

Report of Working Group 38 on Mesoscale and Submesoscale Processes

The second meeting of the Working Group on *Mesoscale and Submesoscale Processes* (WG 38) was held in Yokohama, Japan, from 9:00 to 18:00 on October 27, 2018 during the PICES Annual Meeting. Twelve WG members participated in this 1-day meeting, and five observers participated for part of the day (**WG 38 Endnote 1**). The meeting was co-chaired by Dr. Annalisa Bracco (USA) and Dr. Hiromichi Ueno (Japan). This report summarizes discussions at the meeting over some of the Agenda Items (**WG 38 Endnote 2**).

AGENDA ITEM 2

Recent studies/activities on mesoscale eddies

Shelf eddies in the Bering Sea: Oculus Coastal Glider 2017 mission

Dr. Carol Ladd discussed shelf eddies in the Bering Sea. Autonomous gliders can economically sample at ecologically relevant spatial and temporal scales. The new Oculus Coastal Glider is designed for use in shallow (< 200 m), high stratification environments. The glider was deployed in August/September 2017 along the 70 m isobath of the eastern Bering Sea, a region with a long history of shipboard observations. Multiple eddies with spatial scales not resolvable with typical shipboard sampling were observed with the glider. These features influence water properties, nutrient, oxygen, and chlorophyll distributions, and possibly distributions of higher trophic levels and may have important effects on the ecosystem.

Mesoscale and large-scale dynamic features and the spatial distribution of sardine and mackerels east of the Kuril Islands in early and late summer

Dr. Elena Ustinova talked about mesoscale and large-scale dynamic features and the spatial distribution of sardine and mackerels based on the data sets from the CTDs and acoustic-trawl TINRO-Center R/V surveys in the Northwest Pacific. The sardine and mackerel spatial distributions during their feeding migration are substantially affected by mesoscale fronts and topography of the seasonal thermocline upper boundary. In June, mackerel and sardine high concentrations were confined to the high-gradient zone of the Northern Subarctic Front, mostly from the warmer water side. In July, the large majority of both species migrated to the subarctic area. Isothermal surface of 8°C is their northern and deep habitat limit.

Dynamic structures in the northwestern Japan Sea from satellite imagery and subsurface thermohaline anomalies from the Aqualog moored profiler: the case of the Primorye Current intrusion.

Dr. Olga Trusenкова gave a presentation on the Primorye Current. Infrared/visible imagery from the NOAA and Suomi/NPP satellites and data from the moored Aqualog profiler deployed off the Primorye (Russian) coast in the northwestern Japan Sea from mid-April through mid-October 2015 were analyzed. The nature of thermohaline anomalies in the subsurface waters (64–70 m) was revealed using the satellite data. In particular, in late April 21–24 an offshore excursion of the Primorye (Liman) Current was detected on the satellite images and the thermohaline characteristics of the cold and fresh Primorye Current water were measured by the Aqualog.

Information about the International Symposium on “Understanding Changes in Transitional Areas of the Pacific”

Dr. Sachihiko Itoh reported the summary of the International Symposium on “*Understanding changes in transitional areas of the Pacific*” held at La Paz, Mexico, in April 2018. This symposium focused on

various transitional areas in the Pacific, and gathered 140 scientists from 12 countries to have 6 topic sessions. In the report, Dr. Itoh especially emphasized the contributions by WG 38 members/participants, including himself as a symposium co-convenor and Dr. Daisuke Hasegawa as an invited speaker. He also briefly introduced one of invited talks, by Dr. Masao Kurogi, that developed a high-resolution coastal ocean model, which could inspire WG 38 to conduct analyses on submesoscale-resolving model outputs.

AGENDA ITEM 3

Proposal to review mesoscale eddies in the North Pacific

Dr. Hiromichi Ueno briefly introduced a series of comprehensive papers focused on physical properties of mesoscale eddies and their impact on chlorophyll distribution. He indicated that in the PICES region, eddies had been studied from the view point of their formation area, *e.g.*, Sitka eddies formed off Sitka. He proposed a plan for the WG to write a review paper evaluating the properties of mesoscale eddies in the North Pacific based on their formation area, to achieve [Terms of Reference 1–4](#).

AGENDA ITEM 4

Review paper on mesoscale eddies in the North Pacific

After the presentations on mesoscale eddies, the WG discussed and agreed on the outline of the review paper on mesoscale eddies (*WG 38 Endnote 3*). Dr. Ueno will lead the review paper. The timeline and the authors in charge of each section/subsection was partially determined at the Annual Meeting, and will be finalized via email soon after it.

AGENDA ITEM 5

Recent studies/activities on submesoscale processes

Numerically simulated regional mesoscale and submesoscale processes around Korea

Dr. Sung Yong Kim presented the preliminary results to analyze the submesoscale numerical model outputs (MITgcm llc4320) around the Korean Peninsula and the turbulent characteristics of the observed coastal surface currents and chlorophyll concentrations at submesoscale scales off the east coast of Korea. The O(10)-km baroclinic instability is a primary source of the regional submesoscale processes instead of the mesoscale-driven frontogenesis based on the modification of the spectral decay slopes in both observations and the zero crossing wavenumbers in the energy flux estimates of the coastal surface current maps.

Results from 1/30° North Pacific OFES (OGCM for the Earth Simulator) simulation

Dr. Yoshikazu Sasai reviewed the comparison of two numerical simulations, which are 1/10° horizontal grid with 54 vertical levels and 1/30° horizontal grid with 100 vertical levels to investigate the seasonal variations of submesoscale dynamics in several regions of the whole North Pacific. Comparison clearly emphasizes in the whole North Pacific, not only a significant kinetic energy (KE) increase by a factor up to 3, but also the emergence of seasonal variability when the scale range 16–50 km (submesoscales) is taken into account. However, the mechanisms explaining these KE changes display strong regional contrasts. In high KE regions, such the Kuroshio Extension and the western and eastern subtropics, frontal mixed-layer instabilities appear to be the main mechanism for the emergence of submesoscales in winter.

AGENDA ITEM 6

Synthesis paper on submesoscale processes, Session proposal for PICES-2019, future activities

The WG discussed the possibility to also work on synthesis paper on submesoscale processes. It was decided soon after the PICES-2017 meeting that such a paper should include a regional characterization of submesoscale processes and their impact on the marine ecosystem in the North Pacific, focusing on seasonal variations, through the analysis of high-resolution model output. However, the analysis was delayed due to problems independent of the WG. During this meeting, the analysis of OFES data with a horizontal resolution of $1/30^\circ$ was proposed as an alternative for this regional characterization by Dr. Sasai. WG members supported the proposal. Based on the discussion, the WG requested a 1-year extension to complete the analysis and the manuscript.

The WG submitted a 1-day Topic Session proposal for PICES-2019 entitled “*Impacts of meso-/submesoscale processes on heat/material transport and on marine ecosystems*” (**WG 38 Endnote 4**).



Participants of the second meeting of WG 38 at PICES-2018, Yokohama. Left to right: Sachihiko Itoh, Tetjana Ross, Yoshikazu Sasai, Carol Ladd, Young-Gyu Park, Yisen Zhong, Annalisa Bracco, Hiromichi Ueno, Olga O. Trusenkova, Daisuke Hasegawa, Elena I. Ustinova, Sung Yong Kim.

WG 38 Endnote 1

WG 38 participation list

Members

Annalisa Bracco (USA, Co-Chair)
Daisuke Hasegawa (Japan)
Sachihiko Itoh (Japan)
Sung Yong Kim (Korea)
Carol Ladd (USA)
Young-Gyu Park (Korea)
Tetjana Ross (Canada)
Yoshikazu Sasai (Japan)
Olga O. Trusenкова (Russia)
Hiromichi Ueno (Japan, Co-Chair)
Elena I. Ustinova (Russia)
Yisen Zhong (China)

Members unable to attend

Maxim V. Budyansky (Russia)
Xiaopei Lin (China)
Sergey Prants (Russia)
Irina Rypina (USA)
Bin Xiao (China)
Dongfeng Xu (China)

Observers

Song Feng (China)
Daiki Ito (Japan)
Zhencheng Tao (China)
Nan Wang (China)
Yantao Wang (China)

WG 38 Endnote 2

WG 38 Meeting Agenda

1. Welcome and Introduction. Goals of the day (Annalisa Bracco & Hiromichi Ueno)
2. Recent studies/activities on mesoscale eddies
 - 2.1 Shelf eddies in the Bering Sea: Oculus Coastal Glider 2017 mission (Carol Ladd)
 - 2.2 Mesoscale and large-scale dynamic features and the spatial distribution of sardine and mackerels east of the Kuril Islands in early and late summer (Elena Ustinova)
 - 2.3 Dynamic structures in the northwestern Japan Sea from satellite imagery and subsurface thermohaline anomalies from the Aqualog moored profiler: the case of the Primorye Current intrusion (Olga Trusenкова)
 - 2.4 Information about the International Symposium on “*Understanding Changes in Transitional Areas of the Pacific*” (Sachihiko Itoh)
3. A proposal to review mesoscale eddies in the North Pacific (Hiromichi Ueno)
4. Discussion: Review paper on mesoscale eddies in the North Pacific
5. Recent studies/activities on submesoscale processes
 - 5.1 Numerically simulated regional mesoscale and submesoscale processes around Korea (Sung Yong Kim)
 - 5.2 Results from 1/30° North Pacific OFES simulation (Yoshikazu Sasai)
6. Discussion: Synthesis paper on submesoscale processes, Session proposal for PICES-2019, future activities

WG 38 Endnote 3**Outline of review paper on mesoscale eddies in the North Pacific**

1. Introduction
2. Mean state/trend analysis
 - New analysis of satellite data over PICES region to motivate regional summaries
3. Regional summaries

literature review (Area division: Figure 1)

 - 3.1 Region 1
 - 3.2 Region 2
 - 3.3 Region 3
 - 3.4 Region 4
 - 3.5 Region 5
 - 3.6 Region 6
 - a. Timescales
 - Mean state
 - Trends
 - Interannual
 - Seasonal
 - b. Physical Metrics
 - Temperature/salinity profiles – stratification
 - Eddy kinetic energy/SSH
 - Eddy lifetime
 - Formation regions vs transit regions
 - c. Ecosystem metrics
 - Nutrient
 - Chlorophyll
 - Higher trophic levels: Zooplankton/fish/marine mammals/seabirds
4. Synthesis section
 - Similarities and differences across regions (highlighting where observations/studies are absent in some regions)
 - Highlighting what is important – goal is an executive summary that can be understood/used by fisheries colleagues within PICES
 - Connecting coast to offshore
5. Concluding remarks

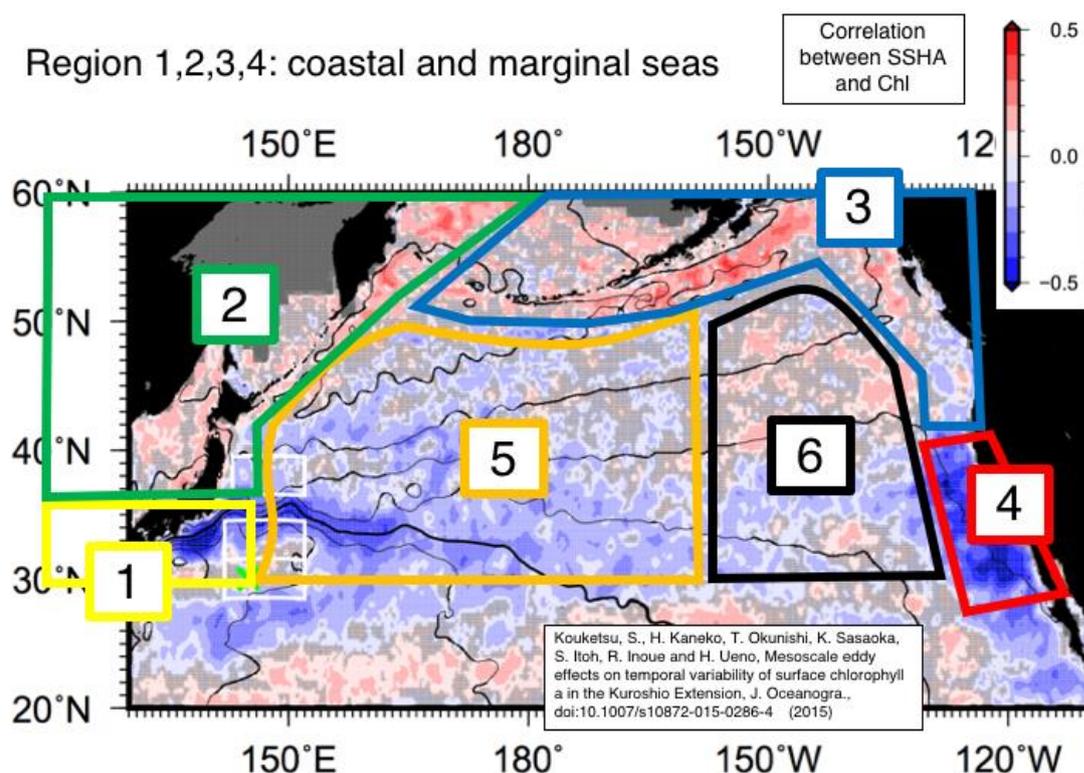


Figure 1 Area division of review paper on mesoscale eddies in the North Pacific

WG 38 Endnote 4

**Proposal for 1-day Topic Session on
“Impacts of meso-/submeso- scale processes on heat/material transport and on marine ecosystems”
at PICES-2019**

Mesoscale and submesoscale processes (with scales of 0.1 – 100 km) are widely distributed in the world’s oceans; from coastal regions to the open ocean. These phenomena can be examined using in-situ and satellite observations as well as high-resolution numerical models. However, there is still a lot to be learned about the detailed structure and dynamics of these fine-scale features. Studies indicate that mesoscale and submesoscale processes have a significant impact on horizontal heat and material transport, *e.g.*, from coastal regions to the open ocean, as well as vertical transport, *e.g.*, from subsurface to surface layers. The heat and material transport by mesoscale and submesoscale processes are important not only in the context of physics and chemistry, but also to marine ecosystems including plankton, nekton, birds and mammal. This topic session aims to discuss how the physics, chemistry, biology and fisheries of mesoscale and submesoscale processes interact and also how these processes mediate interaction between regions (lateral) and layers (vertical). We invite presentations based on both observations and modeling.

Co-Convenors: Hiromichi Ueno (Japan), Tetjana Ross (Canada), Olga O. Trusenkova (Russia)

Invited Speakers: TBD