Regional Characteristics of Diel Vertical Migration of the Sound Scattering Layer in the North Pacific

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Diel vertical migration of Sound Scattering Layer (SSL) over time and depth from sunset to sunrise.
Objectives

- Diel vertical migration of Sound Scattering Layer (SSL)
- The changes of $S_A$ due to the diel vertical migration of SSL
- Regional differences of biological composition of SSL
- Acoustical and biological characteristics of SSL
Biomass estimation by Acoustics

$SV = TS + 10 \log \rho$

$SV$ Volume Backscattering strength

$SA$ Area Backscattering strength

$TS$ (Target Strength)
Backscattering strength from single fish

$\rho$ Density
Multidisciplinary observation in the North Pacific Ocean

Oshoro-maru cruise

• Biological sampling
  Motoda net (2001)
  Frame Trawl (2001)
  Bongo net (2002)

• Oceanographic data
  CTD· XCTD· XBT

• Solar Illumination (2002)
  Luxmeter: MINOLTA· T-10

• Acoustic data sampling

  Echo sounder: SI MRAD EK60
    (38kHz, 120kHz, 200kHz)

  Post-processing system:
    SI MRAD BI 500
Diel Vertical Migration of SSL

Sunset

Sunrise

SL$_{low}$

SL$_{high}$

38kHz

120kHz

200kHz

0m

500m

100m

30min

SV

-44dB

-80dB
Regional characteristics of SSL

Off Hokkaido

Central Pacific

Bay of Alaska

38kHz

120kHz

200kHz

Southward of Lat. 50 ° N

Northward of Lat. 50 ° N

0m

500m

SV

-44dB

-80dB
Change of surface illumination in twilight

Sunset

Sunrise

Illuminance (lux)

Time difference from sunset (min)

-120 -60 0 60 120

55-60° N
50-55° N
45-50° N
40-45° N
Regional differences of biological composition in SSL

Off Hokkaido  Central Pacific  Bay of Alaska

Net sampling

38kHz  120kHz  200kHz

Southward of 50 ° N  Northward of 50 ° N

Invalid  Invalid

-44dB  -80dB

Invalid
Regional difference of biological composition in SSL

- Copepods
- Euphausiids
- Chaetognaths
- Amphipods
- Fish
- Cephalopods
- Others

Values:
- 392.0 g/m³
- 68.7 g/m³
- 87.5 g/m³
- 61.0 g/m³
Frequency characteristics caused by biological composition of SSL
Difference of species composition between $SL_{\text{high}}$ and $SL_{\text{low}}$
Difference of length composition between $SL_{\text{high}}$ and $SL_{\text{low}}$

**Euphausiids**

- $SL_{\text{high}}$ $n=275$ mean=8mm
- $SL_{\text{low}}$ $n=44$ mean=12mm
Frequency characteristics of TS for marine organisms

- Fish
- Zooplankton

Gas bubble model
- L=30mm
- L=10mm

Fluid sphere model
- L=30mm
- L=10mm
- L=1mm

Frequency (kHz): 1 38 120 200

Target Strength (dB): -160 -120 -80 -40 0
Conceptual model of diel vertical migration of SSL

- **Copepods** and **Euphausiids** migrate during different phases of the day:
  - **1h after sunset**: SL$_{high}$
  - **1-2h after sunset**: SL$_{low}$
  - **1-2 before sunrise**: SL$_{low}$
  - **1h before sunrise**: SL$_{high}$

- **Fish** and **Larger euphausiids** also exhibit migration patterns:
  - **1h after sunset**: SL$_{low}$
  - **1-2h after sunset**: SL$_{low}$
  - **1-2 before sunrise**: SL$_{low}$
  - **1h before sunrise**: SL$_{high}$
Diel Change of $S_A$ in surface layer (<100m)

165 °W

145 °W

Time (GMT)

$S_A (m^2/NM^2)$

50

0

5:00 9:00 13:00 17:00 3:00 7:00 11:00 15:00
Conclusion

At sunset, a layer comprising small zooplankton ascended to the surface earlier than a layer comprising larger zooplankton and fishes, whereas at sunrise, the layer comprising small zooplankton descended later than the other layer.

The SSL dominated by copepods around Hokkaido showed stronger backscattering at 200 kHz than at 38 kHz, whereas the SSL dominated by euphausiids and fishes in the northwest Pacific showed stronger backscattering at 38 kHz than at 200 kHz.

The depth range of vertical migration was shallower north of 50N than south of this latitude in conjunction with the changing rate of solar illumination was smaller in north than in south.