Synoptic Arctic Survey Workshop 2023
June 7-8, 2023

Update on Korea's contribution to SAS: Araon 2020-2022 cruises

Presenter: Kyoung-Ho Cho
E.J. Yang, J. Jung, J.-H. Kim, Y. Lee and SAS-Korea Team

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KOPRI KIMST 해양수산부

Synoptic Arctic Survey (SAS) – Korea

A single, overarching question on a Pan-Arctic scale focused in SAS:

"What are the present state and major ongoing transformations of the Arctic marine system?"

– SAS Science & Implementation Plan –

Three focal areas in SAS

- Physical Drivers
- Ecosystem Response
- Carbon Cycle & Ocean Acidification

9 Research Questions

Box 1: Research questions in the three focal areas

Physical Drivers:

RQ1. How are Arctic Ocean water masses and circulation patterns responding to changes in sea ice properties, and atmospheric, advective and freshwater forcing?

RQ2. What are the states of, and changes in, heat and freshwater budgets in the Arctic region?

RQ3. What are the changes in water mass sources, sinks and transformations?

Ecosystem Response:

RQ4: How does primary production and associated availability of nutrients vary between Arctic regions?

RQ5: Does northward range expansion of subarctic species vary regionally and are any of these species likely to establish permanent populations in Arctic regions?

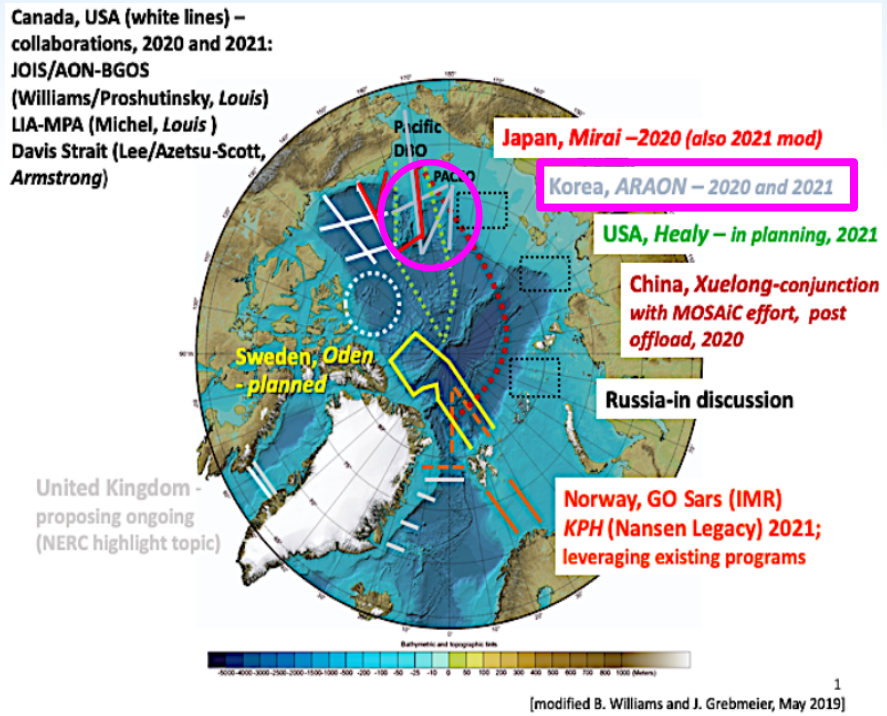
RQ6: How does biomass flow vary across regional ecosystems of the Arctic?

Carbon Cycle and Ocean Acidification:

RQ7: What is the contribution of the Arctic Ocean to maintaining the global ocean carbon dioxide reservoir and uptake?

RQ8: What are the input and fate of terrestrial and subsea carbon to the Arctic Ocean?

RQ9: What are the magnitude, drivers, and impacts of Ocean Acidification in the different regions of the Arctic?

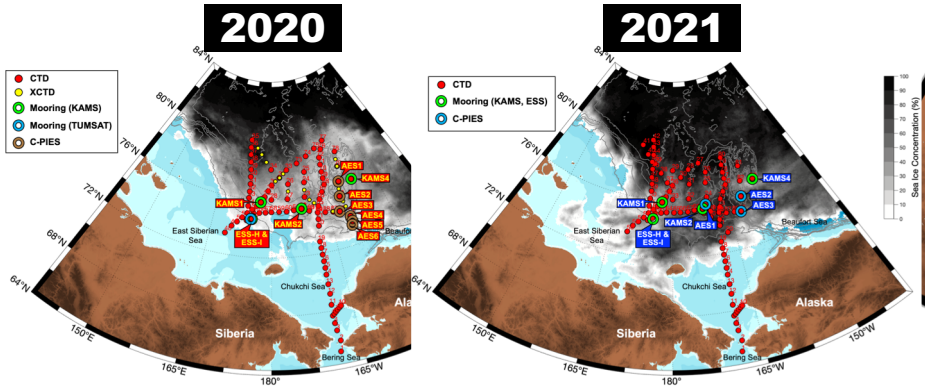


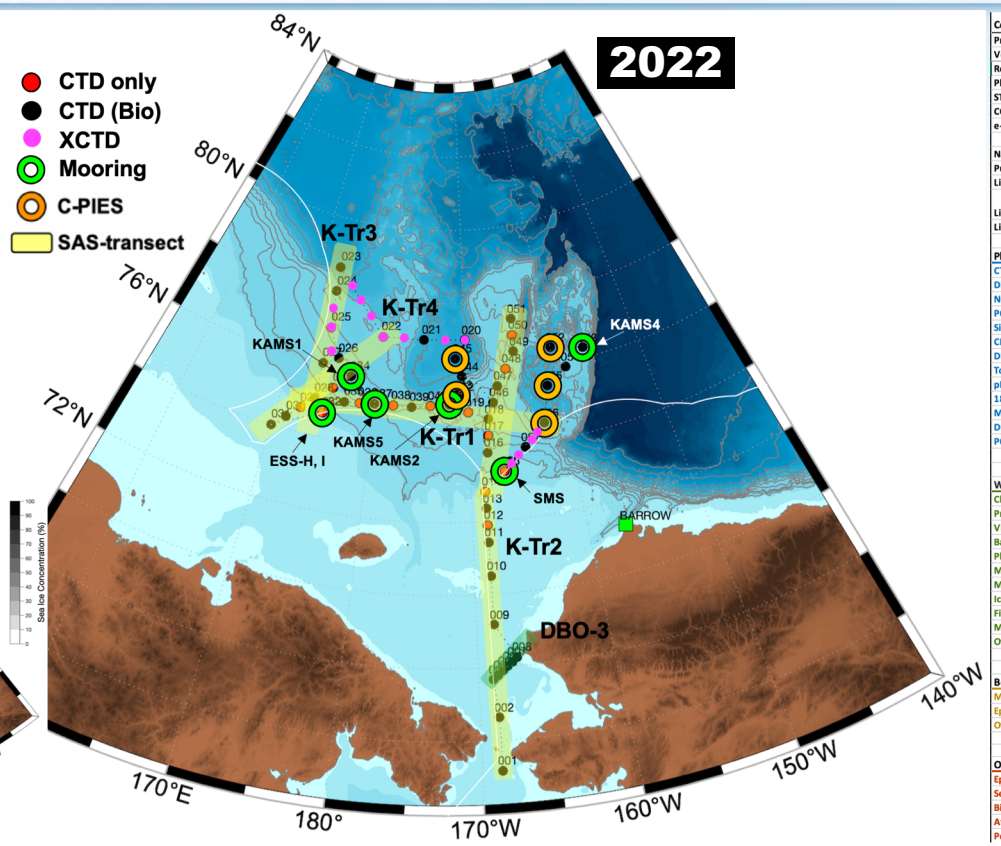
(from the Report of 2019 SAS Workshop held in WHOI, May 15-16, 2019)

The objective of the SAS-Korea research is to seek the answers to those research questions joining the Arctic cruises and sharing observations and analyses of data.

2020-2022 ARAON Arctic Ocean Cruises

	2020	2021	2022
CTD	88	96	58
XCTD	16	0	14
Period	08/04~ 08/31	07/20~ 08/18	07/22~ 08/19





cruise matrix

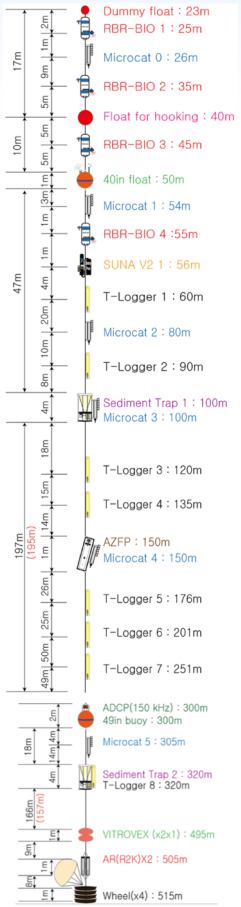
Country:	Korea	Korea	Korea
Project:	SAS		Arctic warming?
Vessel:	R/V Araon	R/V Araon	R/V Araon
Region:	Bering Strait, Chukchi Sea,	Bering Strait, Chukchi Sea,	Bering Strait, Chukchi Sea,
Planned dates: (start - end)	Aug 8 - Sep 4, 2020	Jul 20 - Aug 18, 2021	Jul 22 - Aug 19, 2022
STATUS:	Completed	Completed	Completed
CONTACT PERSON:	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
e-mail:	kcho@kopri.re.kr	kcho@kopri.re.kr	kcho@kopri.re.kr
Name of data repository:	Korea Arctic Ocean-data Syste	Korea Arctic Ocean-data Syste	Korea Arctic Ocean-data Syste
Publically available (yes/no)	Available on request	Available on request	Available on request
Link to data location:	https://kaos.kopri.re.kr/	https://kaos.kopri.re.kr/	https://kaos.kopri.re.kr/
Link to cruise report:	Available soon	Available soon	Available soon
Link to blog post about cruise:			
Physical and chemical measurements:	Contact person responsible for each measurment:		
CTD	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
Dissolved Oxygen	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
NO3/NO2	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
PO4	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
SiO3	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
CFCs and SF6	No	No	No
DIC	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Total Alkalinity	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
pH	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
18O of H2O	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Methane	No	No	No
DOC	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
POC	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Water column ecosystem measurements:			
Chlorophyll	Eunjin Yang	Eunjin Yang	Eunjin Yang
Primary production	No	No	No
Viruses	No	No	No
Bacteria	Eunjin Yang	Eunjin Yang	Eunjin Yang
Phytoplankton composition	Eunjin Yang	Eunjin Yang	Eunjin Yang
Microzooplankton	Eunjin Yang	Eunjin Yang	Eunjin Yang
Meso- and Macro- zooplankton	Eunjin Yang	Eunjin Yang	Eunjin Yang
Ichthyoplankton	Eunjin Yang	Eunjin Yang	Eunjin Yang
Fish	No	No	No
Marine mammals	No	No	No
Other carbon transformation rates	No	No	No
Benthic measurements:			
Meio- and Macro- fauna	No	No	No
Epifauna	No	No	No
Other carbon transformation rates	No	No	No
Other:			
Epontic Communities	No	No	No
Seabirds	No	No	No
Bioaerosol	No	No	No
Atmospheric measurements	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Pollution			

CTD | Nets | Microscopy | Fire | Sediment trap | ADCP | IPS | EK80 | AZFP | Hydrophone

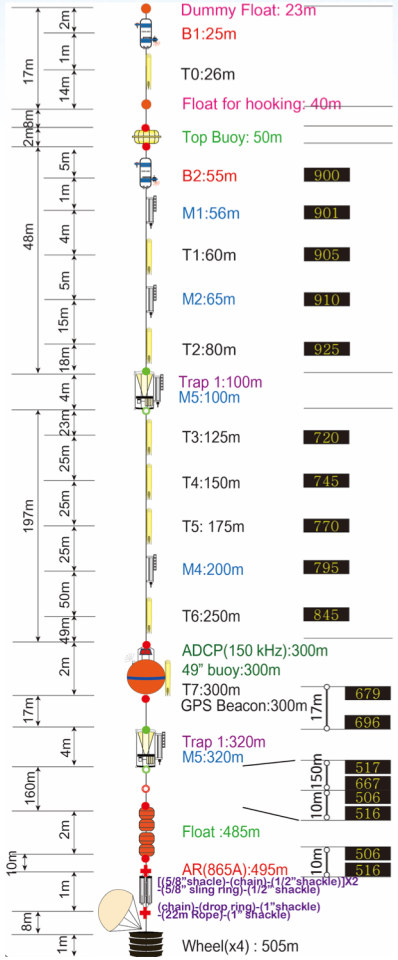
Korea Arctic Mooring System (> 500 m)

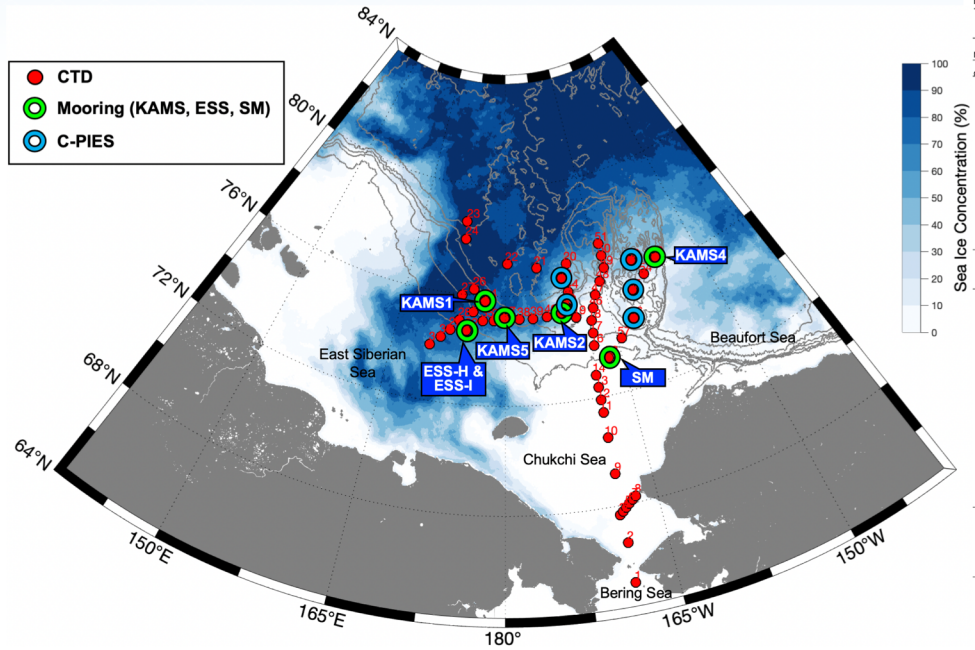
newly deployed!

KAMS1(17~)

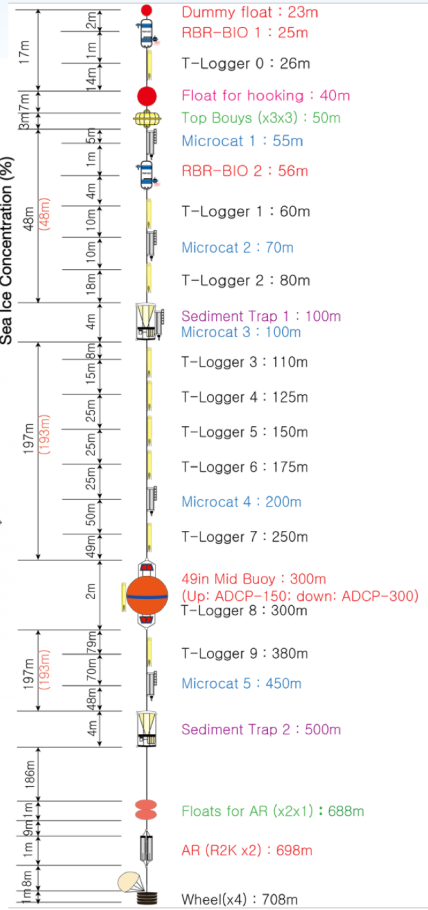


KAMS2(17~)

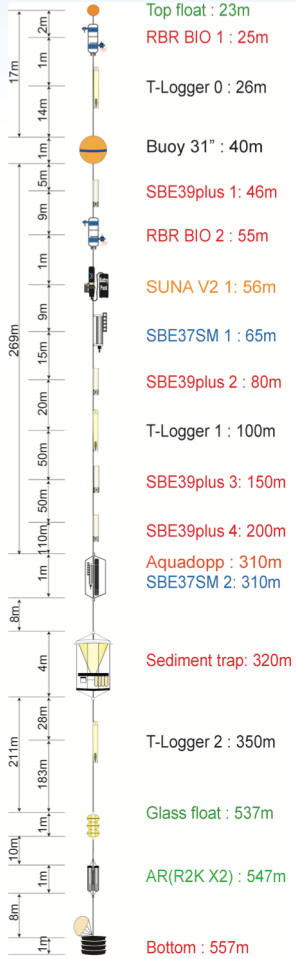




KAMS4(18~)



KAMS5(22~)



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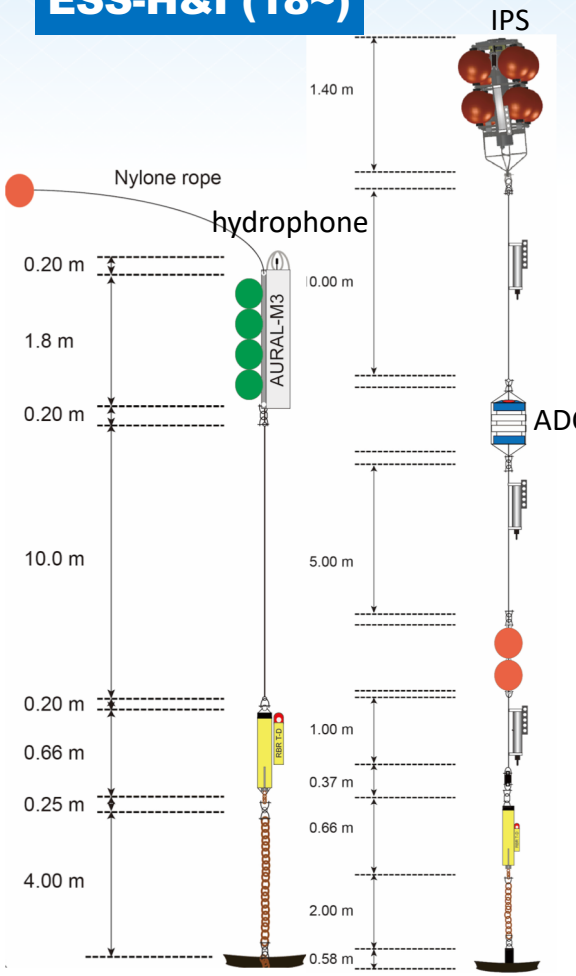
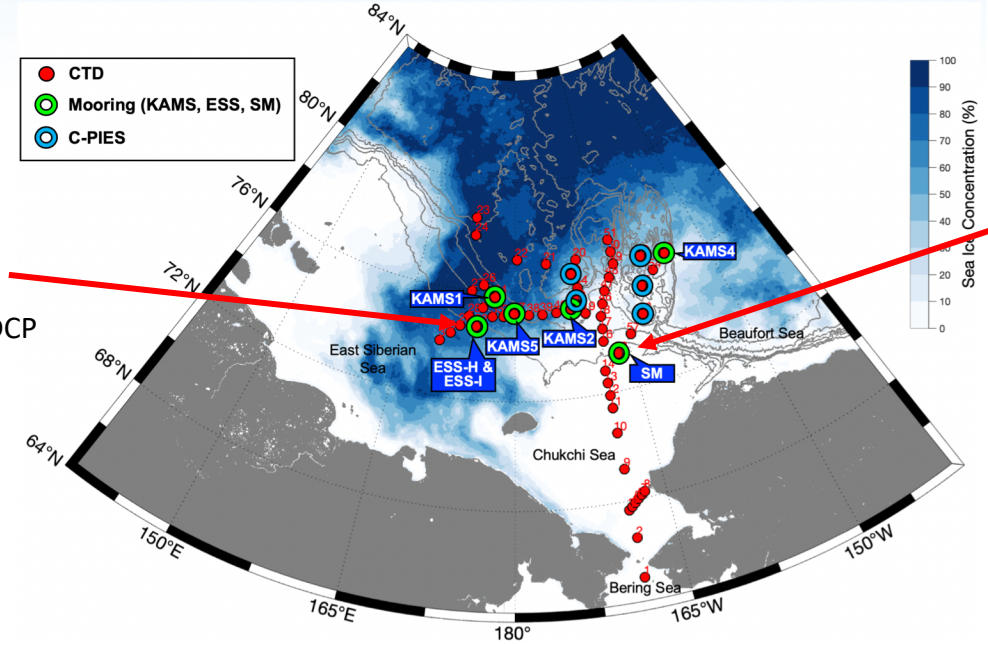
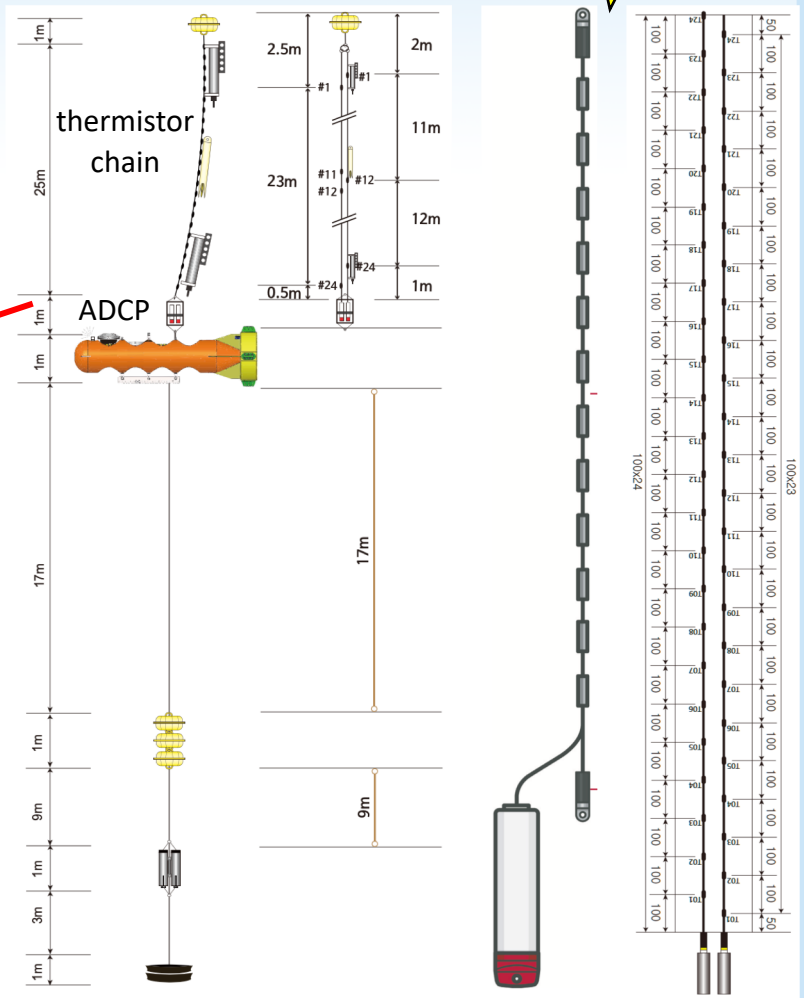
Korea Arctic Mooring System (< 100m)

ESS-H&I (18~)



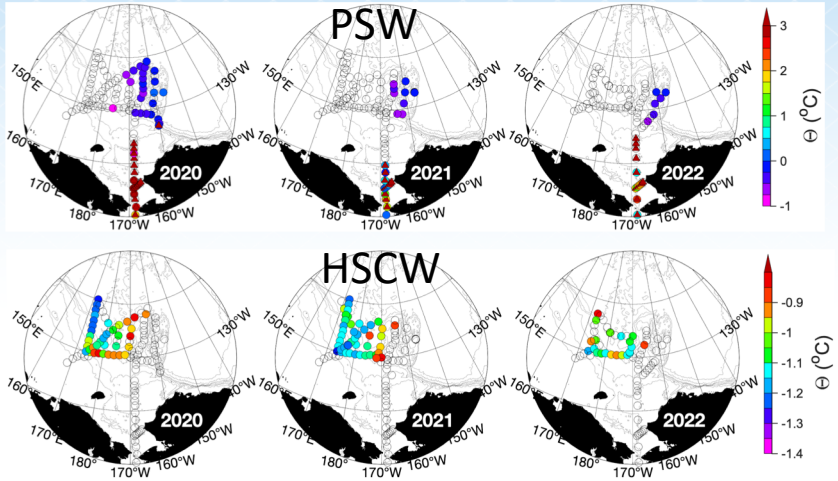


NCS-SM (22~)

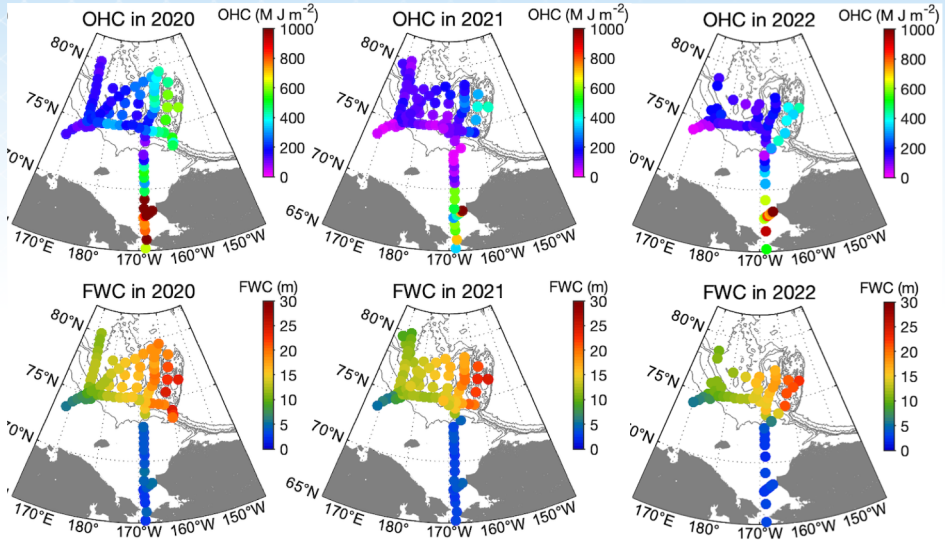


SAS-Korea Activities, 2020-2022: Physical Oceanographic Study

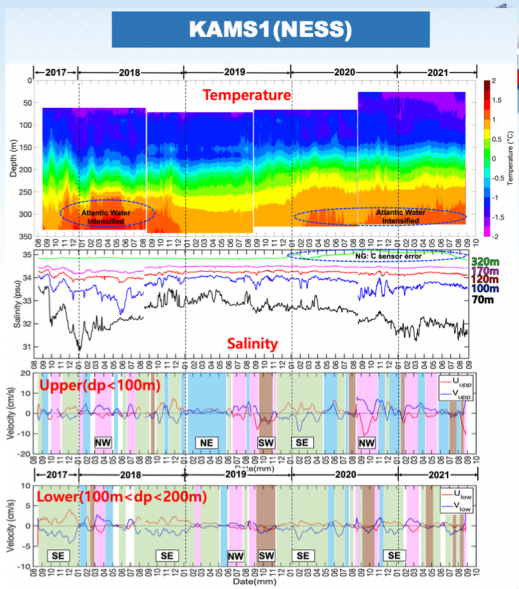
Spatial patterns of water masses & circulation

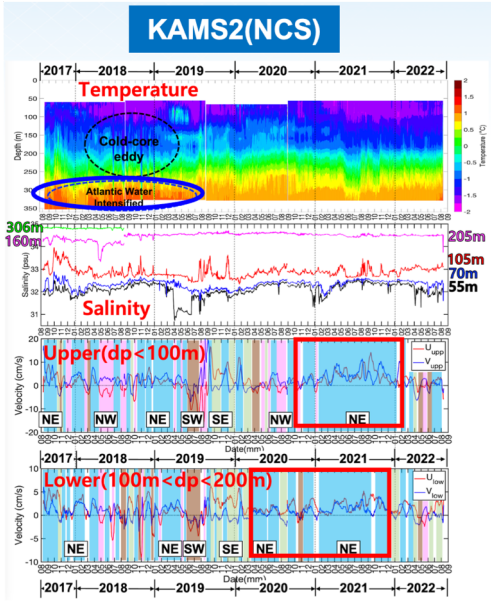


Changes in heat & freshwater contents

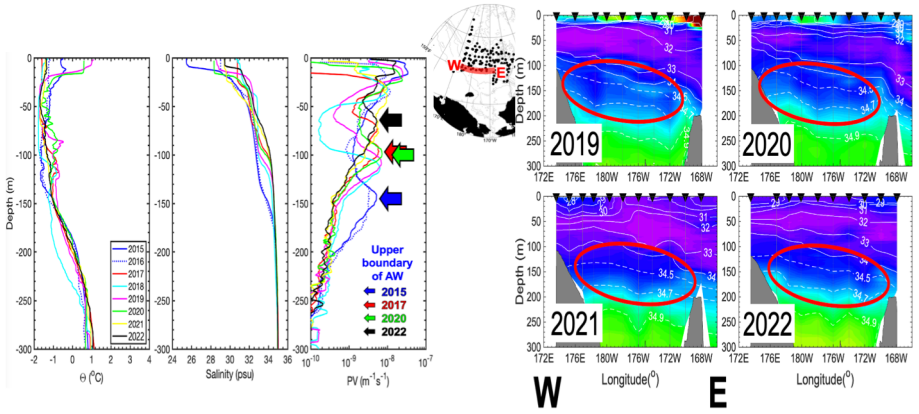


Long-term variations of T, S, and current

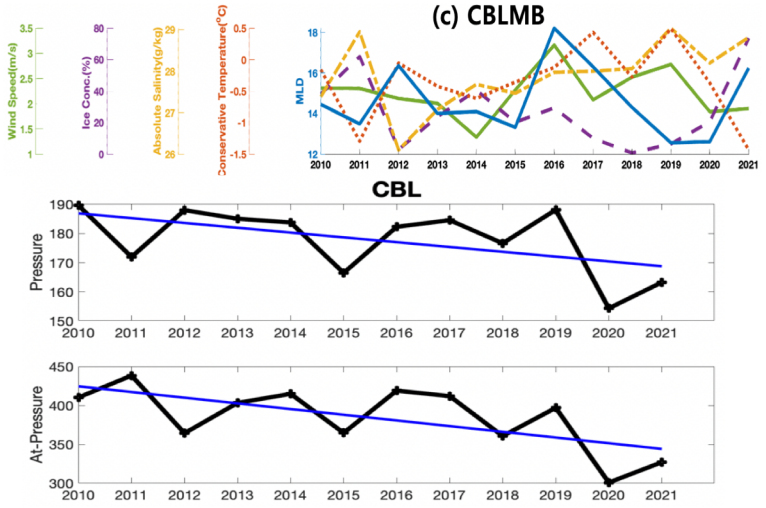




Variations of S & T structures



Interannual variability & trend of water properties



*Contact: Kyoung-Ho Cho (kcho@kopri.re.kr)

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SAS-Korea Activities, 2020-2022: Biological Oceanographic Study

Phytoplankton community & physiology

- Total and size-fractioned Chl-a
- Picophytoplankton (FACs)
- Flowcytobot & Microscopy (species)
- Pigments (HPLC)
- Physiology (FIRe)


[IFCB]


[FIRe II system]

Mesozooplankton community & production

- Community (Bongo Net 150 & 330um)
  -> Microscopy & UVP 6
- Respiration
- Grazing Exp (deck incubation)


Bongo net


[UVP6]

Carbon & Nitrogen Uptake rates

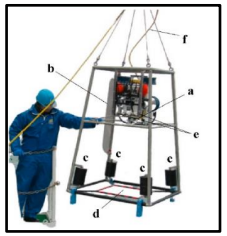
- Six depths for PP and NP
- 4-24h incubation with stable isotopes (^{13}C, $^{15}NH3$ and $^{15}NH4$)


Incubation

Ichthyoplankton and Fish

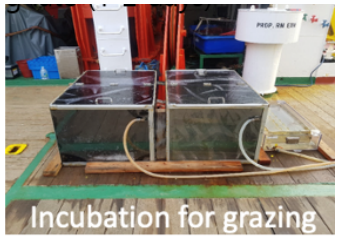
- Bongo net, Frame trawl net, and hand net
- eDNA sampling from water depth
- Deep sea Camera system


Frame trawl net



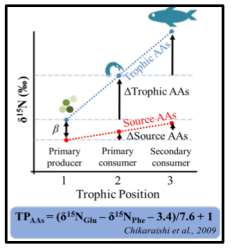
Protozoa community & Grazing

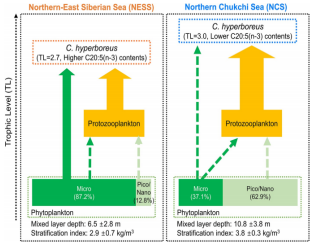
- Abundance of heterotrophic protists (4-5 depths)
  -> Microscopy
- 1- 2 days incubation for grazing rate (deck incubation)


Incubation for grazing

Marine Food web

- Amino acid $\delta^{15}N$ analysis to determine its trophic position



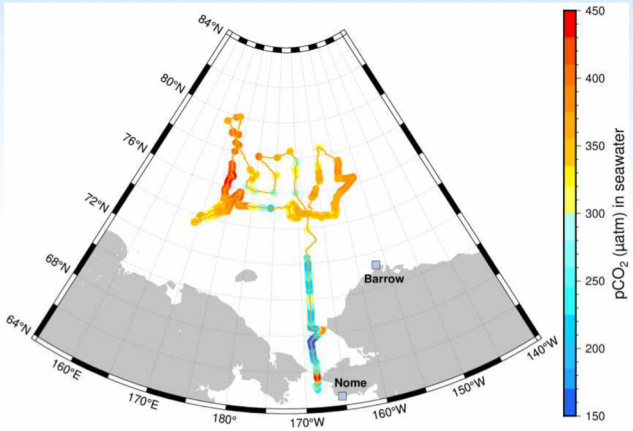


AA $\delta^{15}N$ enrichment pattern

*Contact: Eun Jin Yang (ejyang@kopri.re.kr)

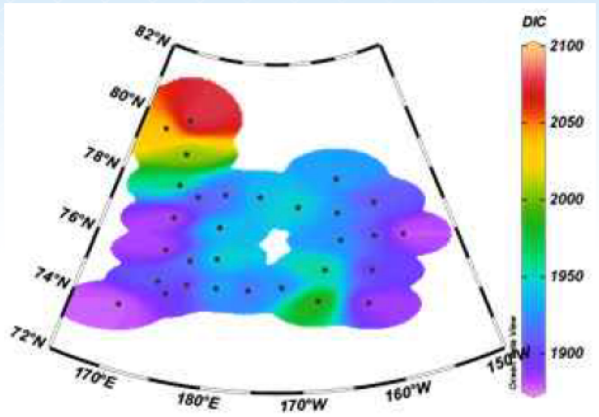
SAS-Korea Activities, 2020-2022: Chemical Oceanographic Study

Spatial and temporal variations of pCO_2



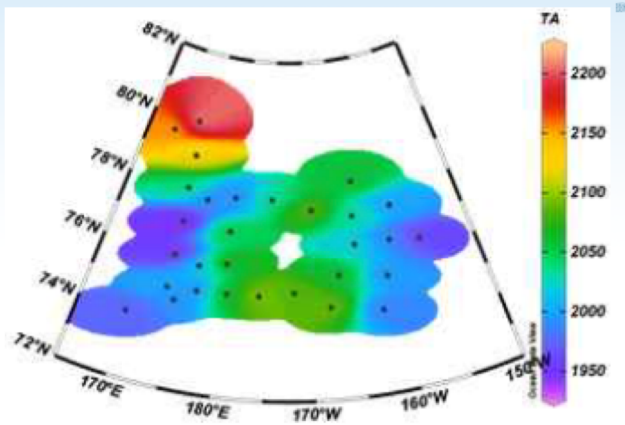
Dissolved pCO_2 along the track

Characteristics of dissolved inorganic carbon (DIC)



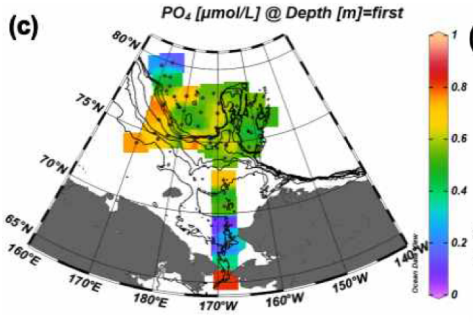
Dissolved inorganic carbon (surface)

Characteristics of total alkalinity (TA) & aragonite saturation

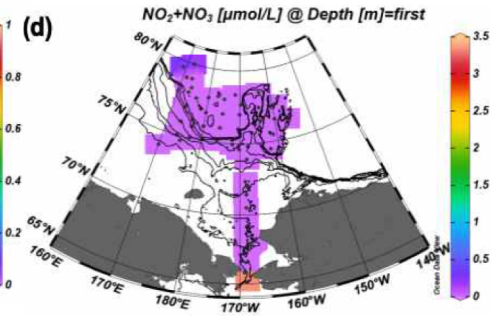


Total alkalinity (surface)

Distributions of nutrients (NH_4, NO_2+NO_3, PO_4 & SiO_2)

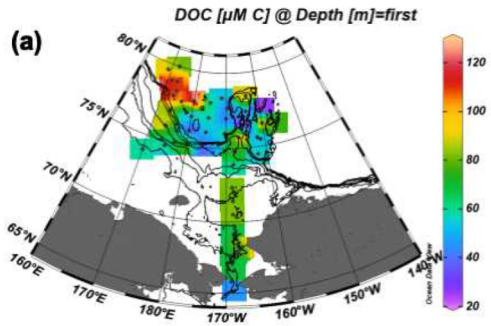


Nutrient (PO_4)



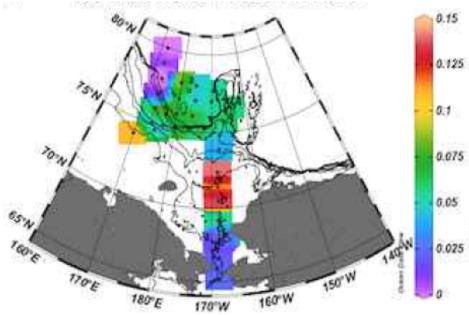
Nutrient (NO_2+NO_3)

Characteristics of dissolved and particulate organic matters (DOM & POM)

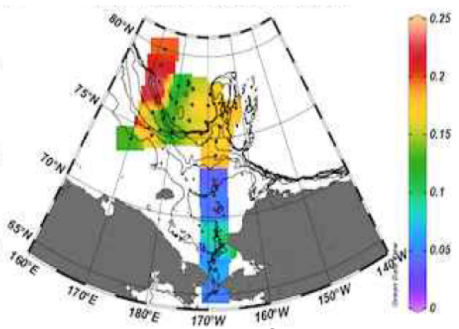


Dissolved organic carbon

Distributions of river water and ice melt water fractions



Ice melt water fraction



River water fraction

*Contact: Jinyoung Jung (jinyoungjung@kopri.re.kr)

Research papers published, submitted, or in preparation

#NO	Primary Author(s)	Title(tentative)	# SAS year data used	Status	
1	Youngju Lee	Multi-Year Variability of Summer Phytoplankton Biomass and Size Structure in the northern Chukchi and the East Siberian Seas, Arctic Ocean (2015-2020): Role of Light and Nutrient Availability	2020	in writing	
2	Eunho Ko	The actual seasonal cycles of Arctic phytoplankton including under-ice bloom detected by moored chlorophyll fluorometer	2020	in writing	
3	Dongseon Kim	Interannual variation in aragonite saturation state in surface waters of the western Arctic Ocean	2020~2022	under review	
4	Shigeto Nishino, Jinyoung Jung	Beaufort Gyre shrinkage and Atlantification induced an anomalous biogeochemical event in the western Arctic Ocean	2020	in revision	Synthesis
5	Soyeon Kwon	Summer net community production in the Northern Chukchi Sea: Comparison between 2017 and 2020	2020	published in 11/2022	
6	Wuju Son	Distinct vertical behavior of key Arctic copepods following the midnight sun period in the East Siberian continental margin region, Arctic Ocean	2020	published in 05/2023	
7	Jee-Hoon Kim	Metazoan biodiversity and community structure through eDNA emtabarcoding in the western Arctic Ocean	2020~2021	envisioned	
8	Kyoung-Ho Cho	Characteristics of Pacific-derived warm water in the Arctic Chukchi Borderland during 2015-2020	2020	in writing	
9	Jee-Hoon Kim, Matsno	Zooplankton community structure in the western Arctic Ocean from Araon and Mirai cruises (eDNA)	2020~	envisioned	Synthesis

Published

frontiers | Frontiers in Marine Science
TYPE Original Research
PUBLISHED 22 November 2022
DOI 10.3389/fmars.2022.1050791

Summer net community production in the northern Chukchi Sea: Comparison between 2017 and 2020

Soyeon Kwon[1,2], Inhee Lee[1], Keyhong Park[3], Kyoung-Ho Cho[3], Jinyoung Jung[3], Taewook Park[3], Youngju Lee[3], Chanhyung Jeon[1,4], Seongbong Seo[5] and Doshik Hahm[1,4]*

frontiers | Frontiers in Marine Science
TYPE Original Research
PUBLISHED 24 May 2023
DOI 10.3389/fmars.2023.1137045

Distinct vertical behavior of key Arctic copepods following the midnight sun period in the East Siberian continental margin region, Arctic Ocean

Wuju Son[1,2], Jee-Hoon Kim[1], Eun Jin Yang[1,2] and Hyoung Sul La[1,2]*

Under review

Interannual variation in aragonite saturation state in surface waters of the western Arctic Ocean

Dongseon Kim[1*], Sosul Jo[2], Eun Jin Yang[3], Kyoung-Ho Cho[3], Jinyoung Jung[3]

In revision

Atlantic-origin water extension into the Pacific Arctic induced an anomalous biogeochemical event

Shigeto Nishino[1]*†, Jinyoung Jung[2]†, Kyoung-Ho Cho[2], William J. Williams[3], Amane Fujiwara[1], Akihiko Murata[4], Motoyo Itoh[1], Eiji Watanabe[1], Michio Aoyama[4,5], Michiyo Yamamoto-Kawai[6], Takashi Kikuchi[1], Eun Jin Yang[2] & Sung-Ho Kang[7]

In writing

Title

Multi-Year Variability of Summer Phytoplankton Biomass and Size Structure in the northern Chukchi and the East Siberian Seas, Arctic Ocean (2015-2020): Role of Light and Nutrient Availability

Authors

Youngju Lee*, Kyoung-Ho Cho, Jinyoung Jung, Jung Kuk Moon, Eun Jin Yang, Sung-Ho Kang

The actual seasonal cycles of Arctic phytoplankton including under-ice bloom detected by moored chlorophyll fluorometer

Eunho Ko[1], Jisoo Park[1*], Kyoung-Ho Cho[1*], Jae Il Yoo[1], Chorom Shim[1], and Eun Jin Yang[1]

Characteristics of the Pacific-derived Warm Water in the Arctic Chukchi Borderland during 2015—2020

Kyoung-Ho Cho [1,*], Taewook Park [1], Jaeill Yoo [1], Jinyoung Jung [1], Jihee Lee [1], and Eun Jin Yang [1]

Core Parameters + additional parameters

cruise matrix

Country:	Korea	Korea	Korea
Project:	SAS		Arctic warming?
Vessel:	R/V Araon	R/V Araon	R/V Araon
Region:	Bering Strait, Chukchi Sea,	Bering Strait, Chukchi Sea,	Bering Strait, Chukchi Sea,
Planned dates: (start - end)	Aug 8 - Sep 4, 2020	Jul 20 - Aug 18, 2021	Jul 22 - Aug 19, 2022
STATUS:	**Completed**	**Completed**	**Completed**
CONTACT PERSON:	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
e-mail:	kcho@kopri.re.kr	kcho@kopri.re.kr	kcho@kopri.re.kr
Name of data repository:	Korea Arctic Ocean-data Syste	Korea Arctic Ocean-data Syste	Korea Arctic Ocean-data Syste
Publically available (yes/no)	Available on request	Available on request	Available on request
Link to data location:	https://kaos.kopri.re.kr/	https://kaos.kopri.re.kr/	https://kaos.kopri.re.kr/
Link to cruise report:	Available soon	Available soon	Available soon
Link to blog post about cruise:			
Physical and chemical measurements:	Contact person responsible for each measurment:		
CTD	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
Dissolved Oxygen	Kyoung-Ho Cho	Kyoung-Ho Cho	Kyoung-Ho Cho
NO3/NO2	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
PO4	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
SiO3	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
CFCs and SF6	No	No	No
DIC	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Total Alkalinity	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
pH	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
18O of H2O	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
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Meso- and Macro- zooplankton	Eunjin Yang	Eunjin Yang	Eunjin Yang
Ichthyoplankton	Eunjin Yang	Eunjin Yang	Eunjin Yang
Fish	No	No	No
Marine mammals	No	No	No
Other carbon transformation rates	No	No	No
Benthic measurements:			
Meio- and Macro- fauna	No	No	No
Epifauna	No	No	No
Other carbon transformation rates	No	No	No
Other:			
Epontic Communities	No	No	No
Seabirds	No	No	No
Bioaerosol	No	No	No
Atmospheric measurements	Jinyoung Jung	Jinyoung Jung	Jinyoung Jung
Pollution			

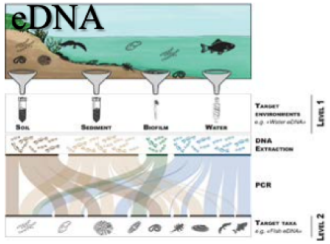
Additional Parameters

- eDNA
- CDOM-fDOM
- Trace metal

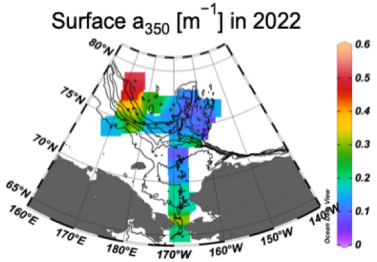
Sampling

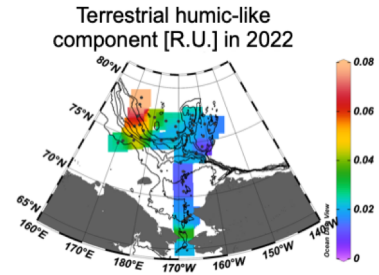
Metabarcoding

or

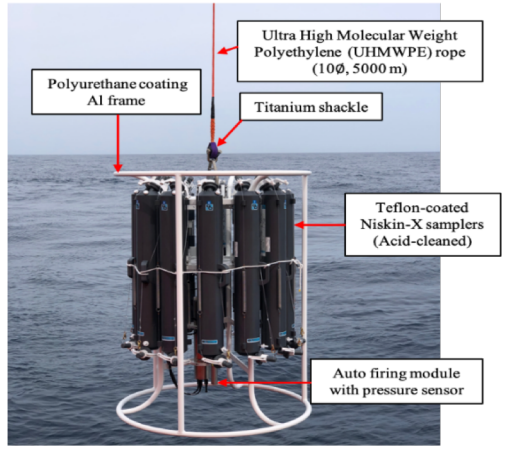


*Contact: Eun Jin Yang (ejyang@kopri.re.kr)





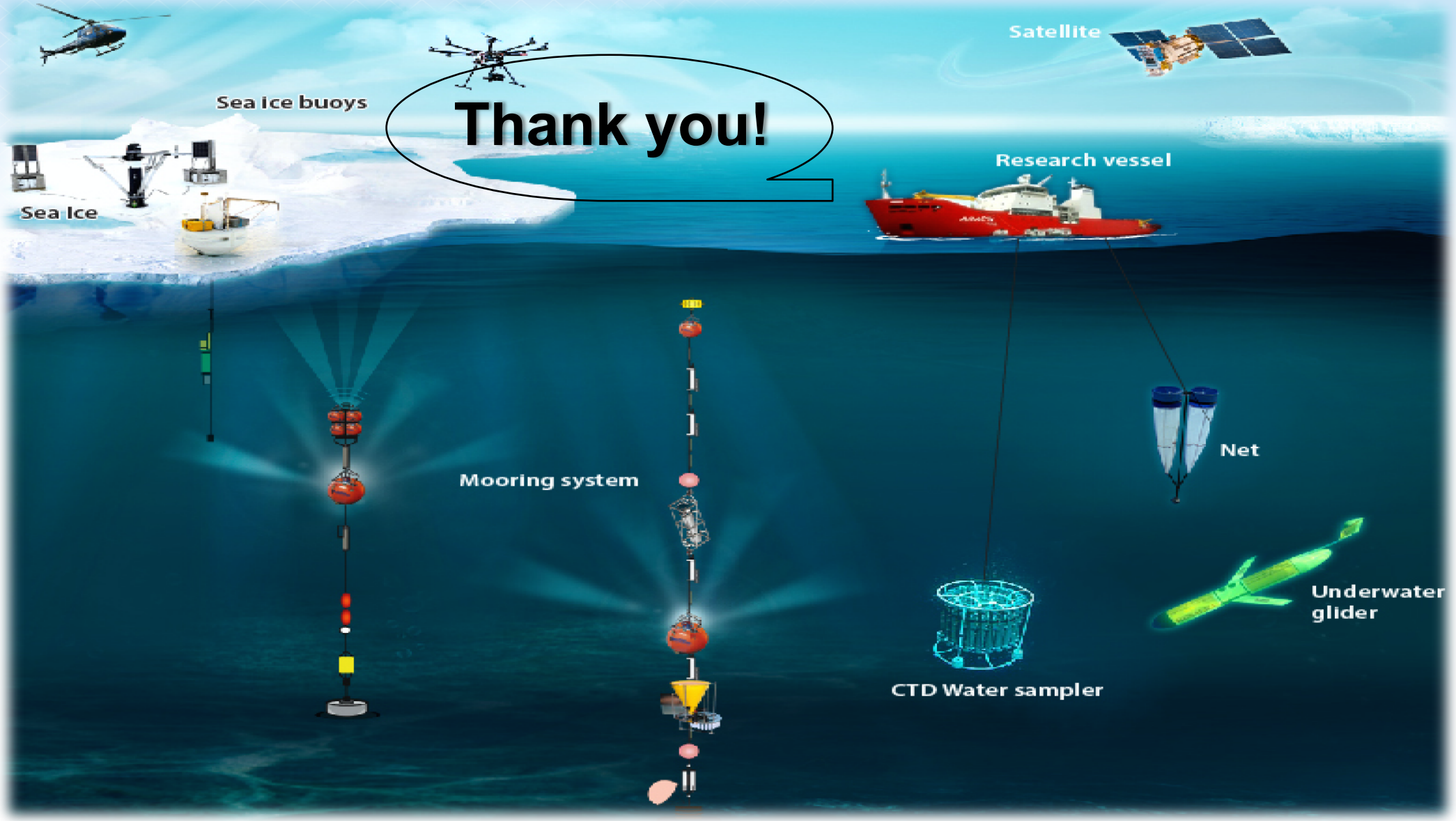
*Contact: Jinyoung Jung (jinyoungjung@kopri.re.kr)



Clean seawater sampling for Trace metal (Cu, Zn, Fe, Cd, Mn)

Data are available via the Korea Arctic Ocean-data System (KAOS)

KAOS [http://kaos.kopri.re.kr]


Satellite
Sea ice buoys
Thank you!
Sea Ice
Research vessel
Net
Mooring system
Underwater glider
CTD Water sampler