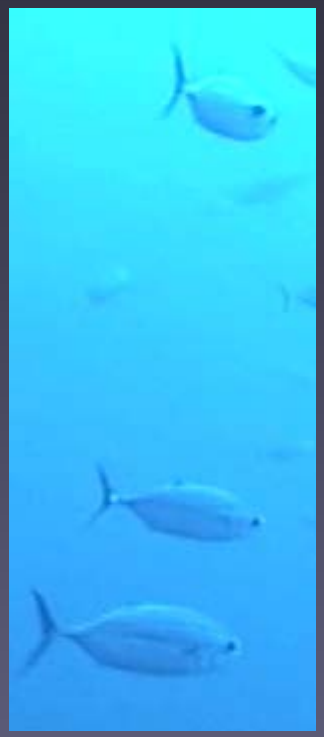
Use of Active Acoustics to Study Fish and its Forage

Réka Domokos



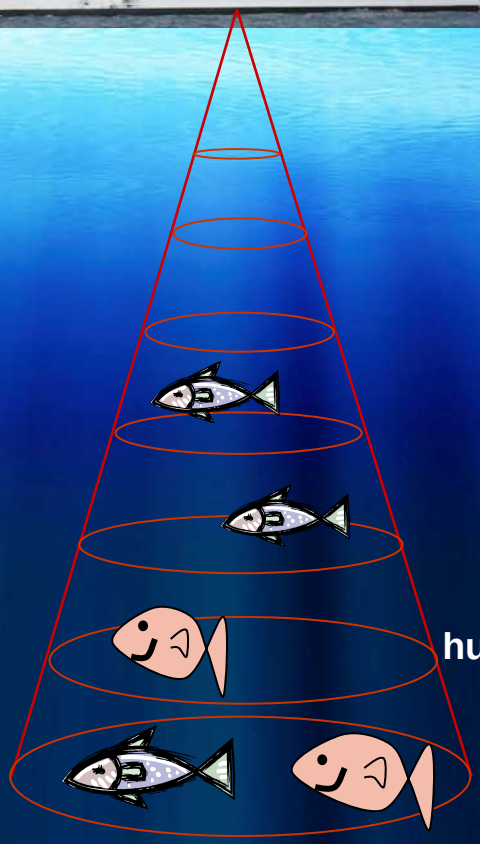
Pacific Islands Fisheries Science Center
Ecosystems and Oceanography Division

Pelagic Fisheries Research Program

Advantages of Active Acoustics

- Fisheries Independent – Unbiased by
  - fishing location
  - gear type
  - catchability
- Predetermined surveys optimized for data accuracy and volume per effort
- Non-lethal, rapid, continuous, and efficient
- Schooling patterns and aggregative behavior
- Simultaneous data on fish and its forage

Active Acoustics on the NOAA Ship Oscar E. Sette



hull-mounted transducer "pod" with

- EK60 bioacoustics transducers
  - split-beam
  - 38 kHz, 70 kHz, 120 kHz

Acoustic Identification of Organisms

- Acoustic descriptors
  - Target strength (TS)
  - Volume backscatter (S_v)
  - Aggregation type (shape, size, density)
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  - Experimental/Commercial fishing data
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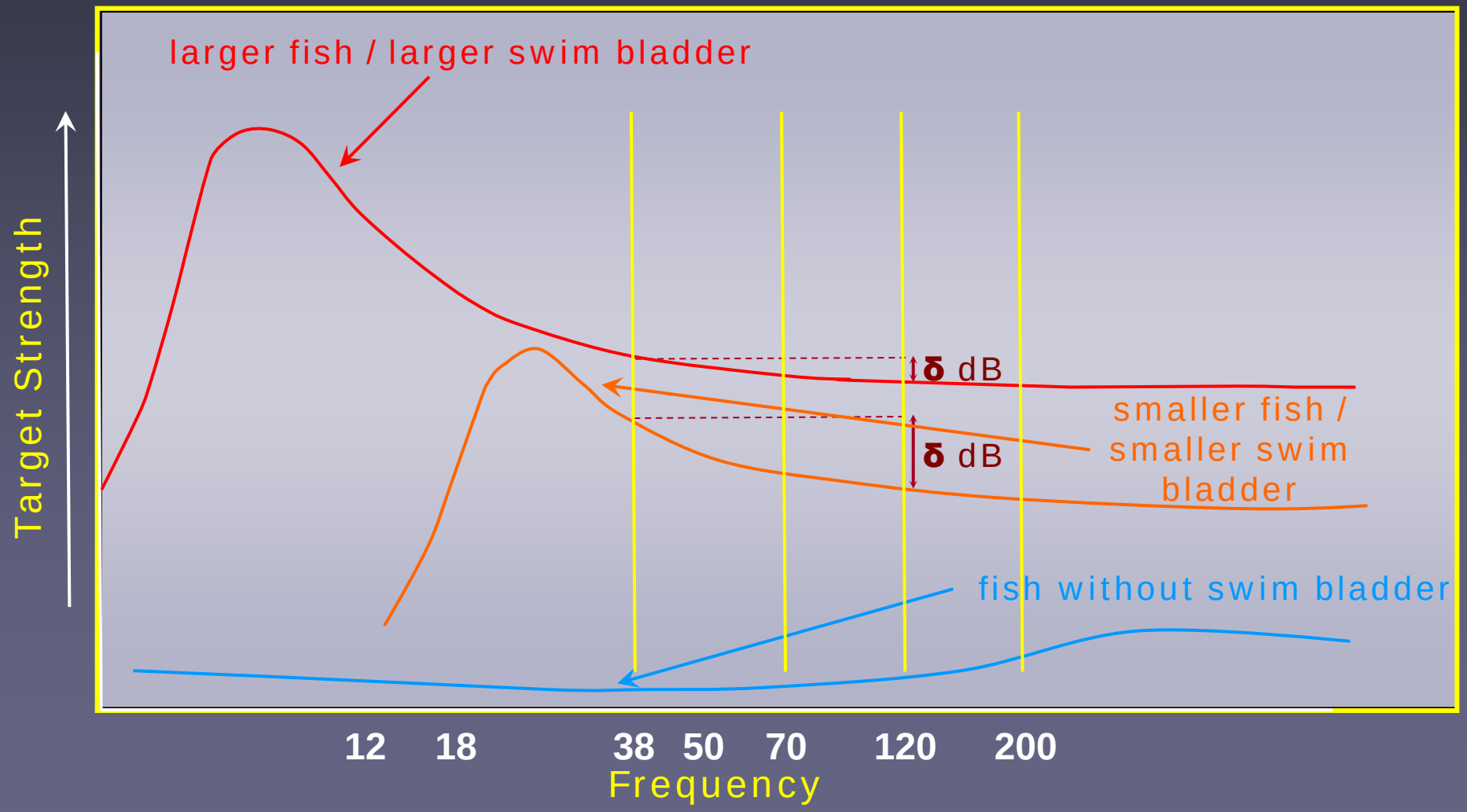
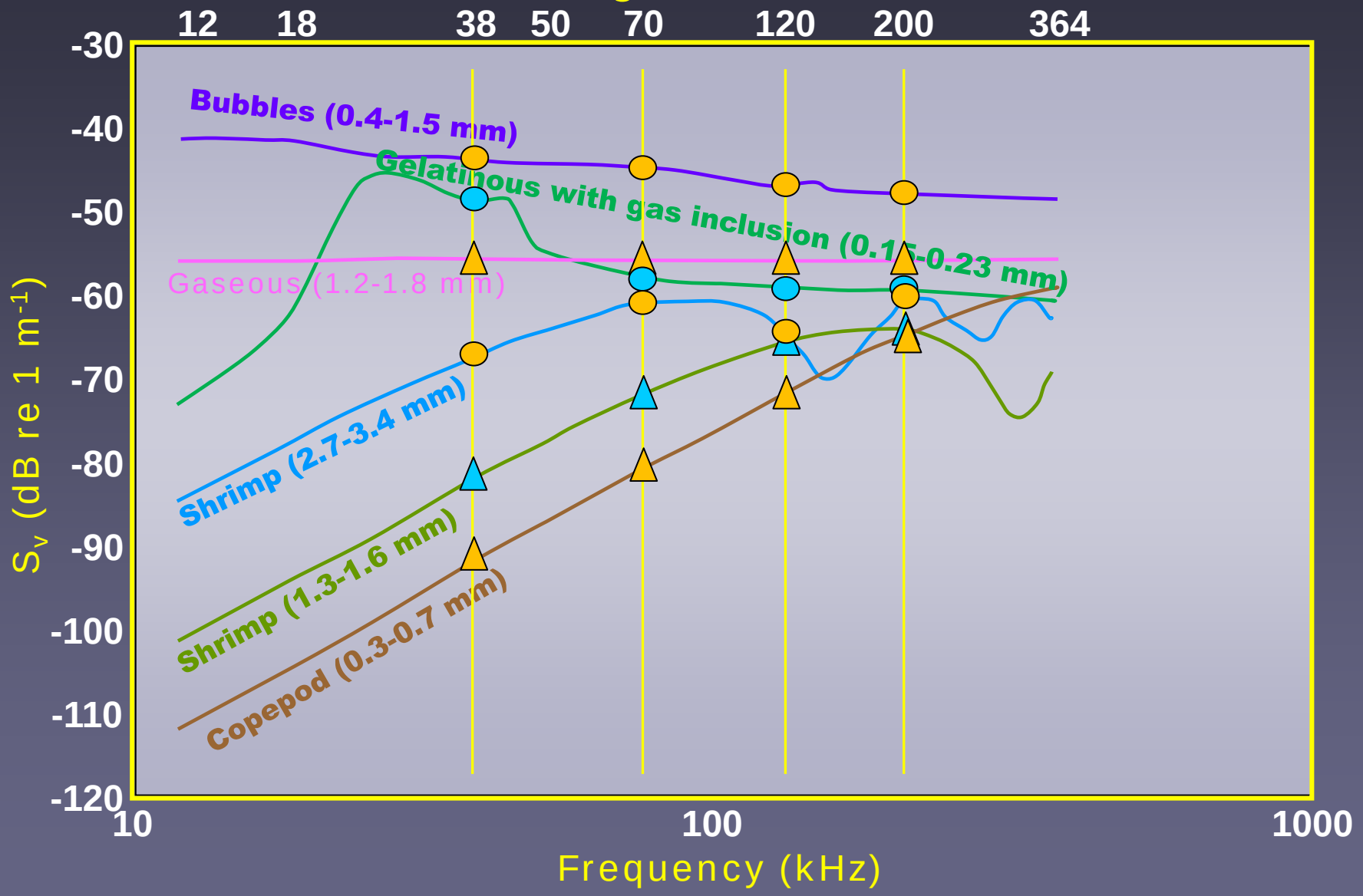
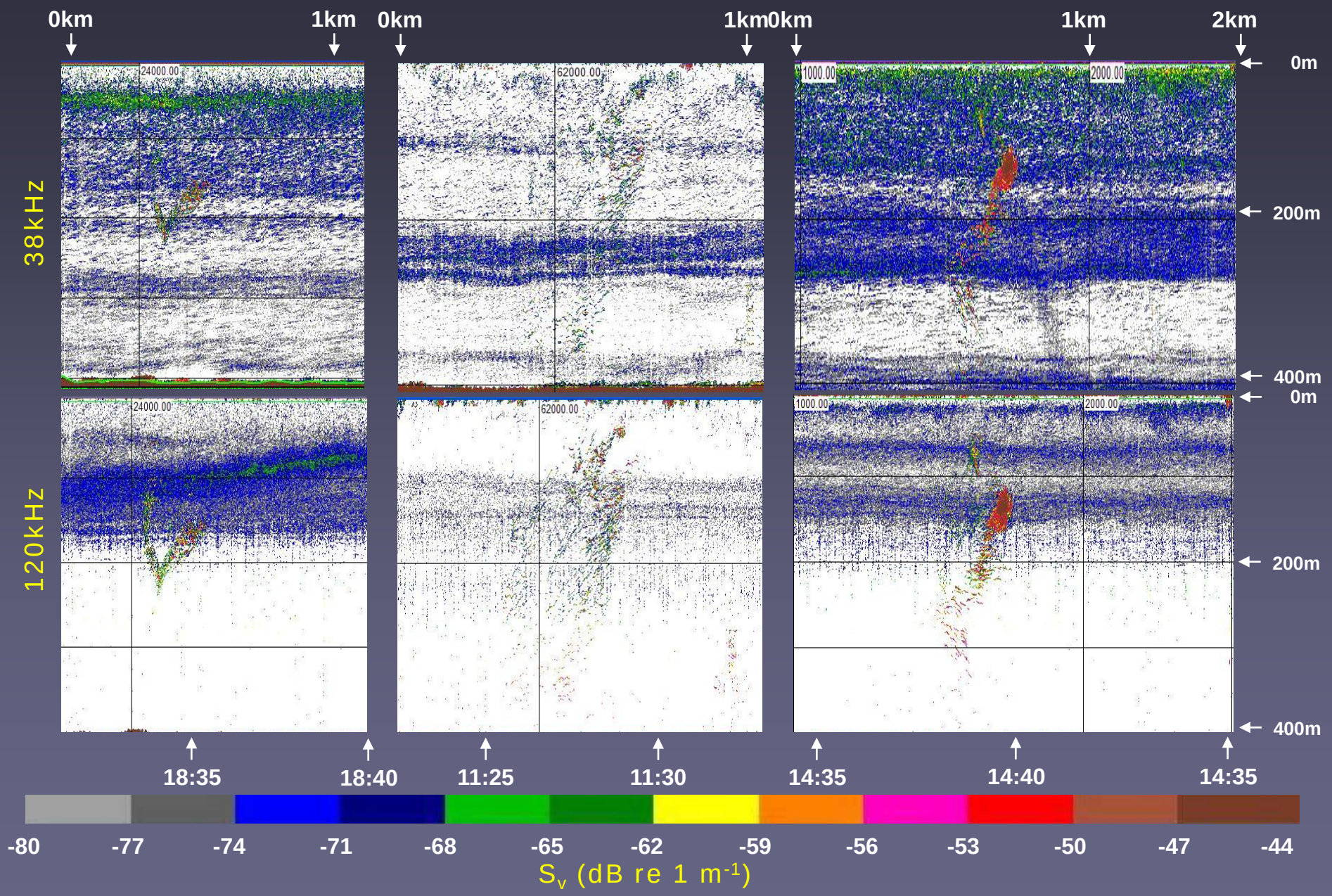
Frequency Dependency of Target Strength



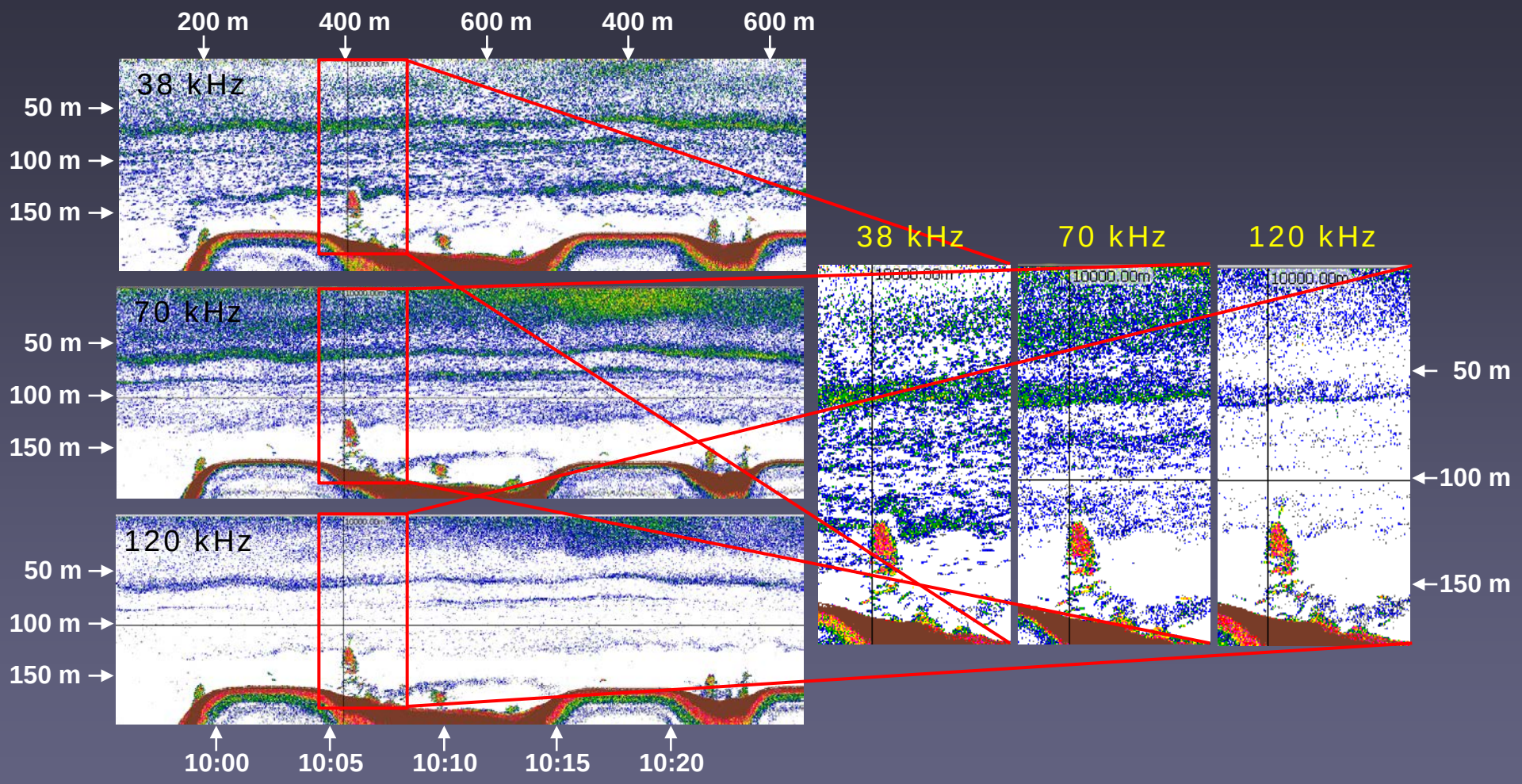
Backscatter Frequency Response of Planktonic Organisms



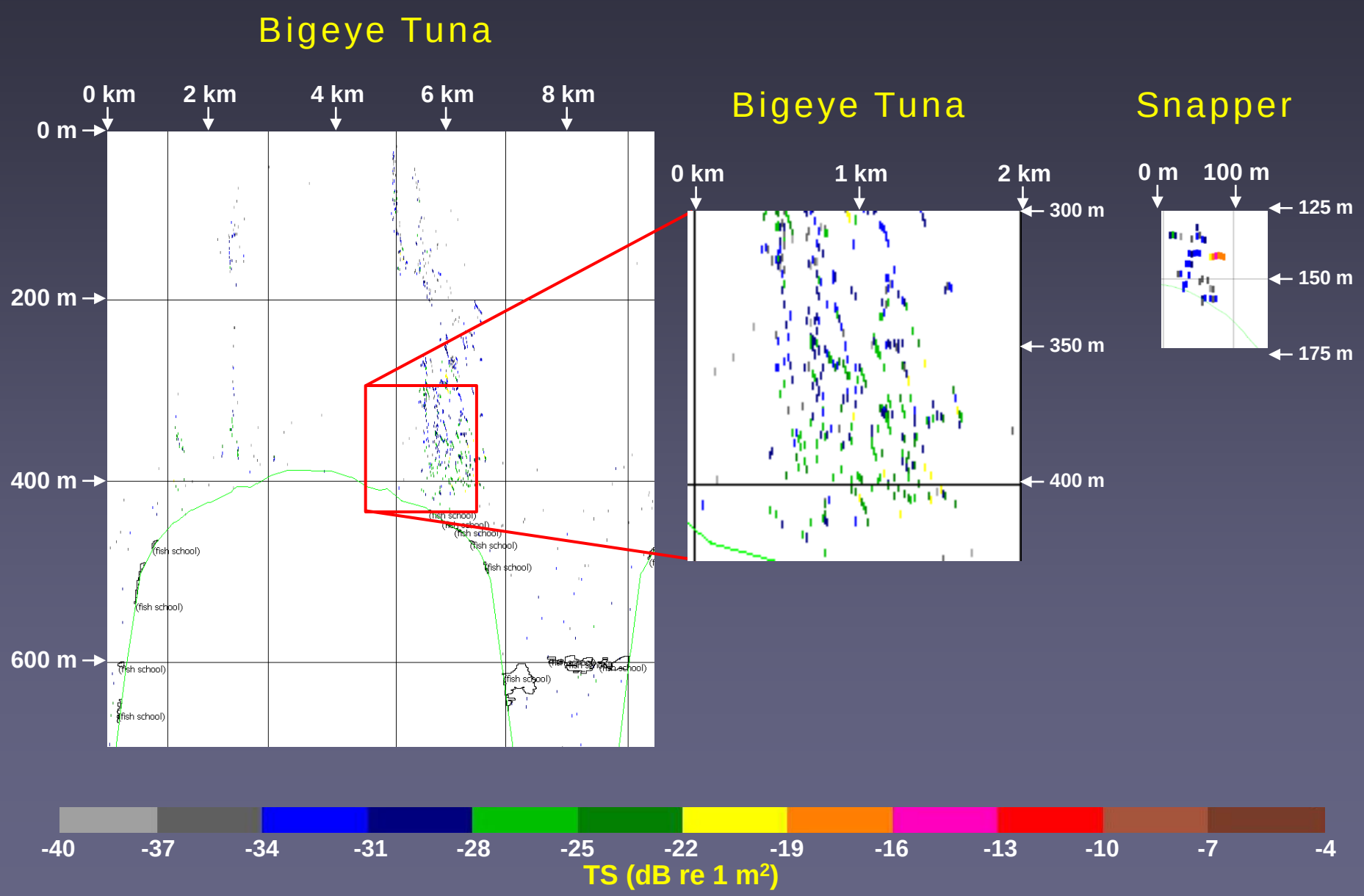
Tuna Aggregations



Snapper Aggregations



TS Aggregation Shape, & Individual Fish Movement



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Expected Fish and Target Strengths (TS) at Cross Seamount

TS of BET is ~ 5 dB higher than that of YFT of the same size (Bertrand et al., 1999)

$TS = a \log_{10} FL + b$

- **BET ➔ a = 24.29 b = 73.31**
- **YFT ➔ a = 24.26 b = 80.62**

100 – 150 m

62% BET (50 cm FL)* ➔ -32 dB

28% YFT (50 cm FL)* ➔ - 38 dB

74% BET (60+cm FL) ➔ -29 dB**

15% YFT (60+cm FL) ➔ -35 dB**

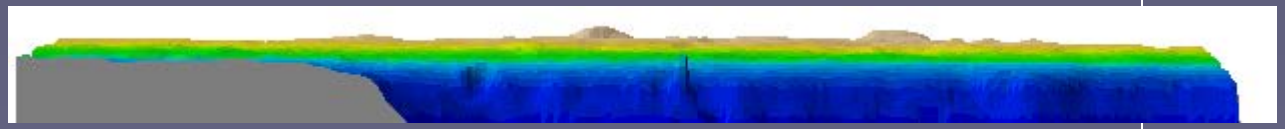
11% POM (60 cm FL) ➔ -36 -- -32 dB ?**

~350 m

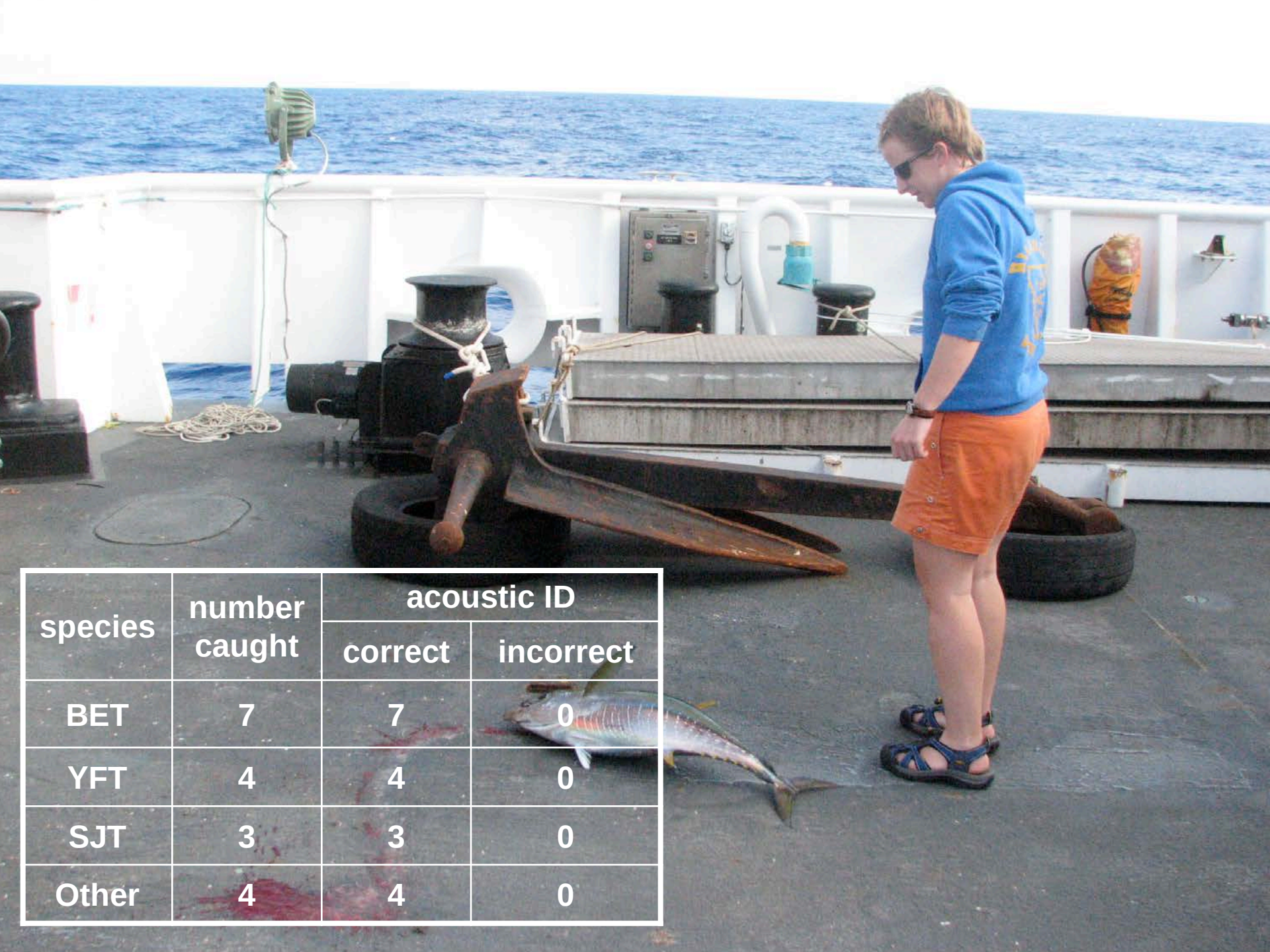
18% BET (80+cm FL) ➔ -27 dB**

16% YFT (80+cm FL) ➔ -32 dB**

66% POM (60 cm FL) ➔ -36 -- -32 dB ?**



*Itano and Holland 2000 (main ref.)
**Itano 2004 (main ref.)



species	number caught	acoustic ID	
		correct	incorrect
BET	7	7	0
YFT	4	4	0
SJT	3	3	0
Other	4	4	0

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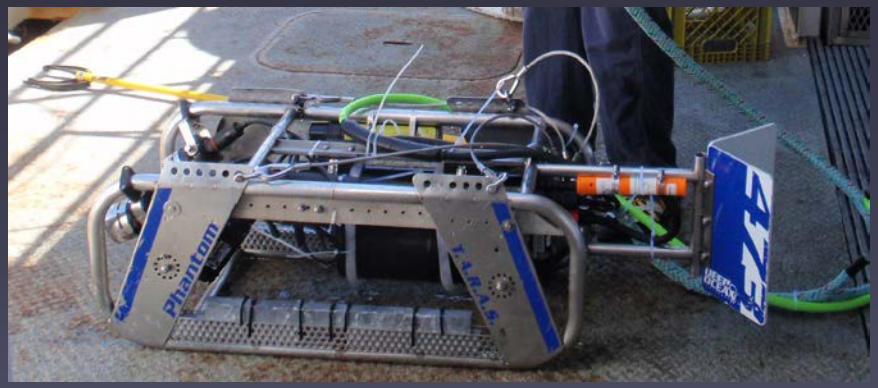
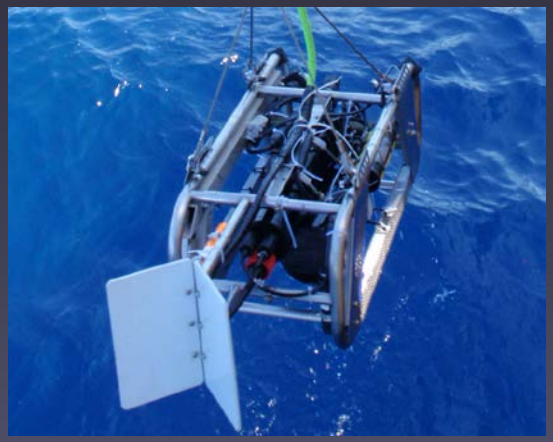
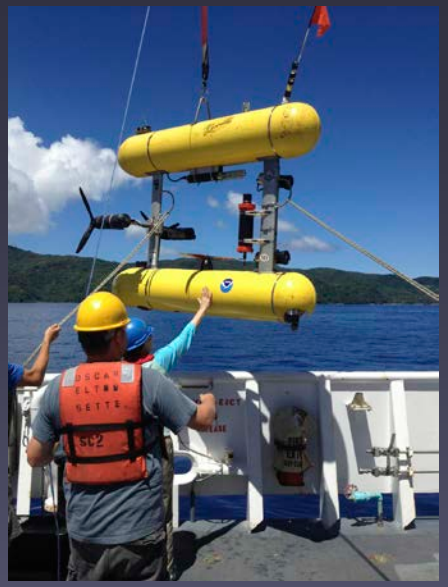
Botcam

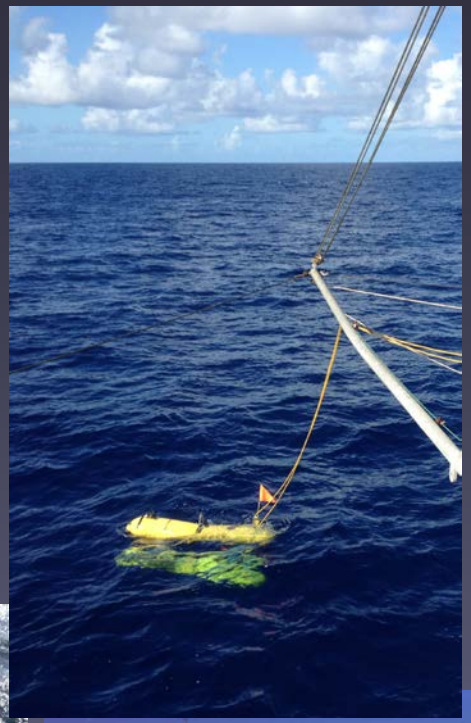
TOAD

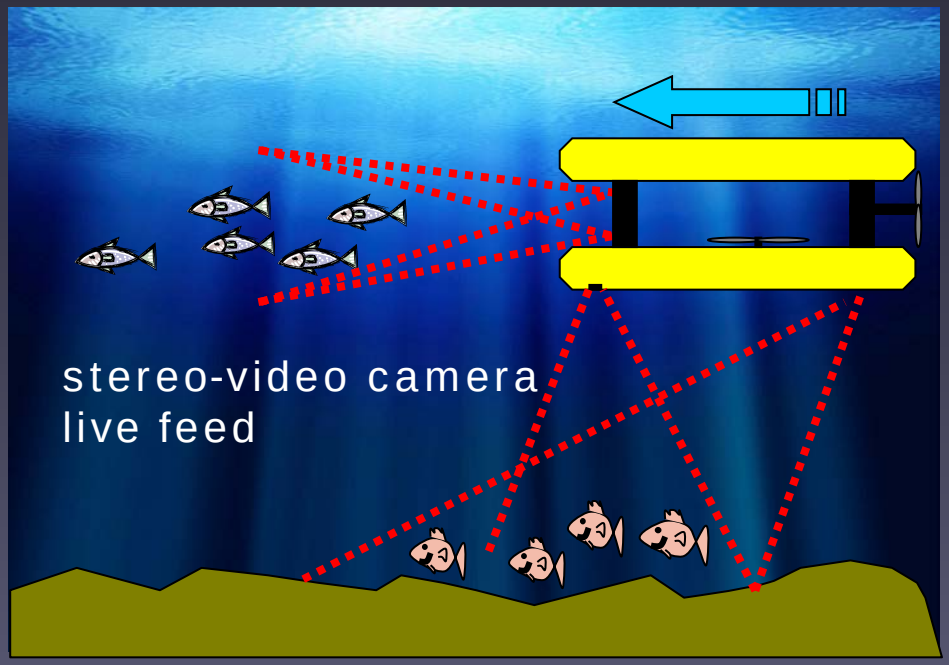


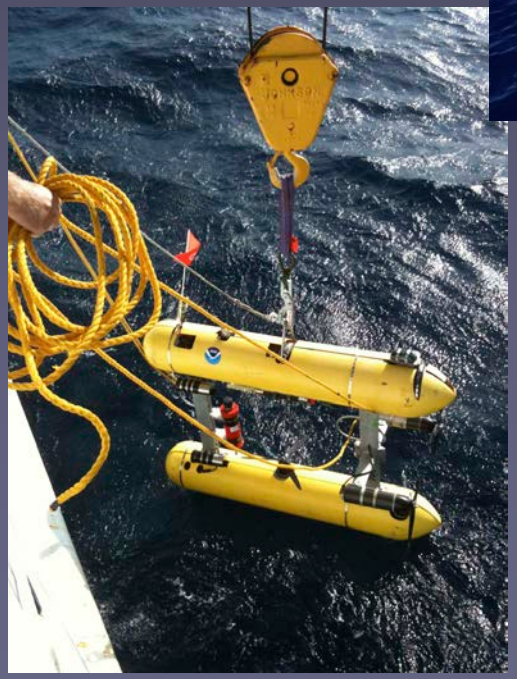


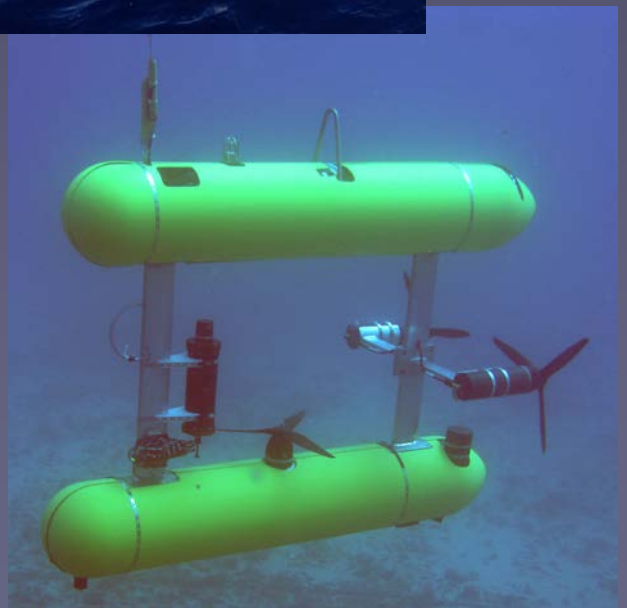
AUV







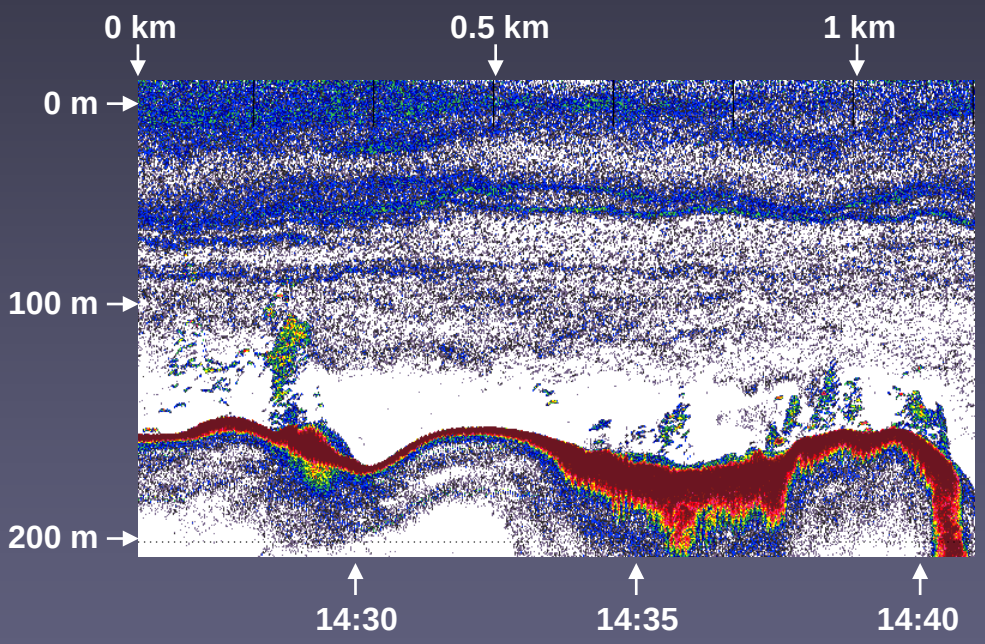




Acoustic Signature of (mostly) kalekale

(Pristipomoides sieboldii)

Simultaneous acoustics and Botcam



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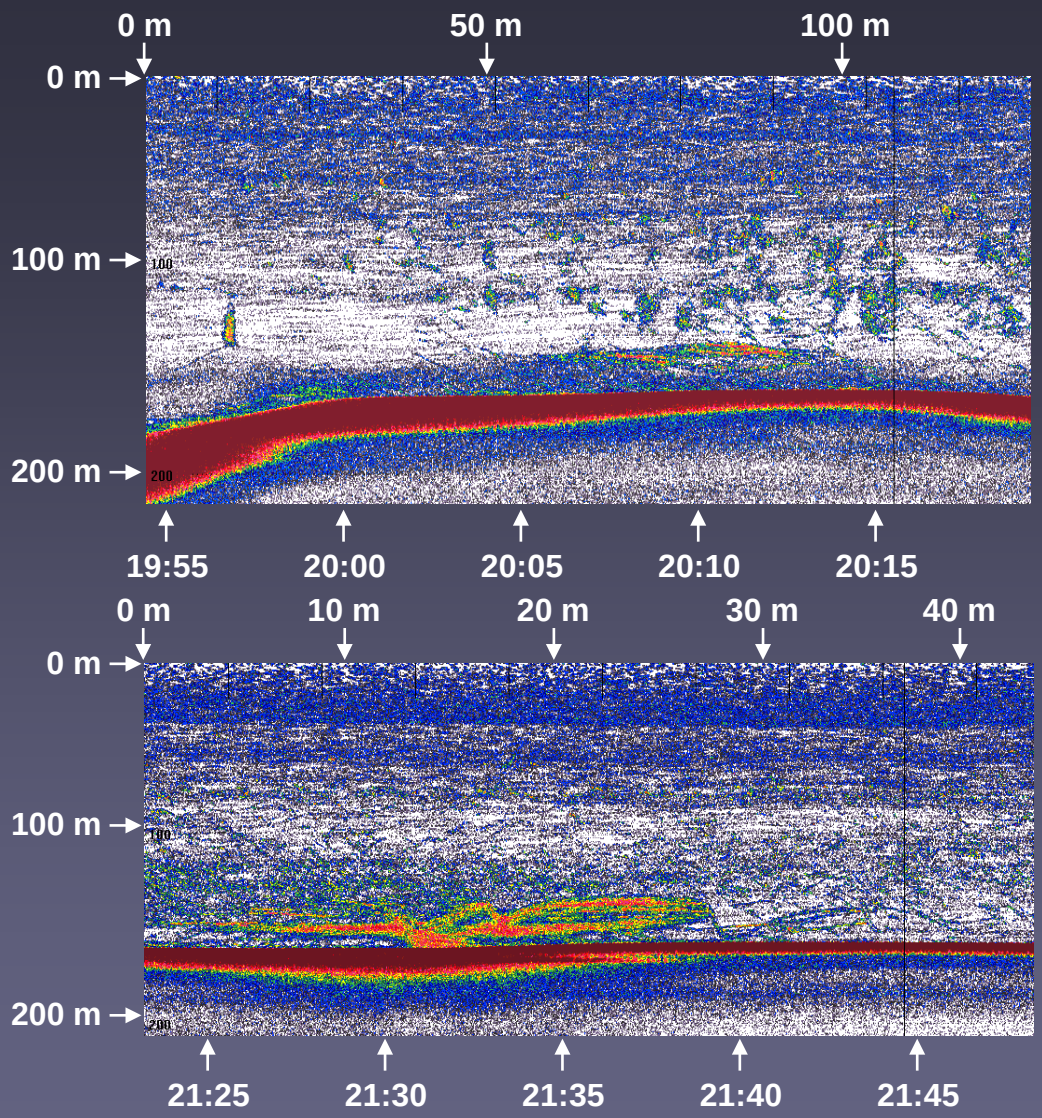
Acoustic Signature of (mostly) opakapaka



70 kHz S_v (dB re 1 m^{-1})

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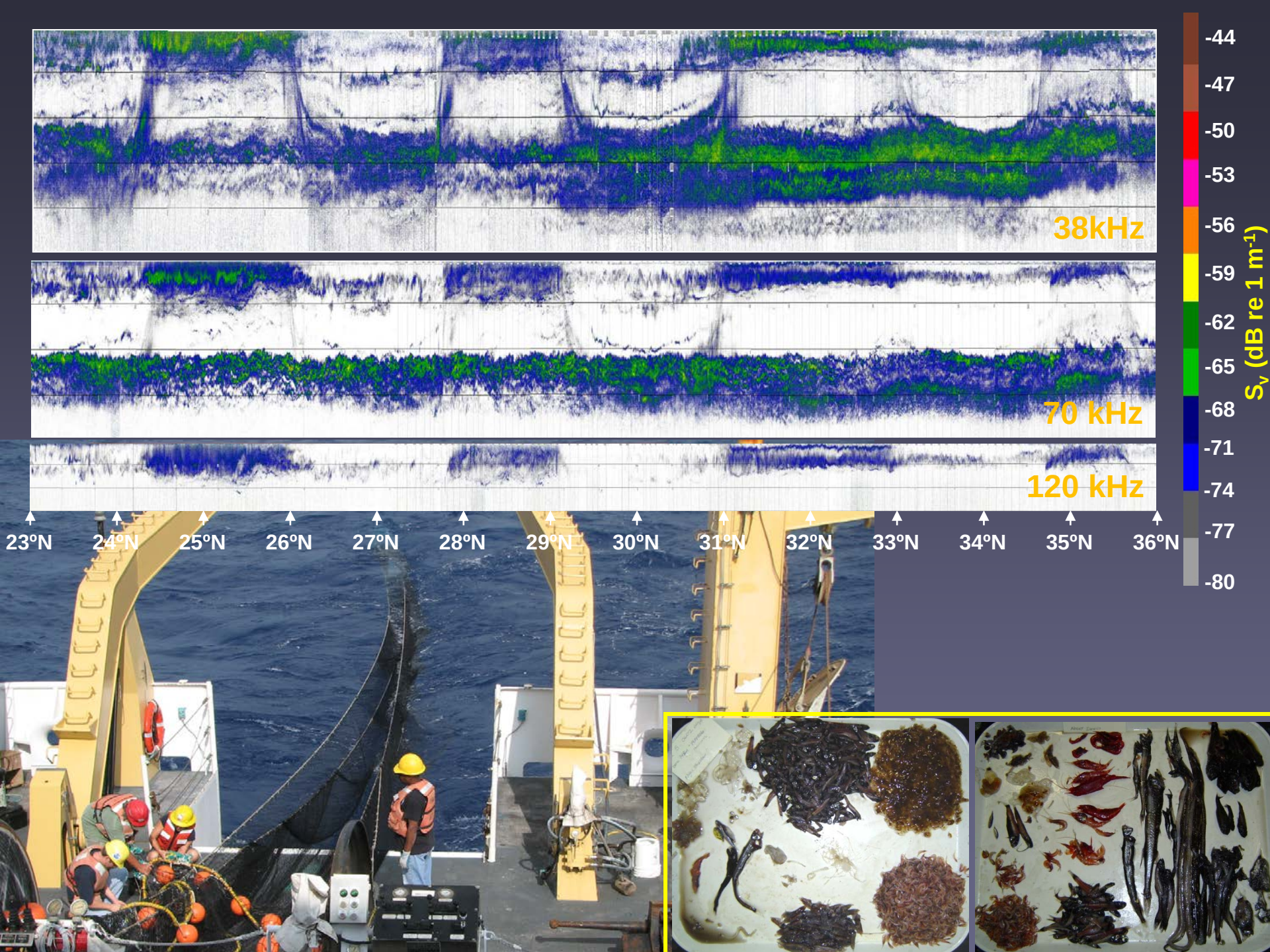
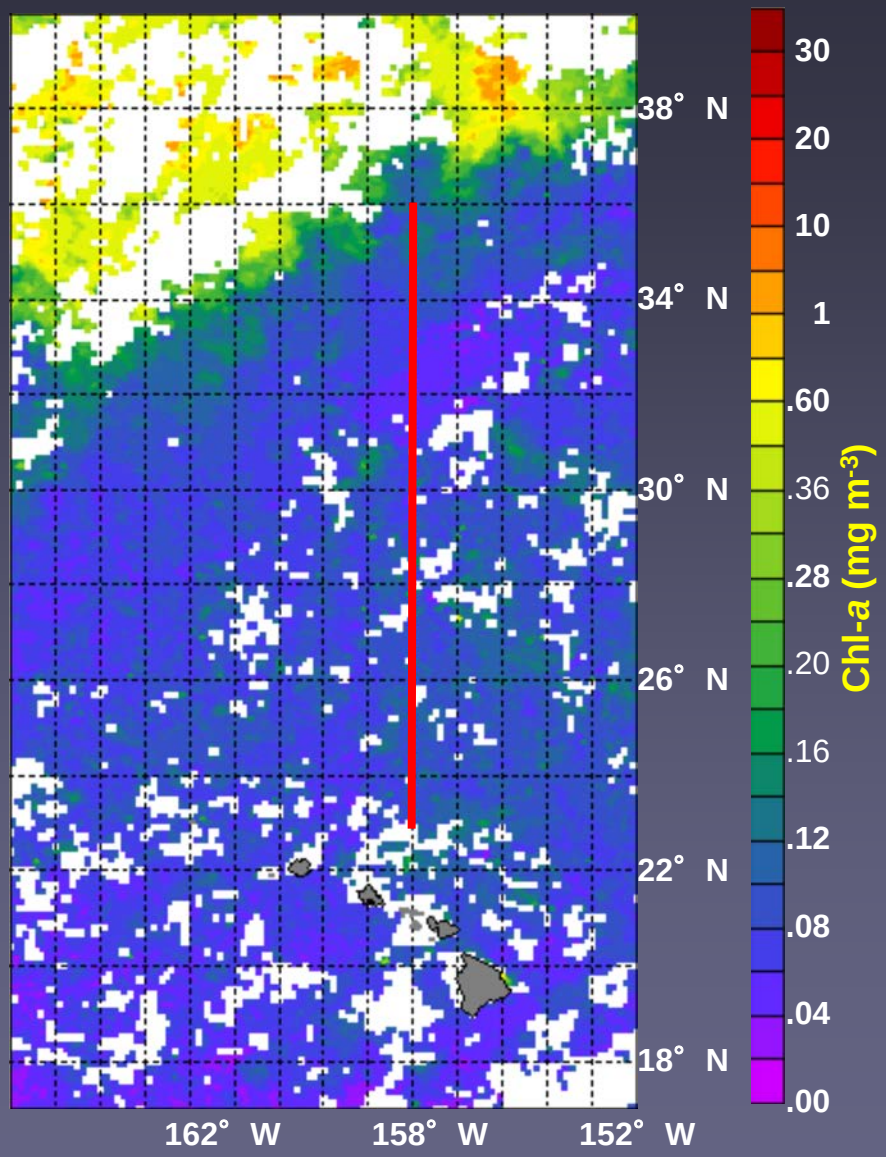

38kHz
70 kHz
120 kHz
23ºN
24ºN
25ºN
26ºN
27ºN
28ºN
29ºN
30ºN
31ºN
32ºN
33ºN
34ºN
35ºN
36ºN
-44
-47
-50
-53
-56
-59
-62
-65
-68
-71
-74
-77
-80
S_v (dB re 1 m^{-1})

Applications

Spatiotemporal distribution, composition, and biomass, and the effects of

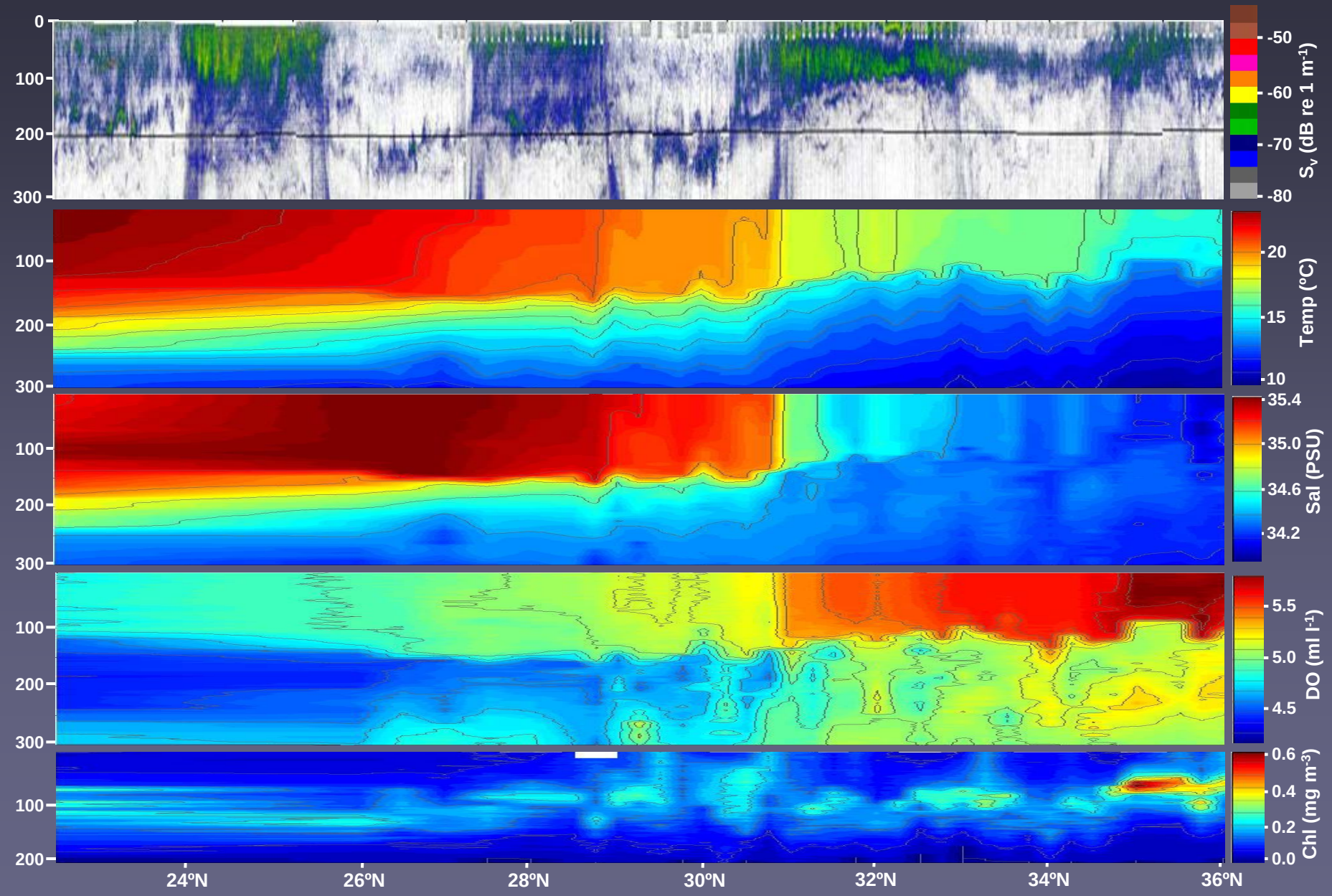
- **environment**
  - **physical characteristics (T, S, DO)**
  - **topography**
  - **currents**
  - **mesoscale eddies**
  - **fronts**
  - **chloropigment concentrations**
- **forage**
- **predators**

Example: Micronekton at the Central North Pacific (Transition Zone Chlorophyll Front)

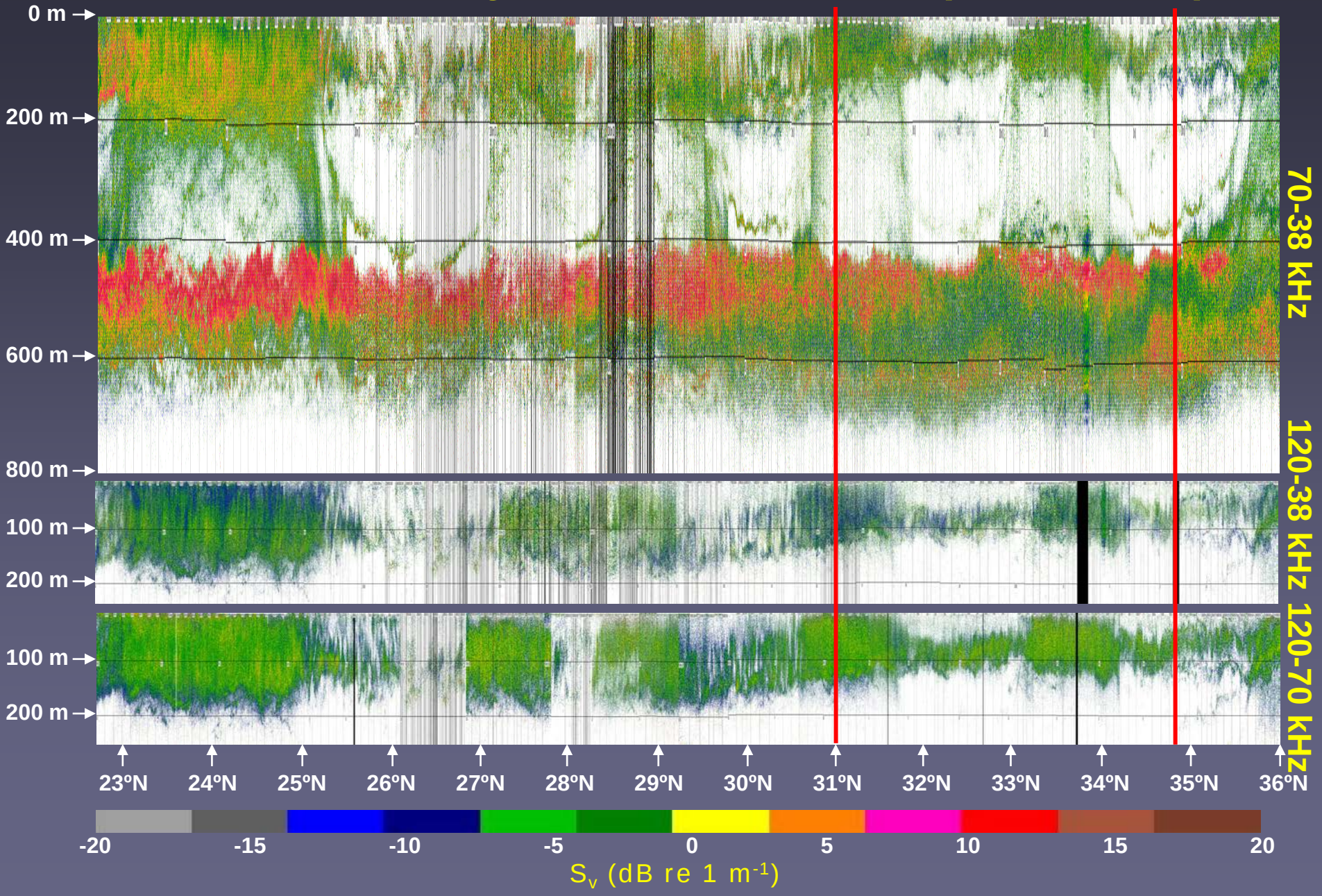


Monthly Ocean Color (SeaWiFS)

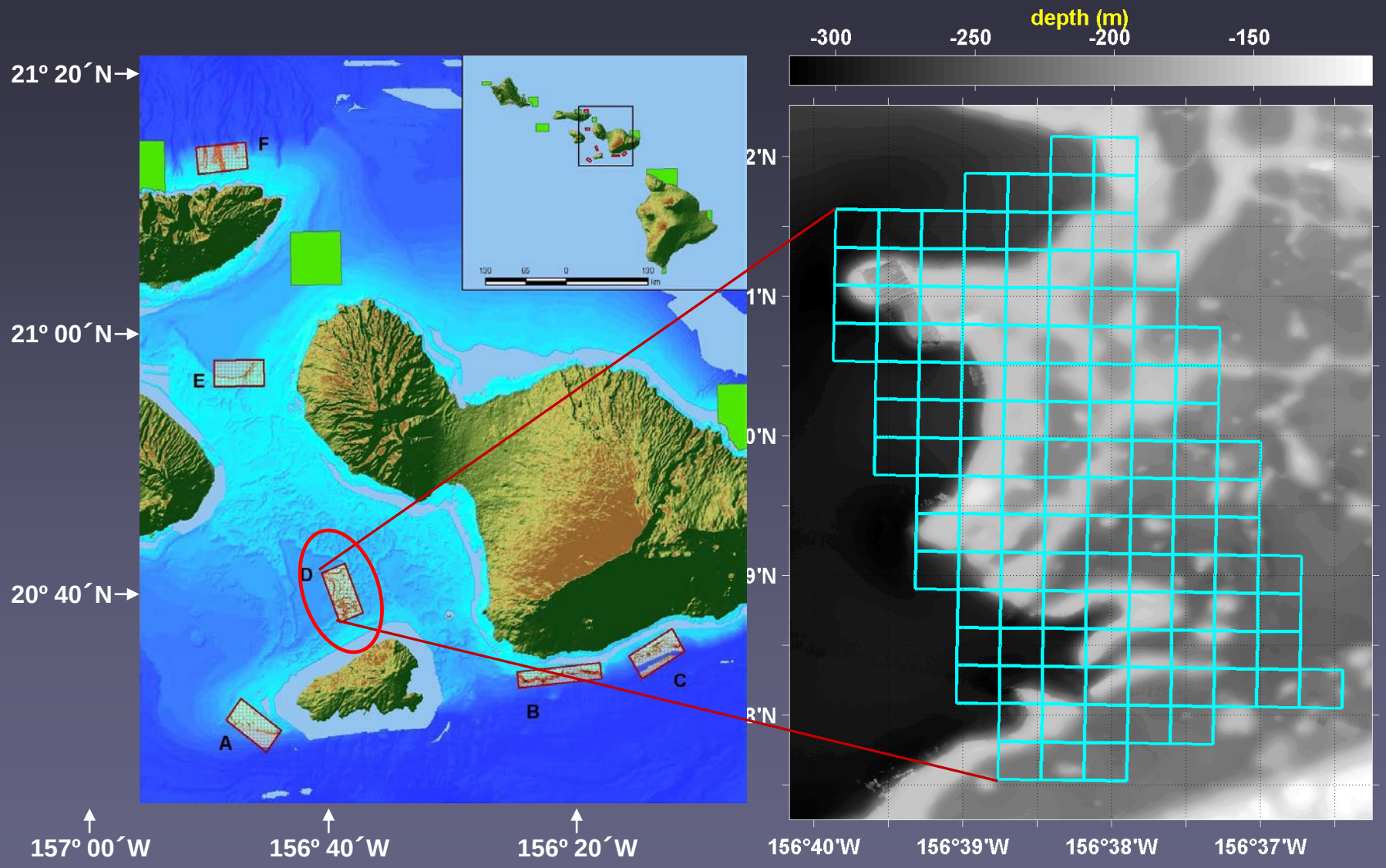
Upper 300 m Water Column along the 158ºW Meridian



Backscatter along the 158ºW Meridian (March 2009)

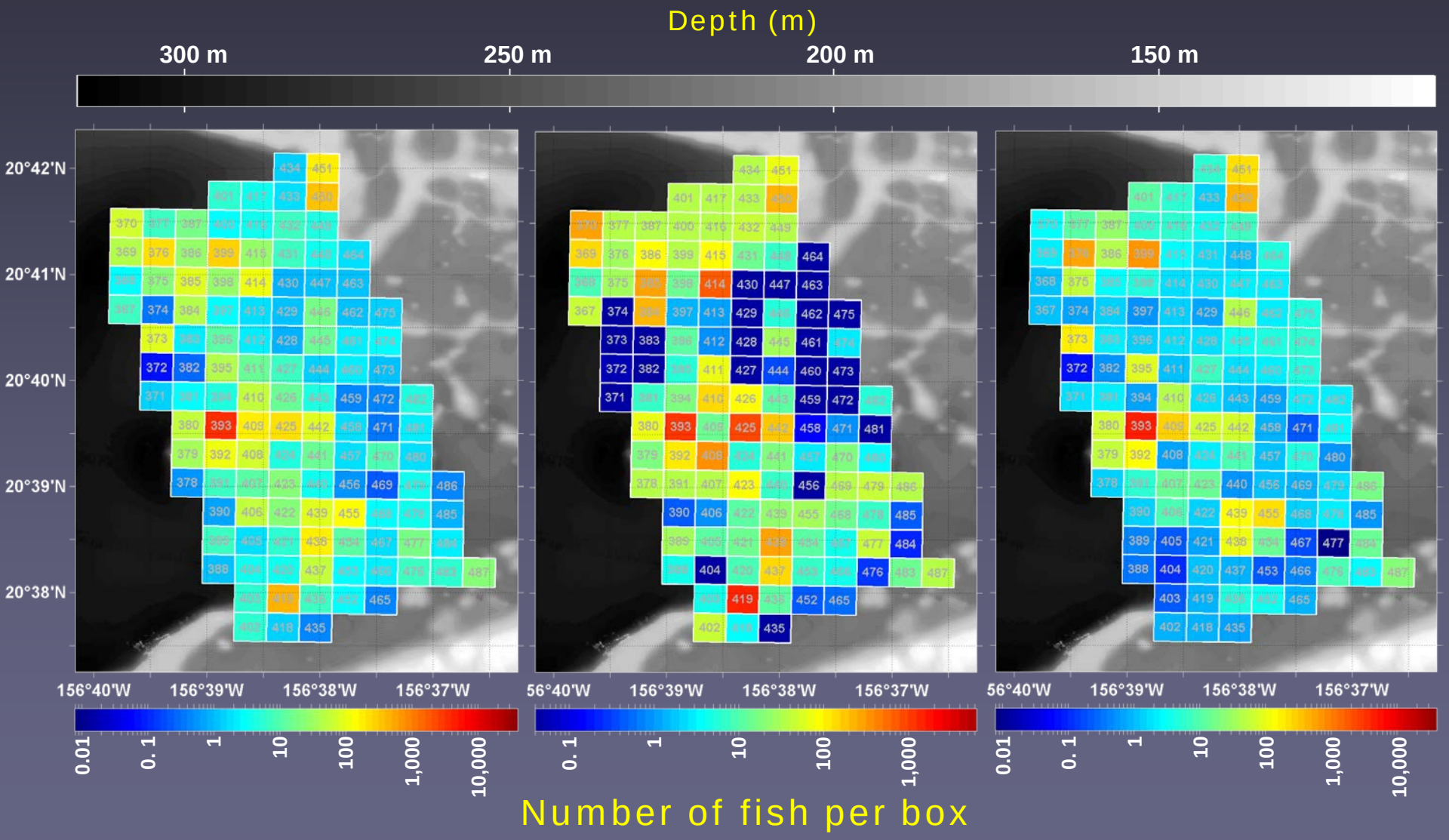


Example: Snappers in the Hawaiian Archipelago

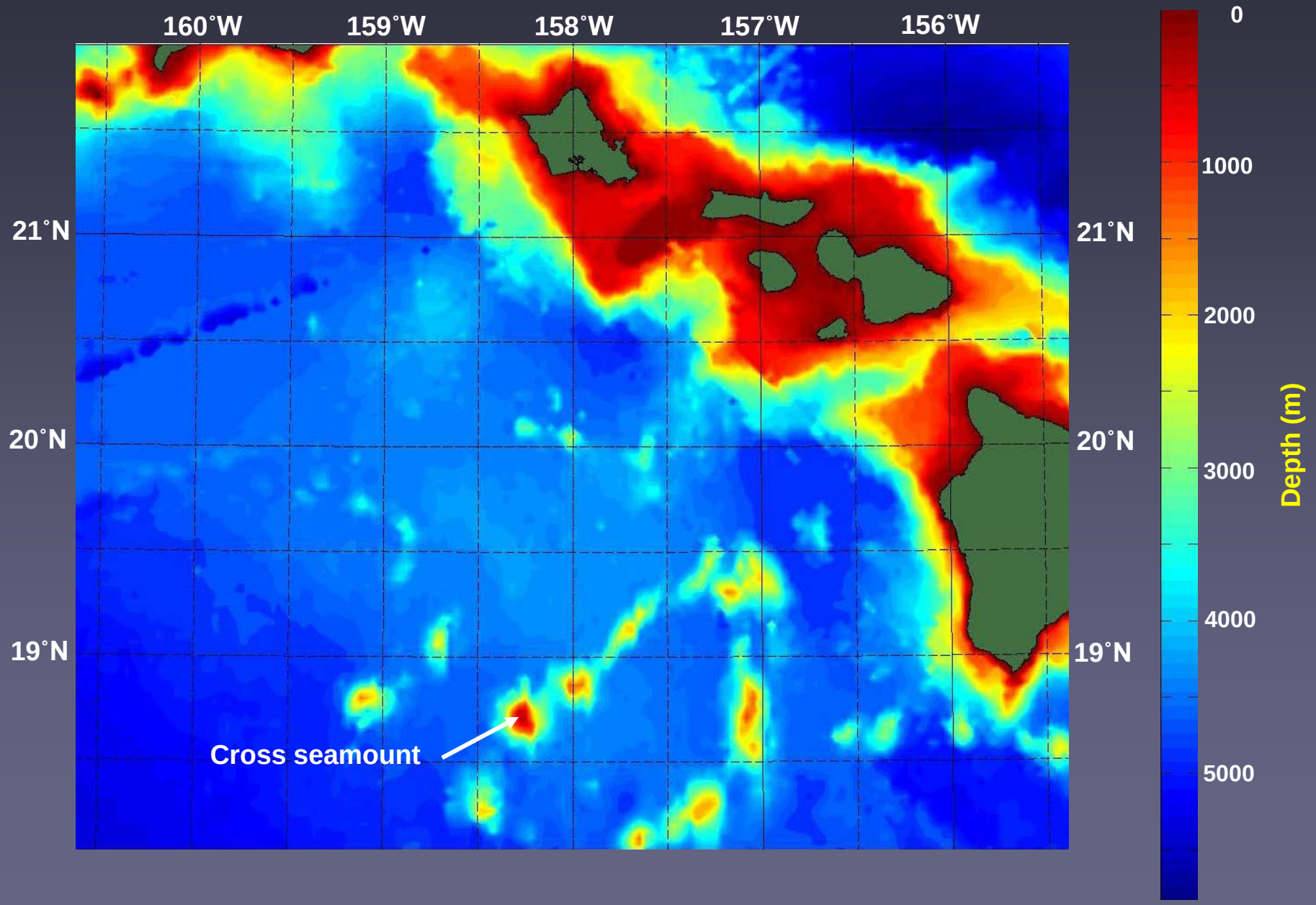


Snapper Abundance Off Maui

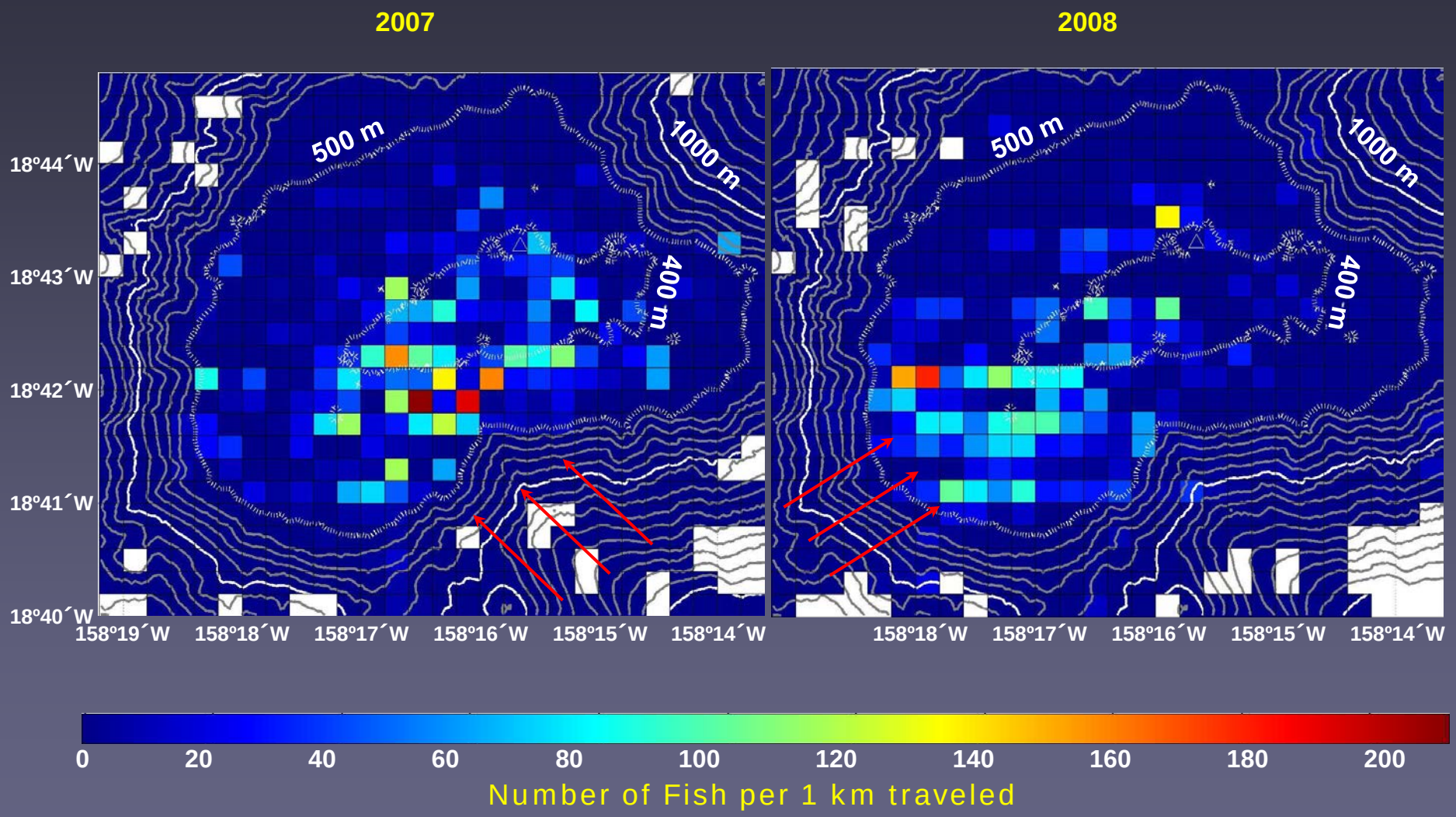
All Surveys | Daytime Surveys | Nighttime Surveys



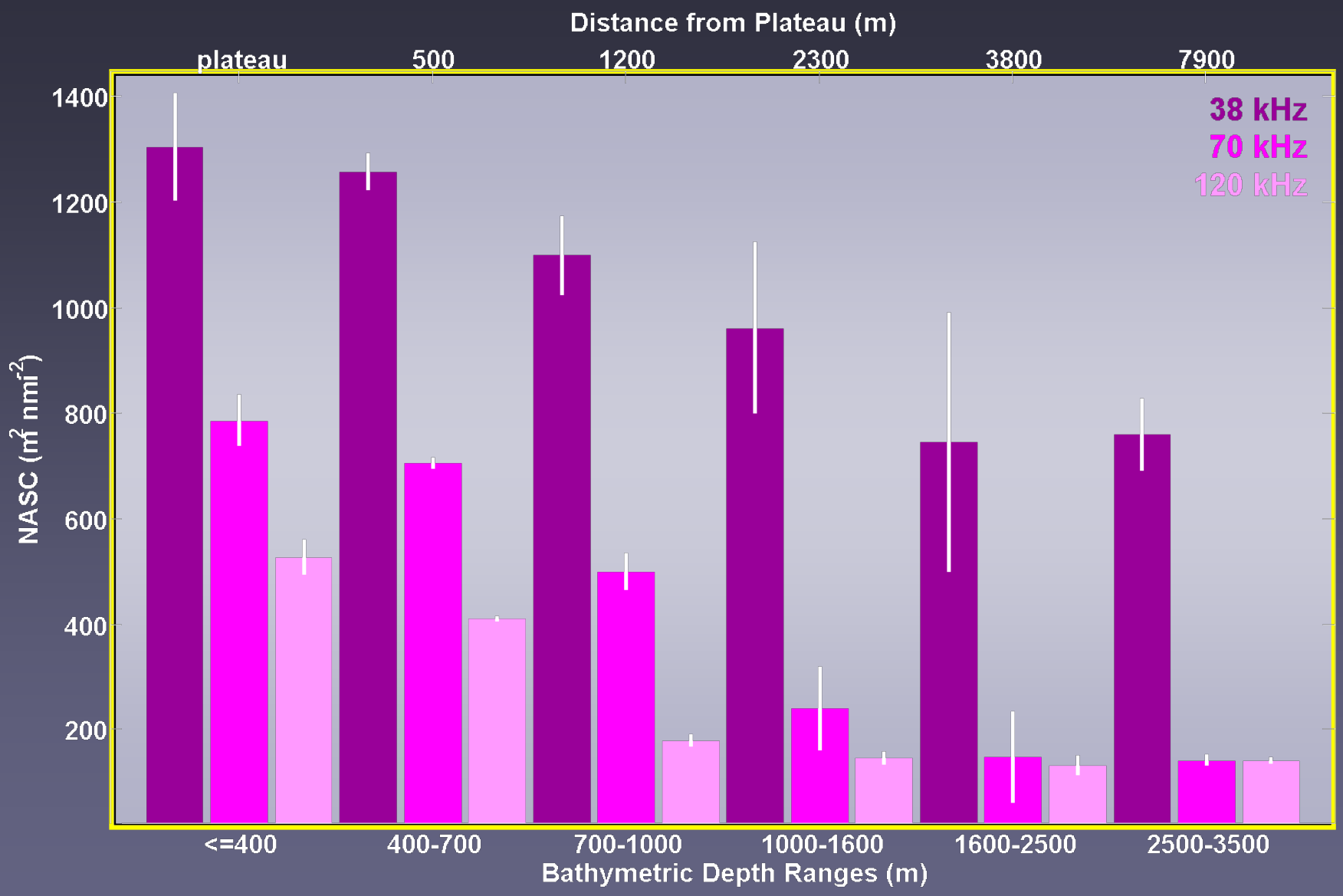
Example: Bigeye Tuna and its Forage at Cross Seamount



Number of Bigeye Over Cross Seamount



Shallow Scattering Layer Relative Biomass at Cross Seamount



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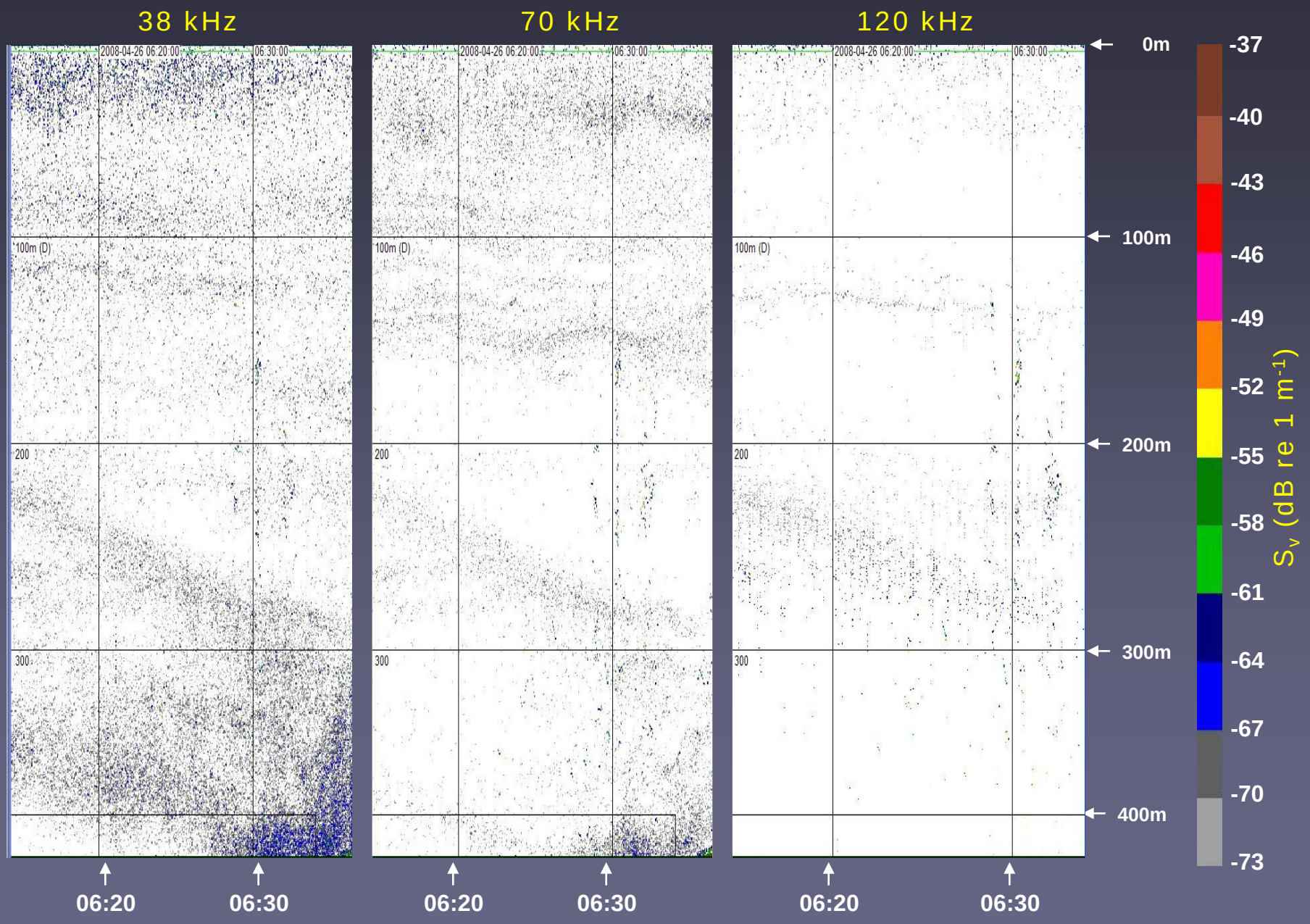
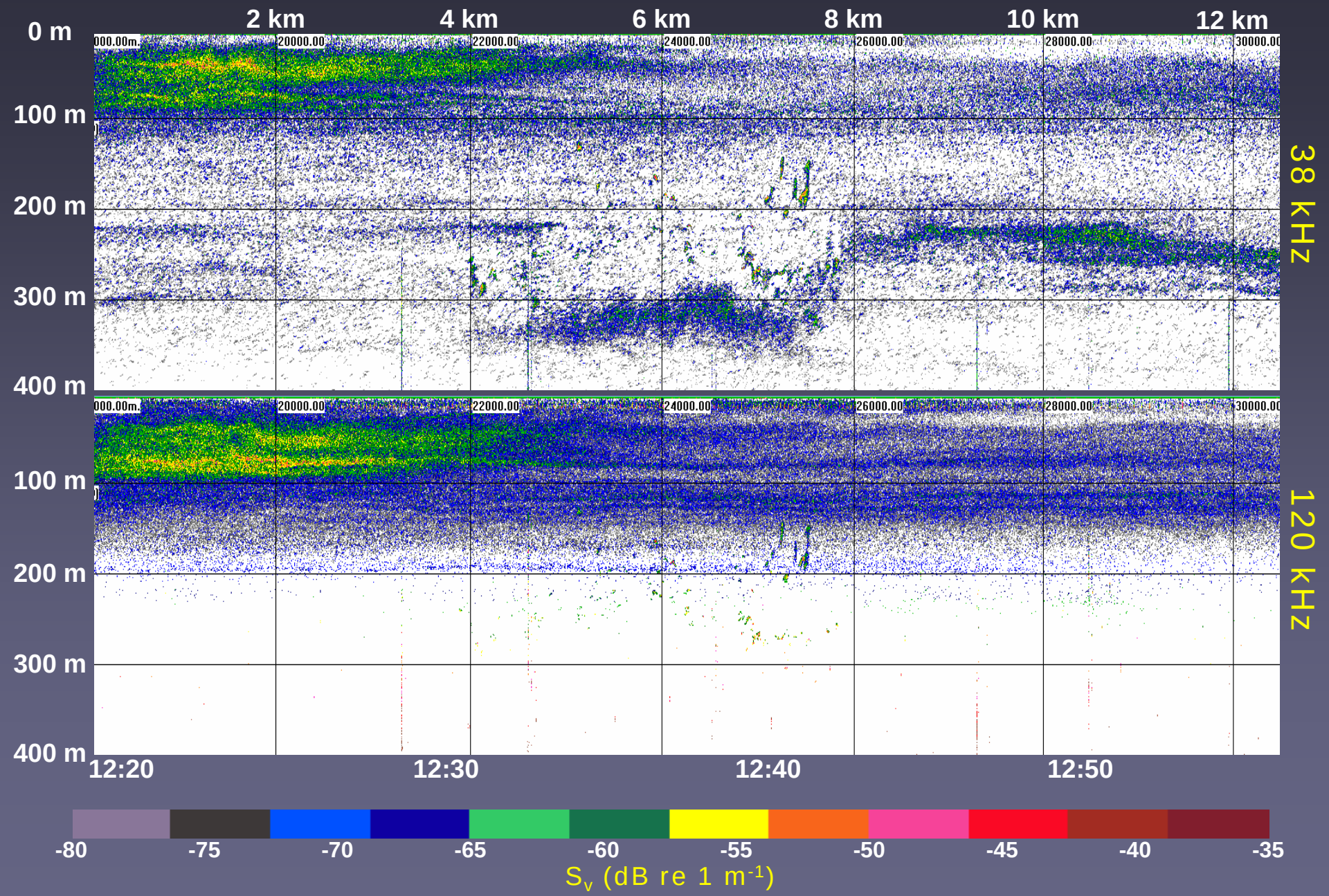
  - **fronts**
  - **chloropigment concentrations**
- **forage**
- **predators**

Bigeye Feeding on Vertically Migrating Micronekton



Avoidance of Predators by Micronekton



Applicability of Acoustic Method

- **Acoustics alone**
  - **known and distinct acoustic descriptors**
  - **relatively homogeneous environment**
- **Complimentary methods**
  - **a priory knowledge**
    - **spatiotemporal distribution**
    - **% species allocation**
    - **habitat association**
  - **simultaneous**
    - **visual observations**
    - **fishing**
    - **net sampling**