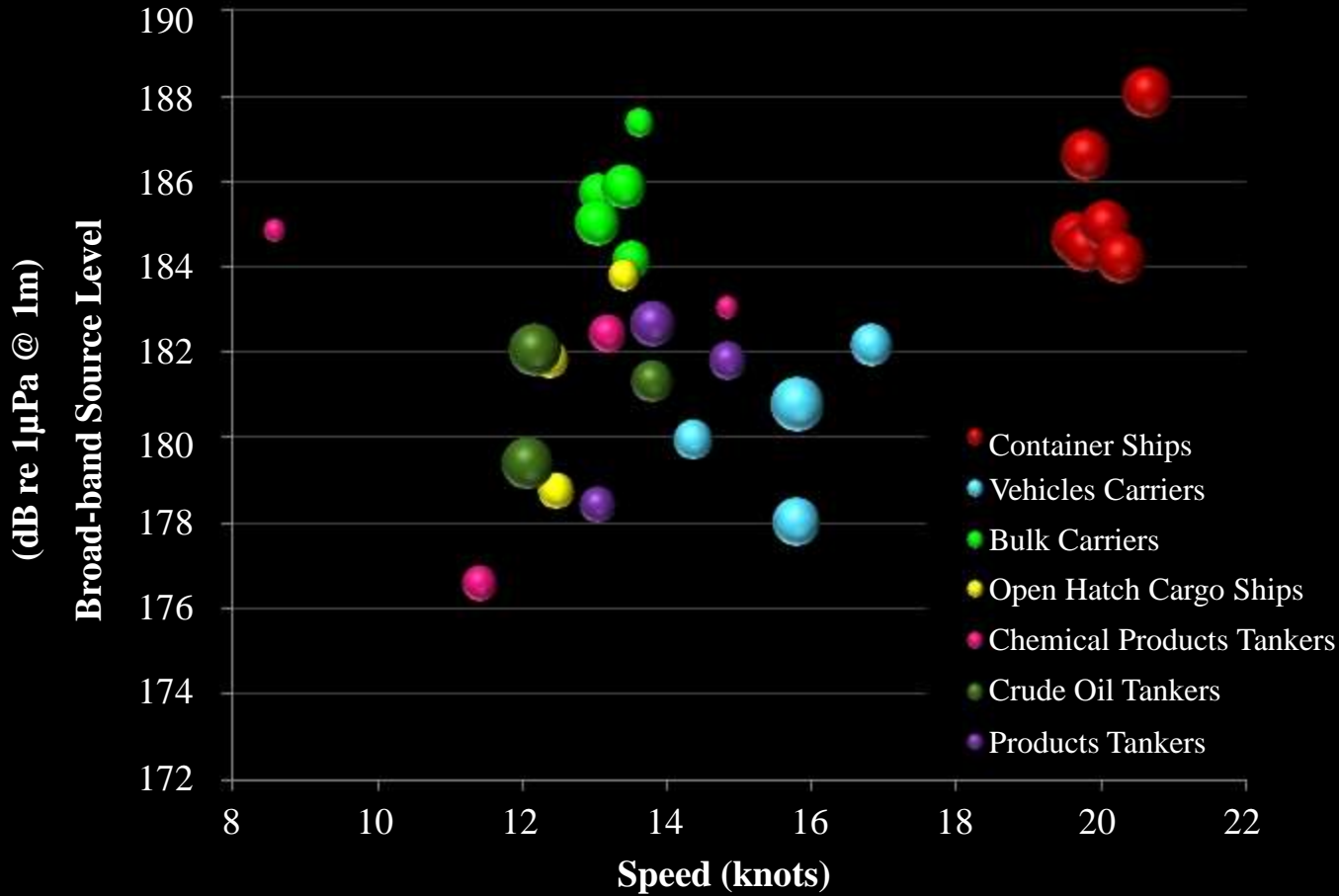


**Frequency (Hz)**

*\*\*time average at CPA = ship length/ speed*



# Ship Speed



# Container Ship Noise

What variables predict the highest source levels?

## Model Input

Response variable

- 593 container ships octave band source level measurements

Predictor variables

- 8 Design (e.g. GT, length, service speed)
- 4 Operational (e.g. speed, CPA)
- 6 Oceanographic (e.g. wave height, current direction)



Step-wise Generalized Additive Model

## Model Output

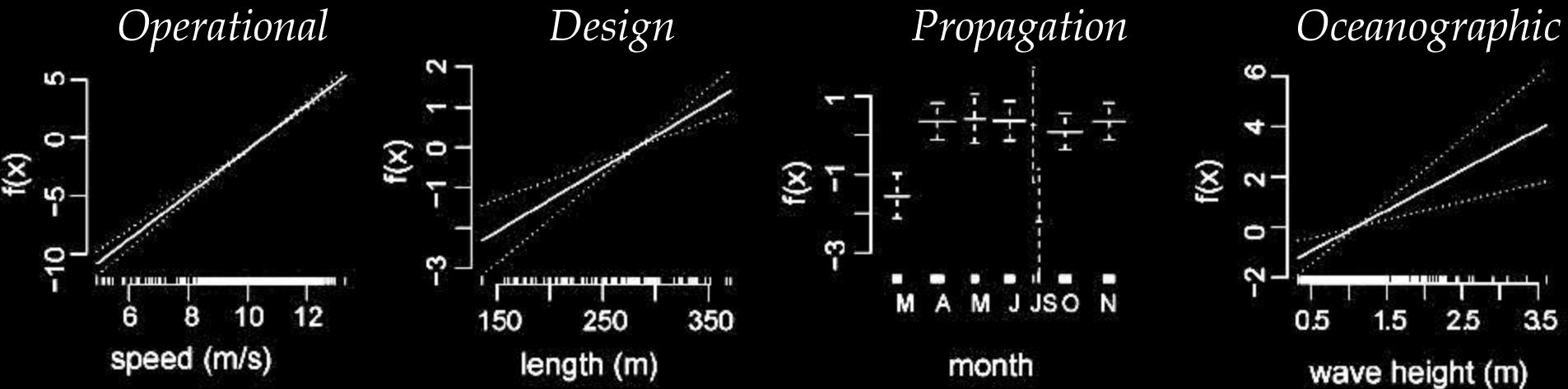
**Identified variables that predict higher source levels**

1. Multiple transits
2. Broad-band
3. 16 Hz
4. 31.5 Hz
5. 63 Hz
6. 124 Hz
7. 250 Hz
8. 500 Hz

# Broad-band Source Level Result

8 predictor variables explaining 56% of the variance

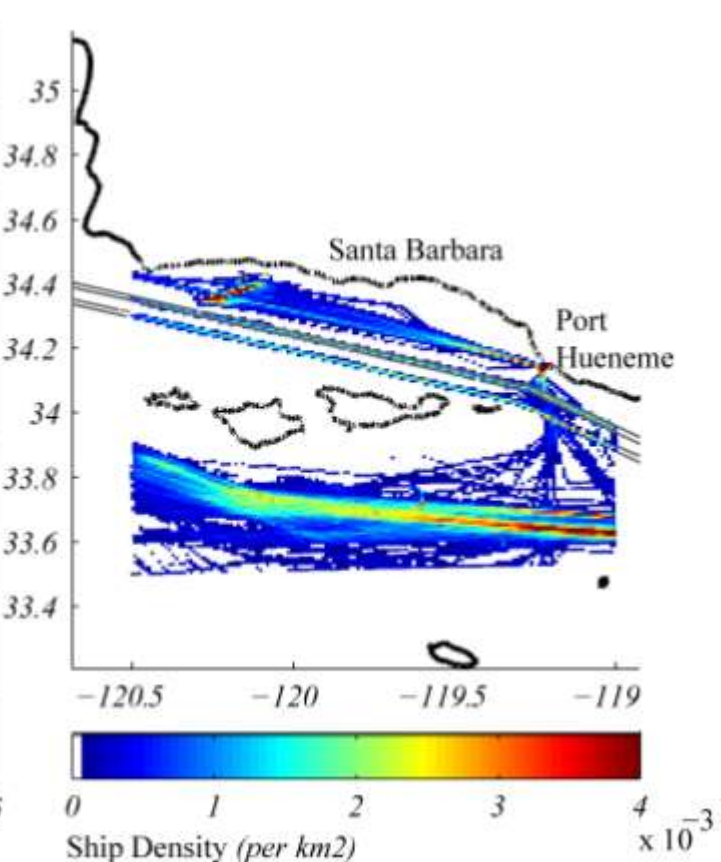
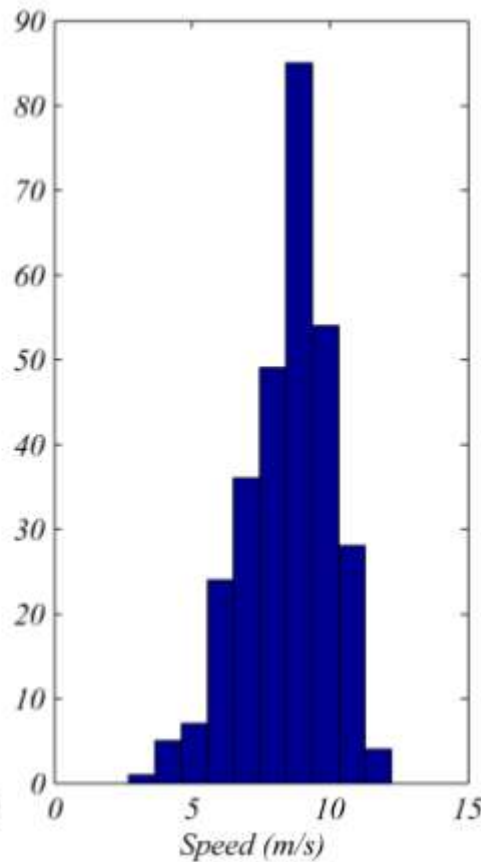
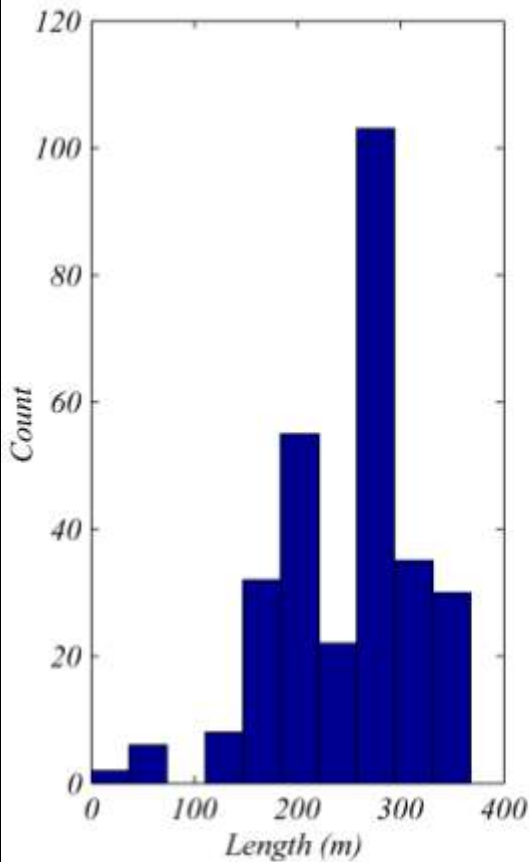
$f(\text{Ship Source Level}) \sim \text{speed} + \text{length} + \text{month} + s(\text{service speed}, 3) + \text{TONE} + \text{direction of waves} + \text{wave height} + \text{current direction}$



Speed had the greatest predictive power in all frequency bands

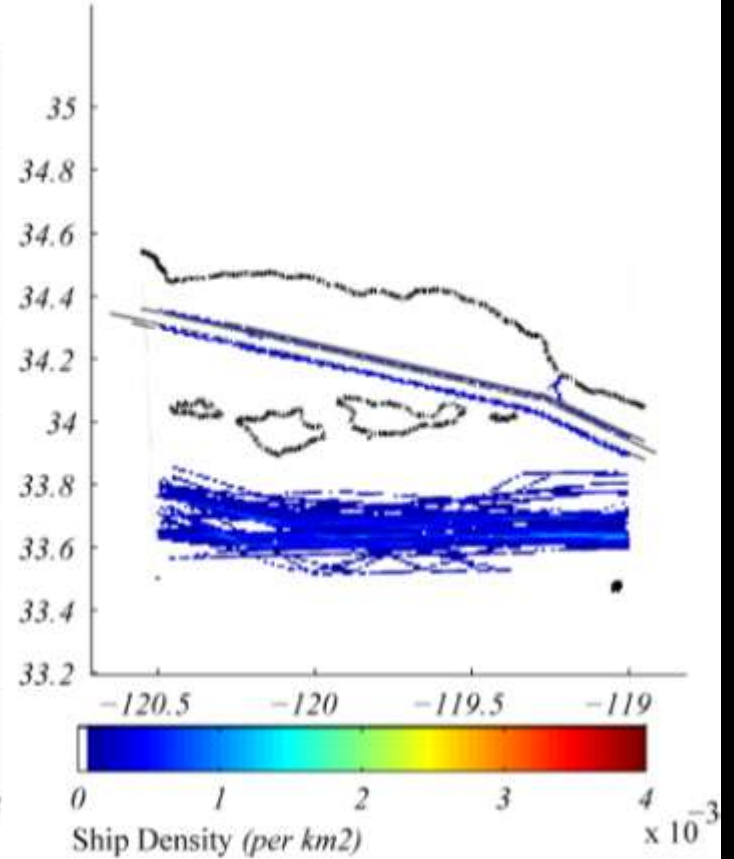
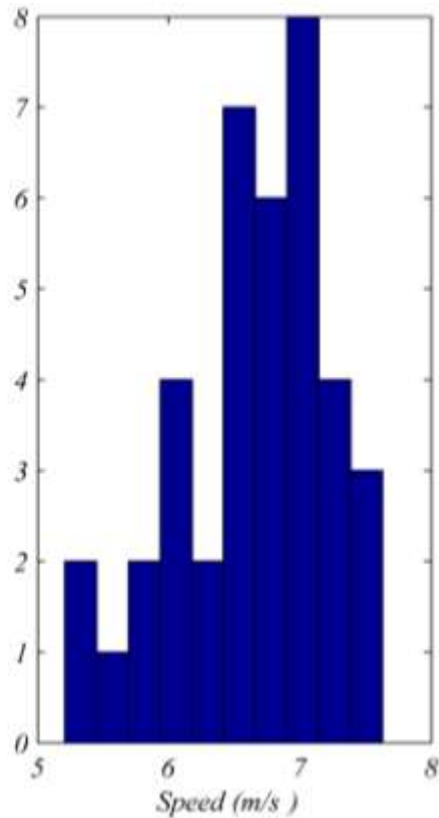
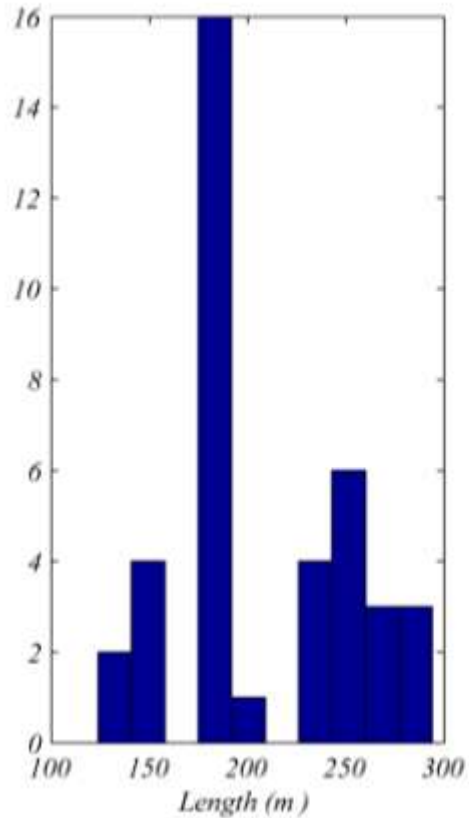
# Statistics on Cargo Ships

CARGO (N=293)



# Statistics on Tankers

TANKER (N=39)





# Channel Islands National Marine Sanctuary

R/V Shearwater, Ben Waltenberger, Steve Katz, Terrance Shinn, Matt Davis, Charlie Lara, and many field volunteers



# University of California, Santa Barbara

Lib Washburn, Brian Emery, Cyril Johnson, and Shaun Walbridge



# Scripps Institution of Oceanography

Chris Garsha, Brent Hurley, Ethan Roth, Michael Smith, Marie Roch, Bill Hodgkiss, Jay Barlow, and Chris Condit



# Funding

US Navy CNO- N45  
Office of Naval Research  
NOAA- Office of Science and Technology  
NSF- IGERT Fellowship

