Spatial distribution of Antarctic krill(Euphausia superba) and crystal krill(E.crystallorophias) in the Western Ross Sea during summer 2018

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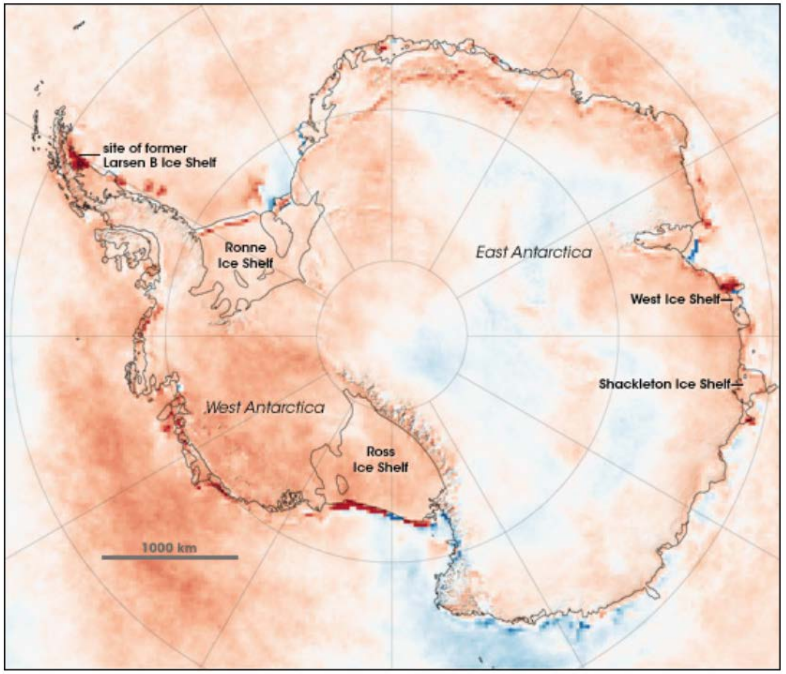
KOPRI 극지연구소 Korea Polar Research Institute

Background

- The Southern Ocean has a powerful influence on global climate
- Antarctic marine ecosystems are increasingly threatened by climate change



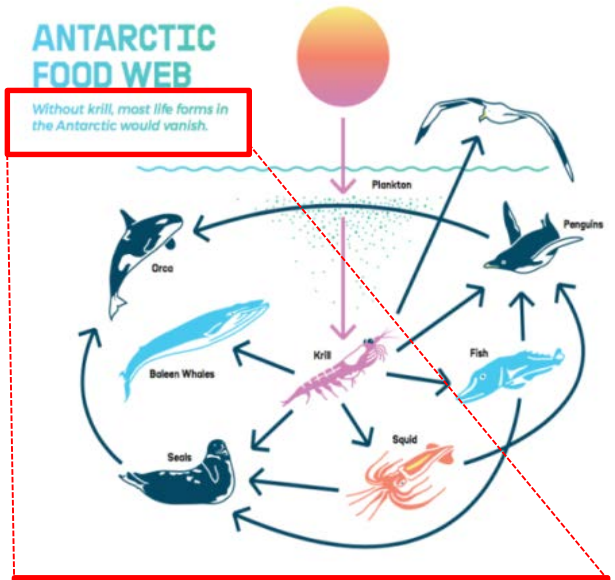
(NASA,2007)

https://www.klima-therm.co.uk/blog/what-are-we-doing-about-global-warming/

Why do we care about krill

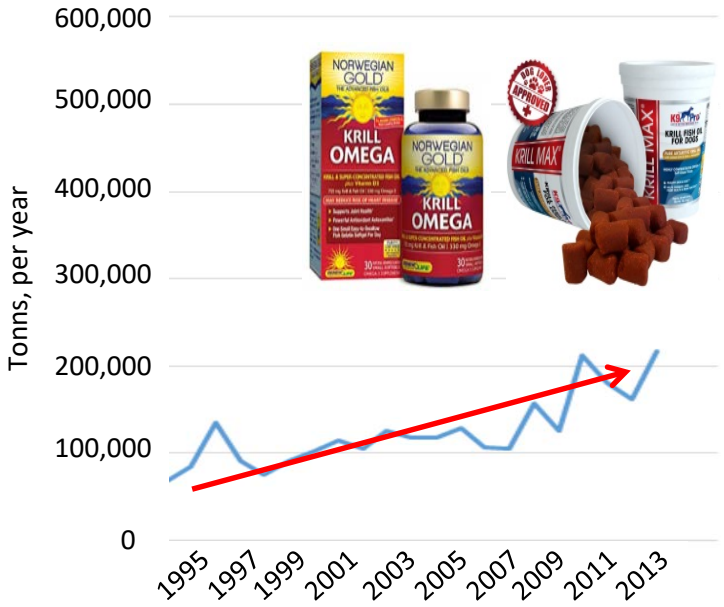
- Krill are '**keystone species**' in the Southern Ocean ecosystem
- Krill are one of the greatest unexploited fisheries stocks

< Antarctic food-web>



Without *krill*, most life forms in the Antarctic would vanish

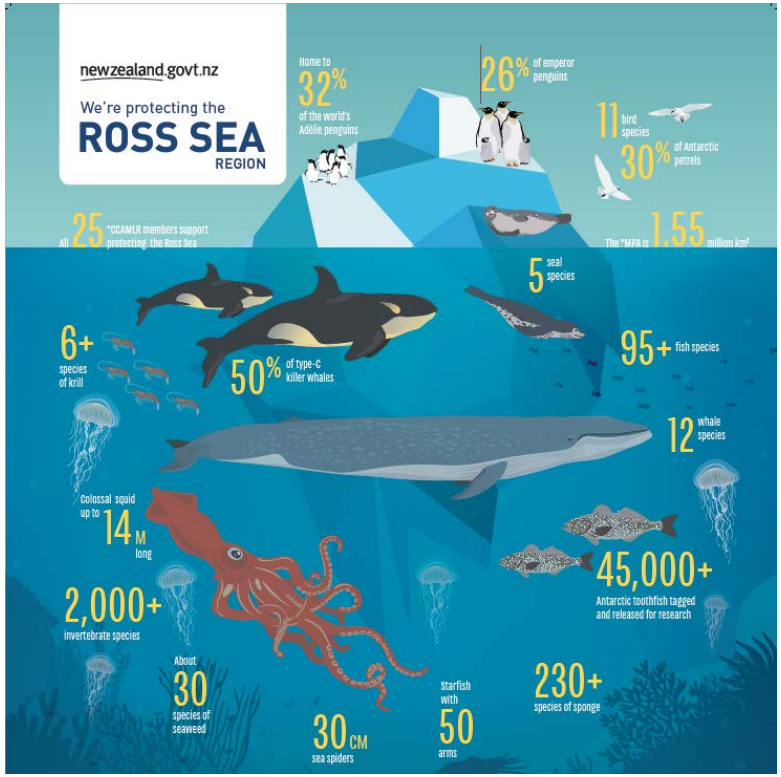
<Antarctic krill fishery, 1995-2013 >



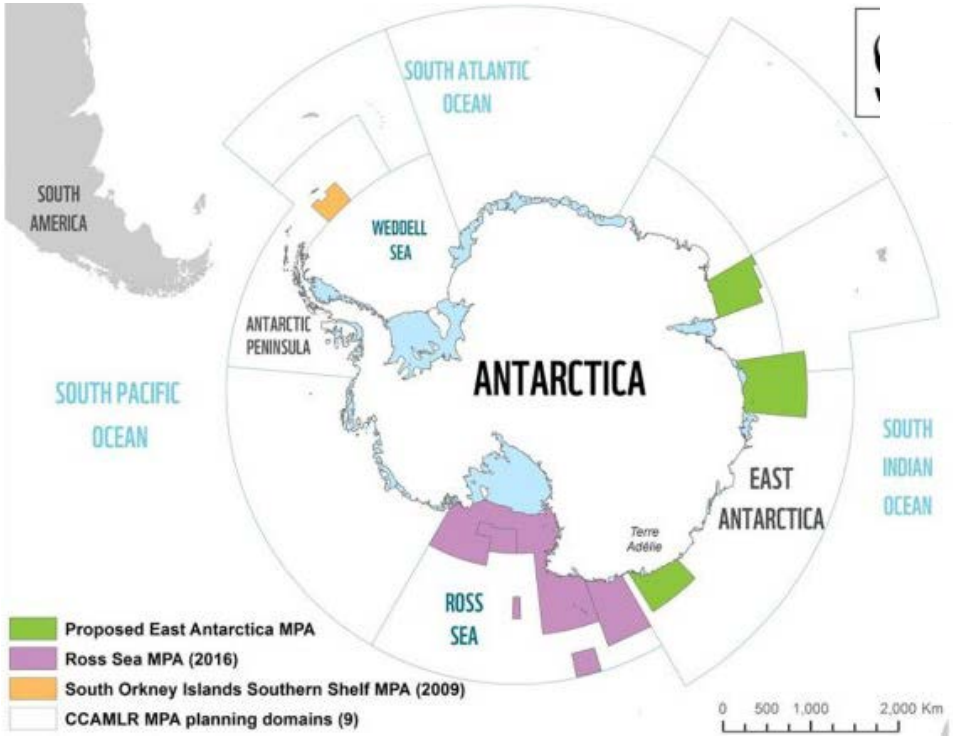
https://www.coolantarctica.com

Why the Ross Sea regional special

- Ross Sea includes one of the most productive areas of the Southern Ocean
- Ross Sea region is the largest marine protected area (MPA)



https://www.mfat.govt.nz/en/environment/antarctica/ross-sea-region-marine-protected-area/

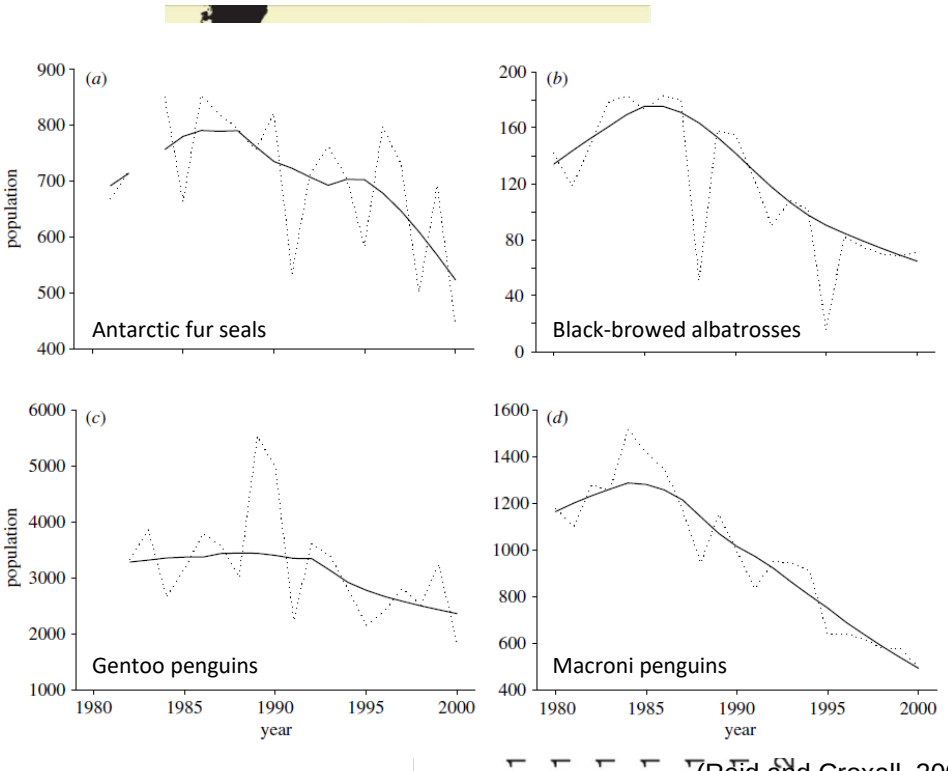


https://fox6now.com/2017/10/13/penguin-catastrophe-leaves-thousands-of-chicks-dead-with-only-two-survivors/

Study of krill biomass and vertical depth

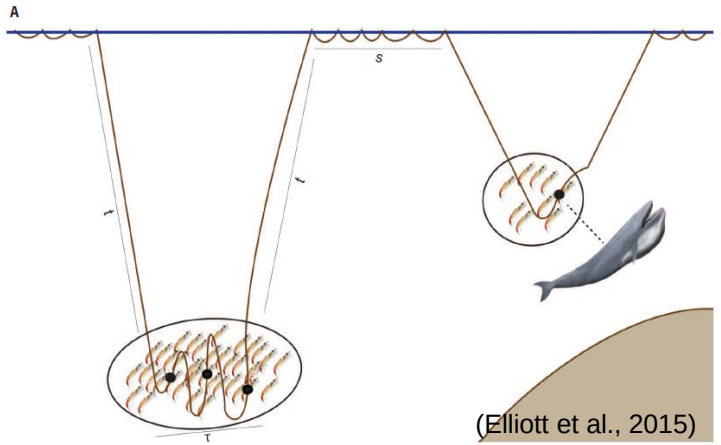
- Krill biomass affects population of Antarctic predators
- Vertical distribution of krill affects predator's feeding activities

< Krill biomass vs. predator population>

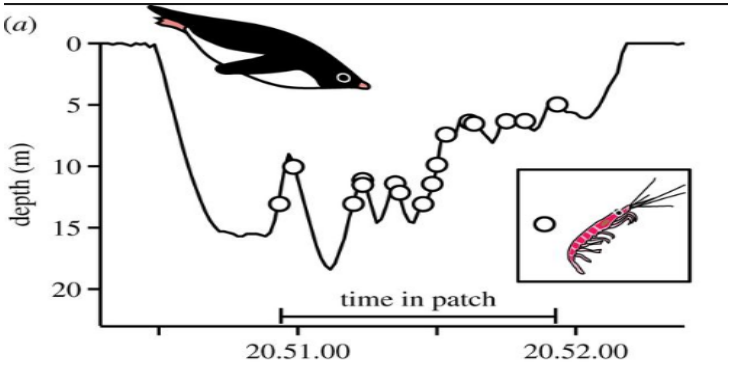


(Reid and Croxall, 2000)

< Krill depth vs. predator's feeding depth >



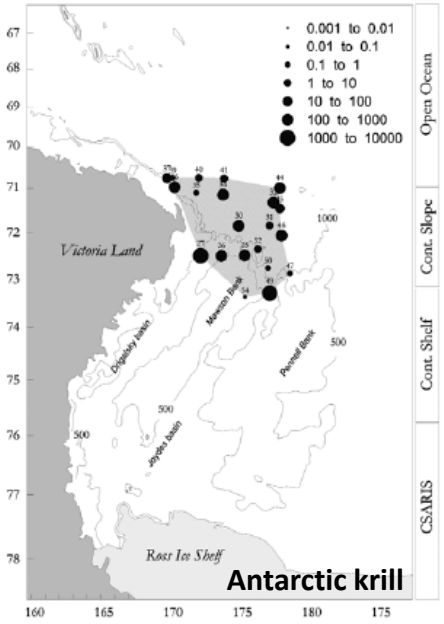
(Elliott et al., 2015)

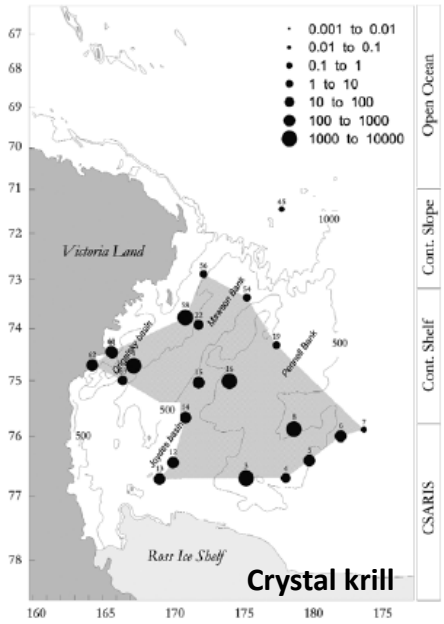


(Watanabe et al., 2014)

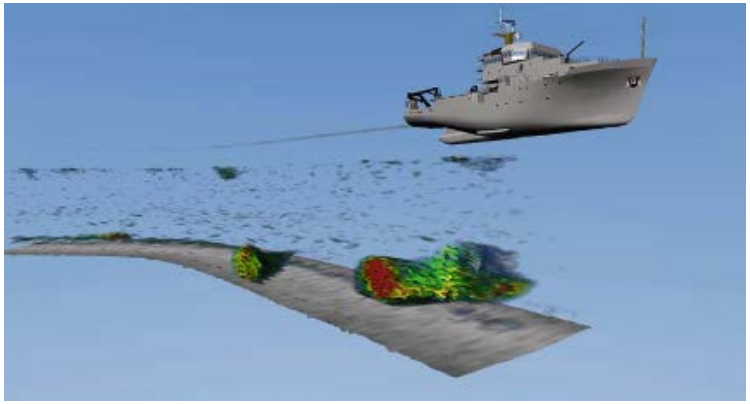
Study of krill research in Ross Sea

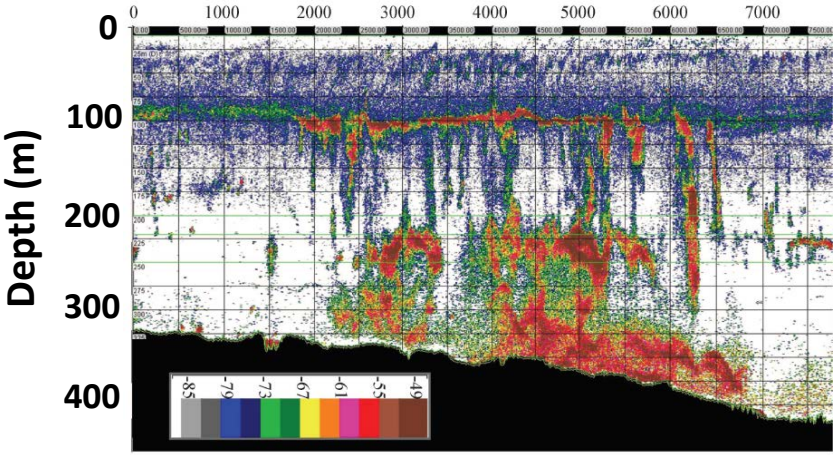
- To estimate spatial distribution of Antarctic krill and crystal krill by acoustic
- To calculate the vertical habitat depth of krill





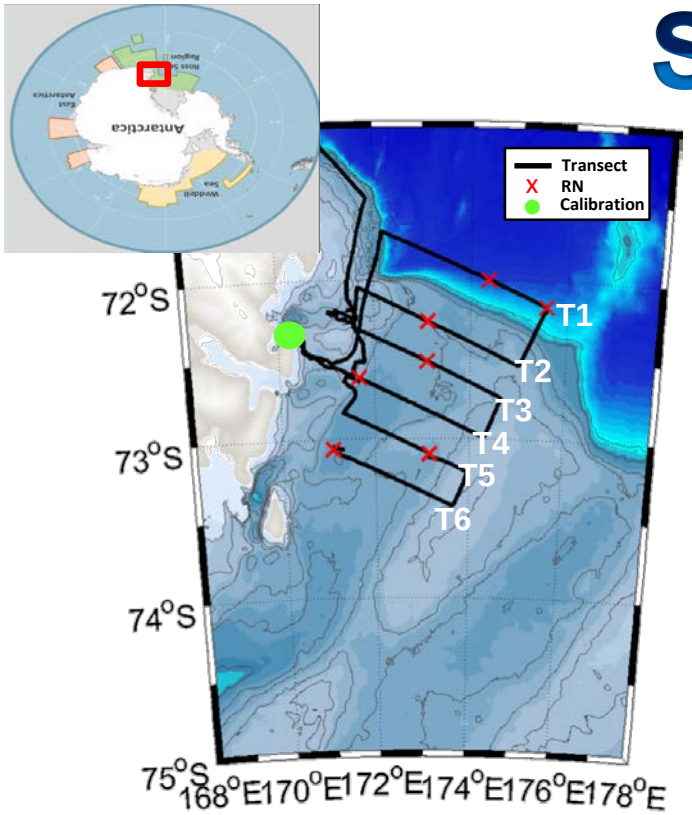
(Sala et al., 2002)





(Schmidt et al., 2011)

Survey area

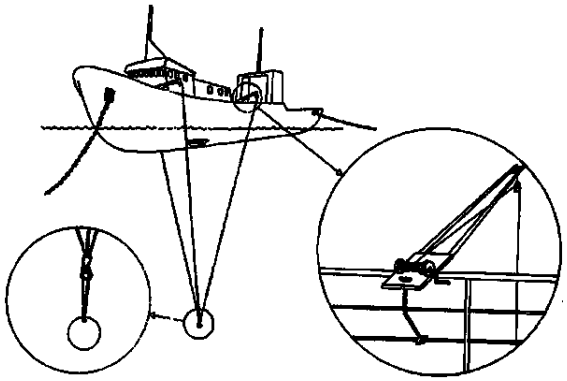


- Survey period : 2018.2.26 – 3.1
- Study area : Cape Hallet, Ross Sea
- Reseach vessel : IBRV ARAON(7,487 ton)
- Acoustic data : EK60 (38 and 120 kHz)
- Net data : Rectangular Net (1 x 1 m, 330 mm)


IBRV Araon

Scientific Echosounder (EK60)


Rectangular net



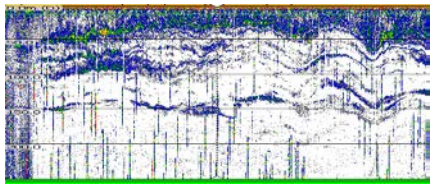
(Foote et al., 1981)

<EK60 Calibration parameters>

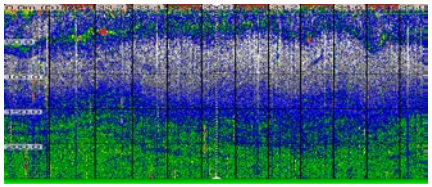
Frequency(kHz)	38	120
Absorption coefficient (dB km^{-1})	9.7	23.9
Sound Velocity (m s^{-1})	1443.9	1443.9
Transmitted power (W)	2000	250
Pulse duration (ms)	1.024	1.024
Transducer gain (dB)	22.47	26.20
3-dB Beam angle (along/athwart) (°)	7.05 / 7.09	6.67/6.47
s_A correction (dB)	-0.45	-0.36
Data deviation beam / Polynomial model (dB)	0.08 / 0.03	0.13 / 0.10

Acoustic data process

<38kHz Raw data>



<120kHz Raw data>



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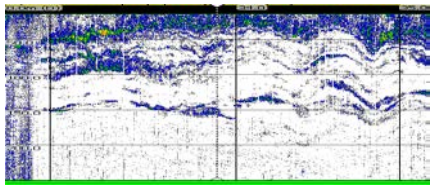

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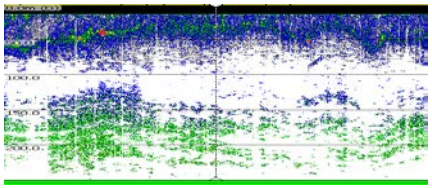
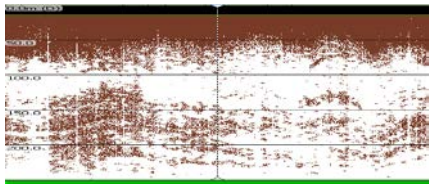
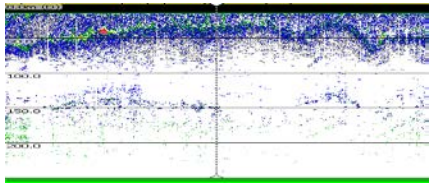
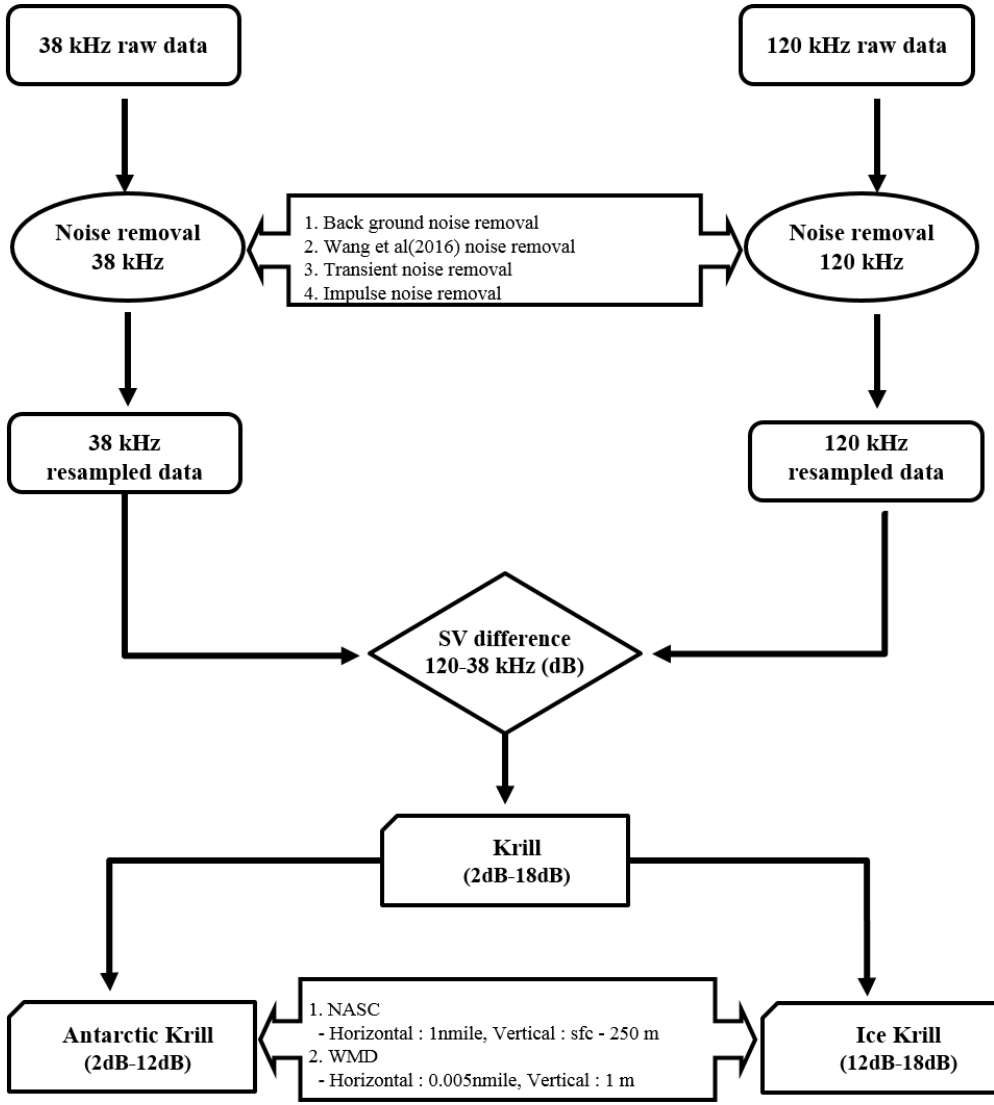


<SV difference 120-38 kHz>



<Krill>





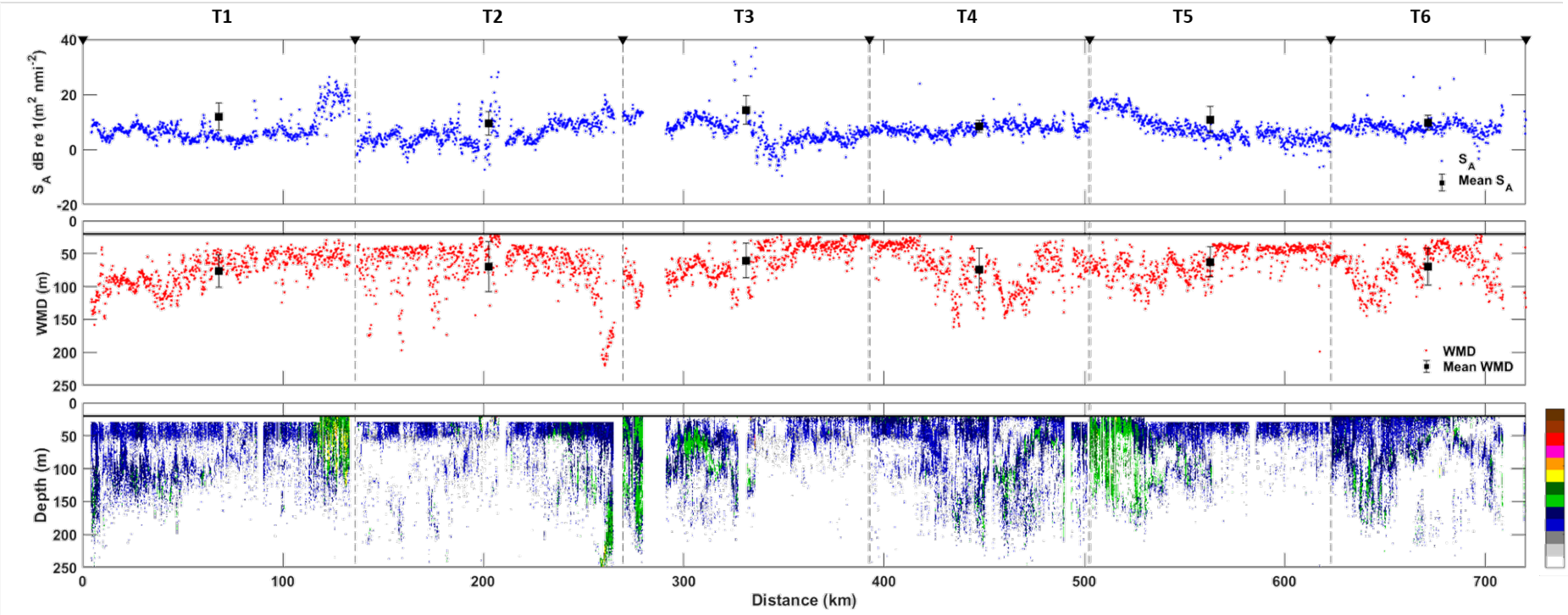
(Watkins **and** Brierley, 2002)

(La, 2015)

Estimate of krill density & vertical depth

- **Discrimination of krill signal using multi-frequency difference method**
- **Estimate relative krill biomass(NASC) and vertical distribution of krill(WMD)**

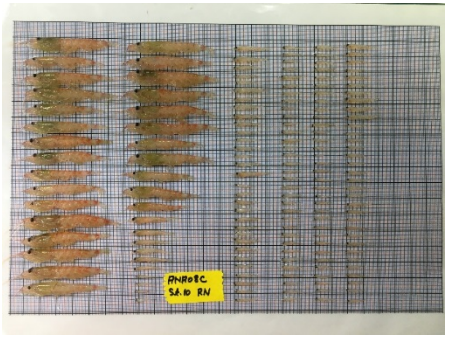
- **NASC (m^2 / nmi^2) :** Averaged over 1nmile and 5 m depth
- **Weighted Mean Depth (m) :** $\sum(S_A * D_i) / \sum S_A$



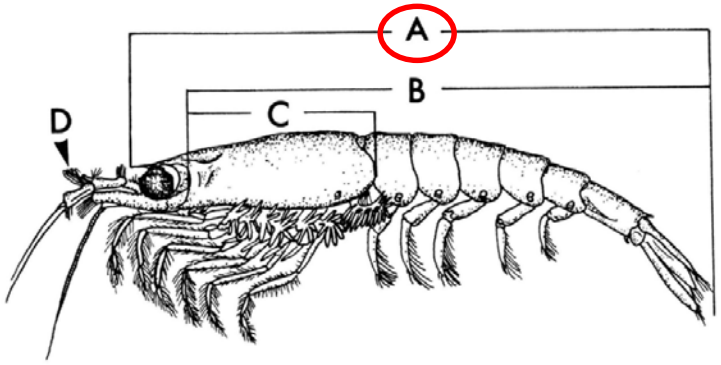
Measurement of krill length

- Randomly extract 100 samples and measure the krill body length(AT)
- Identify krill species and confirm their growing stage

<Identify Antarctic krill and crystal krill>



<krill length>



(Kulka and Corey, 1982)

<Identify krill stage>

Antarctic krill	
Stage	AT length (mm)
Juvenile(J)	L <36
Sub Adult(SA)	36 < L < 45
Adult(A)	L > 45

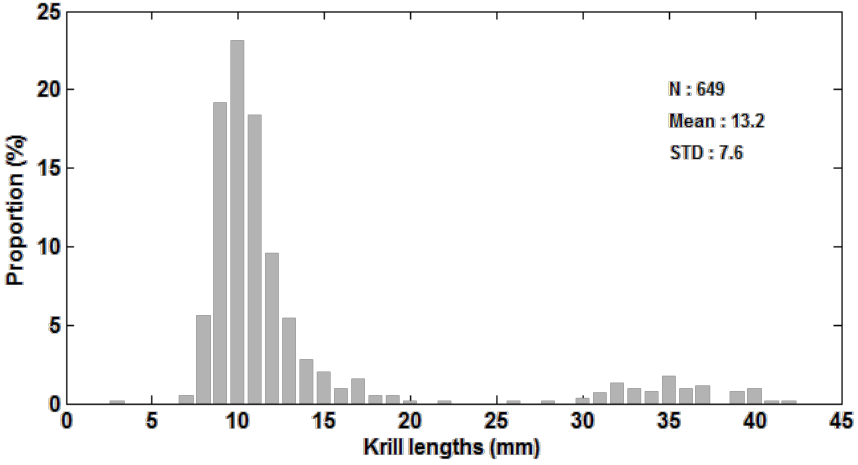
Crystal krill	
Stage	AT length (mm)
Juvenile(J)	L <36
Sub Adult(SA)	36 < L < 45
Adult(A)	L > 45

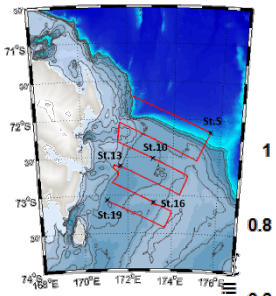
Sala et al., 2002

Estimate of krill body length and stage

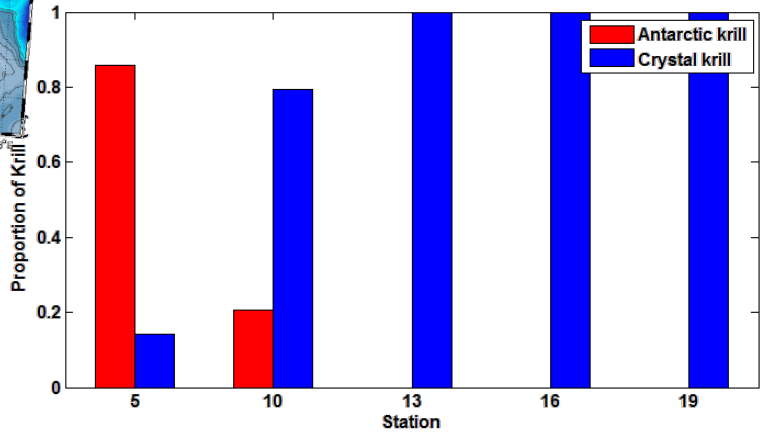
- Antarctic krill is observed near continental slop and open ocean than crystal krill
- Antarctic krill is 94% adult and sub-adult stage, while crystal krill is 87% juvenile

<Antarctic and crystal body length >



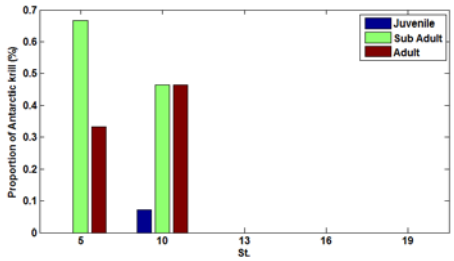


<Proportion of krill>

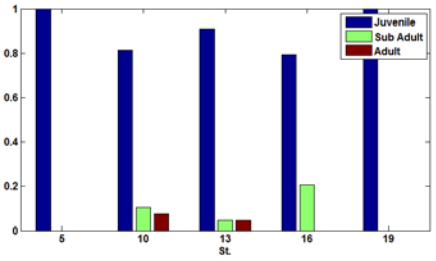


Krill species	Mean length (± S.D.)
Krill	13.2 mm(±7.6)
Antarctic krill	36.5 mm (±5.7)
Crystal krill	7.5 mm (±2.1)

<Antarctic kill stage >

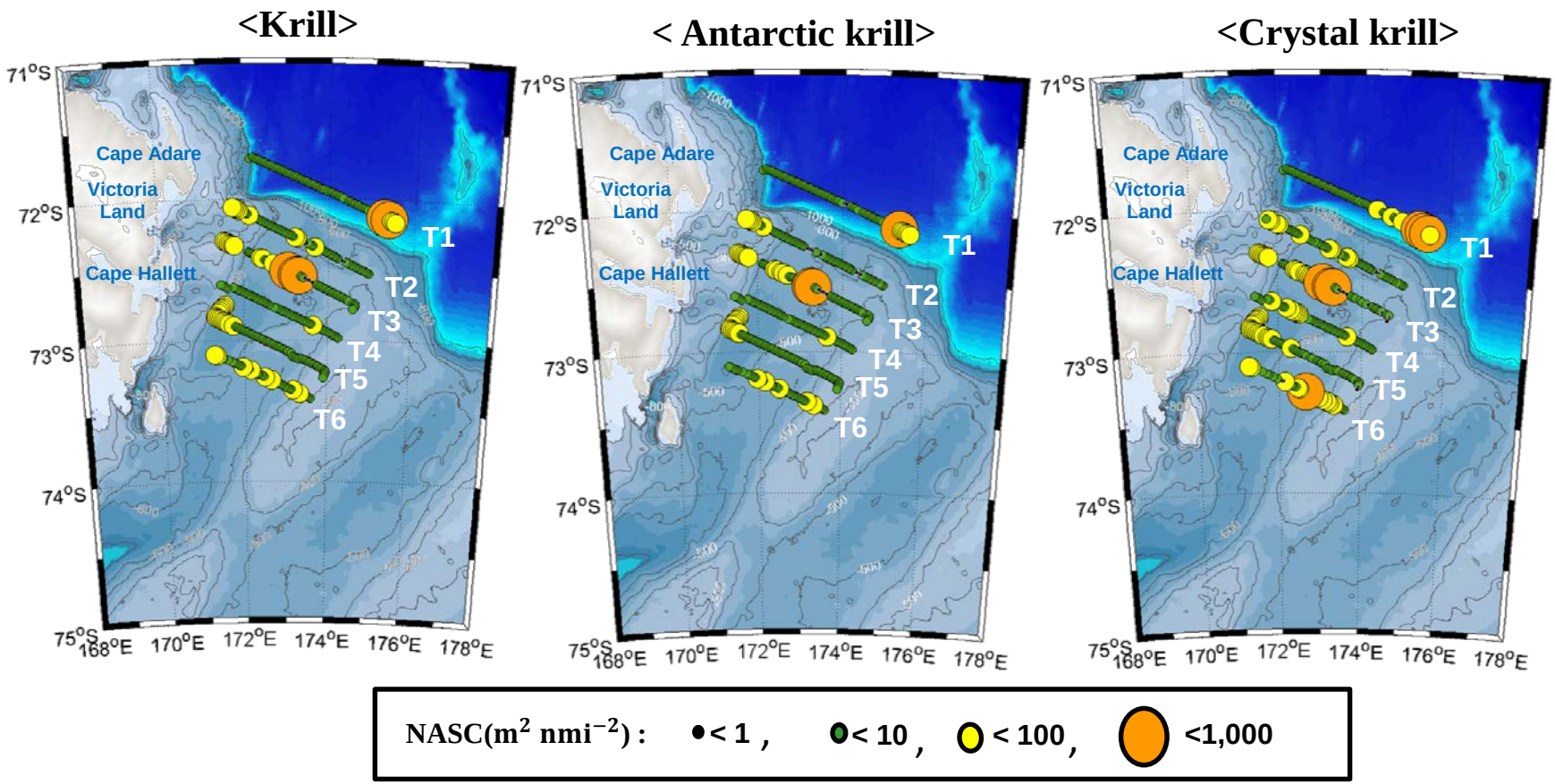


<Crystal kill stage >



Horizontal distribution of krill

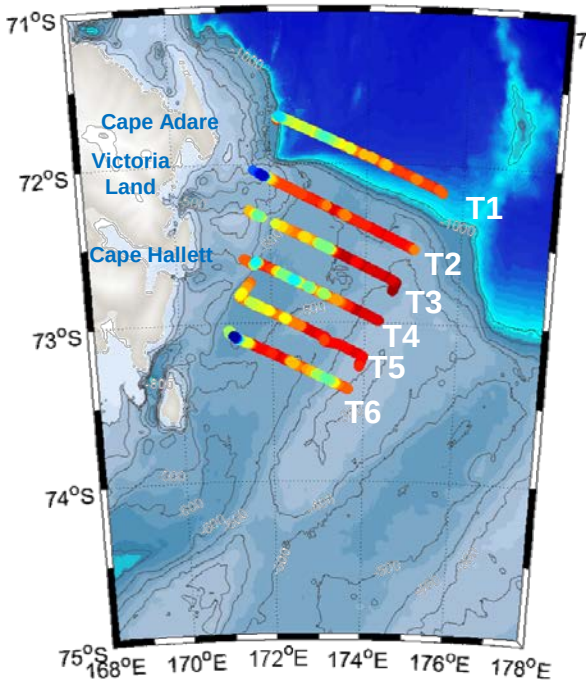
- Antarctic krill is relatively distributed in the open ocean than crystal krill
- Higher NASC results in west than east, except for T1



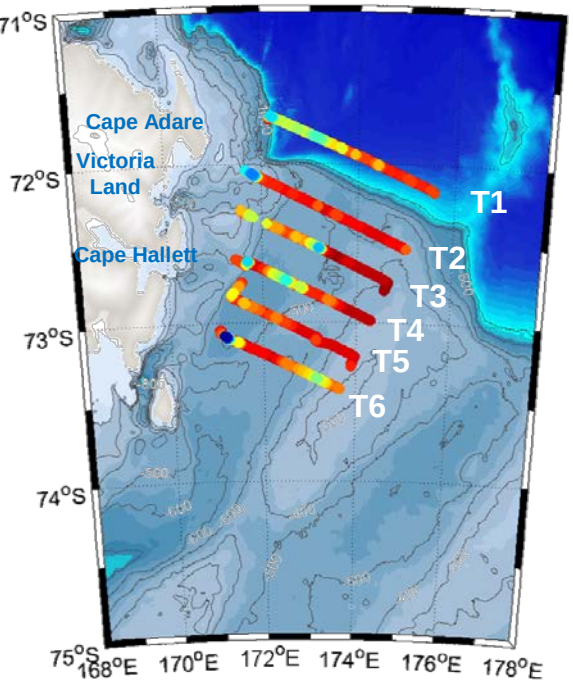
Vertical distribution of krill

- Distribution of crystal krill is deeper than that of Antarctic krill
- Krill distribution is deeper in the west than in the east

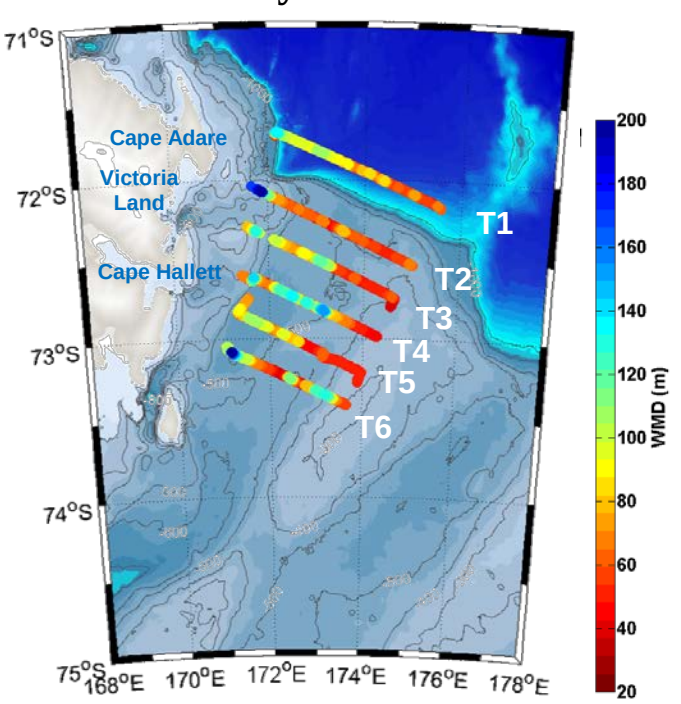
<Krill>



< Antarctic krill>



<Crystal krill>



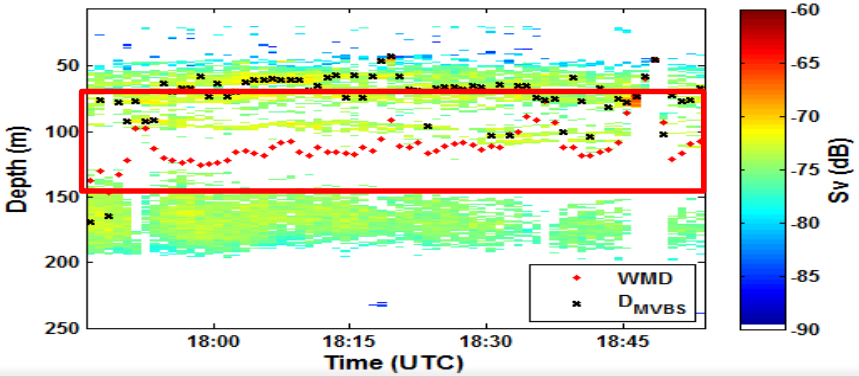
Summary

- First krill survey on the Ross Sea after MPA designation
- Separate acoustic signal attributed Antarctic krill and crystal krill using multi-frequency difference method
- Identify the spatial distribution of Antarctic krill and crystal krill by using net
- Antarctic krill were more distributed near continental slop than crystal krill
- Antarctic krill were distributed relatively shallower than Antarctic krill
- Both krill species showed a difference in density and depth in the east and west

Future Work

- **Development of new algorithm to estimate vertical distribution**
  - **Identification of multiple sound scattering layers**
  - **Calculate thickness change and persistence rate of sound scattering layers**

< Estimation error of WMD>



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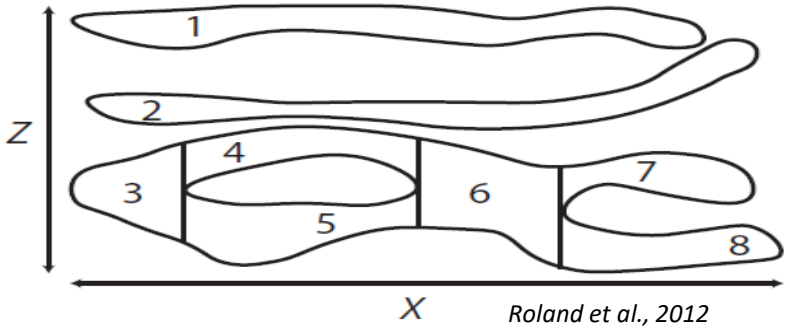
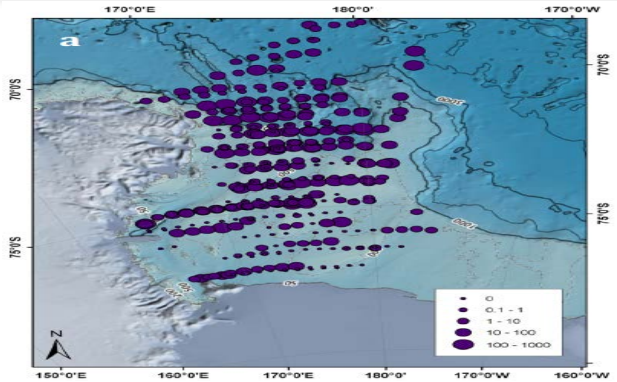
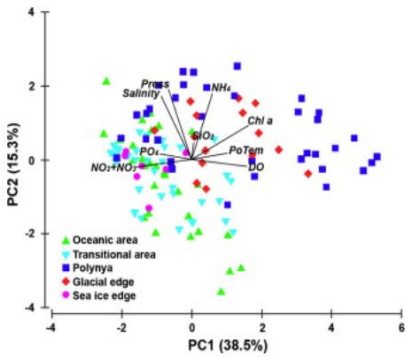


Roland et al., 2012

- **Quantitative krill biomass estimation(g, m^{-3}) using SDWBA model**
- **Multivariate anlaysis between krill distribution and marine environment**



Davis et al., 2016




Thank you

<WMD & NASC Results Table>

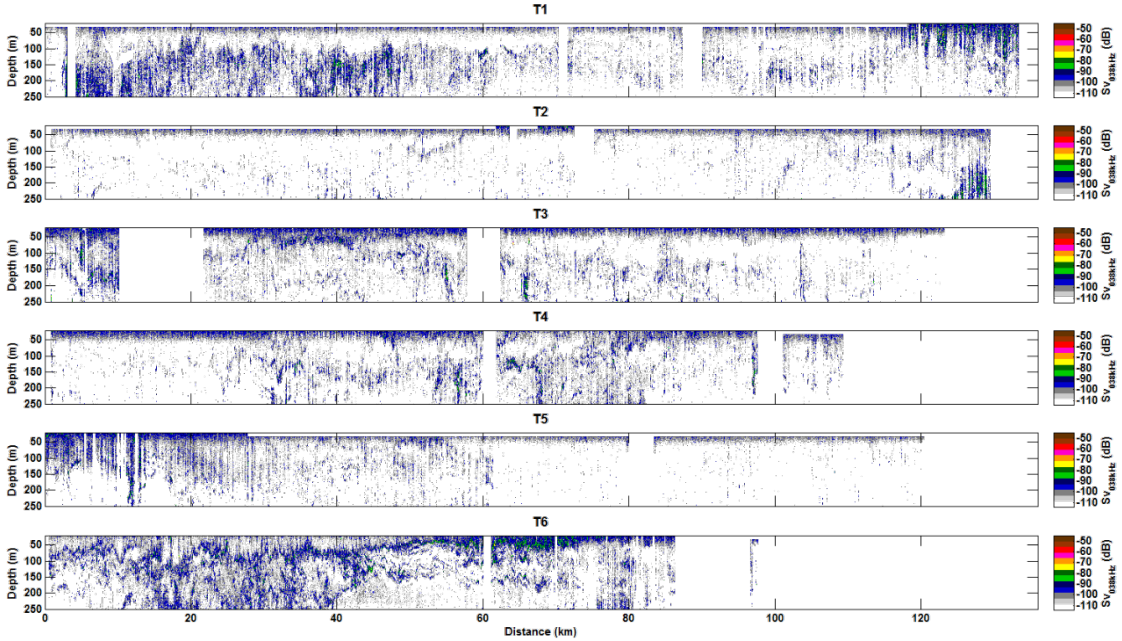
< ANA08C >

No. Transect	WMD (m)		
	Krill	Antarctic krill	Ice krill
1	73 (±28)	71 (±30)	75 (±27)
2	59 (±35)	53 (±32)	69 (±39)
3	54 (±27)	48 (±25)	68 (±26)
4	65 (±33)	58 (±30)	77 (±36)
5	58 (±23)	50 (±20)	66 (±25)
6	65 (±28)	60 (±24)	74 (±34)

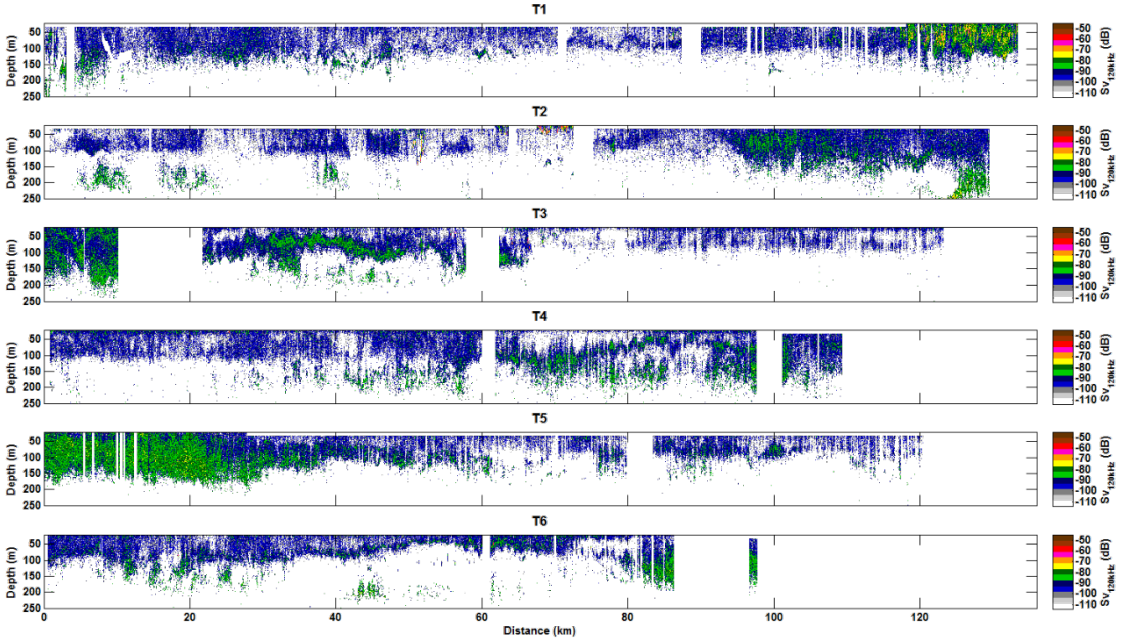
No. Transect	NASC ($m^2\ nmile^{-2}$)		
	Krill	Antarctic krill	Ice krill
1	14.1 (±30.3)	9.4 (±20.0)	15.5 (±35.1)
2	5.0 (±6.0)	4.0 (±5.7)	5.9 (±8.0)
3	16.1 (±52.8)	13.9 (±45.6)	18.9 (±65.1)
4	5.1 (±2.8)	4.8 (±2.1)	5.8 (±4.4)
5	10.7 (±15.2)	7.1 (±9.9)	12.5 (±18.0)
6	7.8 (±8.3)	6.9 (±8.7)	18.1 (±43.8)

<Line echogram (H:0.005nmile,V:1m>

<ANA08C, 38 kHz>



< ANA08C, 120 kHz>

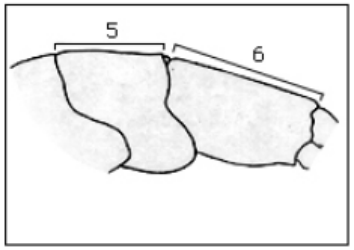


Identify Antarctic krill and crystal krill

1. Body 부분의 5 , 6 segment 길이비율로 구분

2. 문헌에서 찾아본 결과 Antenular의 길이가 길고, 검은 눈동자의 사이즈가 큼

<Crystal krill>



<Antarctic krill>