Acoustic identification and density estimate of a lanternfish *Diaphus theta* off Hokkaido, Japan

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Diaphus theta (Myctophidae)

The most abundant mesopelagic fish in the northwestern Pacific

Contribute to the transportation of organic matter, through diel vertical migration

No adequate method exists for quantitative monitoring

Objective

To develop the acoustic method for getting the quantitative information of *D. theta*

Contents

Target strength

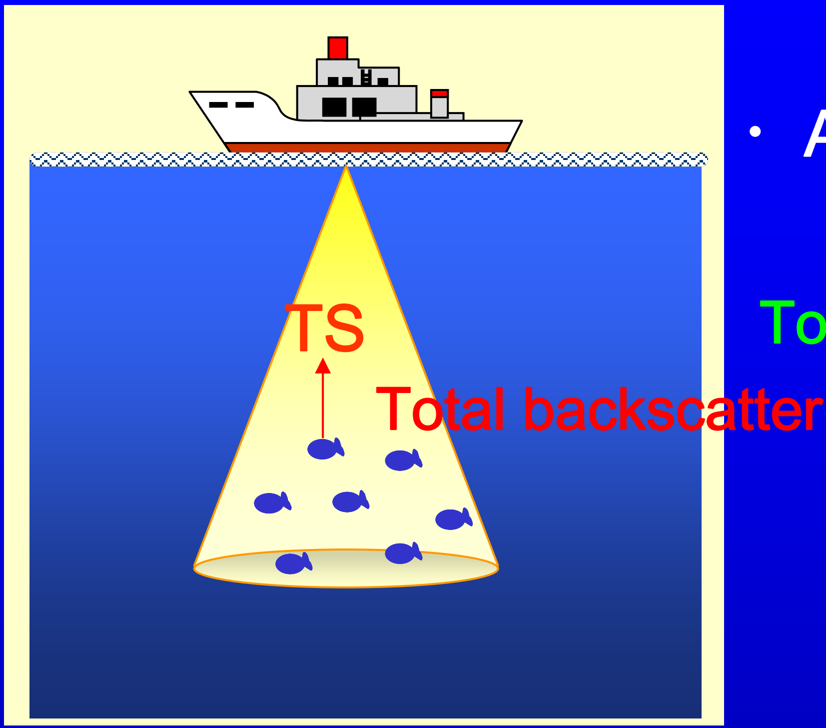
General characteristics of the difference in target strength between 38 and 120 kHz

Estimates of target strength using a theoretical swimbladder mode

A field data analysis conducted off Hokkaido, Japan (MIE-2)

Echo discrimination and density estimates of *D. theta* using echo-sounder with 38 and 120 kHz

Target Strength （TS （dB））



- Acoustic backscatter from individual fish

Total backscatter ÷ TS ＝ number of fish

- TS values differ depending on the frequency used. (TS difference: ⊿TS)

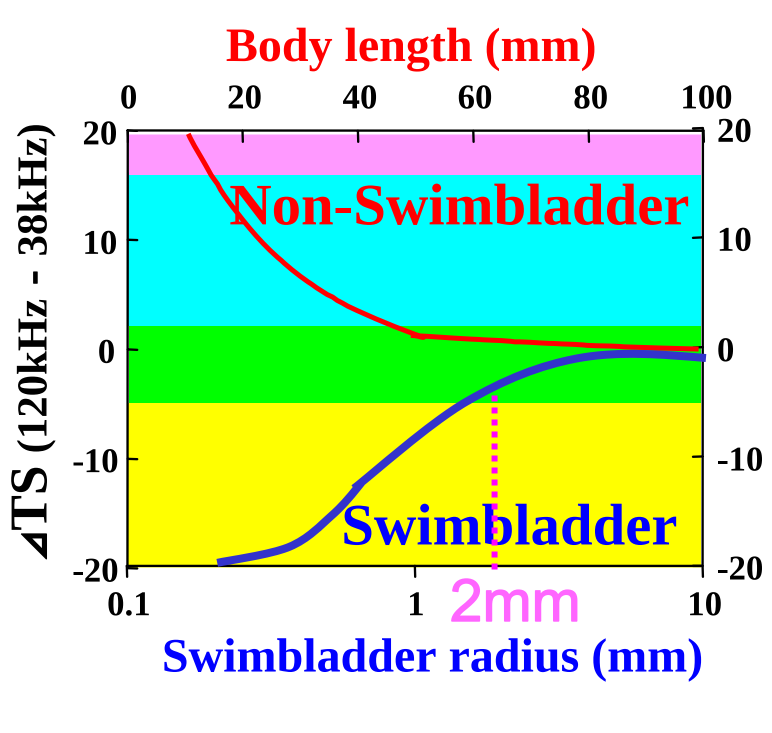
⊿TS ＝ TS (at 120 kHz) – TS (at 38 kHz)

- The values of ⊿TS vary with species. （useful for fish discrimination?

- Swimbladder size (or Body size) is the critical parameters for ⊿TS.

Characteristics of the ⊿TS

⊿TS ranges and major organisms, off Japan (Yasuma *et al*. 2006)



Target	ΔTs Range
Small zoo plankton (Copepods, Amphipods etc.)	16 <
Large zooplankton (Krill etc.) Small fish -without swimbladder- (Myctophids, Gonostomatids, Larval anchovy etc.)	16 ~ 2
Large fish -without swimbladder- (Myctophids >60mm) Fish -with swimbladder- (Anchovy, Pollock, Myctophid, etc)	2 ~ -4
Fish -with small swimbladder- (Myctophids, Larval anchovy (night))	< -4

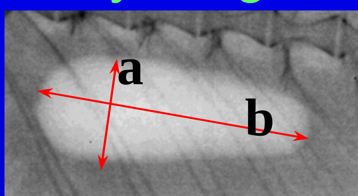
- Non-swimbladder : Smaller body size → Positive ⊿TS
- Swimbladder : Smaller swimbladder → Negative ⊿TS

To know the TS and ⊿TS → "With or without" swimbladder ?
Swimbladder shape?

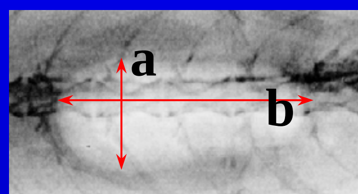
Swimbladder shape

Sample : 182 fishes (27-90 mm)

X-ray image



Dorsal aspect

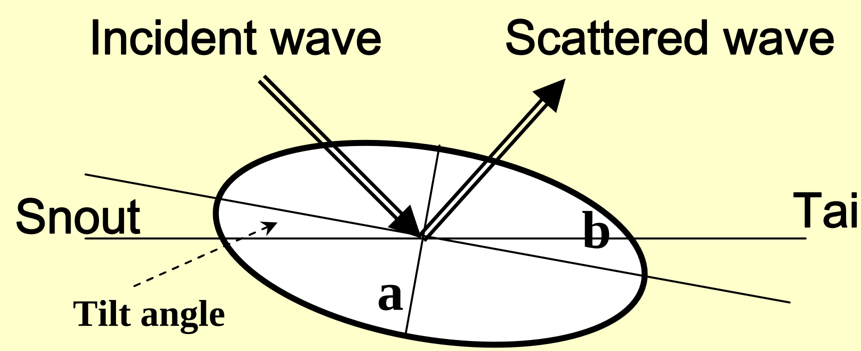


Lateral aspect

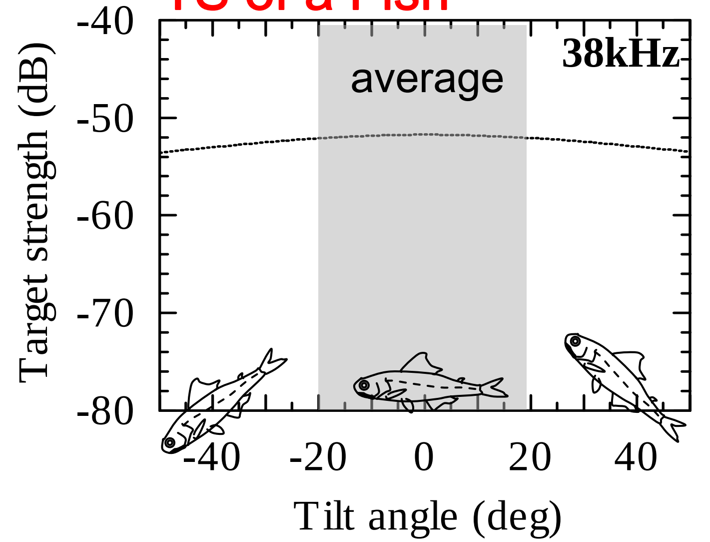
Theoretical estimate of TS

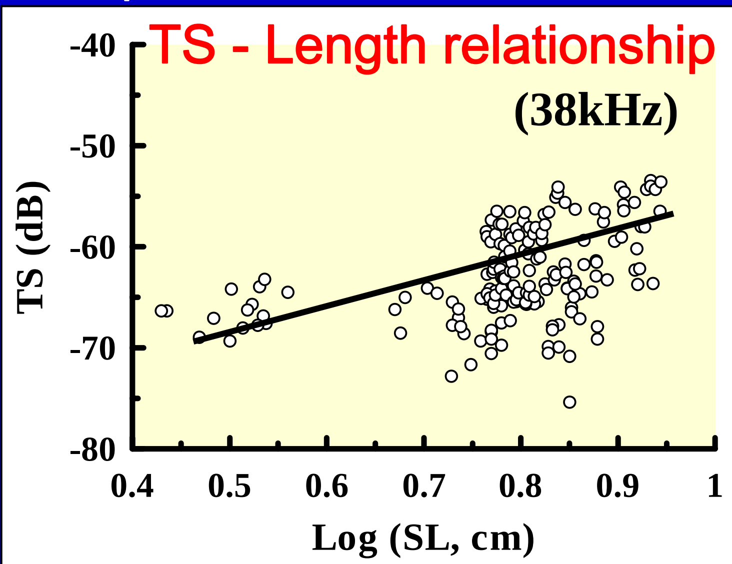
Prolate Spheroid Model (Furusawa , 1988

(S w i m b l a d d e r Approxima



TS of a Fish





Swimbladder shape

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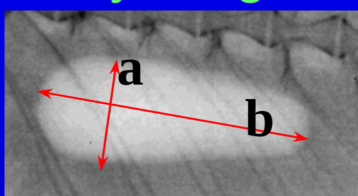

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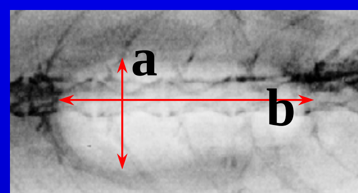

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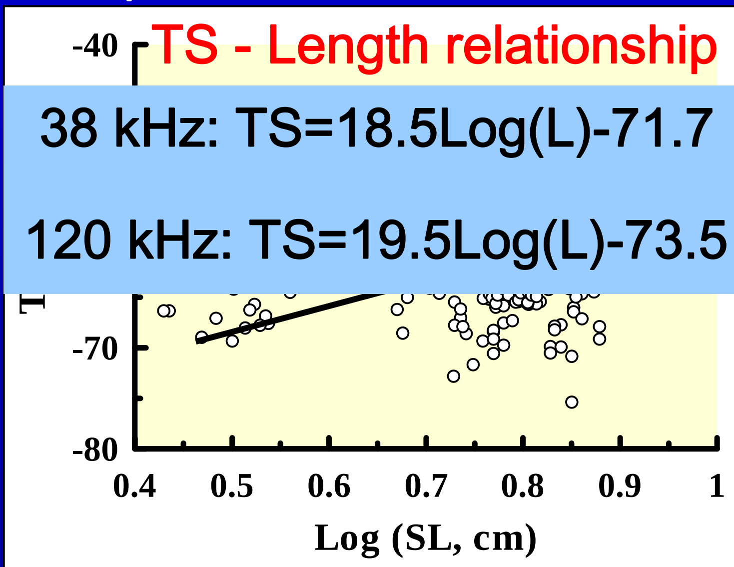

38 kHz: TS=18.5Log(L)-71.7

120 kHz: TS=19.5Log(L)-73.5

Theoretical estimate of TS

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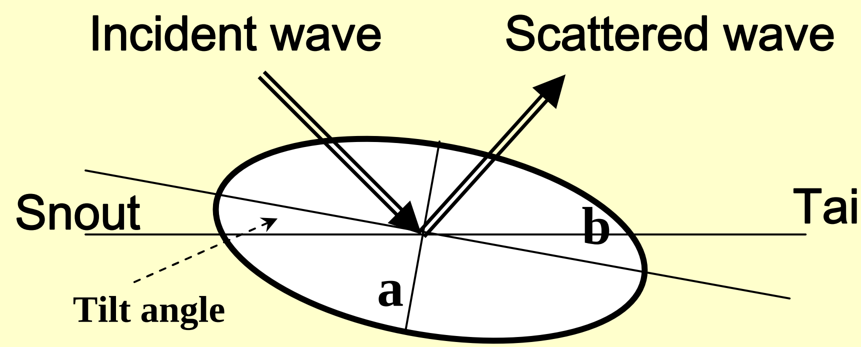
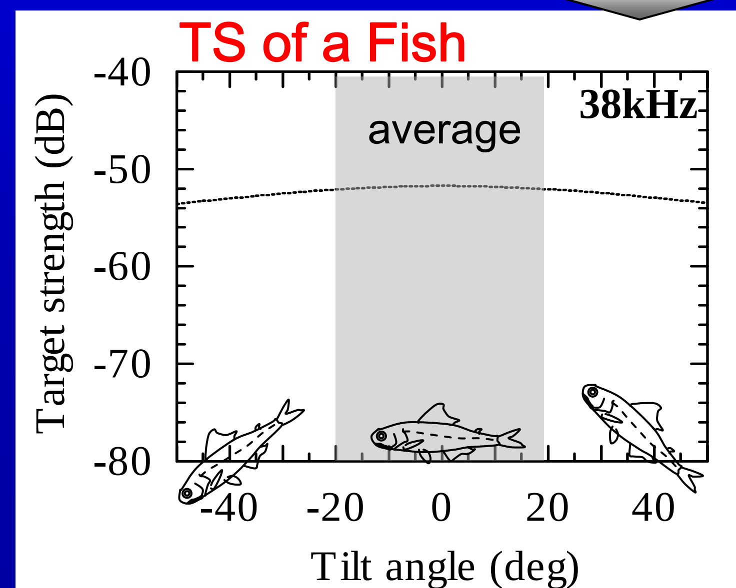
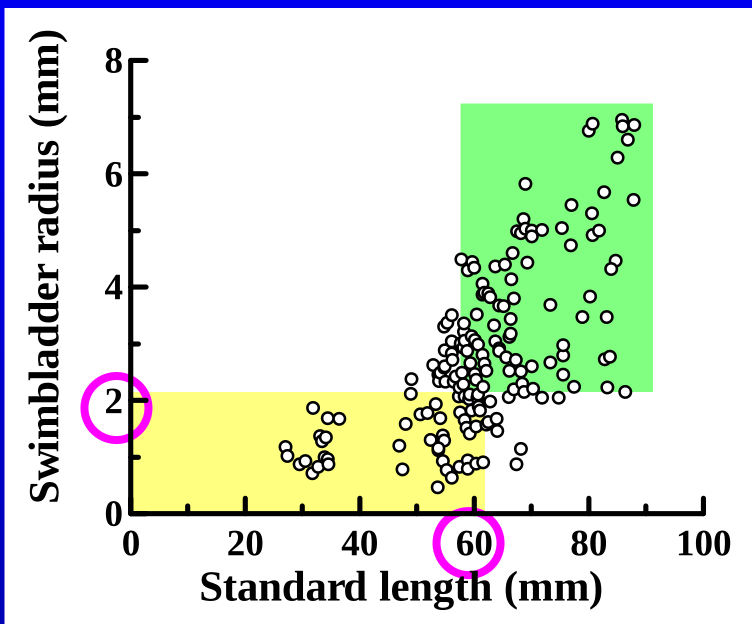
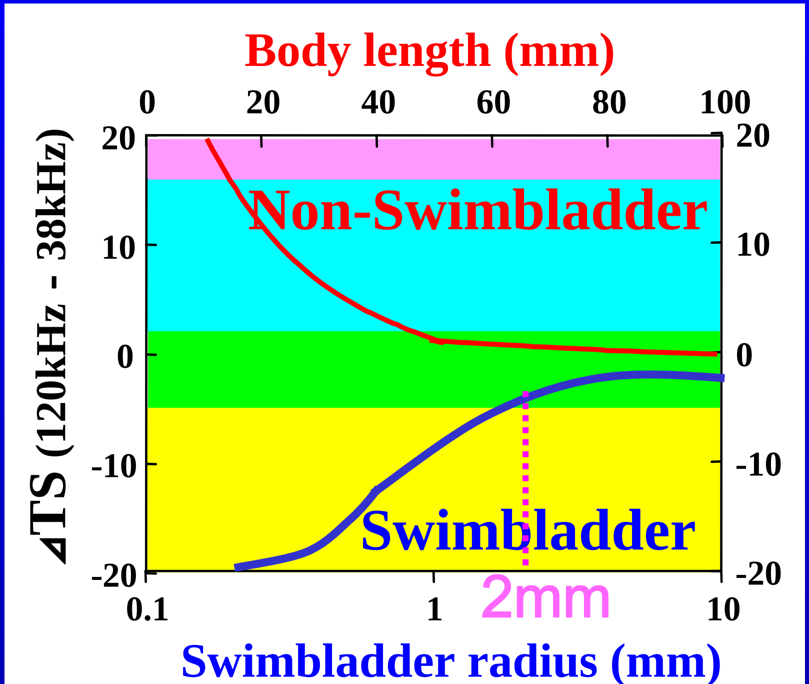




Swimbladder size and ⊿TS of *D. theta*



Body length – swimbladder radius



Swimbladder radius - ⊿ T S

Swimbladder size and ⊿TS of *D. theta*

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Fish -with small swimbladder- (Myctophids, Larval anchovy (night))	< −4

D.Theta (> 60mm)

D. Theta (< 60mm)

Summary - Target strength -

D. theta had a well inflated swimbladder

TS equations were determined using theoretical model

$TS = 18.5 Log(L) - 71.7$ (38kHz)

$TS = 19.5 Log(L) - 73.5$ (120kHz)

TS difference will change on the boundary of 60mm in body length.

$> 60mm \rightarrow \Delta TS \fallingdotseq 0$ ($38kHz \fallingdotseq 120kHz$)

$< 60mm \rightarrow \Delta TS < 0$ ($38kHz \fallingdotseq 120kHz$)

Field data analysis

Survey

Sep. 2005 (MIE- 2 Cruise)

Day and Night observation

Echo-sounder

EK-60 (SIMRAD co.)

Freqency: 38kHz, 120kHz

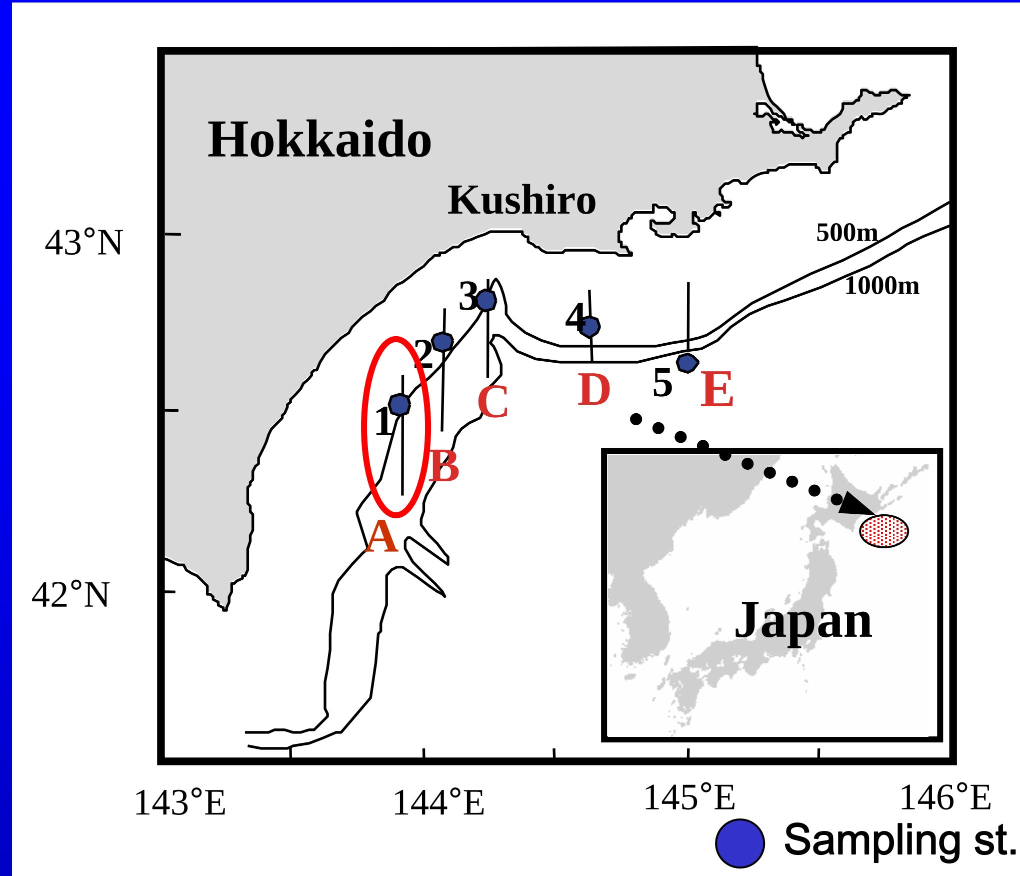
Echo data analysis

Echoview (Sonar Data co.)

Biological sampling

MOCNESS (10 m^2)

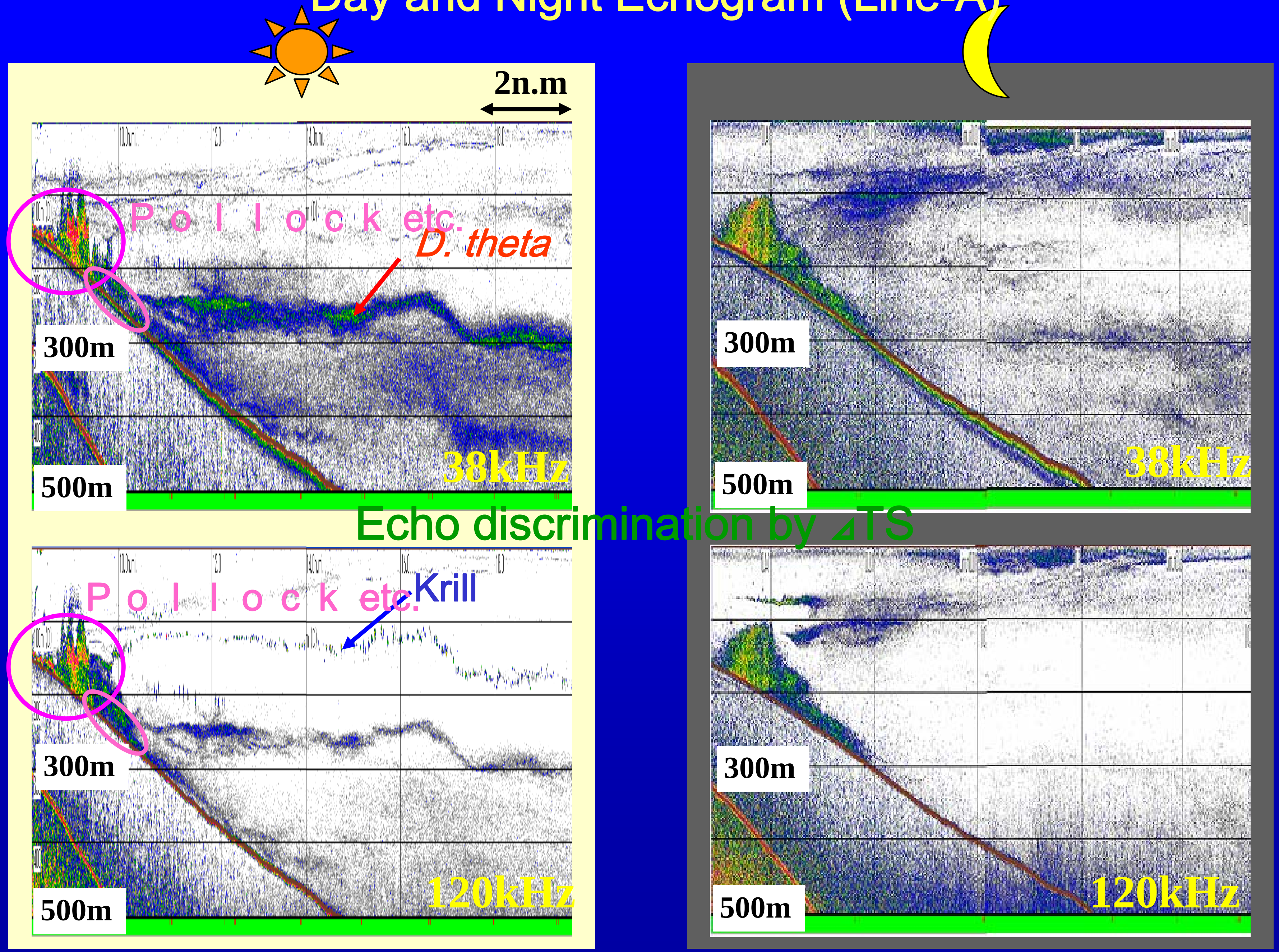
MOHT net (5 m^2) etc.

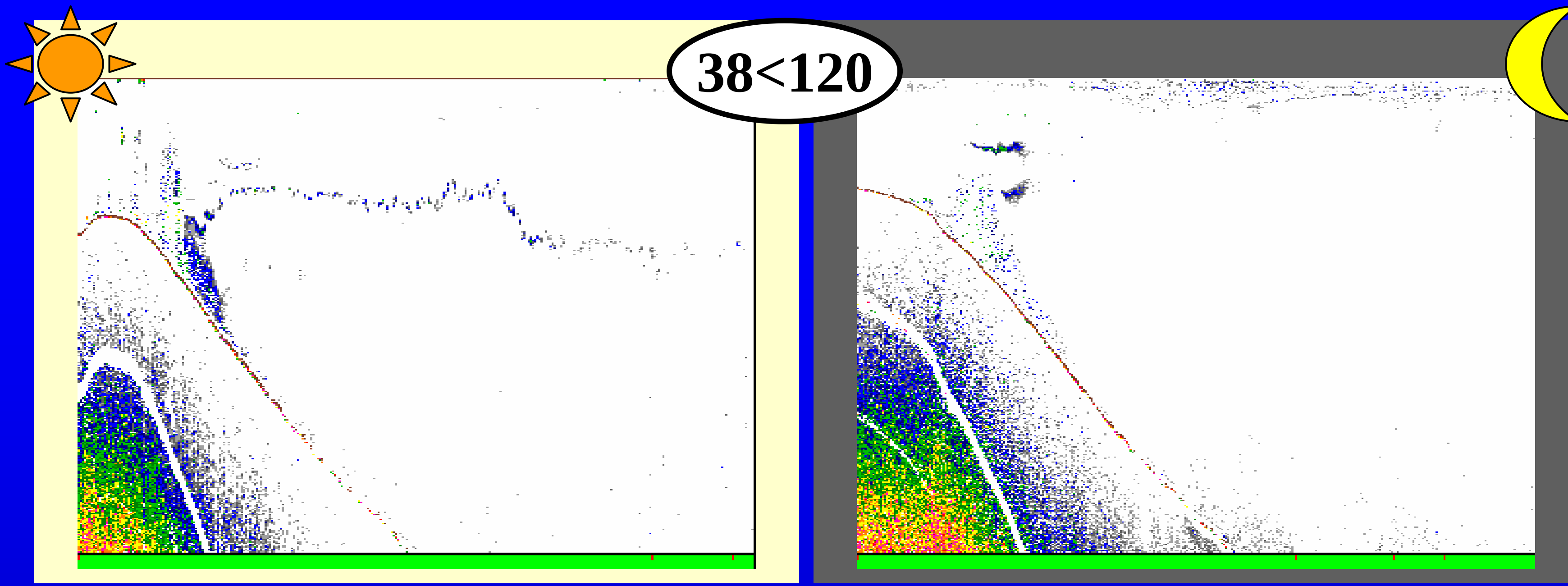


MOCNESS

MOHT

Day and Night Echogram (Line-A)





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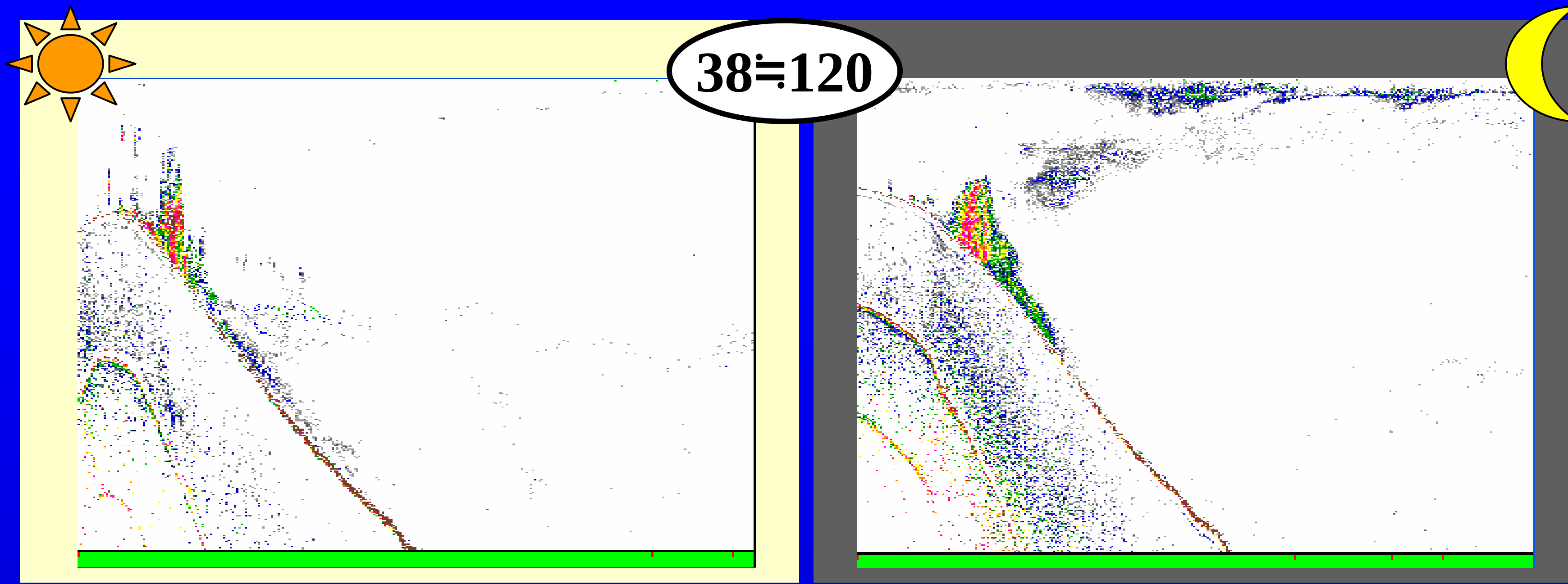
Main species and TS difference (⊿TS)

38 < 120 : *Euphausia pacifica*

38≒120 : *D. Theta* (> 60mm) Walleye pollock

38 > 120 : *D. theta* (< 60mm)



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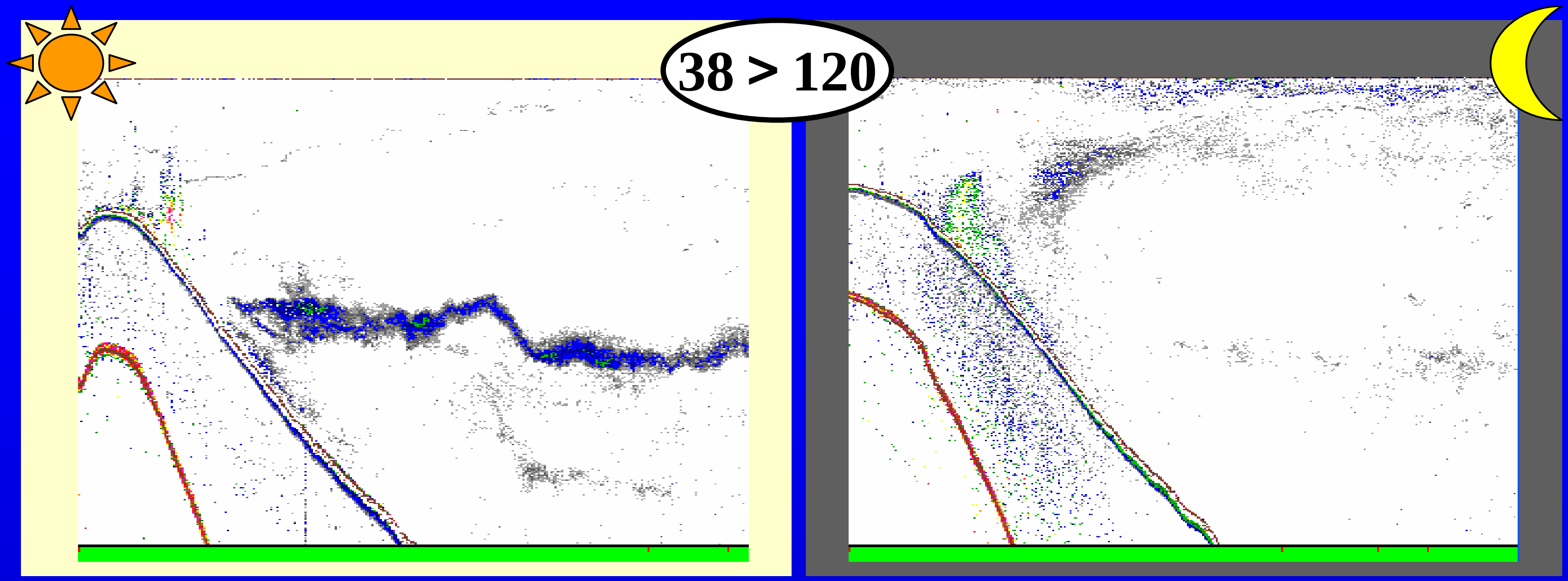

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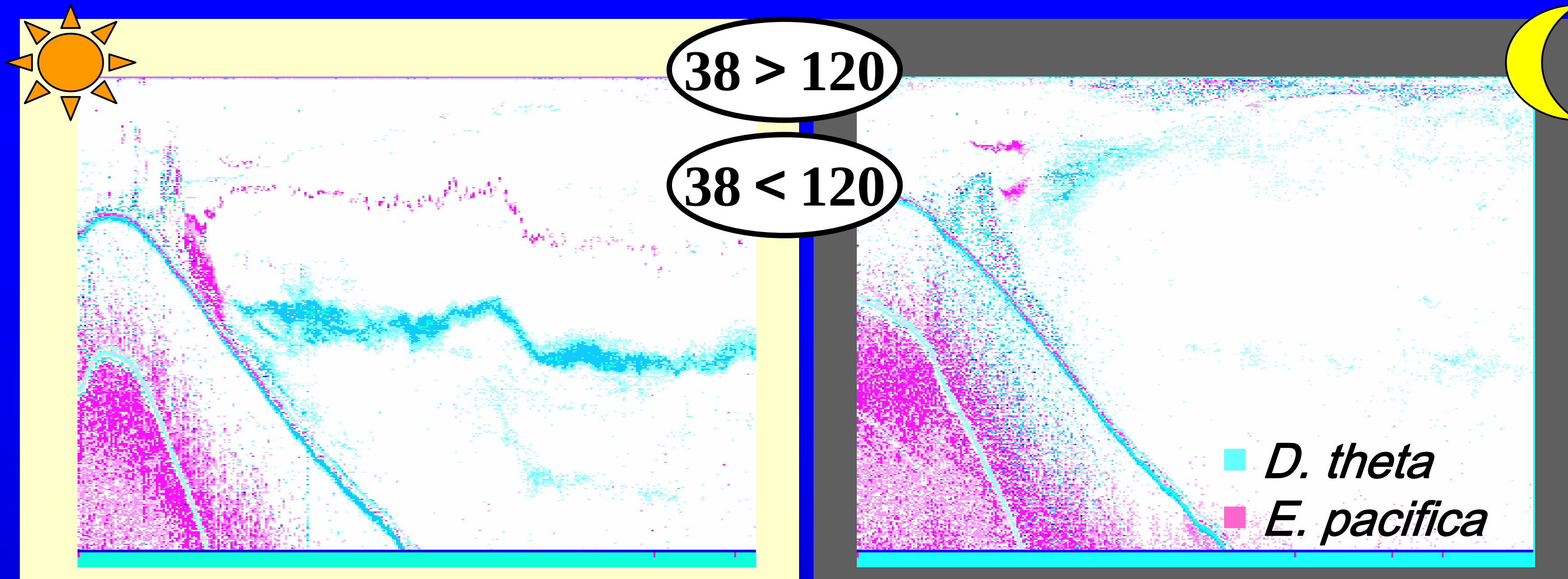

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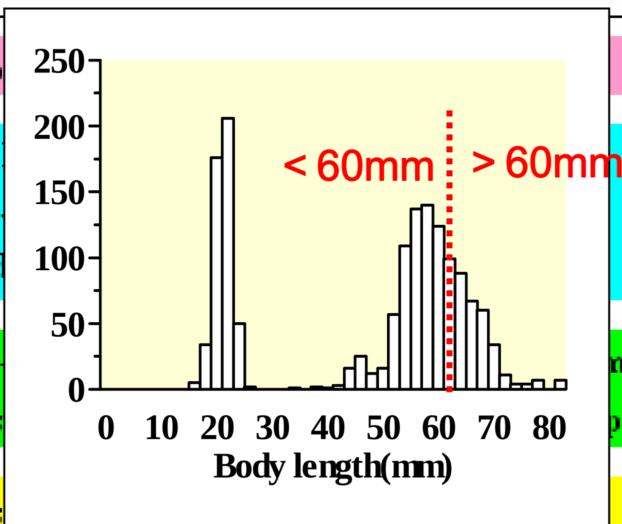

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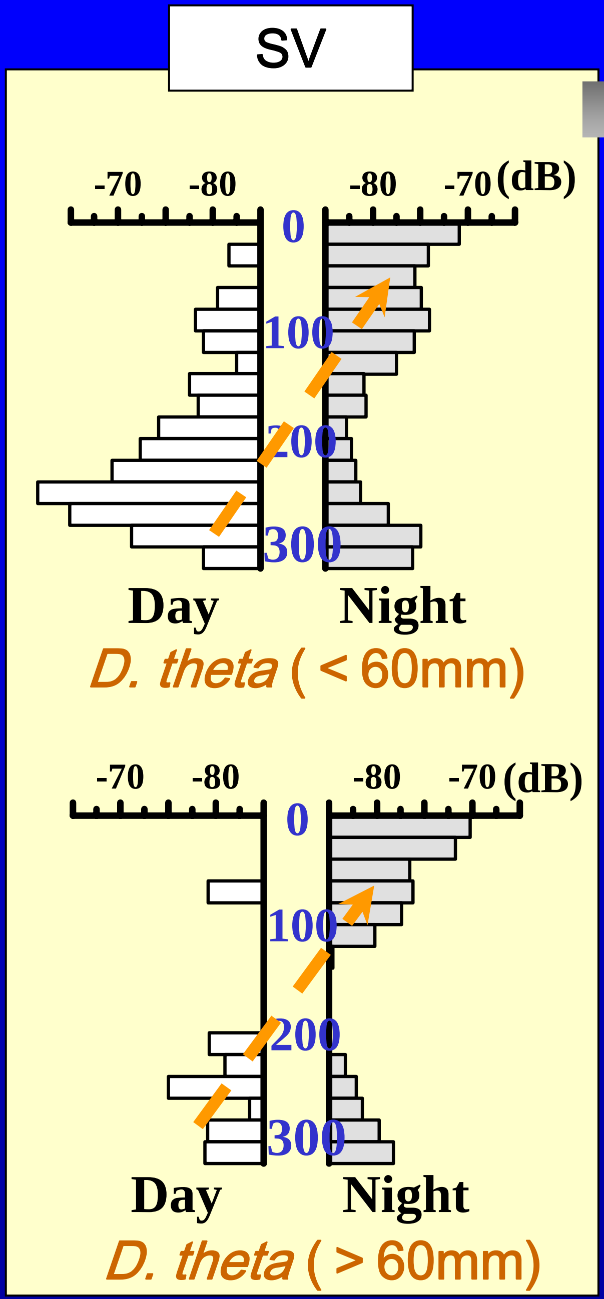
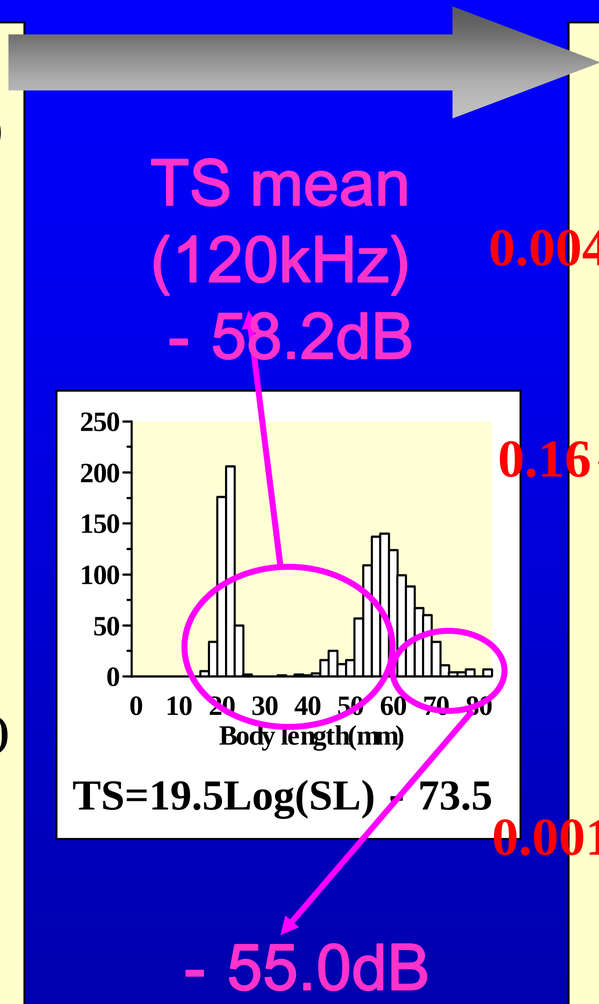
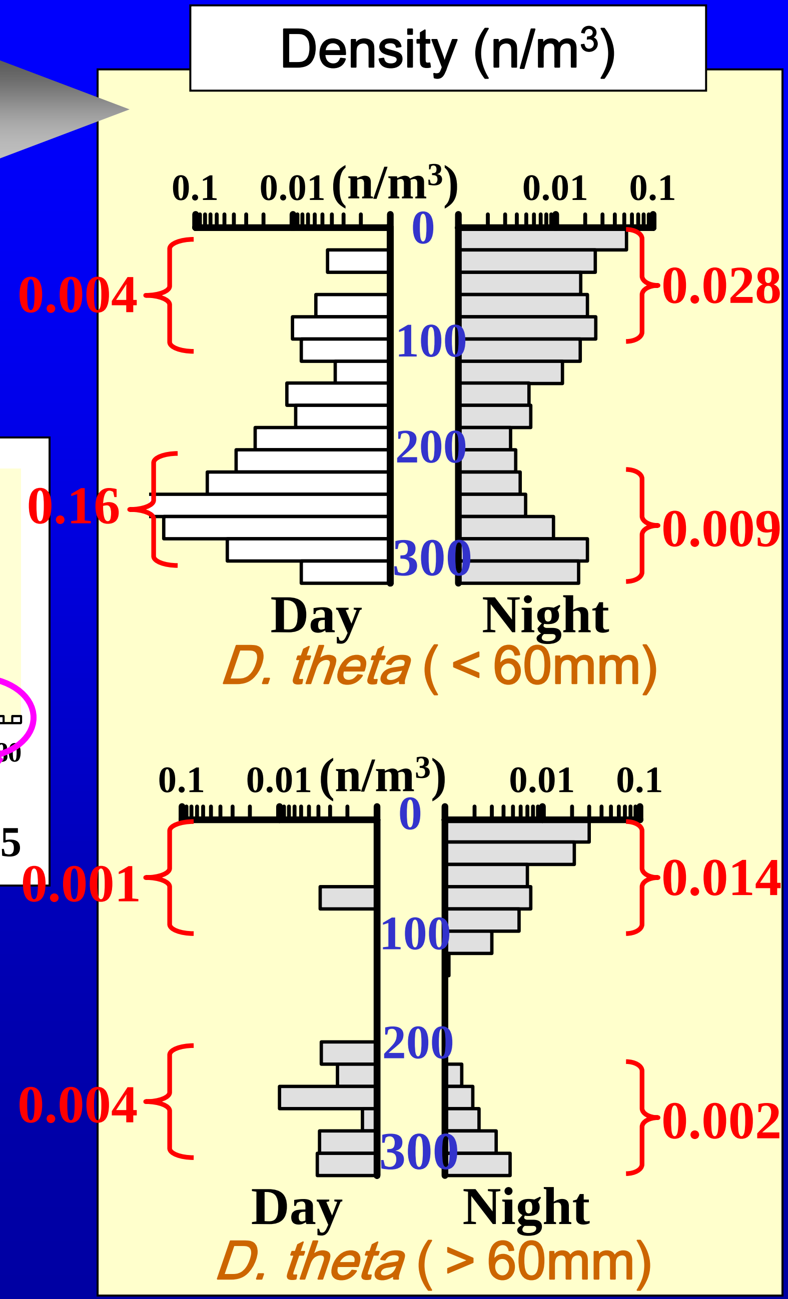
Day - Night vertical distribution of *D. theta*

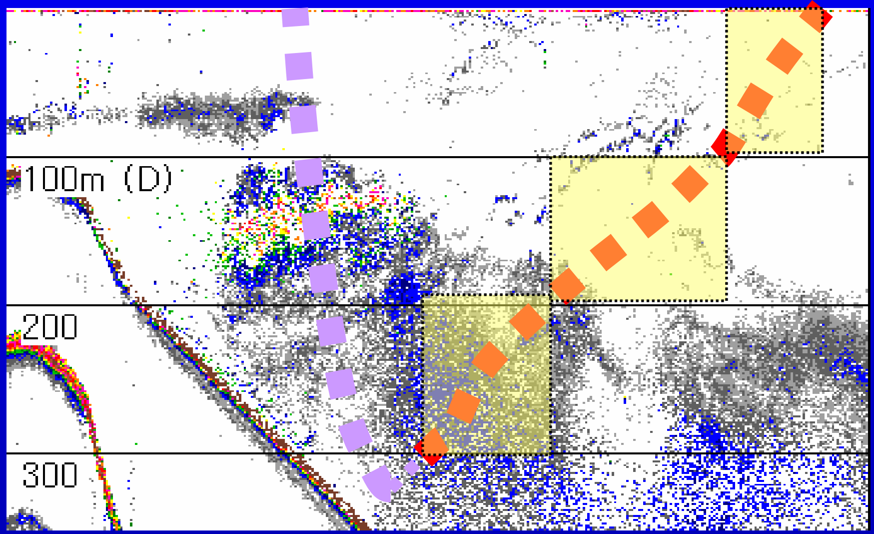




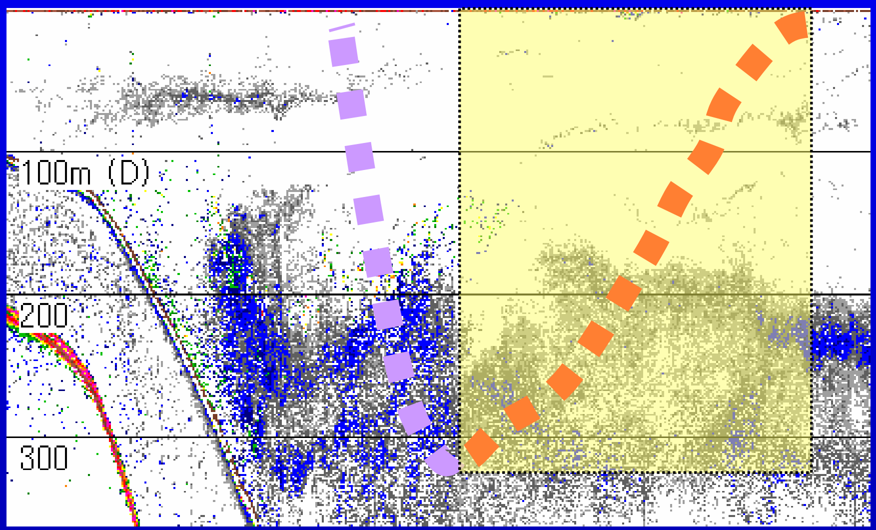


Estimated fish density
- Acoustics vs. Sampling gears (ind/m^3) -

MOCNESS (10m^2)



MOHT



Estimated fish density
- Acoustics vs. Sampling gears (ind/m^3) -

Acoustic - MOCNESS

		Day			Night		
St.	Depth	MOC.	Aco.	Aco./MOC.	MOC.	Aco.	Aco./MOC
1	0-100	0	6.7×10^{-3}	-	1.2×10^{-2}	1.9×10^{-2}	2
	100-200	0	2.1×10^{-3}	-	2.0×10^{-4}	5.7×10^{-3}	29
	200-300	0	2.9×10^{-2}	-	0	9.6×10^{-3}	-
2	0-100	0	2.7×10^{-3}	-	2.7×10^{-4}	2.8×10^{-2}	103
	100-200	2.5×10^{-4}	9.0×10^{-2}	354	5.7×10^{-4}	4.7×10^{-2}	84
	200-300	9.0×10^{-4}	3.5×10^{-2}	39	0	5.6×10^{-3}	-
3	0-100	0	2.5×10^{-3}	-	1.7×10^{-3}	1.6×10^{-2}	10
	100-200	0	5.3×10^{-3}	-	5.4×10^{-4}	1.5×10^{-2}	28
	200-300	0	2.4×10^{-2}	-	2.2×10^{-4}	9.7×10^{-3}	44
4	0-100	0	1.0×10^{-3}	-	3.4×10^{-4}	7.8×10^{-3}	23
	100-200	0	1.1×10^{-1}	-	0	2.1×10^{-3}	-
	200-300	0	1.2×10^{-1}	-	2.3×10^{-4}	8.8×10^{-3}	38

Estimated fish density
- Acoustics vs. Sampling gears (ind/m^3) -

Acoustics - MOHT

	Day			Night		
St.	MOHT	Aco.	Aco./MOHT	MOHT	Aco.	Aco./MOHT
1	3.2×10^{-2}	1.2×10^{-1}	4	4.9×10^{-2}	1.1×10^{-1}	2
3	3.1×10^{-3}	1.0×10^{-2}	3	3.7×10^{-3}	4.0×10^{-2}	11
4	2.0×10^{-3}	8.0×10^{-2}	40	7.6×10^{-4}	2.9×10^{-2}	38

Summary - Field data -

Thick scattering layer of *D. theta* was found in the depth about 300m, in daytime.

D. theta could be discriminated from other major species (Walleye pollock, Krill etc.) by using of the TS difference between 38 and 120 kHz.

Diel vertical migration of *D. theta* was measured quantitatively.

→ In surface layer (~ 100m), fish density became larger (about 10-fold) at night than in daytime.

Fish densities estimated by acoustic method were dozens or hundreds of times higher than two types of gears.