

FINAL REPORT – MARCH 2024 (PIs AGV Salvanes & M Gibbons)

PRIMA Learning: Connecting hands-on-**PR**actice and **I**nnovative **MA**rine ecological sampling methods and analysis tools for enhancing student **LEARNING** of ocean science

Background and objectives

PRIMA Learning has been built on the Centre for Excellence in Teaching (SFU) at the University of Bergen (**bioCEED**, **UiB**), the Thon Foundation funded teaching project “*Ecosystem, climate and variation in a “mini-ocean-ecosystem”: a west Norwegian fjord*” (Ocean Science course **BIO325**), strong research environments in South-Africa, and two Centers for Research-based Innovation (SFI) at the Institute of marine Research (**IMR**, first **CRISP**, then **CRIMAC**) and the **FAO**’s flagship for developing sustainable fisheries considering climate and pollution impacts (**EAF-Nansen program**). Our main partner in South Africa is the University of the Western Cape (**UWC**), which houses the hub for Southern African-Nordic Centre (**SANORD**). The **PRIMA Learning** project has renewed and expanded previous strong collaboration organized by Salvanes, Gibbons and Utne-Palm funded by the Norwegian and South African Research Councils (2003-2010) for studies of the Benguela upwelling ecosystem off Namibia and South Africa.

The main objective of PRIMA Learning was to build new knowledge through basic research and educate highly qualified marine scientists with international experience and networks. Innovative teaching and learning methods that integrate hands-on-learning of practical skills required for marine ecological field studies for academia, research institutes and the industry were adopted.

The secondary objectives were: **i)** mobility of MSc and PhD students; **ii)** mobility of scientists; and **iii)** workshops and intensive training/ courses for students and researchers in marine ecological field methods; acoustics to quantify fish populations; non-invasive novel sampling methodologies (Deep-Vision) to monitor marine resources; jellyfish biology and ecology; stable isotope analysis for studies of trophic interactions in marine ecosystems.

1. Main results

PRIMA Learning has provided scientific and educational meeting places in the form of workshops and intensive training courses, exchange opportunities and travel grants to facilitate capacity building, as well as collaborative networks. We have collaborated on capacity building, supervision of graduate students, research projects and papers. The **EAF-Nansen Program** has provided the major data set from the Benguela upwelling ecosystem and from the Indian Ocean onboard R/V *Dr. Fridtjof Nansen*. All manuscripts and publications have been developed in collaboration with the **EAF-Nansen Programme** “Supporting the Application of the Ecosystem Approach to Fisheries management considering climate and pollution impacts”, the **UWC**, the South African **NRF** and the **UiB**’s **PRIMA Learning** project funded by the **NRC**. The **EAF-Nansen Programme** is a partnership between **Norad**, **IMR** and **FAO**, that aims to support participating countries to fulfil their commitment towards implementation of the ecosystem approach to fisheries. All data were collected during scientific surveys onboard the R/V *Dr. Fridtjof Nansen*. All data used follows the Nansen Data Policy available at <https://www.fao.org/3/cc6872en/cc6872en.pdf>. Third parties may gain access to the data conditional to an agreement with **FAO** on behalf of the **EAF-Nansen Program** and the designated national or regional institutions.

We have organised three open graduate courses (March 2019 in Bergen; February 2023 in Cape Town). The two courses in 2023 in Cape Town were originally scheduled to May 2020, but had to be postponed due to the pandemic. **PRIMA Learning** also funded mentors from **IMR** and graduate students at **UWC** on an **EAF-Nansen** acoustics training survey onboard the R/V *Dr. Fridtjof Nansen* in May 2023. In addition, the project has co-organised and co-funded two general and larger workshops dealing with curricula developments in Ocean Science: “*Teaching ocean science and SDGs in higher education: Perspectives from IAU HESD Clusters and South-African Master program in Ocean Science (SAMOS)*”, <https://hyponfjordfish.w.uib.no/2023/ocean-deoxygenation-at-the-intersection-of-sdg-13-and-sdg-14/> (>30 participants), Cape-Town in January 2023; “*UiB Fisheries and Marine Biology Education Revision Workshop*” (>30 participants), Austevoll in February 2024.

Below a short summary of the three graduate courses in PRIMA Learning:

Theory and hands-on learning, Acoustics and advanced sampling techniques March 2019

The theory for fisheries acoustics was introduced to students during a 10-day **BIO333** Acoustics course at **BIO**, **UiB** by Prof Egil Ona before the participants went to sea. Next, the practical teaching cruise was held onboard the **IMR/UiB** vessel *Kristine Bonnevie* in west Norwegian fjords around Bergen. The nine course participants included both postgraduate students and fisheries professionals from South Africa, as well as several

postgraduate students from the UiB. Dr. Bjørn Erik Axelsen (IMR), lectured and demonstrated fisheries acoustics, including calibration of scientific echosounder systems, design of acoustic surveys and analysis of acoustic data. Dr. Shale Rosen (IMR), lectured and demonstrated advanced sampling techniques using different specialized sampling trawls and the Deep Vision in-trawl camera system to identify and measure species passing through the trawl, but not necessarily retained *in situ*. Acoustic surveys and trawling were repeated at different times of day to capture the diel vertical migration of the pelagic fishes and crustaceans encountered. Participants learned also to use manual procedures as well as electronic systems for measuring and recording sizes and weights of individuals, subsampling techniques, and using databases to store and retrieve catch data.



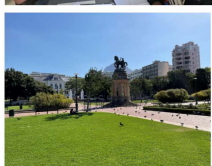
The acoustics lab onboard R/V *Kristine Bonnevie*



In the fish lab onboard R/V *Kristine Bonnevie*

International course on identification of gelatinous zooplankton in Cape Town in February 2023

Jellyfish are important as predators and prey in coastal and oceanic ecosystems, and any fluctuation in their abundance above/below the long-term baseline is an indication of a system in imbalance. However, they are not the easiest animals to identify and yet without a knowledge of identity it is difficult to understand or manage them.



In an effort to address this, scientists and students from African and Norwegian universities and research institutions participated in an international workshop on the identification of gelatinous zooplankton in Cape Town for five days in February 2023 <https://www.uib.no/en/FjordCoast/160648/%E2%80%99Cprima-learning%E2%80%99D-jellyfish-workshop-cape-town-february-2023>. The workshop was organised as part of the mobility project (PRIMA Learning) between the University of Bergen (UiB), Norway and the University of the Western Cape (UWC), South Africa and it built on the specialized training of African students in multifrequency hydro-acoustics held in Bergen at an earlier date. The project is conducted in collaboration with the EAF Nansen Programme, which is funded by the FAO (UN) and NORAD, with implementation via the Norwegian Institute of Marine Research (IMR). Accordingly, the EAF Nansen Programme funded the participation of students from elsewhere in Africa (Cameroon, Ghana, Morocco, Senegal). The jellyfish workshop was organised by Prof. Mark Gibbons and his PhD student Michael Brown from UWC, with co-teachers Aino Hosia and Luis Martell-Hernández from the UiB's museum. The workshop was held at the Iziko South African Museum in Cape Town's historic Company Gardens and fourteen students participated.

PRIMA Learning Stable Isotope Workshop (course) in Cape Town in February 2023

The analysis of stable isotopes in an organism's tissues provides information about its diet and trophic position and has become a useful tool for researching trophic ecology. Stable isotopes of carbon and nitrogen are most-commonly analyzed and provide information about the primary production at the source of an organism's

trophic pathway and the relative trophic level of that organism within that pathway, respectively. Because stable isotope analysis (SIA) is now widely applied, an international workshop to provide post-graduate students and early researchers with an introduction to using this technique for the analysis of trophic interactions in the marine environment was held in Cape Town on the 20th-23rd of February 2023.



The stable isotope workshop was organised as part of the PRIMA Learning collaborative project between the University of Bergen (UiB), Norway and the University of the Western Cape (UWC), South Africa. <https://www.uib.no/en/FjordCoast/161316/prima-learning-stable-isotope-workshop-cape-town-february-2023> The project collaborates with the EAF-Nansen Programme, which is funded by the Norwegian agency for development cooperation (Norad) and implemented by the Food and Agriculture Organization of the United Nations (FAO) in close collaboration with the Institute of Marine Research (IMR), Norway. Accordingly, the EAF Nansen Programme funded the participation of students from elsewhere in Africa.

The workshop was co-organised by Dr. Carl van der Lingen (Department of Forestry, Fisheries and the Environment [DFFE] and UWC) and Dr. Natalya Gallo (UiB) with logistical and technical support from Dr. Michael Brown (UWC) and was held at the Iziko South African Museum in Cape Town. The workshop comprised (i) introductory lectures by the co-organizers and local scientists with expertise in SIA including Prof. Judy Sealy (University of Cape Town [UCT]), Associate Prof. AJ Smit (UWC), and Mr. M. Horton (UCT); (ii) a tour of the Light Stable Isotope Laboratory, UCT; and (iii) guided, hands-on analysis by participants of actual SI data collected from several marine fish and invertebrate species sampled from the Benguela and California upwelling ecosystems as well as from Norwegian fjords. A total of 17 post-graduate students and early researchers from African and Norwegian universities and research institutions participated in the workshop.

2. Research groups, activities and use of resources.

The steering committee has consisted of AGV Salvanes (UiB, PI - Norway), DL Aksnes (UiB), MJ Gibbons (UWC, PI South Africa), G Bianchi (IMR, Nansen Program), BE Axelsen (IMR) and S Rosen (IMR CRISP/CRIMAC). The kick-off meeting was held at Geilo in March 2018 followed by a writing and planning workshop. The closing up and a writing workshop was held at Sodwana Bay, Kwa-Zulu Natal, South Africa in January 2024 with 12 participants. The course in acoustics was held in Norway in 2019. The two workshops/courses was held in February 2023. The project was mostly on hold during the pandemic, but we did have digital board meetings and seminars so that students could present preliminary work. Two senior researchers from South Africa and Namibia (B Currie and C van der Lingen) visited Norway in 2023 and contributed to teaching graduate students at UiB during the Ocean Science (BIO325) field course in west Norwegian fjords.

3. Research stays abroad.

The project has funded, student- and supervisor participation on the ICES Fisheries and Plankton Acoustic Symposium in Portland, Maine, USA in March -April 2023, and student participation at the Southern African Marine Sciences Symposium in Durban during June 2022. Many writing workshops both in Norway and South Africa were organised, as too were research stays for UWC- graduate students to visit co-supervisors in Bergen, a few research stays in South Africa that lasted longer, and numerous short exchange visits of 1-2 weeks for researchers focusing on PhD supervision and writing research articles. No Norwegian graduate students had

significant exchanges with South Africa, but many students from the University of Bergen participated on the courses/workshops on jellyfish taxonomy and stable isotope methods for studies of trophic interactions and that our South African colleagues on PRIMA Learning gave in Cape Town in 2023.

4. Expected benefits of the research

PRIMA Learning has provided an added value by top-up funding mobility for students with bursaries from the South African NRF projects (PI MJ Gibbons). This funding allowed participation in international conferences, intensive work to completing papers on jellyfish, mesopelagic fishes and the ecology of the bearded goby in Benguela. Moreover, it has funded numerous short exchange visits for researchers to continue working on joint scientific papers started on previous projects, and for future collaboration.

PRIMA Learning has built new knowledge through basic research and educated highly qualified marine scientists with international experience and networks. Our innovative teaching and learning methods that integrate hands-on-learning of practical skills and marine ecological field studies are useful for academia, research institutes and industry. PRIMA Learning funding has contributed to *three* completed PhD degrees at UWC (Michael Brown, Benedicto Kashyindie and Verena Ras) all currently employed, *two* MSc degrees at UWC (P Sishuba & B Govuza) both currently employed, and *two* BSc Hon degrees, currently MSc students. Further *two* more PhDs and *two* more MSc degrees are due for completion in 2024.

Dissemination plans

Project participants have already published eleven peer-review papers in research journals and two book chapters, but the group has still ten papers in progress on mesopelagic fish in preparation for a special issue in *African Journal of Marine Science* (Guest editors MJ Gibbons and AGV Salvanes). Tentative title: “Studies on mesopelagic fishes in the Benguela and other regions”. Submission is due by May/June 2024. Numerous papers are in progress based on MSc, PhD and BSc Honours theses produced under the project. Work in progress has been presented at multiple international conferences, and at project seminars and workshops.

Paper list for the special issue in African Journal of Marine Science (in alphabetical order):

1. Chacate OE, Coetzee JC, Axelsen BE, Gibbons MJ. Micronekton assemblages in the Southwestern Indian Ocean and the Bay of Bengal, and their relationships to hydrography.
2. Coetzee JC, possibly other co-authors. Mesopelagic fish: Acoustic target strength, biomass estimation and potential for commercial exploitation in the Southern Benguela.
3. Gibbons MJ, Salvanes AG. Overview of the Mesopelagic Fishes Suite.
4. Kashindye BB, Axelsen BE, Yemane D, Coetzee JC. Environmental factors influencing the distribution of mesopelagic fish in the Benguela region off Namibia.
5. Kashindye BB, Coetzee JC, Axelsen BE. Identification and abundance estimation of mesopelagic fish in the Namibian Benguela using multifrequency acoustics.
6. Staby A, Axelsen BE, van der Lingen, Coetzee JC, Fairweather TP, Sikongo B, Angolan co-author. A collation/synthesis of information on mesopelagic fishes of the Benguela Current region from surveys by the *Dr Fridtjof Nansen* and Namibian and South African vessels.
7. van der Lingen CD, Staby A, Shannon LJ. A review of the diversity, distribution, abundance, biology, ecology and fisheries potential of mesopelagic fishes in the Benguela Current.
8. van der Lingen CD, Shongwe T, Reed CC, Geja Y, Petersen J, Staby A, Hulley PA. Levels and effects of infection by the copepod *Cardiodyctes bellotti* (Copepoda: Pennellidae) on Hector's lanternfish *Lampanyctodes hectoris* (Actinopterygii: Myctophidae) in the Southern Benguela Current upwelling ecosystem.
9. Zacharias L, Gibbons MJ, van der Lingen CD. Trophic ecology of 12 mesopelagic fish species in the Northern Benguela Current ecosystem.

Other papers in preparation by senior PRIMA Learning participants and former students:

Staby A, Yemane D, others. Distribution and abundance of eggs and larvae of *Lampanyctodes hectoris* and *Maurolicus* spp and buoyancy of *Maurolicus* spp eggs in the Benguela Current ecosystem; **Currie B**, Wilhelm M, Salvanes AGV, Utne-Palm AC, Kainge P et al. Key players in the northern Benguela ecosystem – hake, gobies and seals and their trophic interactions; **Thibault D**, Kuplik Z, Prieto L, Enrique-Navarro A, Brown MK, Uye S, Doyle TK, Pitt K, Fitt WK, Gibbons MJ (in press) Ecology of Rhizostomeae. In: Morandini AC, Reinicke GB, Holst S (Eds.). Advances in Rhizostomeae Jellyfish Research. *Adv Mar Biol* 98; **Gibbons MJ** Jellyfish, people and the United Nations' Sustainable Development Goals. *J M Biol Ass India*; **Samsodien Y**, Brown MK, Gibbons MJ A new species of *Cyanea* (Scyphozoa: Cyaneidae) from the West coast of Africa. *Zootaxa*; **Straehler-Pohl I**, Brown MK, Gibbons MJ Observations on Cubozoa from the coastal waters of Mozambique, including the description of two new species. *Zootaxa*; **Govuza B**, Engelbrecht A, Ras V, Brown MK, Gibbons MJ Specimens of *Pelagia* from around Africa and the Indian Ocean shed light on the identity of this widely distributed warm-water scyphozoan. *J Biogeography*; **Brown MK**, Gómez-Daglio L, Dawson MD, Abrahams M, Gibbons MJ The genus *Drymonema* (Scyphozoa) may be more speciose than previously thought: a description of new species from the Atlantic Ocean. *Zootaxa*; **Ras V**, Engelbrecht, Gibbons MJ (in preparation, 2025) Population structure of three species of *Chrysaora* (Scyphozoa; Pelagidae) around the west coast of Africa. *Evolution*; **Ras V**, Engelbrecht, Gibbons MJ Using BioGeoBEARS to explore the evolutionary history of Pelagidae (Scyphozoa; Discomedusae). *Evolution*; **Ras V**, Engelbrecht, Gibbons MJ How does the addition of African material change our global understanding of genetic and geographic differentiation in macromedusae? *J Biogeography*; **Ras V**, Engelbrecht, Brown MK, Gibbons MJ (in preparation, 2025) Observations on species richness of jellyfishes (Scyphozoa) around Africa: missed taxa. *A J M Sci*