

Leak detection

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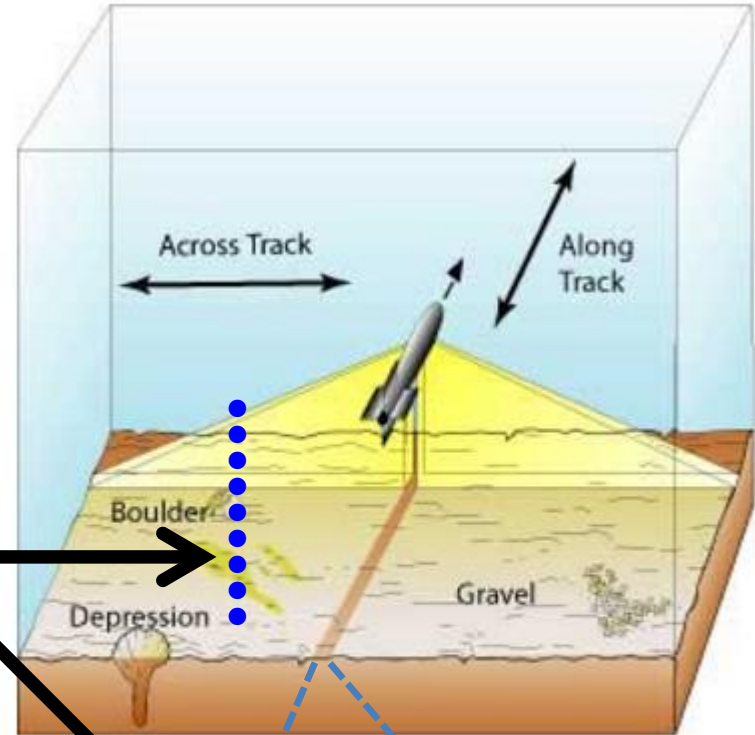
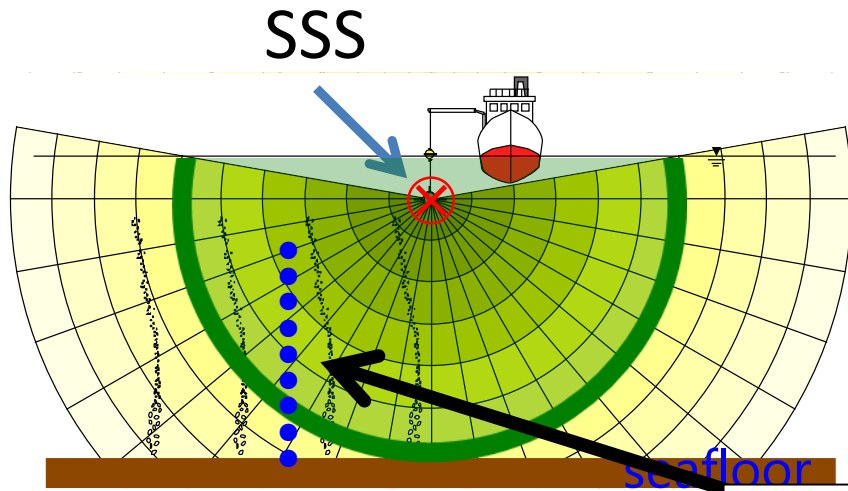


CONTENTS

- Detection of **CO₂ bubbles** with side-scan sonar (SSS)
- Detection of **high pCO₂** (partial pressure of CO₂) in seawater
 - due to leakage of CO₂ or natural variability?

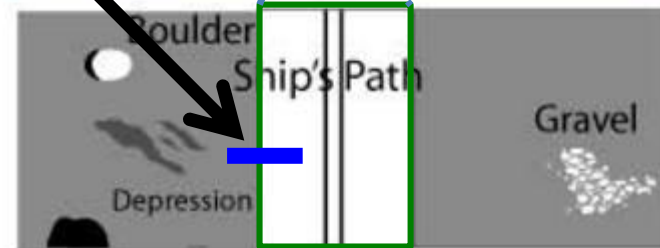


Bubble detection with SSS



bubbles

Side-scan sonar (SSS) detects the seafloor or objects in the water column by **transmitting** acoustic pulses and **receiving** the reflections.



SSS image

water column

Bubble detection with SSS

Bubble release experiment

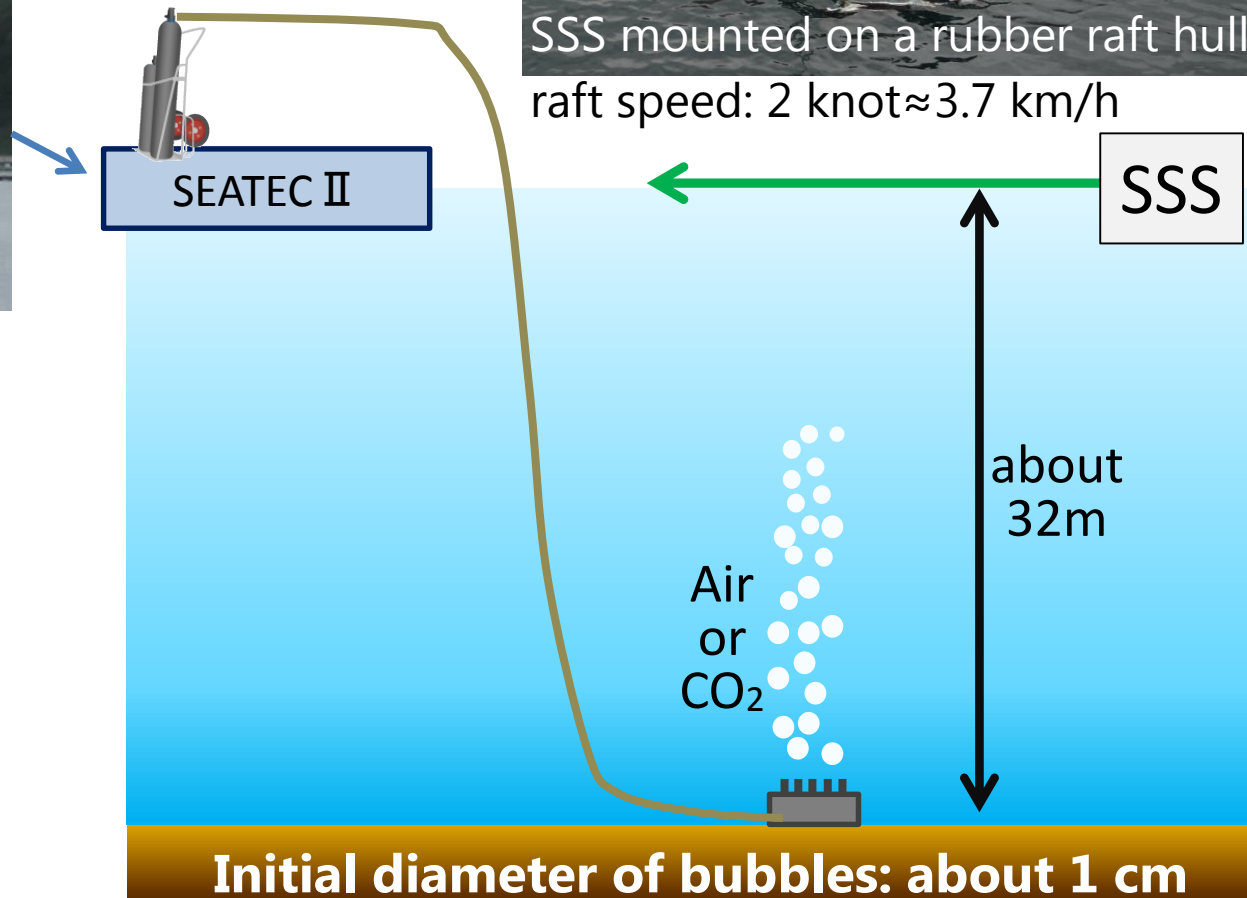
- What is the minimum leakage rate which is detectable with SSS?
- What differences are there in SSS images depending on the distance between SSS and bubbles?

Bubble detection with SSS

Experimental design



SSS: EdgeTech4200MP
Frequency: 600kHz



Bubble detection with SSS

Release rate

Air bubbles

- 750 ml/min ○
- 250 ml/min ○
- 100 ml/min ○

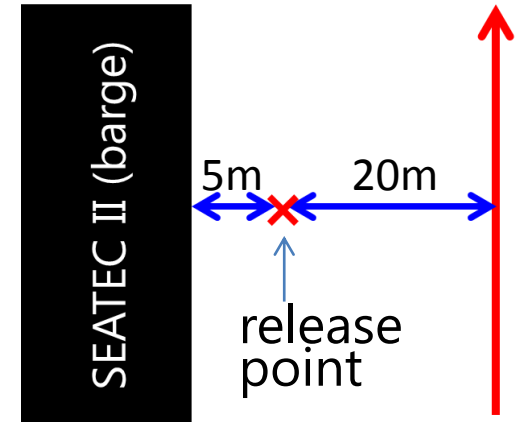
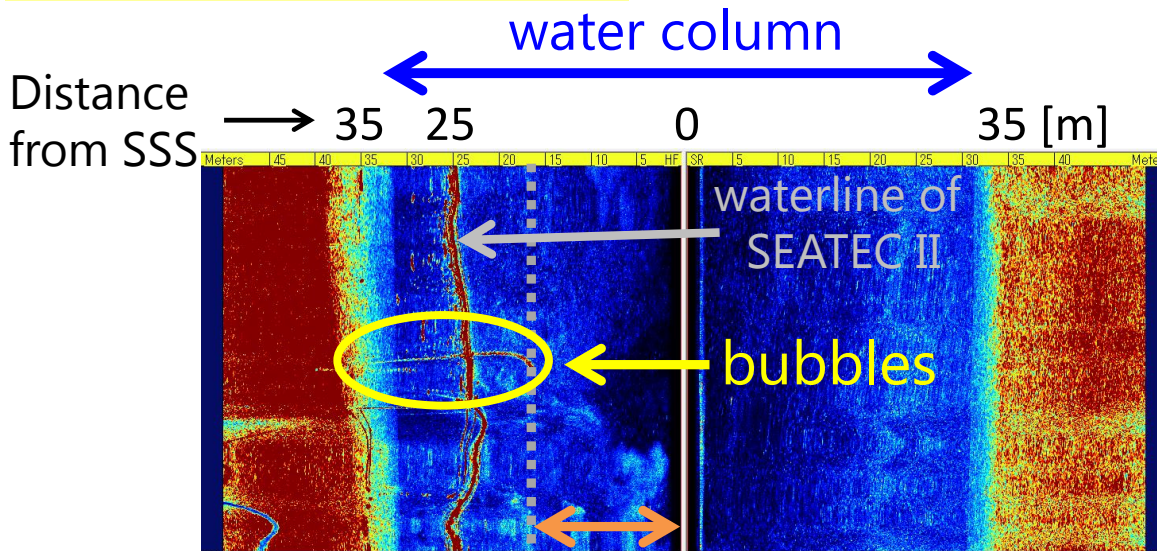
CO₂ bubbles

- 2500 ml/min ○
- 1500 ml/min ○
- 500 ml/min ×
- 250 ml/min ×

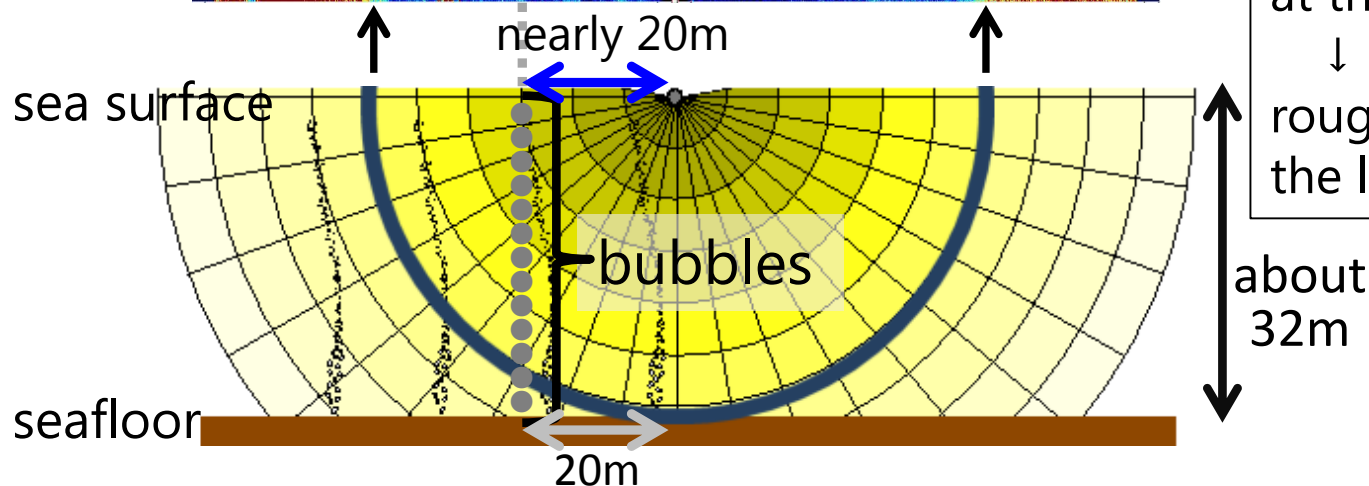
Detecting CO₂ bubbles is more difficult than air

Bubble detection with SSS

SSS image: **air** bubbles
release rate: 250ml/min

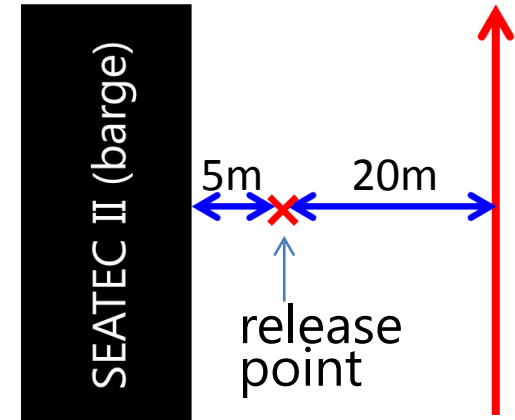
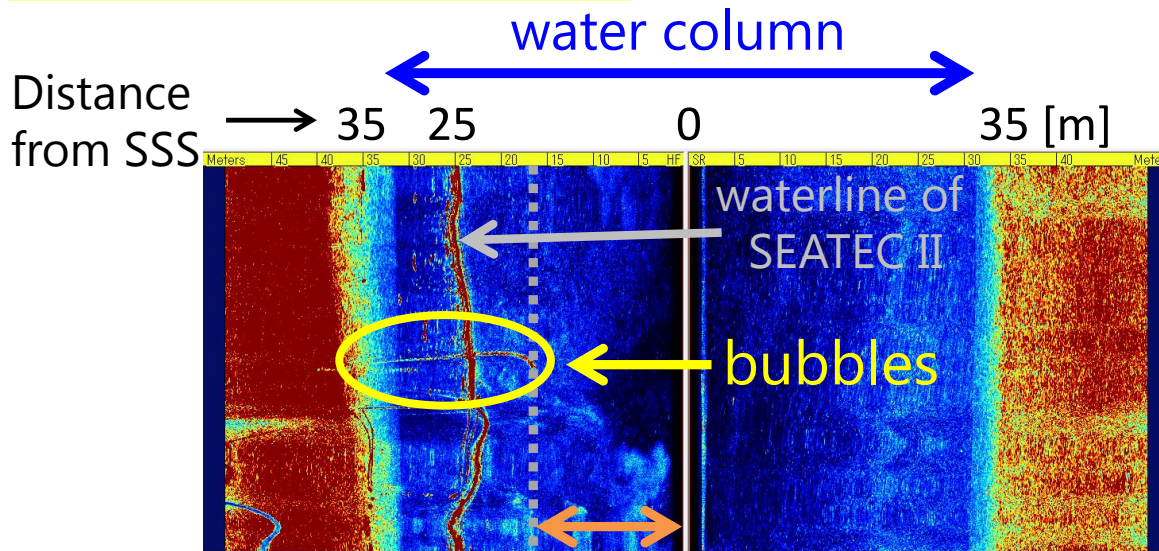


The right end of the bubble signal represents the position of bubbles at the depth of SSS
↓
rough identification of the leakage point

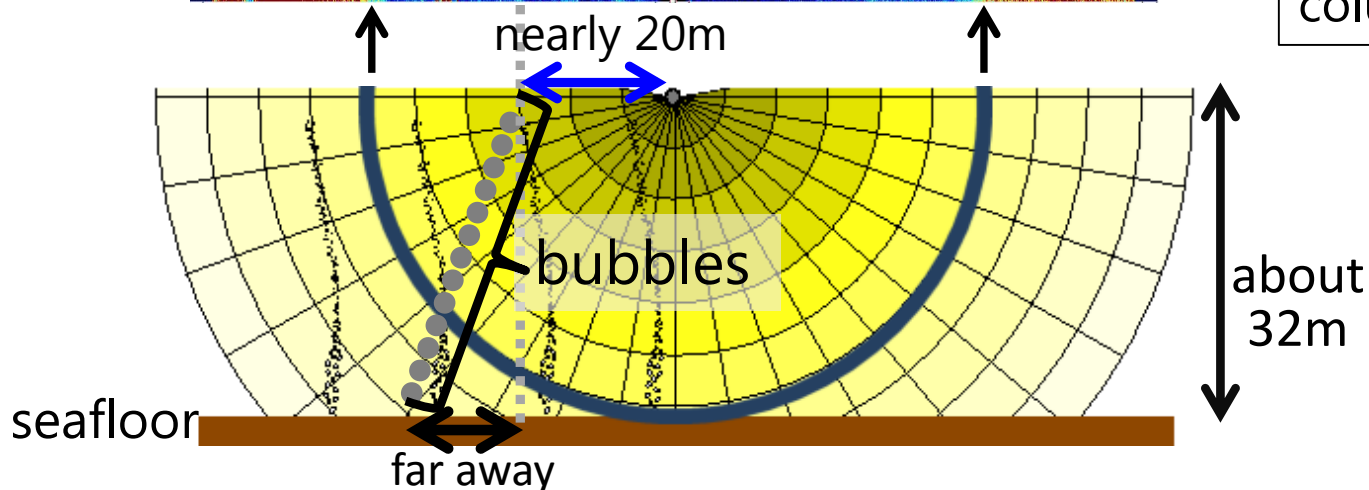


Bubble detection with SSS

SSS image: **air** bubbles
release rate: 250ml/min

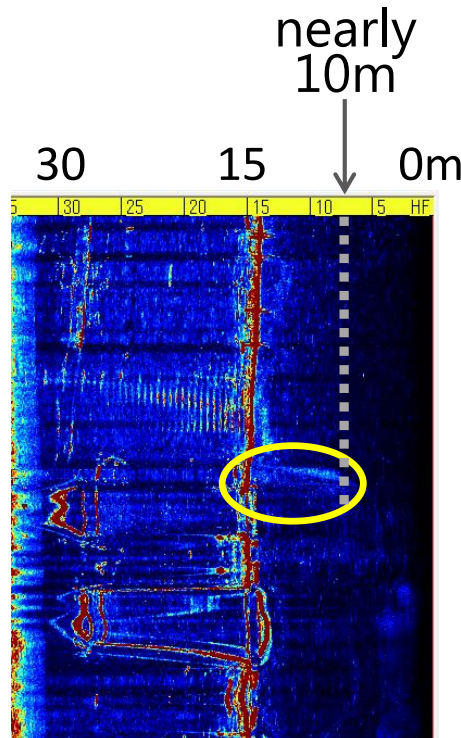
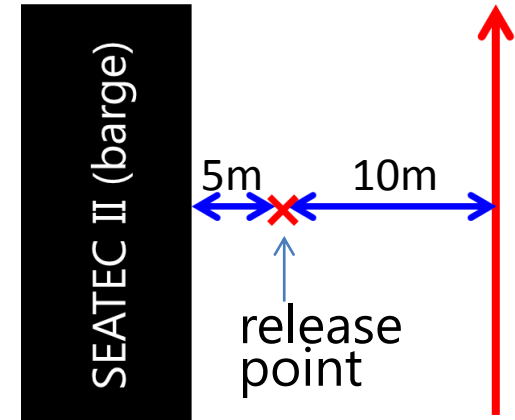


Note: Bubbles do not always rise straight in the water column.

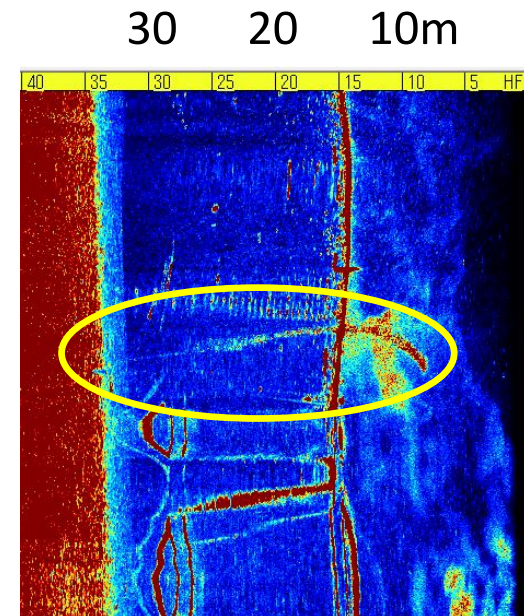


Bubble detection with SSS

SSS image: **CO₂** bubbles
release rate: 1500ml/min \approx 6tonnes/yr



CO₂ bubbles (1500ml/min)



air bubbles (250ml/min)

Signal of CO₂ is weak.

High pCO₂ detection

What is the problem?

Anomalously high value of pCO₂

- due to CO₂ leakage
- due to natural variability

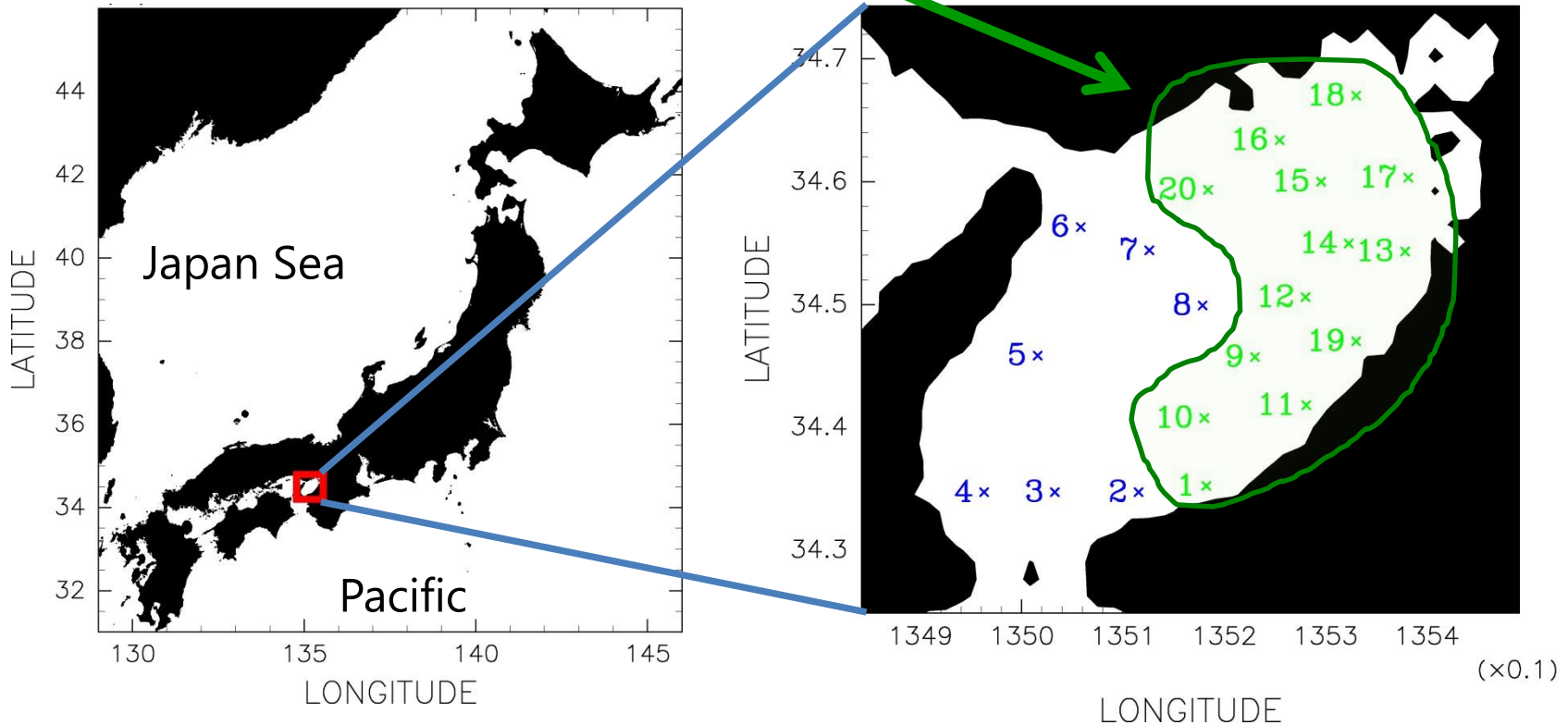
A constant value of pCO₂ is unsuitable for the threshold where natural variability of pCO₂ is large.



A threshold using not only pCO₂ but also dissolved oxygen (DO)

High pCO₂ detection

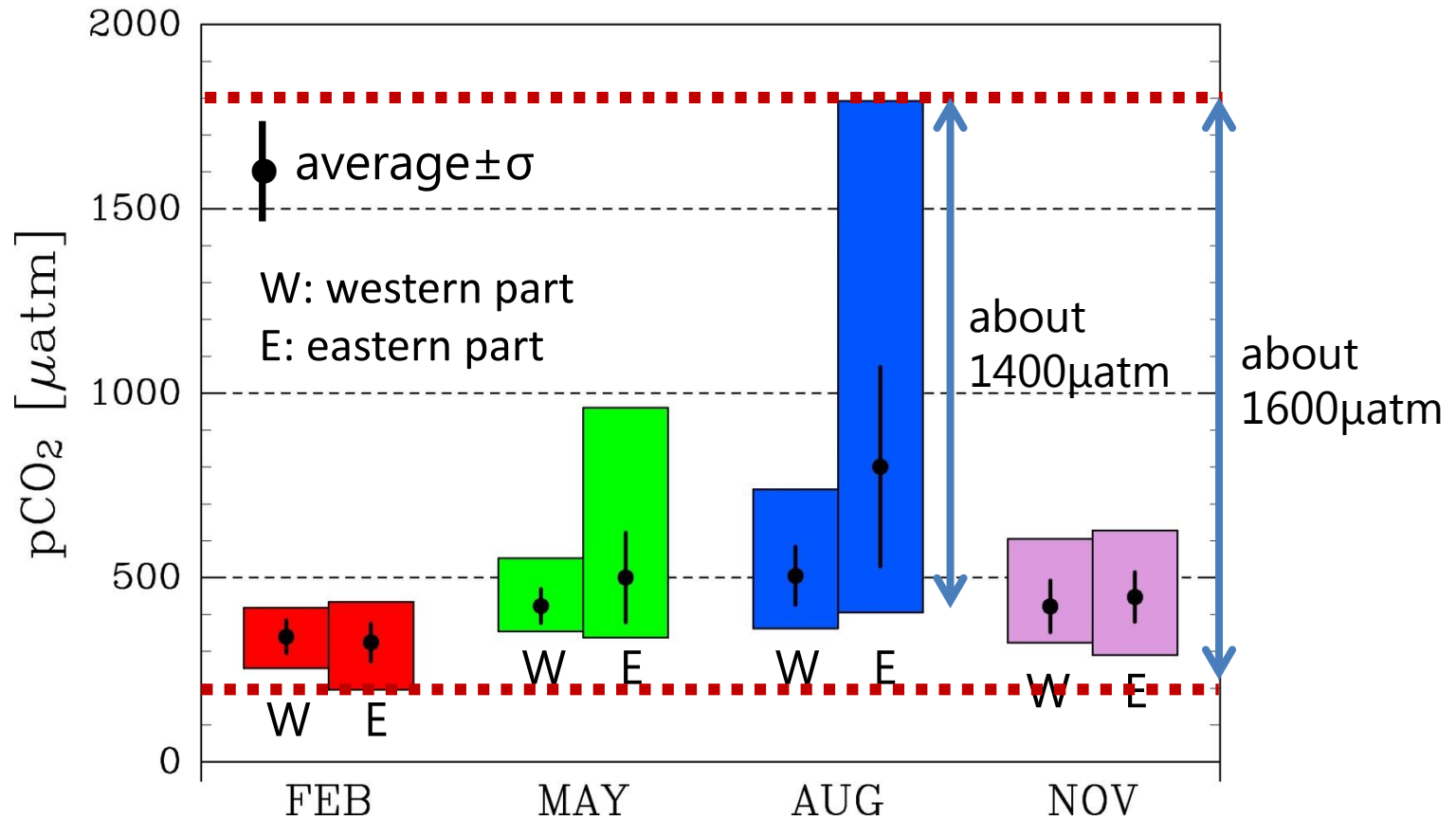
Example: **Eastern part** of Osaka Bay in Japan



O₂ and pH: observed near the bottom 4 times a year from 2002 to 2010
pCO₂: calculated using CO2SYS from pH and alkalinity estimated from salinity.

High pCO₂ detection

Natural variability in the Eastern part of Osaka Bay is very large

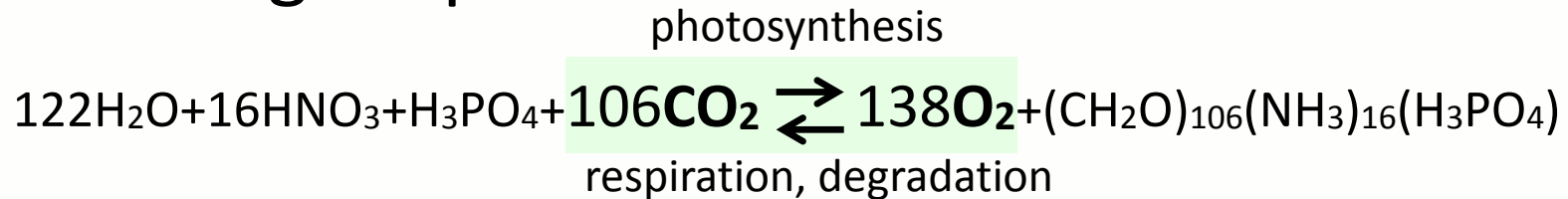


Range of pCO₂ between 2002 and 2010 in Osaka Bay

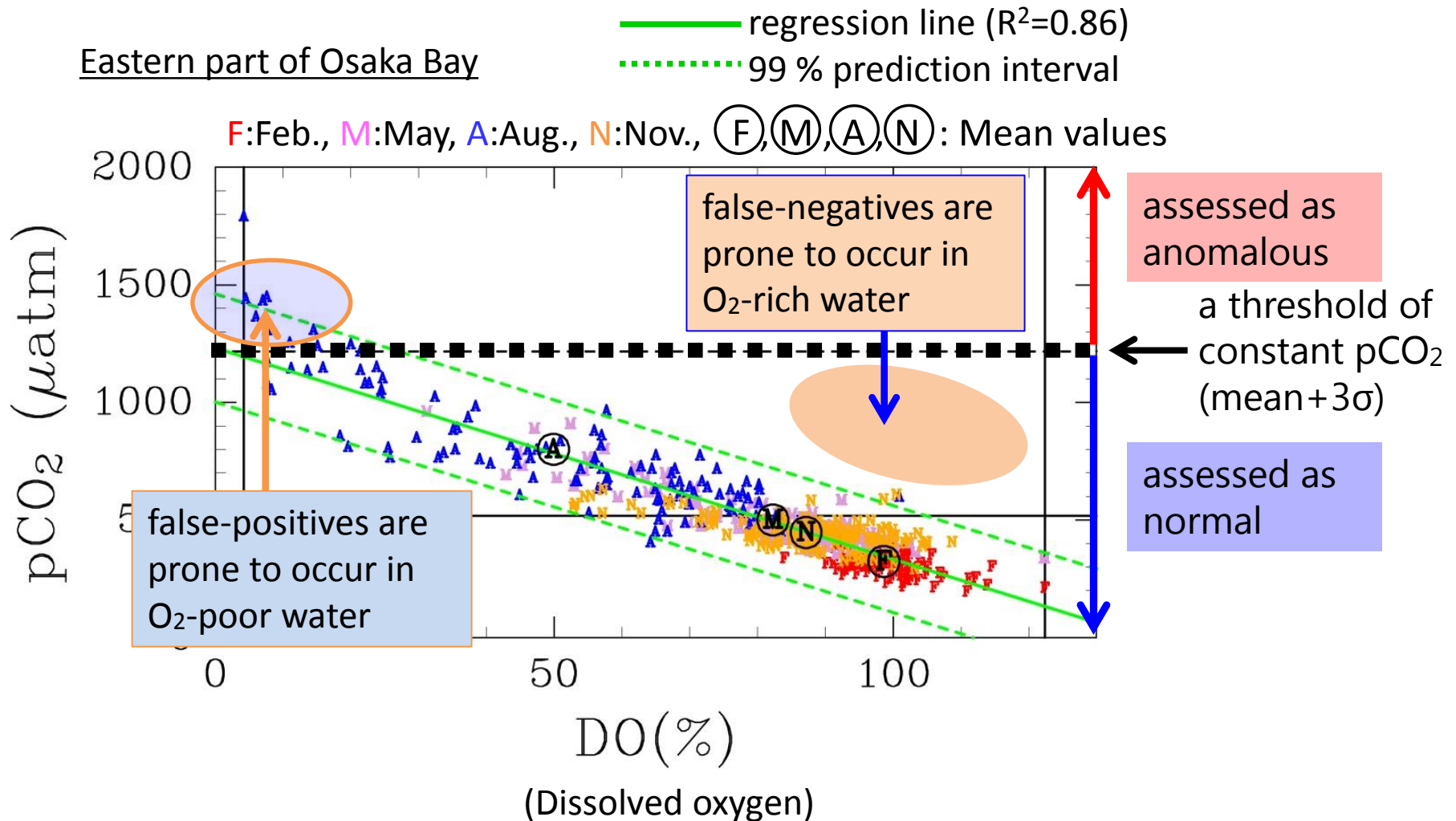
High pCO₂ detection

Using relationship between pCO₂ and O₂

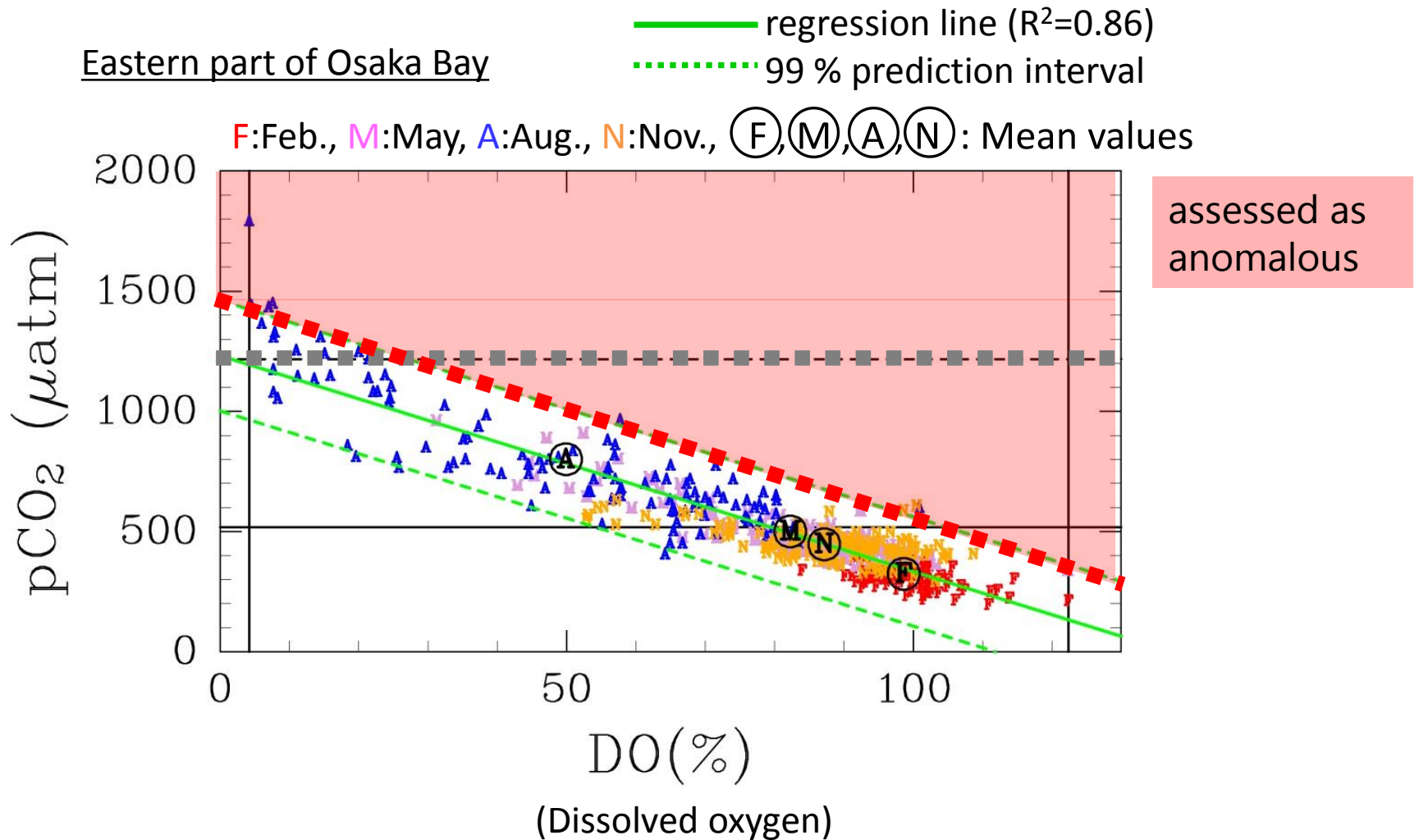
◆ Biological process



High pCO₂ detection



High pCO₂ detection



Summary

Two methods for detecting leakage in the sea

- **Detection of CO₂ bubbles** with side-scan sonar
 - SSS can detect CO₂ bubbles released at 1500 ml/min
 - SSS images provide us a clue to identifying the leakage point
- **Detection of anomalously High pCO₂** using the relationship between pCO₂ and DO (dissolved O₂)
 - false-positive/negative problem are improved

Challenges to be tackled

CO₂ bubble detection with SSS

To clarify

- dependency on the speed of the observation boat
 - the faster, the better for the monitoring
- dependency on the initial size of bubbles
 - Smaller bubbles are easier to dissolve in seawater

High pCO₂ detection using the pCO₂-DO relation

To clarify

- how many data is necessary to make a reliable threshold?