Project Endorsement Form

1. PROJECT TITLE

Full title	Quantifying vertical and lateral ocean transport due to submesoscale fronts and eddies
Acronym	
Website	NA
Keywords (up to 10, describing the project research)	Physical oceanography, SWOT, submesoscale eddies, ocean transport
New initiative or continuing programme?	New

2. APPLICANTS

Lead applicant / Project Leader / key research contact person:

First name	Nicole
Last name	Jones
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Other key participants / research team leaders: *(repeat as needed)*

First name	Matthew
Last name	Rayson
Role in the project	Lead of numerical modelling and algorithm development
Affiliation	University of Western Australia
Country	Australia
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Other key participants / research team leaders: *(repeat as needed)*

First name	Greg
Last name	Ivey
Role in the project	
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Other key participants / research team leaders: *(repeat as needed)*

First name	Shane
Last name	Keating
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Other key participants / research team leaders: *(repeat as needed)*

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Last name	Ponte
Role in the project	
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Other key participants / research team leaders: *(repeat as needed)*

First name	Jessica
Last name	Benthuysen
Role in the project	
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Other key participants / research team leaders: *(repeat as needed)*

First name	Madi
Last name	Rosevear
Role in the project	
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Country	Australia
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Institutional or personal website	https://research-repository.uwa.edu.au/en/persons/madi-rosevear

Other key participants / research team leaders: *(repeat as needed)*

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Last name	Rosevear
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Institutional or personal website	io-warnemuende.de

N.B.: Please note that all these names and contact details will be added to the IIOE-2 membership database.

3. ABSTRACT– Brief description of the project: *(1/4 page maximum)*
This will be placed on the IIOE-2 Website after endorsement.

This project aims to quantify the intensity and location of submesoscale ocean currents (<50 km) with unprecedented spatial and temporal resolution in the biologically and economically significant Australian North West Shelf region. Ocean processes at these scales dominate the lateral and vertical transport of ocean- borne material, including heat, larvae and pollutants, yet are poorly understood. Our project offers a once- off opportunity to collect simultaneous in-situ data during the unique rapid-sampling orbit of the pioneering high-resolution SWOT altimetry mission.

The target site is one of 14 globally (and the only site in the Indian Ocean) where SWOT will make daily high-resolution measurements of sea surface height during a 3-month window in 2023. A novel spatial array of moorings will support the detailed ship-based observations, together providing critical data for development and testing of new algorithms for estimating ocean surface currents at unprecedented fine scales. This new knowledge will enable characterisation of submesoscale dynamics across broader spatial and time scales, elucidate relationships between mesoscale / submesoscale processes and vertical mixing, and establish physical understanding and data required for parameterisations.

Expected outcomes include a paradigm shift in quantification of fine-scale ocean dynamics with global relevance. This novel high-resolution ocean current information is directly applicable for search and rescue, offshore oil and gas operations, defence, ship routing, pollution response and ecosystem assessments in Australian waters. Our observations will advance regional- and global-scale ocean model predictions by improving our understanding of important subgridscale processes. The project will therefore bring economic, human safety and environmental benefits to Australia, while providing research training that will build Australian capacity in utilising remotely sensed environmental data and more generally in the space technology sector.

4. LINKS TO IIOE-2 SCIENCE PLAN: *(1/2 page maximum)*
How do you anticipate your project to contribute to the IIOE-2 strategy and science delivery, with reference to which (either one or more) of the six IIOE-2 Science Plan themes that your project responds.Please state the specific issues and questions addressed by your project in the context of the IIOE-2 Science Plan themes and key issues.

Our project fits well within the IIOE-2 strategy and science delivery plan. We ait across a variety of Science Themes including: ST-2: Boundary current dynamics, upwelling variability and ecosystem impacts and ST-6: Unique geological, physical, biogeochemical, and ecological features of the Indian Ocean. We summarise our project outputs and benefits below.

Key research outputs:

1. Software tools for extracting and processing the remote-sensing data to estimate ocean surface currents and mesoscale dynamics
2. Prototype gridded surface currents for the Australian NWS for 2023-2024 period:
3. In-situ data sets from moored and ship-based observations:
4. Improved understanding of submesoscale dynamics that translates to improved parametrisations for larger-scale models:
5. Capacity building

Benefits:

Submesoscale ocean dynamics, varying on scales of 1-10s km and evolving on timescales of days to weeks, dominate the horizontal dispersion of ocean-borne material, including heat, coral larvae, pollutants like oil and plastics, and floating objects, and enhance the vertical exchange of gases and nutrients. Historically, submesoscale flows have been difficult to observe because the spatial and temporal scales evolve rapidly. Our study will characterise and understand submesoscale ocean currents on the Australian Northwest Shelf (NWS) using new Earth observing satellites, in-situ ocean observations and building upon the team's innovative numerical and theoretical analyses.

Our project outcomes will result in three major sources of new knowledge:

1. Novel and robust methods for reliably estimating submesoscale currents from satellite data.
2. A detailed understanding of lateral and vertical transport processes associated with oceanic submesoscale currents.
3. Characterisation of the submesoscale current fields on the Australian NWS.

This new knowledge will have direct commercial and environmental benefits by improving predictions for search and rescue operations, offshore oil and gas operations, defence operations, pollution response, ship routing and climate predictions. For example, improved predictions of hazardous spill trajectories would allow a targeted response and efficient allocation of resources. Furthermore, the ability to predict future marine heat waves, which cause coral bleaching and ecosystem collapse, is dependent on quantifying lateral transport of heat in the upper ocean due to small-scale processes. A final example is improvements in predictions of global ocean circulation, which will lead to increased accuracy in climate change predictions.

5. INTERNATIONAL COLLABORATION(S):

Is the project part of a related multi-national activity? **YES/NO**

If No, would you welcome international collaboration in your project? **YES/NO**

6. REGION(S) OF STUDY

Provide a description of 'where' the research is to be conducted (for field based activities) and/or the region or regions to which the research pertains (you are encouraged to consider providing either the coordinates of the area of studies or the coordinates of the planned cruise tracks, as well as a figure as an addendum to your proposal).

The Australian North West Shelf (NWS) is an environmentally, economically and strategically significant region of the Australian Exclusive Economic Zone and is also a globally important test location for the new SWOT SSH satellite. Past intensive hydrographic surveys and satellite SST have revealed rich eddy fields, with baroclinic instability due to transient lateral density gradients hypothesised as the main submesoscale eddy generation mechanism. The shelf is relatively wide (~250 km) and deep (up to 500 m) and therefore eddies can form and evolve without being impeded by boundaries. From a remote-sensing perspective, the region has some of the best clear-sky conditions on Earth, resulting in greater temporal data coverage for passive instruments, e.g., infrared sensors for SST. Furthermore, the lack of energetic mean flow and smaller surface waves is predicted to result in a greater effective horizontal resolution of the SWOT SSH sensor in tropical regions where it is predicted to resolve wavelengths down to 15 km, i.e., an eddy diameter of 7 km and the minimum submesoscale eddy size is larger in the tropics. Finally, NWS internal tides are large yet predictable compared to other regions. These combined NWS characteristics mean that **we will be able to extract higher fidelity estimates of submesoscale ocean currents from remotely-sensed data in this region, making the NWS an important test location globally.**

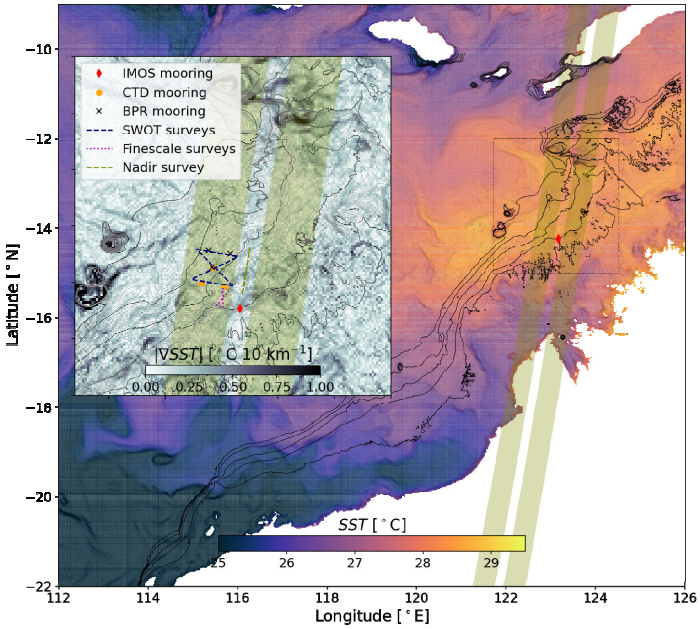

Figure 1 ***Instantaneous sea surface temperature (SST) from the Himawari-8 satellite in April 2021 with SWOT fast-sampling swaths (khaki), and IMOS mooring (red diamond). (Inset) Study region showing submesoscale eddies and filaments at one instant in time as the sea surface temperature gradient (greyscale). The location of the moorings and ship-surveys are shown (described in legend). BPR= bottom lander pressure sensor.***

6. TIMETABLE OF THE PROJECT

Start date:	End date:
Jan 2022	Dec 2024

7. LINKAGES WITH OTHER PROJECTS / PROGRAMMES / INITIATIVES

Is the project part of a related national or multi-national activity?
If yes, provide the related activity title and website for reference, if available:

Part of international focus on ocean outcomes of the next-generation Surface Water and Ocean Topography (SWOT) Satellite e.g.,
https://swot.jpl.nasa.gov/science/science-team-projects/?order=created_at+desc&per_page=50&page=0&search=&fs=&fc=229&ft=&dp=&category=229
https://www.swot-adac.org/

Is your project part of, or affiliated to, another SCOR, IOC or IOGOOS activity or project?
If "yes", please indicate which activity or project:

No

8. DATA MANAGEMENT AND SHARING

1. Will new data be collected as part of this project (yes or no?

Yes

2. Contact information if any, of the person in charge of the data management from whom the metadata can be accessed by interested IIOE-2 stakeholders.

Please note that for all IIOE-2-endorsed projects, IIOE-2 will have developed its own metadata portal. Once the project is endorsed, the project leader will be asked to provide the metadata information of the project.

Nicole Jones

3. Recognizing the need for an initial period of exclusive data use, would you be willing to provide timely access to all data generated under this project and associated metadata in accordance with relevant national and funding agency data sharing policies? **YES/NO see section 11**

9. FUNDING

Please note that IIOE-2 strongly encourages funded/resourced projects. However, IIOE-2 may endorse projects yet to receive funding/resourcing if IIOE-2 endorsement can be clearly shown to significantly aid in prospects for funding/resourcing.

Has funding and resources to successfully achieve and undertake the project been obtained? Indicate the sources of funding and resources that have been approached and/or secured.

Funding for the personnel and research costs has been obtained through a Australian Research Council Discovery Project. We have just submitted an Australian Marine National Facility application for shiptime.

10. BENEFITS FROM IIOE-2 ENDORSEMENT *(1/4 page maximum)*

Specify why you are seeking endorsement and how the activity would benefit from endorsement, and how the IIOE-2 SC could assist in the implementation of your project.

We are seeking endorsement to increase the impact of our research by sharing it with the IIOE2 community. We plan to create tools for other researchers to use at their sites. We also hope to create collaborations to biological oceanographers to extent the impact of our work.

11. OPTIONAL: OTHER COMMENTS/INFORMATION/MATERIAL *(length and detail may be at the discretion of and as deemed necessary by the applicant)*

Please feel free to provide any other comments, information or materials that you feel relevant to your proposal for the IIOE-2 Steering Committee's information and benefit. You may provide this as general information or provide the additional comments/information/materials as relevant to any of the specific Sections above.

Data will be made publicly available through a combination of MNF Data, Australia Data Network, and UW research repository. Some data will be available shortly after the voyage. Other data will be made available 2 y after the voyage. Tools for analysis will be created in open-source software and made publicly available.

(Signature of the PI)