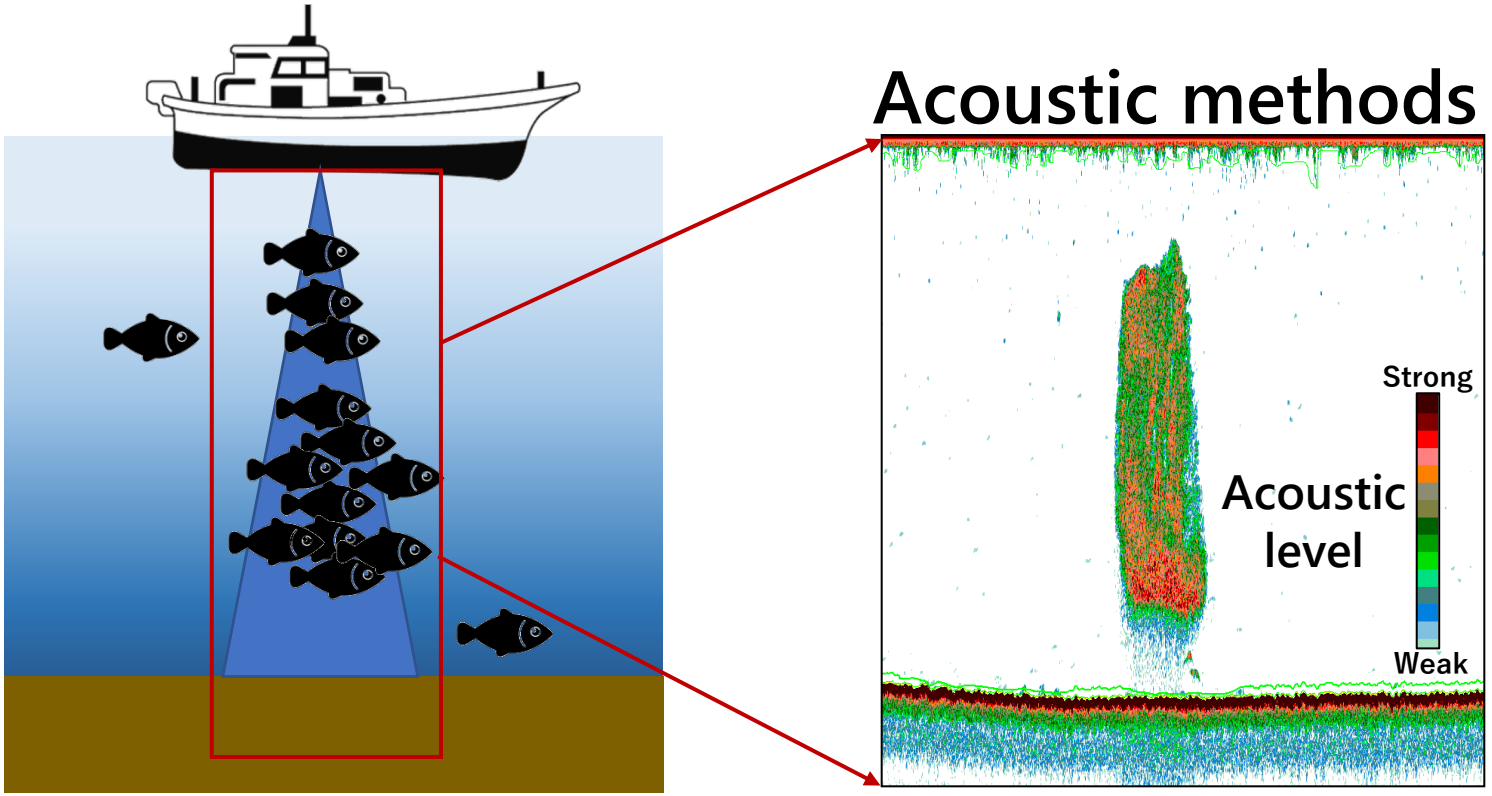
Calibration of Multiple Fishing Vessels Using Secondary Reflection from Seabed

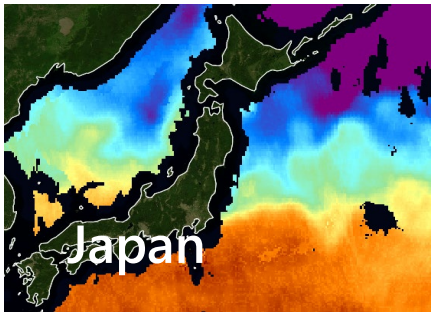


Yanhui Zhu[1*], Kenji Minami[2], Yoshihiro Nishiyama[3], Akinori Kasai[3], Tsutomu Tokeshi[4], Mitsuhiro Matsuura[5] and Kazushi Miyashita[2]

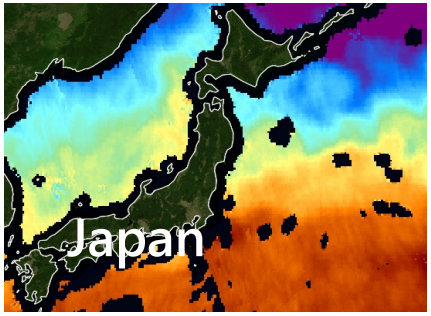
* Hokkaido University, Environmental Science, Laboratory of Marine Ecosystem Change Analysis

Introduction: Fish ecology affected by environmental changes

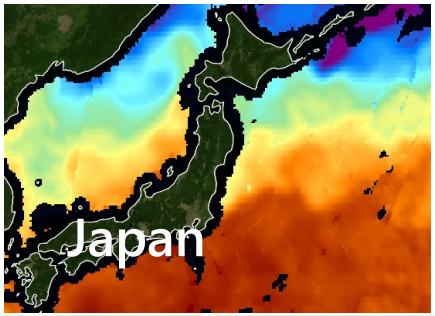
Surface water temperature



2004 Sep.

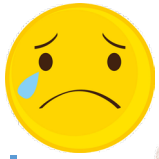


2016 Sep.



2022 Sep.

[℃]
15 19 23 27 31
National Aeronautics and Space Administration (NASA)



Decrease in habitat and catch

Atka Mackerel

Pacific squid

Salmon

Hokkaido

Rising water temperature

Increased catch

Go up North

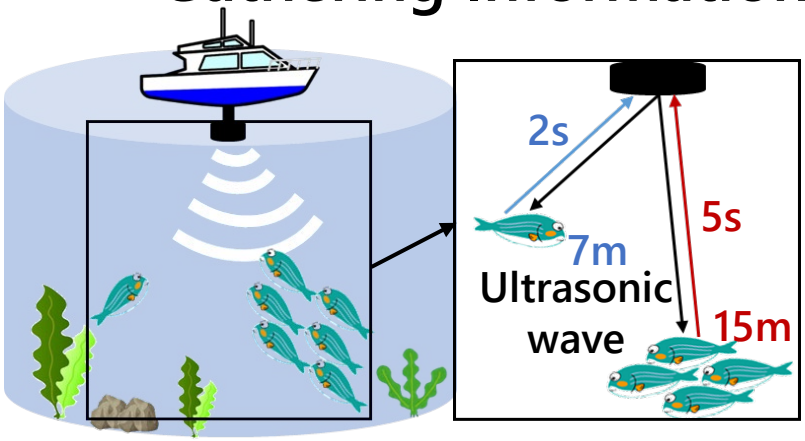
Yellowtail

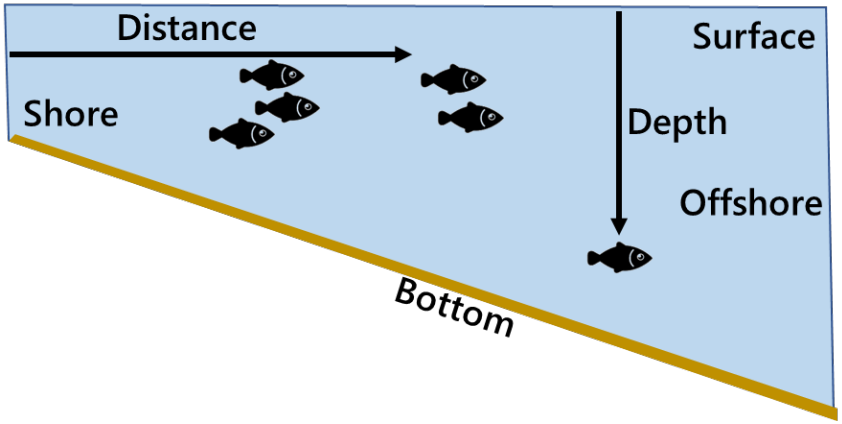
N

Changes in fish distribution and abundance due to environmental changes need to be studied in detail

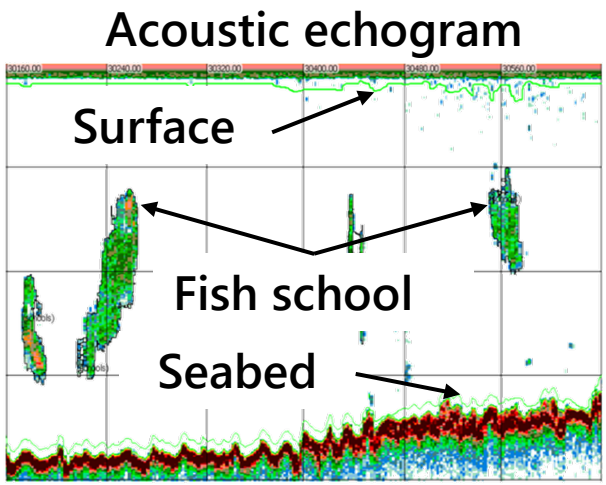
Introduction: Commonly used echo sounder for fishery resource survey

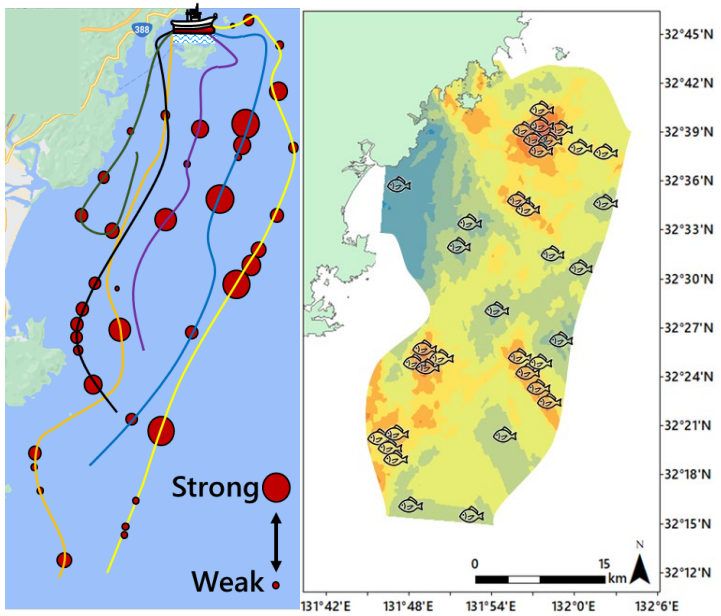
Gathering Information in the Sea (general function)



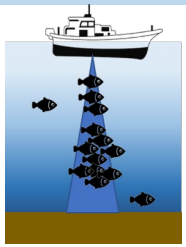


Fish school volume can be calculated (high accuracy)





Introduction: Two types of echo sounder



Echo sounder

Quantitative echo sounder

General echo sounder

Quantitatively

Expensively
Large-scale
Fewer surveys
Difficult to operate

Inexpensive
Small-sized
On all fishing vessels
Easy to operate

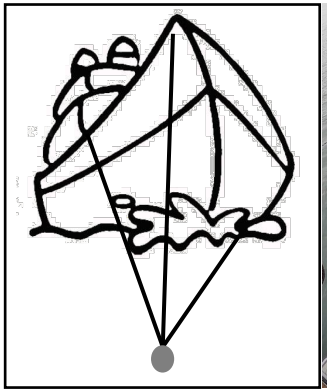
No quantitatively

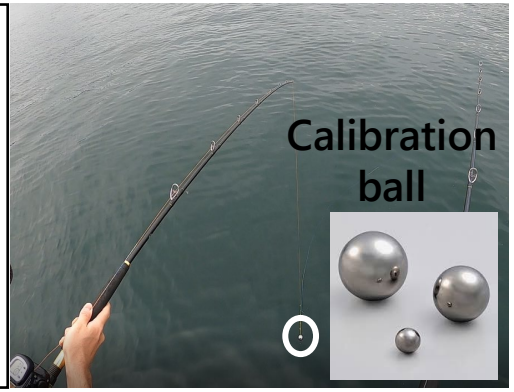
For broad-scale high-frequency biomass estimation

Make General echo sounder quantifiable

Adding quantifiability to general echo sounder, more detailed changes in fish distribution & abundance will be determined

General calibration method using a calibration sphere

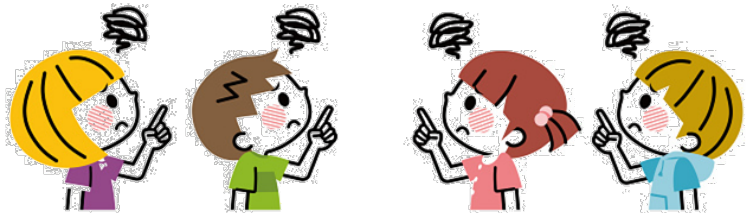




Calibration ball
(Known acoustic level)

Measurement acoustic level ⟷ Com. ⟷ Theoretic acoustic level

・Affected by sea conditions
・Cannot be done frequently
・Cannot do multiple vessels at a time



Need a simple and frequent calibration method

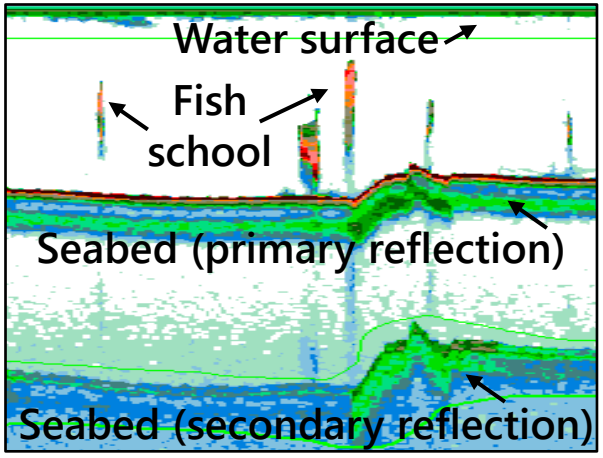
Introduction: Simple calibration using sound level of the seabed

Calibration using seabed

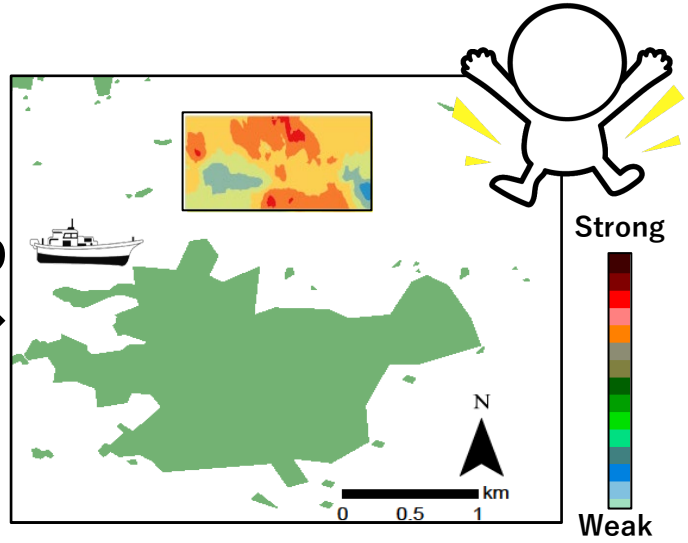
Theoretic value
(Standard seabed acoustic map)
Instead of theoretic calibration ball

Com.

Measured value
(Passing on the map)



Make a standard map



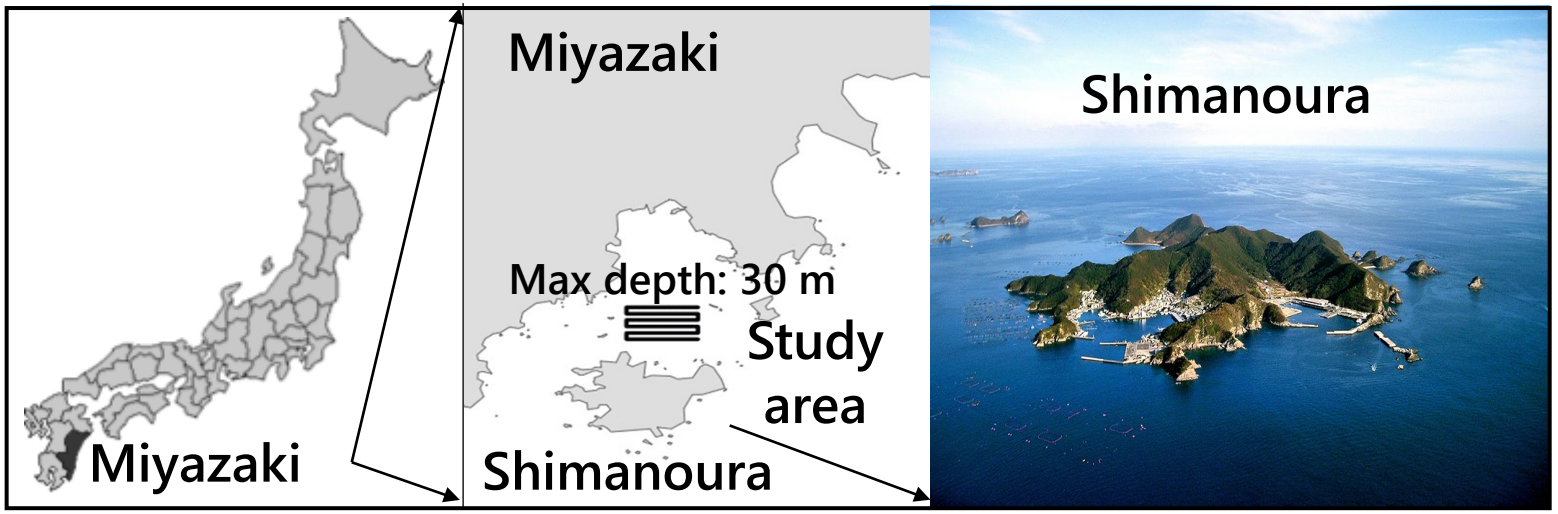
Using seabed acoustic level maps
Regularly and easy calibration of multiple echo sounders

Purpose

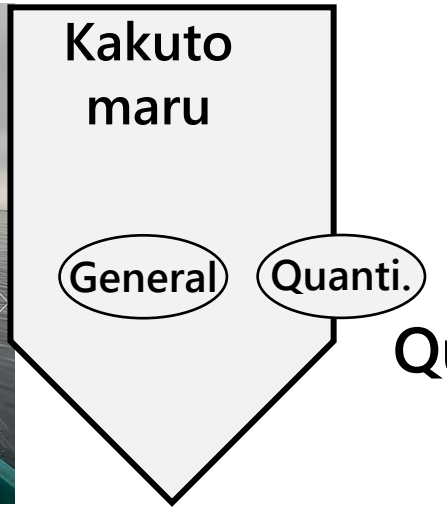
1. Make a standard map using seabed sound levels

2. Examine the validity of the calibration using seabed

Methods: Study area and experimental echo sounders



Vessel name: Kakuto maru

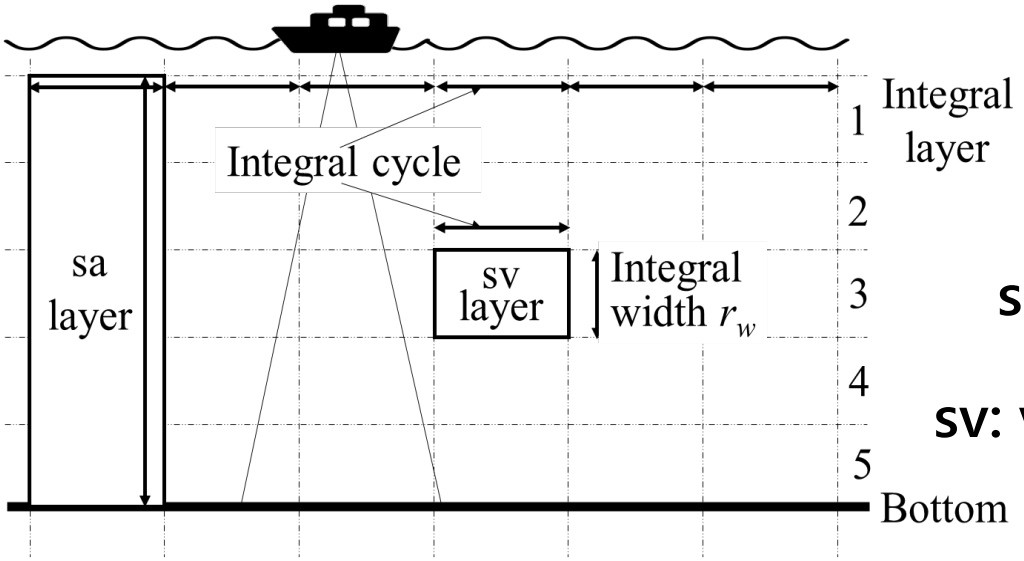


General echo sounder
FCV-1500L, FURUNO
15kHz & 200kHz

Quantitative echo sounder
KSE300, SONIC
38kHz & 120kHz

Both echo sounders installed on the same vessel

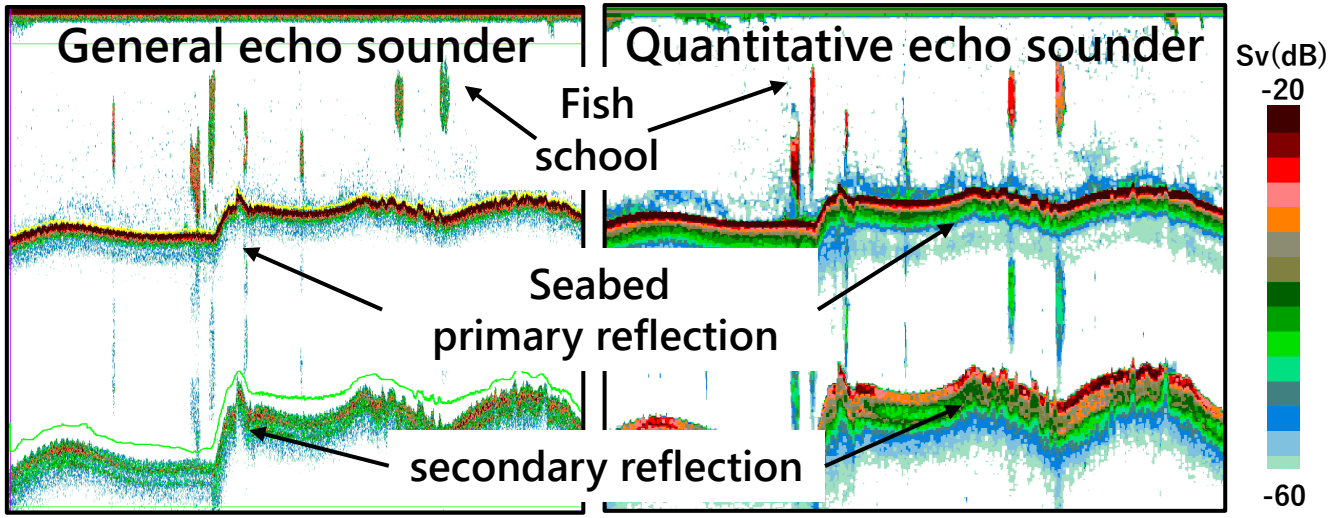
Methods: Analysis of acoustic data

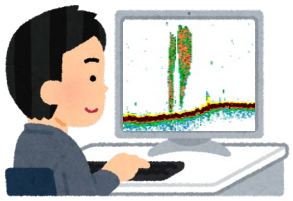


Acoustic indicators (linear value)

sa: area backscattering strength

sv: volume backscattering strength





Parameters used in analysis

Fish school acoustic level: Sa (dB)
Seabed acoustic level: Sv (dB)

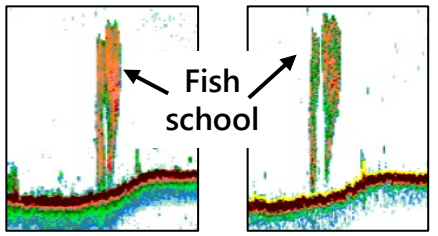
Methods: Diagram of the calibration method using the seabed

Purpose 1. Make a standard map using seabed sound levels

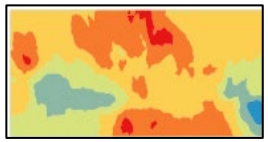
Calibrate a general echo sounder using calibration ball

(Accuracy verification using quantitative echo sounder)

Compared fish school acoustic level

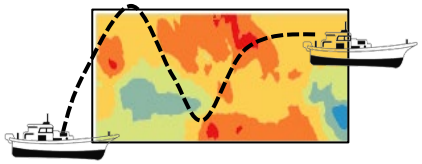


Make a standard map of seabed acoustic level using calibrated general echo sounder



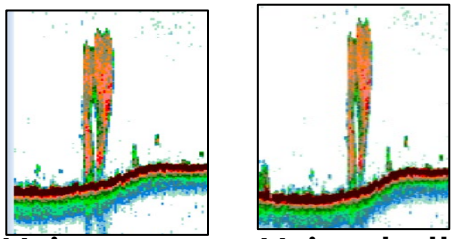
Purpose 2. Examine the validity of the calibration using seabed

Calibrate another general echo sounder using standard map



Examine the validity of the calibration using seabed

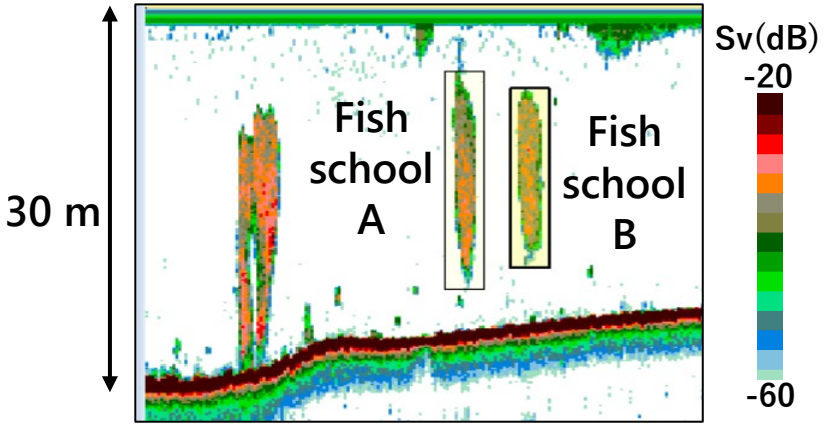
Compared fish school acoustic level



Results & discussions: ①Accuracy verification of calibrated general echo sounder

*Sardine fish school (confirmed from catch data)

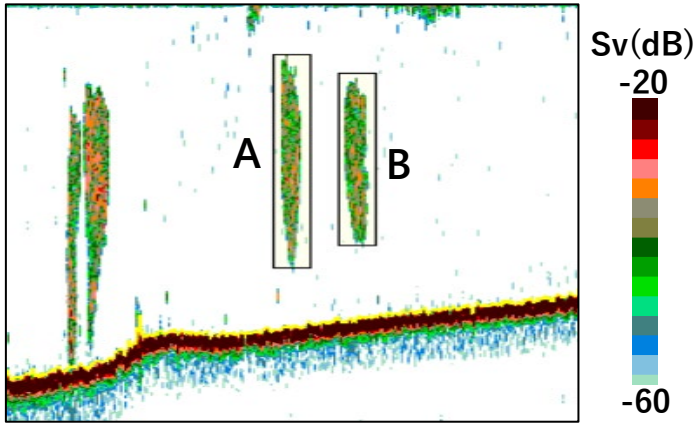
General echo sounder
(15 kHz_using calibration ball)



Sa value (dB)
A: -23.9
B: -24.3

Estimated tails
A: 5,943
B: 4,586

Quantitative echo sounder
(38 kHz)



Sa value (dB)
A: -26.2
B: -27.3

Estimated tails
A: 6,392
B: 4,556

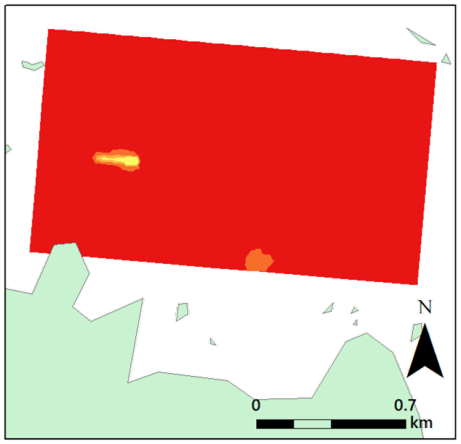
Difference within 7%

General echo sounder could be calibrated with good accuracy

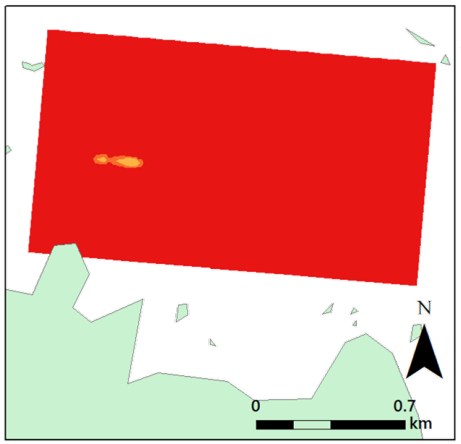
Results & discussions: ①Make a standard map using seabed acoustic level

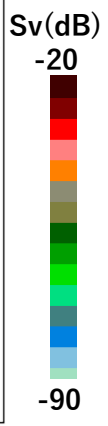
Sv value_using seabed primary reflection

15 kHz



200 kHz

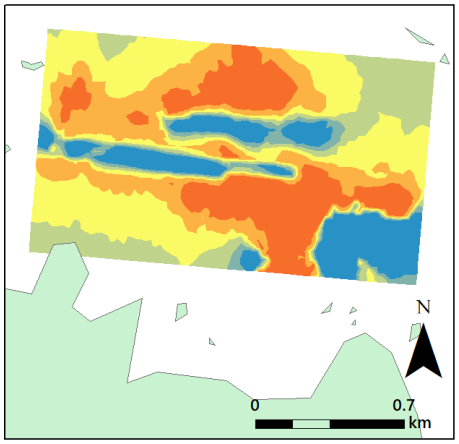




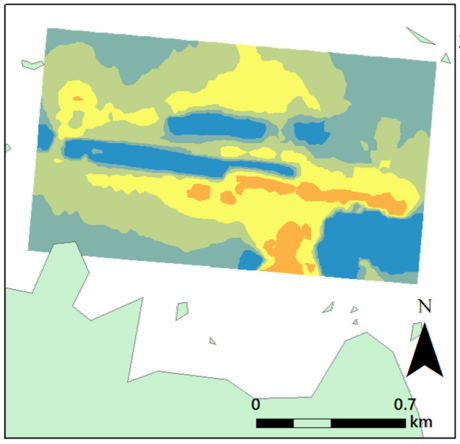
Saturation acoustic level

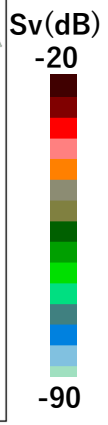
Sv value_using seabed secondary reflection

15 kHz



200 kHz





When making a standard map using general echo sounder use of secondary reflection is recommended

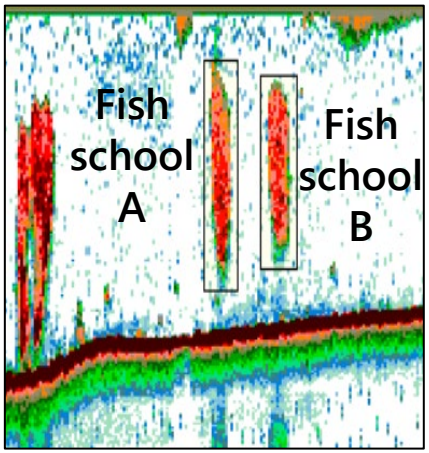
RECOMMENDED

RECOMMENDED

Results & discussions: ②Validity of the calibration using secondary reflection

General echo sounder_15kHz

Before calibration

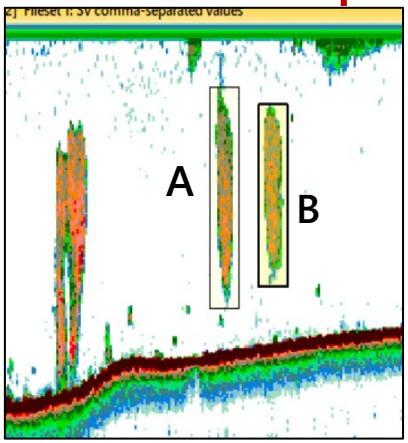


Sa value (dB)
A: -16.5
B: -17.4

Estimated tails
A: 31,196
B: 22,461

Over-valuation

Calibrated using standard map

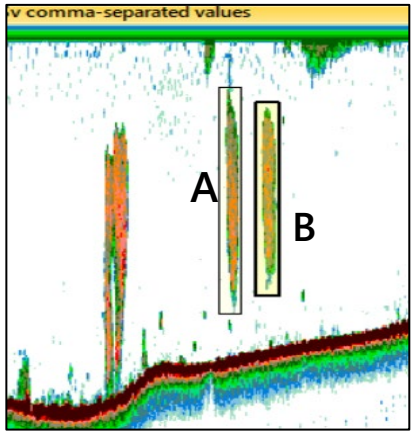


Sa value (dB)
A: -23.7
B: -24.4

Estimated tails
A: 6,224
B: 4,481

Difference within 5%

Calibrated using calibration ball



Sa value (dB)
A: -23.9
B: -24.3

Estimated tails
A: 5,943
B: 4,586

Secondary reflections of the seabed can be used to calibrate general echo sounder

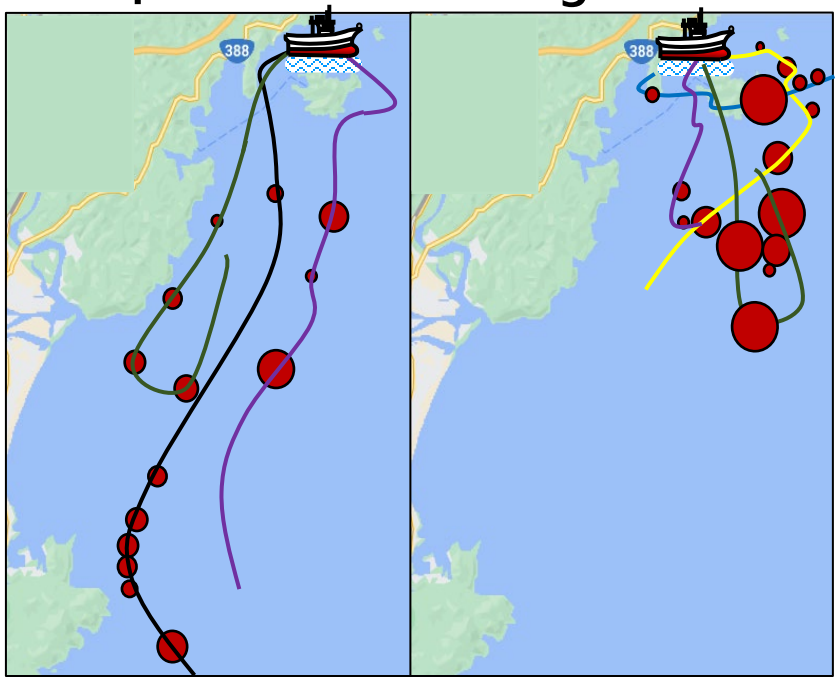
Application case: Estimation of biomass in the Miyazaki coastal sea area

One vessel (Kakuto maru)_one week in 2020

Chub mackerel

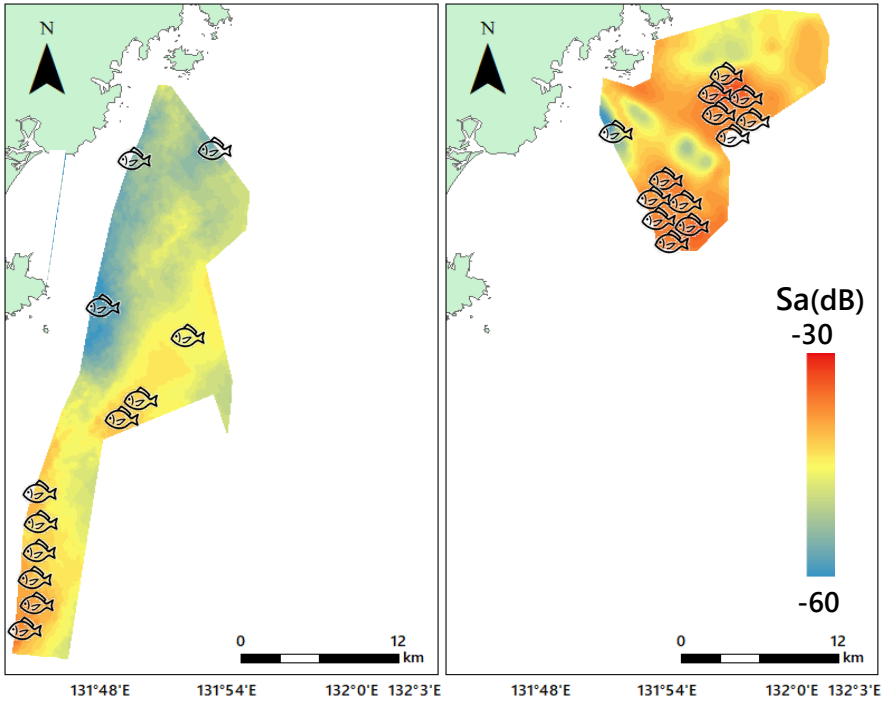
Spring
Apr. 14-19

Summer
Aug. 17-21



Spring
Apr. 14-19

Summer
Aug. 17-21

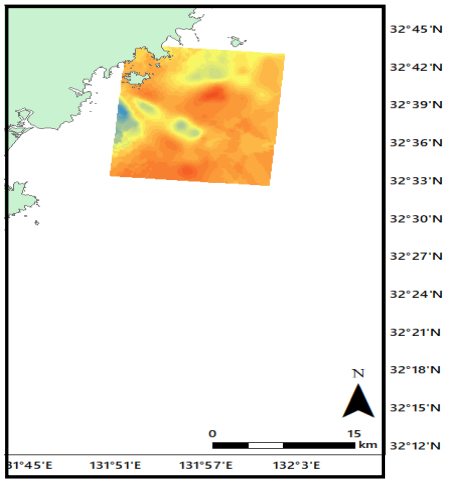


Wide range assessment from multiple acoustic data

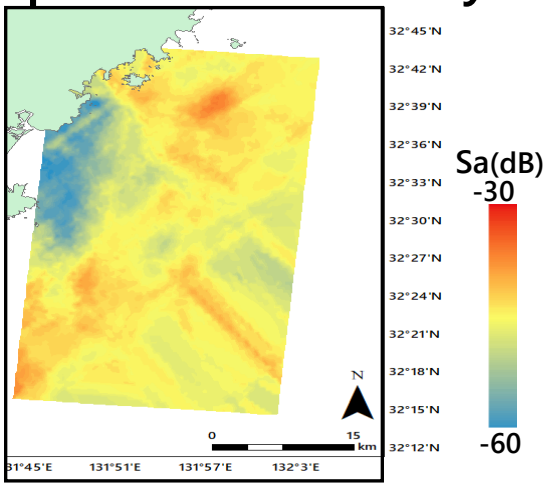
Spring	Summer
Mean Sa: -45.1 dB Area: 327km^2	Mean Sa: -39.2 dB Area: 188km^2
Estimated biomass 12,149 t	Estimated biomass 26,348 t

In the future: Combine the daily acoustic and environment data

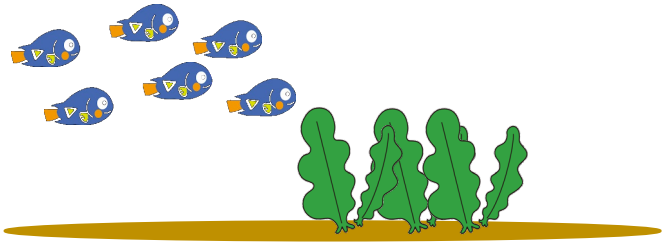
One vessel one week



Multiple vessels one day



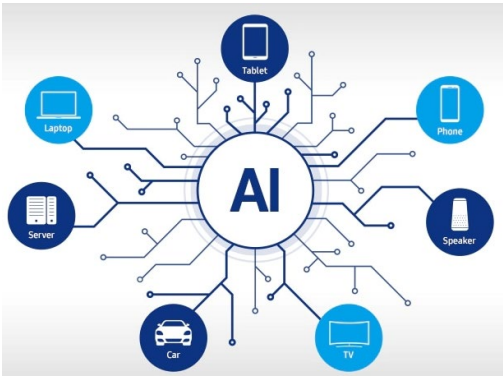
Daily changes in fish distribution and abundance can be monitored over a wide area and at high frequency



Daily environmental data

Can predict the fish distribution and abundance from environmental data

In the future: Adoption of AI and ICT technologies for biological information



Artificial Intelligence(AI)

Information and
Communication Technology (ICT)

AI: make the data analysis automation

ICT: create a system that can be shared on the Internet

More accurate and efficient fishery assessment & stock management can be achieved