漁業者による自主的な海洋モニタリングとデータ取得プロジェクト
Voluntary observing and data acquisition project in fishery platform

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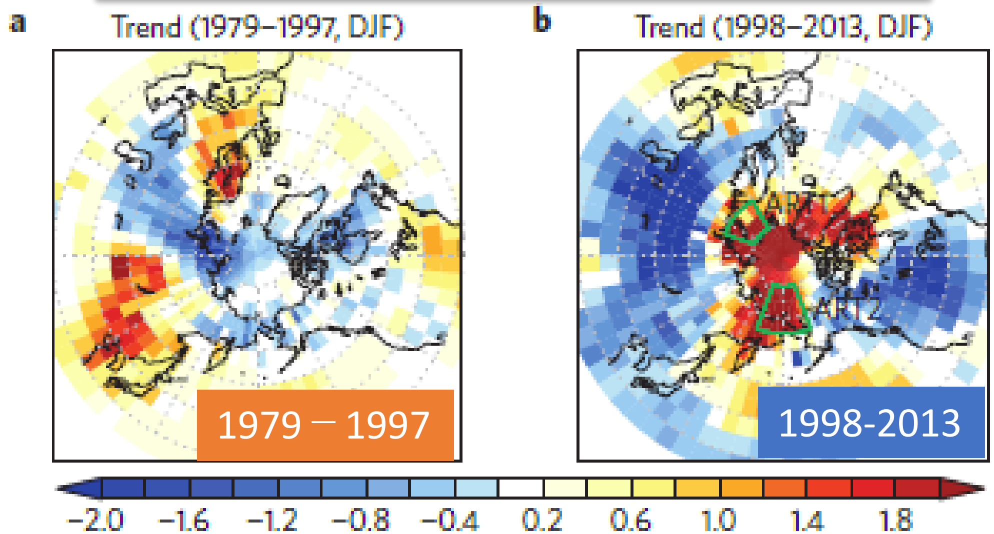
Connections between Arctic sea ice change and mid-latitude ocean environment and fishery resources

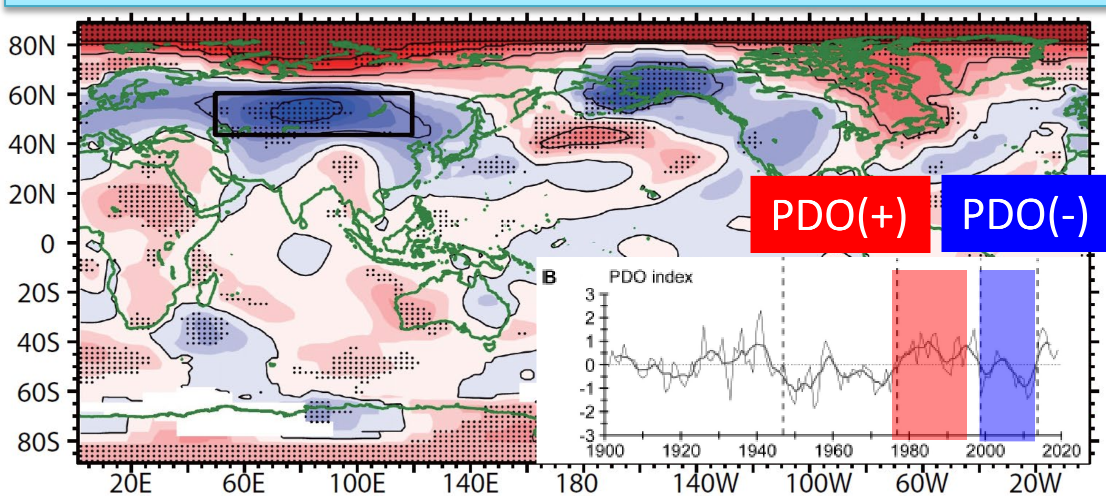
- **WACS (Warm Arctic Cold Siberia)**
  - **Warming signal has amplified in high latitudes** since the late 1990s, **but severe winter has frequently occurred in the mid-latitudes** in particular Eurasia continent and North America
  - One of the possible causes of WACS is the atmospheric response to **the sea-ice decreasing marginal seas such as Barents Sea and Chukchi Sea** (Honda et al. 2009; Mori et al. 2014, 2019; Tachibana et al. 2019)
- **Decadal-scale change in ocean environment and the influence on fishery resources**
  - In the late 1990s, Pacific Decadal Oscillation shows negative phase, but surface air temperature shows cold anomaly in the western subtropical North Pacific (Unconventional regime, Kuroda et al. 2020)
  - Accompanied with cold regime, the **biomass of sardine has gradually increased in late 2000s**, suggesting that the climate change in polar region is linked to the fishery resources in the mid-latitudes
- **It is needed to consider the influence of polar region climate change on mid-latitudes fishery resources**
  - **In recent years, it is difficult to empirically predict ocean environment based on climate index**

Linear trend in surface air temperature in DJF

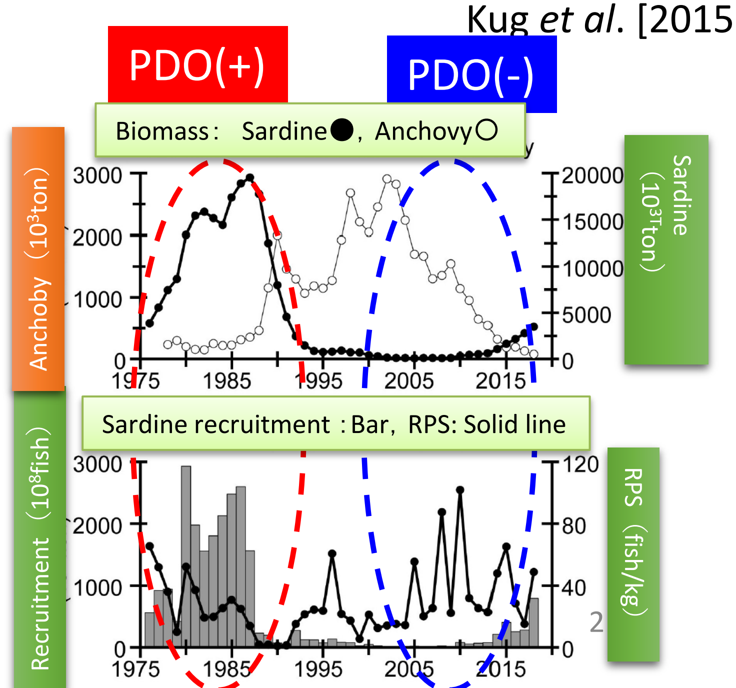


Kug *et al*. [2015]

Linear trends in SAT from winter to spring (2000–2013)

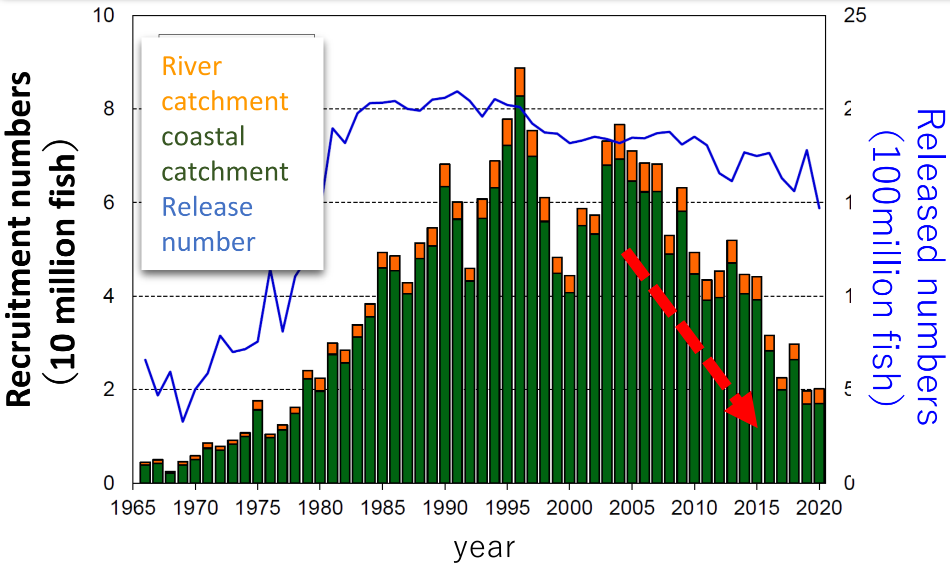


Kuroda *et al*. [2020]

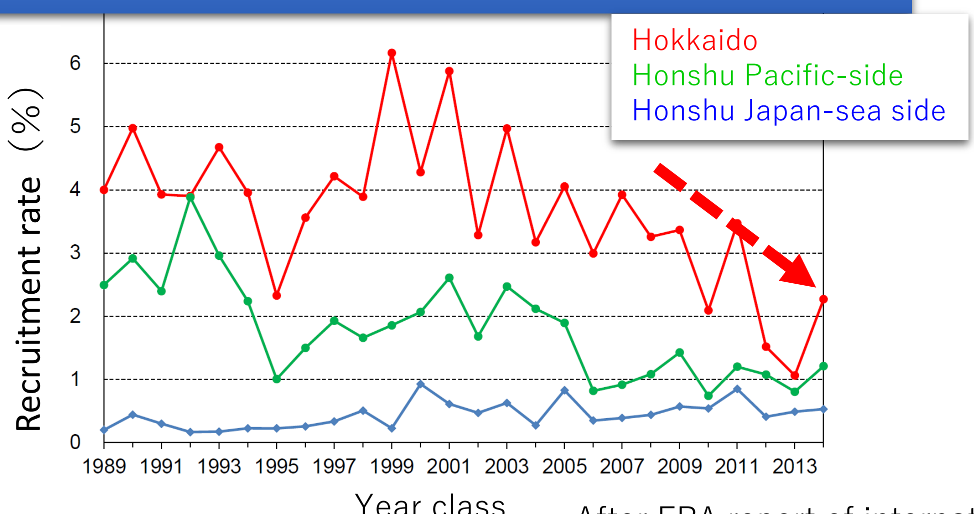


Recent decrease of fishery resources in Japan: Salmon trout

Chum salmon migration and released numbers（1966-2020）



Regional difference in the recruitment rate for Chum salmon in Japan (1989－2014 year class)



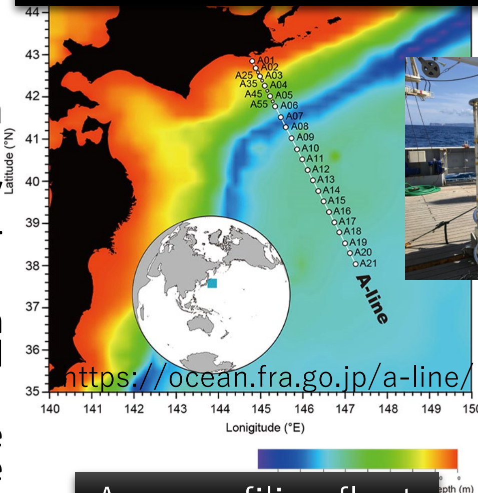
- Recently, cold species of fishery resources has decreased in and around Japan
  - **Catchment and recruitment of chum salmon has decrease since 2010**
  - The decrease trend is also found in the southern boundary of the habitat area such as North America and Canada
  - The decreasing trend of the recruitment is evident in Hokkaido area
- The possible cause of change in the recruitment rate
  - It is said that **there is a positive correlation between the sea surface temperature at the time of salmon fry arrival and the annual group abundance of salmon four years later**
  - There is possibility that the ocean environment change in the coastal area in and around the Sea of Okhotsk is related to the recent decrease in the recruitment rate
- To evaluate the influence of ocean environment change on the decrease in the fishery catchment, **it is necessary to obtain and restore the reliable information of the change in ocean environment from the past to present**

After FRA report of international fishery resources in 2021

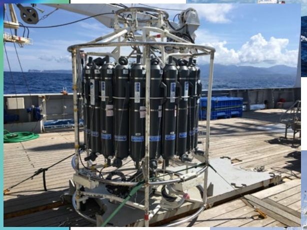
Recent development of oceanographic observations

- Oceanographic observations have an important role on the monitoring the ocean environment and have been conducted by many platform with different spatial-temporal coverages
  - **Repeated hydrographic observations based on research vessel and mooring buoy (Vertical profiles of Temperature and salinity)**
  - Remote sensing observations based on satellite orbital system (Spatial distribution of surface variables such as sea surface height)
  - Automatic observing system based on profiling floats and biologging system
- However, fishery ground observations near the coastal region are not done so much
  - It is usually difficult to access the fishery ground in the shallow coastal area by vessel observations
  - Insufficient oceanographic information from field observations
  - Satellite sensor image is highly influenced by cloud coverage and sea ice in polar regions
- Toward filling the data gap between coastal and open ocean, **the data assimilation technique with ocean model** is very effective!

Repeated hydrographic observation (A-line)

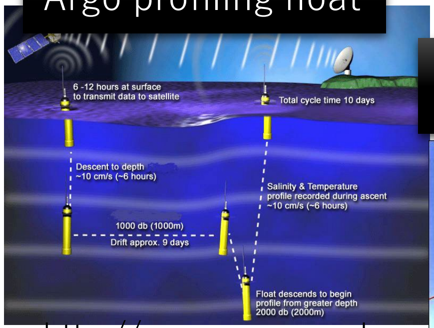


https://ocean.fra.go.jp/a-line/



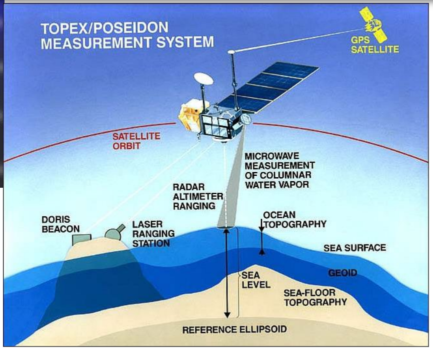
Mooring buoy (TRITON buoy)

Argo profiling float



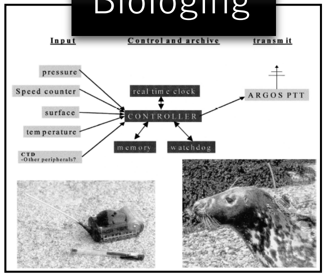
http://www.argo.ucsd.edu/How_Argo_floats.html

Satellite-based altimeter



Sharing Earth Observation Resources(https://directory.eoportal.org/web/eoportal/satellite-missions/t/topex-poseidon)

Biologing



Fedak et al. (2002)

Ocean environment forecast system: FRA-ROMS series

April 2008～Development starts

May 2012～Operation and service starts

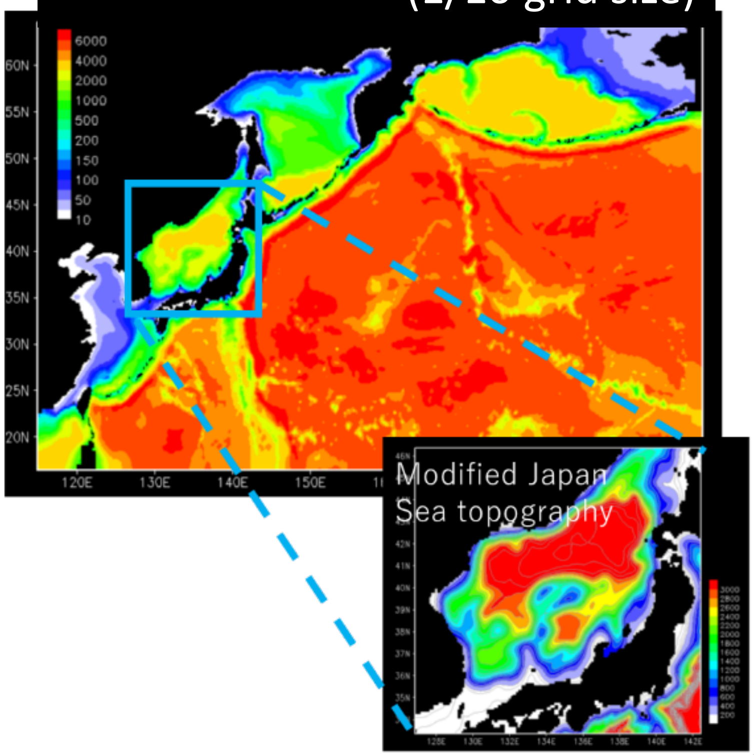
Mar 2022～Operation of updated version starts

FRA-ROMS

FRA-ROMS Ⅱ

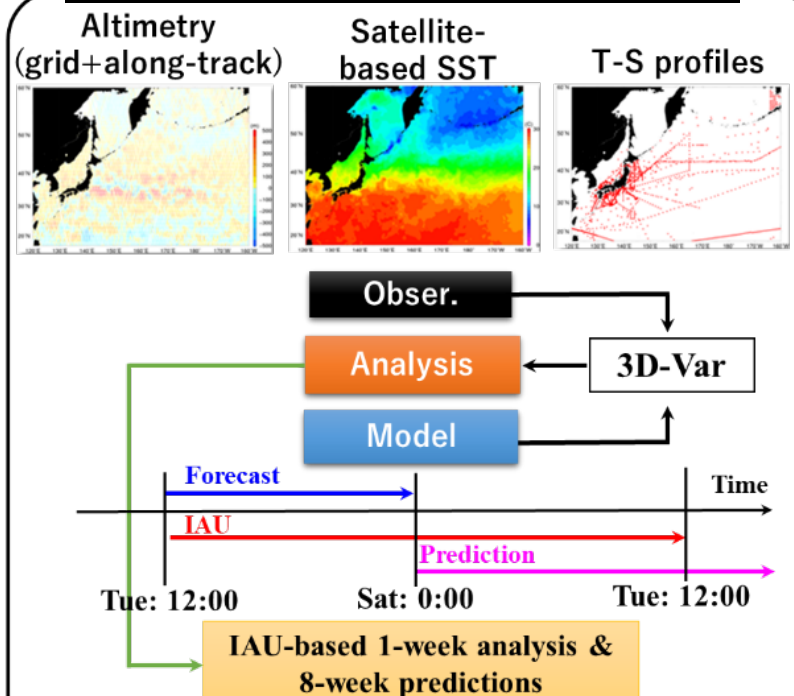
ROMS ocean model

(1/10 grid size)



+

3D-Var data assimilation



Assimilate observation data every week & forecast up to 8 weeks ahead

Data assimilation system enable us to obtain homogeneous ocean environment data!

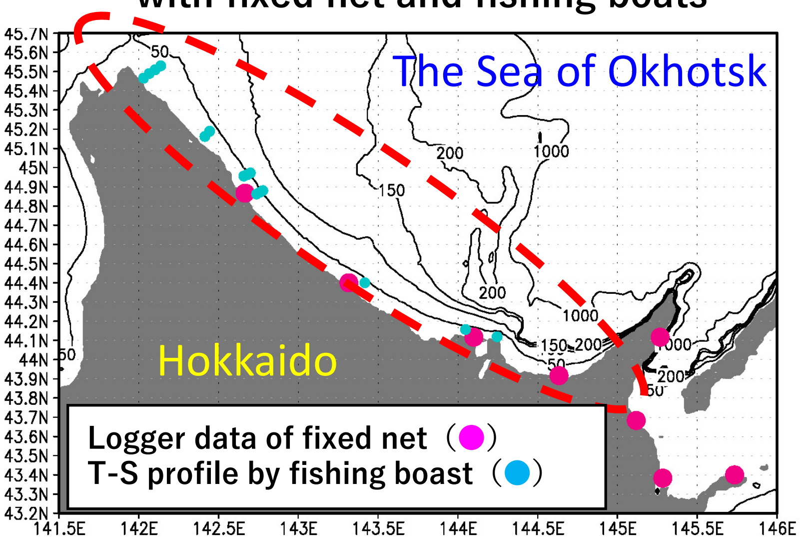
https://fra-roms.fra.go.jp/fra-roms/

Voluntary observing and data acquisition project in fishery platform

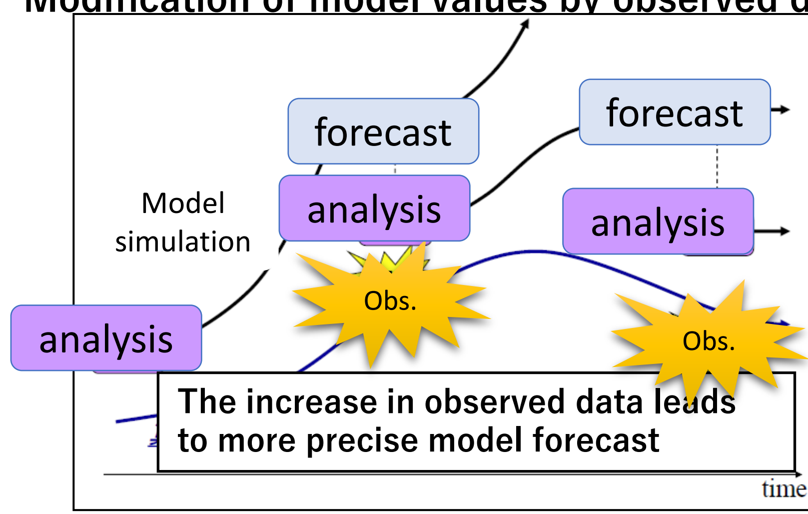
-Development of data assimilation system based on fishery industry data in the Sea of Okhotsk-

- The catchment and recruitment of chum salmon in the Pacific side has significantly decreased since 2010
  - The similar situation has occurred in the Okhotsk Sea side in recent years
- It was reported that there has been a significant correlation relationship between the SST in the coastal area in Spring in which Juvenile fish reaches to ocean and the recruitment rate after 4 years (The warm water temperature tends to lead to the high survival rate)
- The utilization of hydrographic data along the Hokkaido coastal area + FRA-ROMS data assimilation system ⇒ more reliable ocean data for the targeted area can be obtained and provided

Locations for hydrographic observations with fixed net and fishing boats



Conceptual diagram of forecasting using data assimilation system. Modification of model values by observed data



- Additional coastal oceanographic observational data + data assimilation system⇒more reliable ocean data in both current and future states are provided

Fishery ground observational data obtained in the Okhotsk coastal area

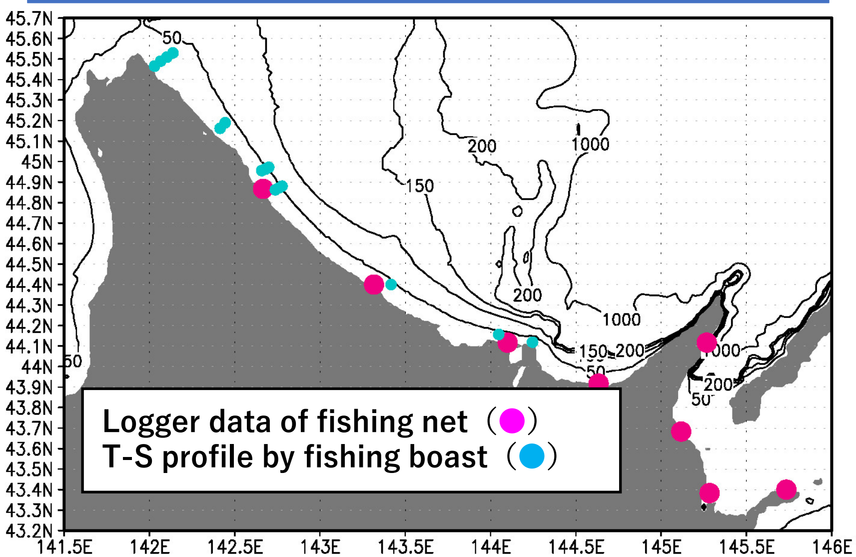
- Hydrographic data in fishing grounds
  - recorded by local fishery cooperatives in each fishing area and archived by Hokkaido government
- **Surface temperature logger data attached with fixed net office**
  - Memory type water temperature sensor
  - 3 m depth, 18 stations (8 sites on the Okhotsk side)
  - March to July (juvenile salmon reaches to ocean)
- **Hydrographic observation with fishing boat**
  - STD and CTD observations
  - Observation item: Water temperature and salinity
  - Surface to max 50m depth, 17 stations (Okhotsk side)
  - Whole year except for winter season

Surface temperature logger

Stations	Period
Esashi	1996－present
Monbetsu	1994－2005
Tokoro	2006－present
Shari	1997－present
Rausu	1994－present
Shibetsu	1997－present
Bekkai	2001－present
Nemuro	1998－2013

Provided by FRA salmon research department

Locations for hydrographic observations with fishing net and fishing boats



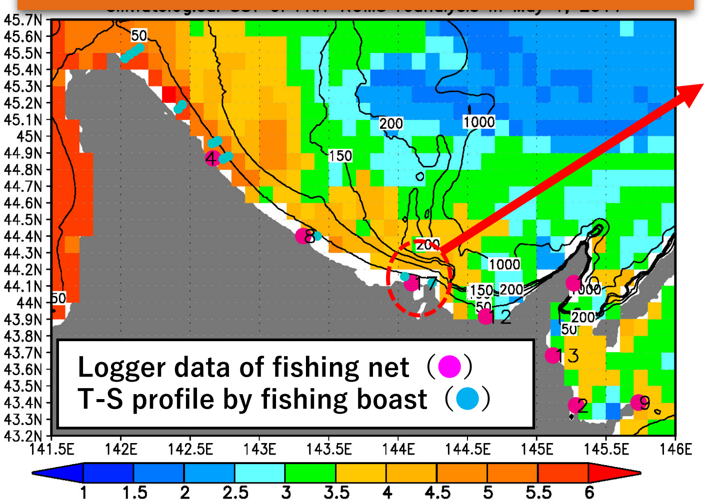
Repeated hydrographic observations in coastal area

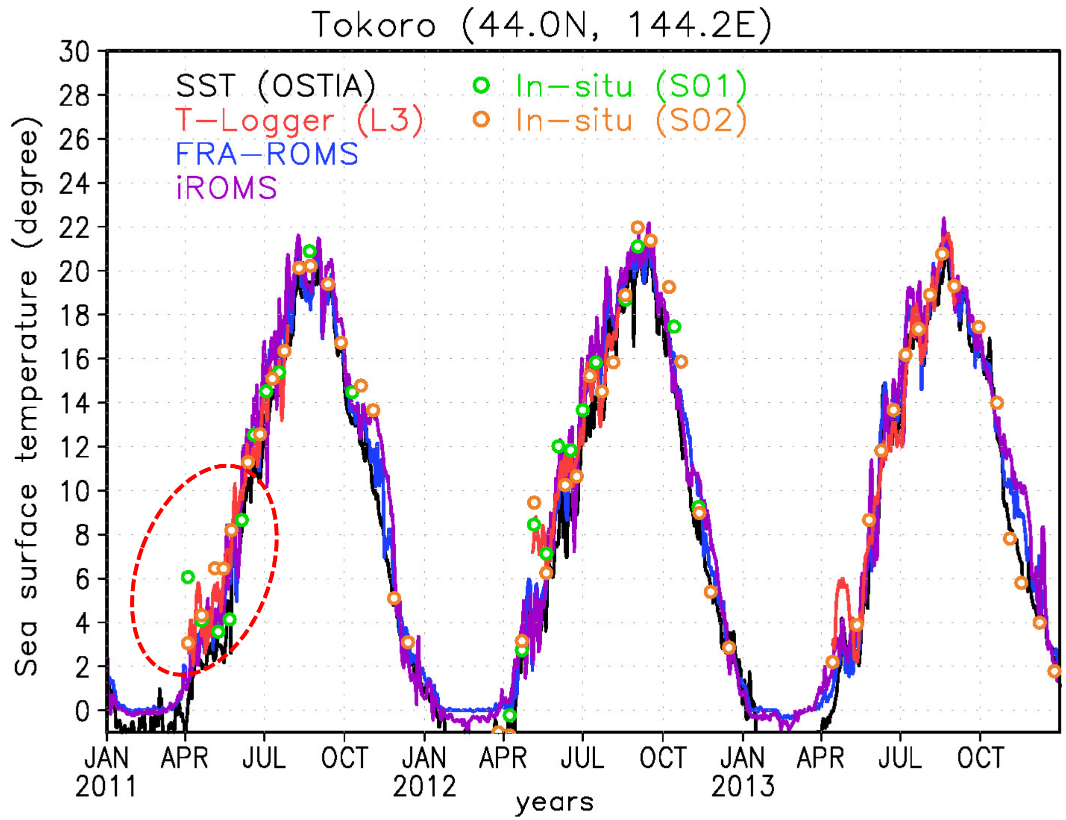
Stations	Period	Depth（Max）
Tokoro	2009－present	～40m
Abashiri	2004－present	～60m
Monbetsu	2014－present	～40m
Oumu	2016－present	～20m
Esashi（3点）	2013－present	～50m
Yamausu（3点）	2013－present	～50m
Tonbetsu（2点）	2004－present	～40m
Soya（4点）	1999－present	～40m

Provided by Hokkaido government and fisheries cooperatives

Comparisons between observed and simulated temperature along the coastal area of the Okhotsk Sea

Simulated surface temperature in the coastal area of the Okhotsk Sea in May 1, 2011 (development version; ice-ocean coupled model) and the locations of fishery ground data by fishers

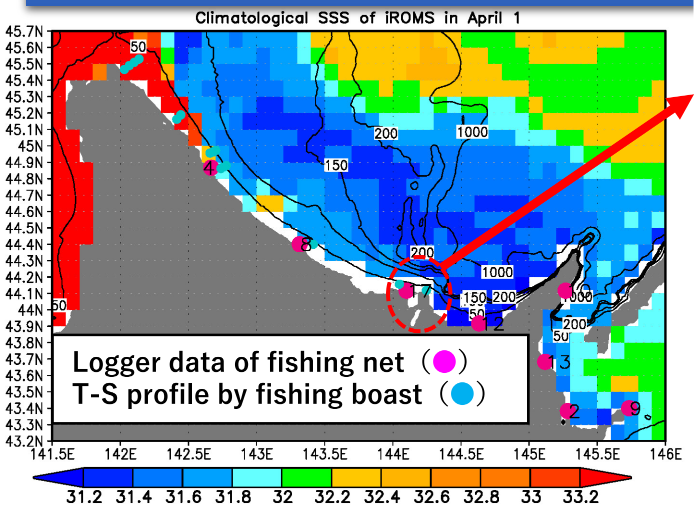


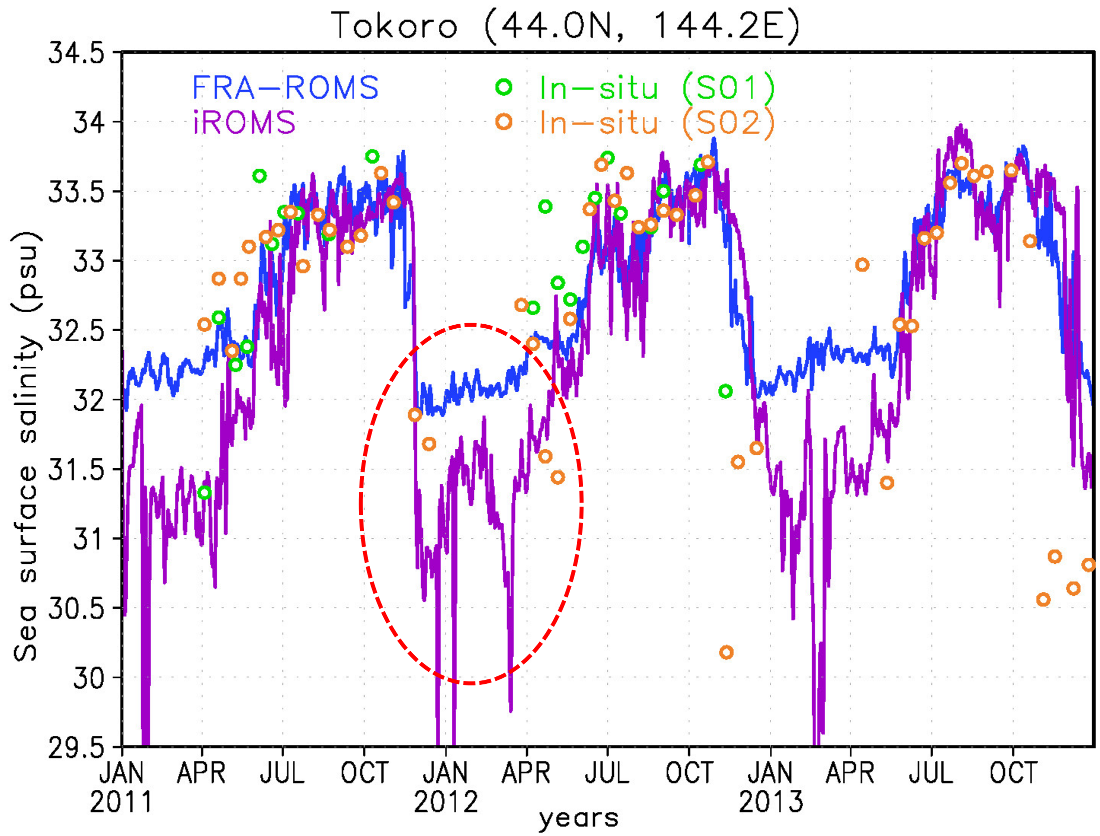


- Seasonal cycle
  - Observed surface temperature shows good correspondence with the simulated values
  - Hydrographic observations by fishery industry are quite useful for the data assimilation
- Spring season (April – June)
  - Coastal ocean temperature starts to be influenced by Soya warm current
  - Simulated and satellite-based temperature is somewhat underestimated
- Additional fishery ground data and its application to data assimilation system would lead to the improvement of the spring model simulation and also its forecast

Comparisons between observed and simulated salinity along the coastal area of the Okhotsk Sea

Simulated surface salinity in the coastal area of the Okhotsk Sea in April 1, 2012 (development version; an ice-ocean coupled model) and the locations of fishery ground data

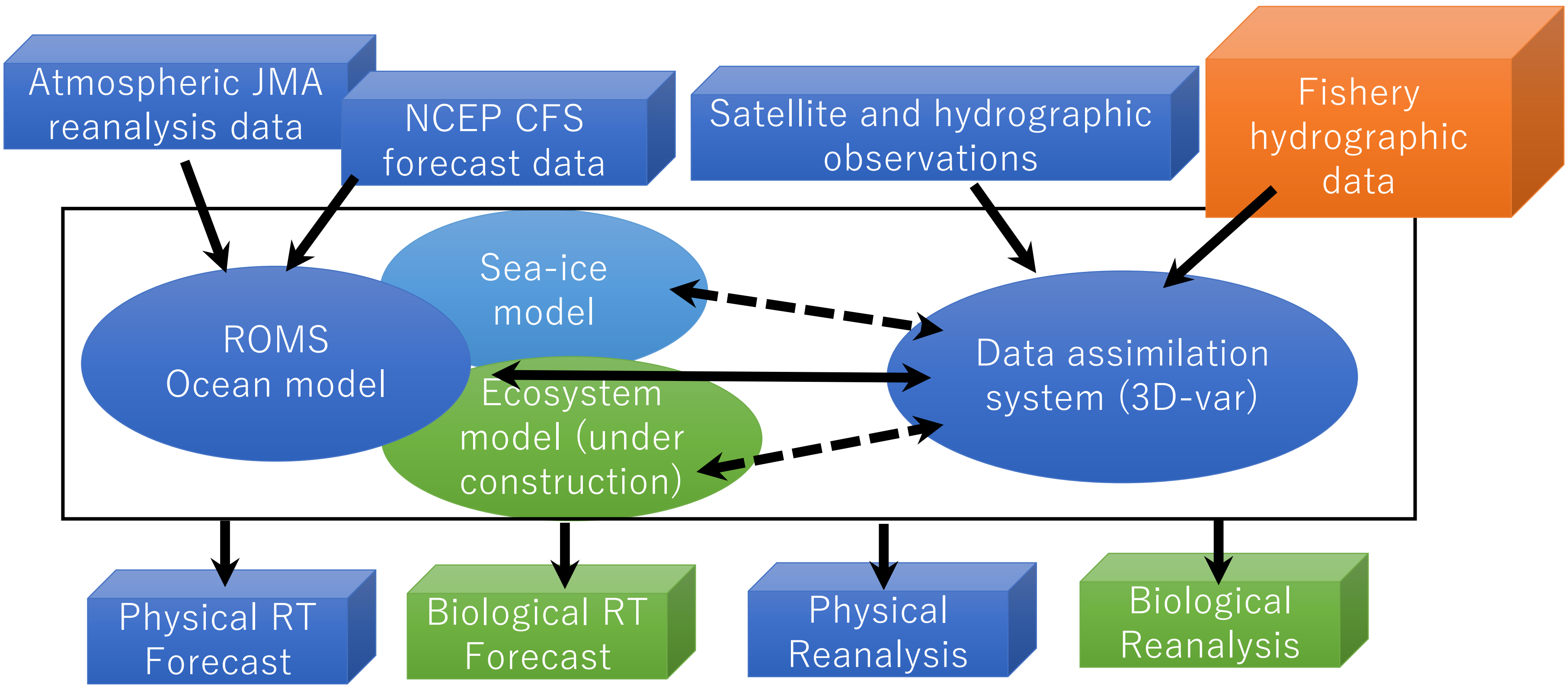




- Sea surface salinity in the coastal area (fishery ground)
  - Observed surface temperature shows large seasonal cycle with minimum in early winter
  - The simulated sea surface salinity (development version) follows the decrease in winter season
  - The wintertime sea surface salinity is found to be influenced by the southward intrusion of coastal blanch of East Sakhalin current
  - It is expected that the inclusion of fishery ground salinity data would lead to the improvement of recreating the density field of ocean model and the resultant current pattern

Application of fishery ground data to ocean data assimilation system

- Development of data assimilation system with fishery ground data
  - The past to present fishery ground data are assimilated
  - The ocean model is updated with near-realtime data assimilation (more reliable data are obtained)
- FRA-iROMS
  - An ice-ocean coupled model (development version) is used for data assimilation system
  - Sea ice formation and melting process and tidal mixing process are implemented
- Products
  - Reanalysis data：The actual ocean environment data in the fishery ground from the past to the present ⇒capturing the ocean environment change and its possible cause
  - Forecast data　：2 months ahead forecast data⇒fishery ground forecast and optimum fishing design



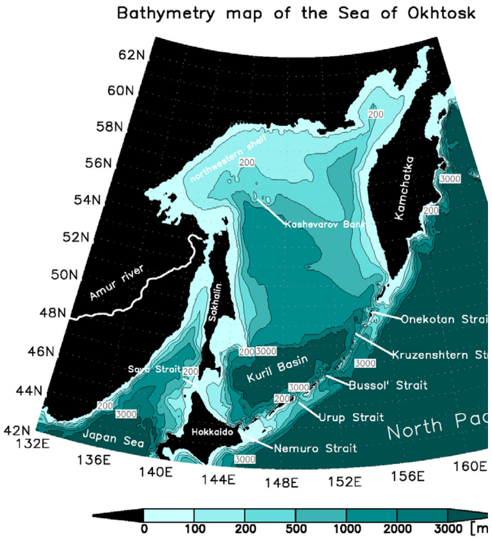
Summary and future plan

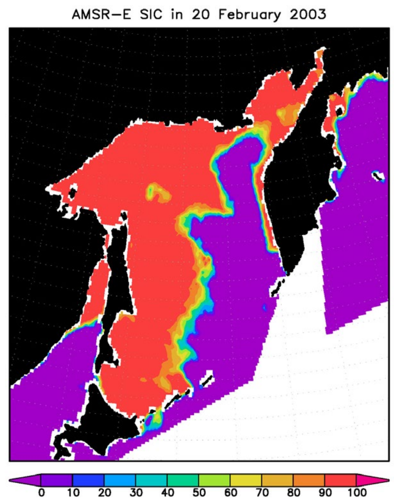
- Fishery ground hydrographic data
  - High potential as a **new platform of oceanographic observations**
  - The data assimilation technique enable us to obtain and monitor the ocean environment in the fishery ground without spatial-temporal gaps
- The benefit of assimilating the large number of hydrographic observation
  - Initial condition of ocean model is improved
  - Feedbacks to fishery industry by providing more realistic information of the targeted area
  - Enhancement of the cooperative voluntary observation is expected
- Future plan
  - Development of near-real time data assimilation system with fishery ground data
- Expected outcomes
  - Marine weather forecast along the coastal area or specific locations
  - Basis knowledge of smart fishing industry
  - New fishery industry adopted to climate change

Schematics of feedback cycle for the voluntary hydrographic observation and forecast system based on an ocean data assimilation system

Appendix

オホーツク海の海洋環境モニタリング

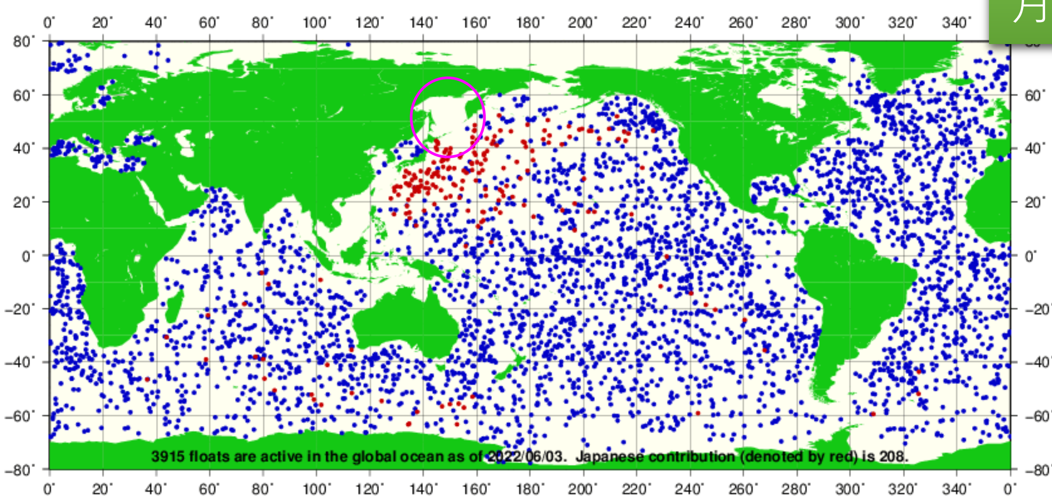




Nakanowatari and Mitsudera (2020)

- オホーツク海
  - 季節海氷域の南限（44°N）
  - 半閉鎖的な縁辺海（クリル海峡の水深は一部を除いて浅い⇒アルゴフロートが侵入できない）
- 冬季は海氷、夏季は霧に覆われる為、現場観測や人工衛星による観測が困難な海域
  - 外洋に比べてオホーツク海の観測データは1オーダー程度少ない
  - 道水産試験場や水研機構の調査船データに限られる
- 沿岸海洋環境だけでなく、オホーツク海内部の海洋環境変動の把握
  - サケ稚魚の生残過程の把握において重要

Argoフロートの分布（2022年6月）



JMA アルゴ計画HPより

海洋観測データの測点（2016年4－8月）