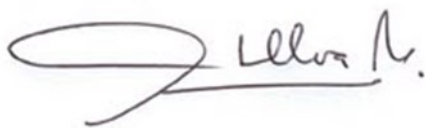



Name of the Center: Millennium Institute of Oceanography Instituto Milenio de Oceanografía	
Type (Institute or Nucleus)	INSTITUTE ICN12_019
Acronym	IMO
Reported period	January 1 to December 31, 2021
Starting date of the Center	DECEMBER 26, 2013
Web Page	http://www.imo-chile.cl
Host Institution(s)	Universidad de Concepción and Pontificia Universidad Católica de Chile
Address	Cabina 7, UdeC, Barrio Universitario S/N, Concepción
Stage	Continuity
End date of the Center	2023
Total amount	USD \$12.500.000 for 10 years
Total amount for the reported period	USD \$ 1.102.362 this period

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Declaración de Singapur

Por este medio declaro que la información entregada en esta memoria anual es fidedigna, y que adhiero a la Declaración de Singapur, contenida en la Resolución Exenta N° 157 del 24 de enero de 2013 de Conicyt, como guía global para una conducta responsable en la investigación.

<i>Institute Director Name</i>	<i>Institute Alternate Director Name</i>
Dr. Oswaldo Ulloa Quijada	Dr. H. Rubén Escribano Veloso
<i>Director's Signature</i>	<i>Alternate Director's Signature</i>
	

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1.1 Executive Summary (2 páginas)

The Millennium Institute of Oceanography (IMO, Instituto Milenio de Oceanografía) is a center of excellence established at the end of 2013, with the aim of exploring and researching the open and deep ocean. During 2021, IMO continued its 5-year second phase. In accordance with its approved extension plan, research was organized along two main lines:

I. A Variable and Changing Ocean.

II. The Deep Ocean.

Additionally, IMO continued its strong **Outreach Program** and **Educational and Networking** activities.

Major Achievements during 2021 include:

Scientific and technological:

Due to the pandemic, a major focus of IMO during year 8 was on the analysis of samples and data collected in previous research cruises, and on the publication of these results. No field activities were carried out during this period.

a) Publications

- 23 journal articles were published in 2021, of which 14 were authored or co-authored by the six current IMO associate researchers (2.3 articles per associate researcher).
- Of the above articles, 4 included more than one IMO associate researcher as author.
- Two exceptional papers in Research Line 1 led by IMO associate researchers were published, one in *PNAS* and the other one in *Nature Communications*, both among the highest impact general interest journals.
- The first two IMO scientific articles on the Atacama Trench were published during 2021, and were led by IMO young researchers.
- Significant advances have been obtained towards answering IMO's main scientific questions.

b) Deep- Ocean Observing System

- Due to the COVID-19 pandemic, the deployment of the Integrated Deep-Ocean Observing System (IDOOS) for geoscience research in the Atacama Trench was postponed to 2022/2023.

Education and capacity building achievements:

- IMO graduated 3 PhD and 2 MSc students.
- All PhD students that have graduated from IMO are currently active in research.
- Two new IMO postdocs were incorporated in 2021.

Networking:

- IMO researchers have consolidated their involvement in major international programs and projects targeting global issues related to the climate impact on ocean dynamics, marine ecosystem services and their social-economic consequences.

IMO signed a formal agreement with the Instituto Milenio de Socio-Ecología Costera (*SECOS*).

Outreach:

During 2021, our outreach team continued to focus its efforts in developing their work in telematic platforms, because of the impediment in carrying out face-to face activities due the pandemic. We released our first popular-science book.

1.2 Resumen Ejecutivo (2 páginas)

El Instituto Milenio de Oceanografía (IMO, Instituto Milenio de Oceanografía) es un centro de excelencia establecido a fines de 2013, con el objetivo de explorar e investigar el océano abierto y profundo. Durante 2021, IMO continuó su segunda fase de 5 años. De acuerdo con su plan de extensión aprobado, la investigación se organizó en torno a dos líneas principales:

- I. Un océano variable y cambiante.**
- II. El Océano Profundo.**

Además, el IMO continuó con su sólido programa de divulgación y actividades educativas y de participación de redes.

Los principales logros durante 2021 incluyen:

Científico y tecnológico:

Debido a la pandemia, un enfoque principal de la OMI durante el año 8 fue el análisis de muestras y datos recopilados en cruceros de investigación anteriores y la publicación de estos resultados. Durante este período no se realizaron actividades de terreno.

a) Publicaciones

- Se publicaron 23 artículos de revistas en 2021, de los cuales 14 fueron escritos o coescritos por los seis investigadores asociados actuales de IMO (2,3 artículos por investigador asociado).
- De los artículos anteriores, 4 incluían a más de un investigador asociado del IMO como coautor.
- Se publicaron dos artículos excepcionales en la Línea de Investigación 1 liderados por investigadores asociados de IMO, uno en *PNAS* y otro en *Nature Communications*, ambas entre las revistas de interés general de mayor impacto.
- Durante 2021 se publicaron los dos primeros artículos científicos del IMO sobre la Fosa de Atacama, los cuales fueron liderados por jóvenes investigadores IMO.
- Se han obtenido avances significativos para dar respuesta a las principales preguntas científicas de IMO.

b) Sistema de observación de aguas profundas

- Debido a la pandemia de COVID-19, el despliegue del Sistema Integrado de Observación del Océano Profundo (IDOOS) para la investigación geocientífica en la Fosa de Atacama se pospuso para 2022/2023.

Logros en educación y desarrollo de capacidades:

- IMO graduó a 3 estudiantes de doctorado y 2 de magister.
- Todos los estudiantes de doctorado que se han graduado de IMO están actualmente activos en investigación.
- Se incorporaron dos nuevos postdocs IMO en 2021.

Redes:

- Los investigadores de la OMI han consolidado su participación en importantes programas y proyectos internacionales que abordan cuestiones globales relacionadas con el impacto del clima en la dinámica de los océanos, los servicios de los ecosistemas marinos y sus consecuencias socioeconómicas.

IMO firmó un acuerdo formal con el Instituto Milenio de Socio-Ecología Costera (SECOS).

Extensión/Vinculación con el Medio:

Durante 2021, nuestro equipo de extensión continuó enfocando sus esfuerzos en desarrollar su trabajo en plataformas telemáticas, debido al impedimento para realizar actividades presenciales debido a la pandemia. Lanzamos nuestro primer libro de divulgación de la ciencia.

1.3. Outstanding Achievements (media página)

Major achievements of 2021 included two exceptional papers in Research Line 1 led by IMO researchers in journals *PNAS* and *Nature Communications*, among the highest impact general interest journals (Ulloa et al. 2021; Vargas et al. 2021), which reported new discoveries about life in the pelagic anoxic marine zone, addressing, respectively, aspects of adaptation at the organism level and biogeochemical function at the system level. With respect to Research Line 2, focused on the Deep Sea, two papers were published in 2021 describing findings from the pioneering ATACAMEX expedition to the deepest “Hadal” zone of the ocean. They involved two or more IMO associate researchers as well as other IMO members, and two were led by young IMO researchers (students or postdocs) (Fernández-Urruzola et al. 2021; Weston, Espinosa-Leal et al. 2021) with IMO associate researchers as senior authors, showing that Chilean researchers are, for the first time, becoming established as leaders in Hadal research.

Beyond achievements in investigation, IMO successfully overcame pandemic limitations to maintain excellence in outreach by highly successful implementation of a panoply of online activities and television series. A notable achievement in a different outreach medium was the **Book release “Journey to the Underworld: The Atacama Trench”** (in Spanish *Viaje al Inframundo: La Fosa de Atacama*) that introduces scientific exploration of the deep sea and emphasizes the knowledge of the Atacama Trench specifically.

Introduction (2 páginas)a) ***Description of the Institute:***

The Millennium Institute of Oceanography (IMO, Instituto Milenio de Oceanografía) is a center of excellence, established at the end of 2013, with the aim of exploring and researching the open and deep ocean. Its vision is to become an internationally recognized institute in oceanographic research and education, leading exploration in the central and eastern area of the South Pacific Ocean, with impact on the country and society in general. IMO's commitment is to provide an intellectually stimulating environment for the production and dissemination of scientific knowledge that generates new understanding about the ocean, from a creative, daring and collaborative perspective. IMO's mission is: *i*) to conduct pioneering and interdisciplinary research in oceanography, addressing scientific problems in an integrative and collaborative manner; *ii*) to develop and apply new technologies and platforms for observational and experimental work in the ocean, including the use of the new Chilean research vessel Cabo de Hornos, and to reach unexplored areas of the South Pacific; *iii*) to increase human resources in ocean sciences in Chile and South America, through higher education and training in research based on direct observation and experimentation in the sea, and by attracting ocean scientists from all over the world to work in Chile; and *iv*) to inform and create awareness among the general public and decision makers about the importance of the ocean, its conservation and its relationship to humans and global change.

IMO has become a Latin American regional center of excellence in oceanography through: • An increasing number of publications in top-ranked international journals, reflecting IMO's cutting-edge research • Integration of the new Chilean research vessel R/V Cabo de Hornos for fundamental ocean research. • Implementation of advanced sampling technologies, including the use of an innovative submarine lander to repeatedly sample the deepest depths of the Atacama Trench. • High impact in human capacity building at regional, national and international levels. • High impact in dissemination of science to society at large through an internationally recognized outreach program. • Becoming integrated into and recognized in the international research community through extensive networking. • In ocean policy, IMO has been called on a) to provide logistical-technical support for reacting to a massive toxic algal bloom, b) to communicate the state-of-the-art of scientific understanding of the ocean to authorities and policymakers reacting to a foreign company's controversial bid to conduct commercial iron fertilization in Chilean waters, c) to participate in the formation of the Chilean National Ocean Policy. This Annual Report is a summary of the eighth year of activities and the sixth as a legal Non-Profit Private Corporation.

b) ***Research Lines:***

I. A Variable and Changing Ocean: This research line is organized around three grand questions:

- a. *How well do biogeochemical flows, community composition, and even population structure of key species correlate with physical oceanographic drivers?*
- b. *How does biogeochemical function differ among norm-oxic, OMZ, and AMZ marine systems?*

- c. *What is the resilience of key communities and organisms to a changing ocean, and can that be predicted by their origin?*

II. The Deep Ocean: This research line is organized around a single grand question:

What are the physical and biogeochemical characteristics of deep and ultra-deep waters of the eastern South Pacific, and which of those determine the diversity and functional structure of their pelagic communities?

Additionally, IMO has a strong Outreach Program and continues with a Geoscience Program (within Research Line II), aimed at linking oceanography with geology and geophysics.

c) **Organization of research teams:**

During 2021, its eighth year, IMO consisted of 33 researchers: 6 of the original associate researchers, 4 senior researchers, including the former associate researcher Dr. Samuel Hormazábal, 12 adjunct researchers, 4 young researchers and 7 postdocs. The associate researchers: Drs. Osvaldo Ulloa (Director), Rubén Escribano (Deputy Director), Oscar Pizarro, Wolfgang Schneider, and Cristian Vargas (from University of Concepción, UdeC) and Peter von Dassow (from Pontifical Catholic University of Chile, PUC). They are distributed in Concepción and Santiago, respectively. IMO also include 16 professionals/technicians and assistants, 5 administrative staff, as well as 50 students (12 undergraduate, 22 M.Sc., and 16 Ph.D.).

A detailed list of the researchers is shown in Annex 1.

During this period, IMO was organized around the 2 research lines, an outreach team (led by Pablo Rosenblatt, Director of Outreach), a central administrative office based at UdeC (led by Atilio Morgado, Executive Director), and a technology development and transfer team (established in 2016) led by Ing. Víctor Villagrán.

IMO had also three senior researchers during the period: Prof. Juan Carlos Castilla (PUC) and Dr. Gerrit van den Engh (MarCy, USA), both as advisors to the institute, and Dr. Samuel Hormazábal (a former associate researcher).

Scientific and technical personnel, laboratories, and equipment are shared across the research lines, and also contribute to outreach and technology development. Drs. Cristian Vargas and P. von Dassow lead Research Line 2 and Drs. R. Escribano and O. Ulloa lead Research Line 1.

Each year, associate researchers meet at the beginning to define annual research priorities for each line —as well as for education, outreach, and technology development and transfer— and the budget is allocated according to these priorities. Meetings are held throughout the year to follow specific priorities.

1. **Scientific and technological research:** (8 páginas para Núcleos / 12 páginas para Institutos)

- a) **Current status of research lines:** *La información detallada sobre líneas de investigación durante todo el desarrollo del centro deberá estar contenida en Annex 2.*

Research Line I:

During 2021 IMO researchers focused mostly on analyses of samples and data obtained in previous field campaigns and lab experiments as well as meta-analyses from global data networks in several studies addressing the questions *How well do community composition and population structure of key species correlate with physical oceanographic drivers?* and *What is the resilience of key communities and organisms to a changing ocean, and can that be predicted by their origin?* The strategy was to explore how organisms are affected by the natural environmental variability in environmental parameters such as temperature, salinity, oxygen and carbonate chemistry (pH, partial pressure of carbon dioxide - $p\text{CO}_2$, saturation state of CaCO_3 minerals), and the targets ranged from microbial plankton to animals.

AI von Dassow was the senior author arising from the doctoral thesis of IMO PhD student **Díaz-Rosas** using Outlying Mean Index Niche Analysis to separate the impact of different environmental parameters on calcified phytoplankton (coccolithophores) (**Díaz-Rosas et al. 2021**). One surprising finding was that pH/ $p\text{CO}_2$ acted orthogonally to CaCO_3 saturation in defining realized niches in these organisms. This was unexpected from current concepts of coccolith calcification (**von Dassow, 2022**), and highlights the importance of the Chilean natural laboratory, where carbonate chemistry parameters can be decoupled as it is predominantly driven by upwelling of high CO_2 waters in some areas while by low salinity inputs in other areas. As temperature was also revealed to be a key parameter in realized niche differentiation both among species and among alternate phenotypes/genotypes of the same species, **AI von Dassow** also led a study specifically exploring whether thermal reaction norms explained distributions of species and genotypes among closely related coccolithophores (**von Dassow et al. 2021**). Focusing on low O_2 high CO_2 conditions of the OMZs, **PI Ulloa** led a study published in *PNAS* using single-cell genomics to reveal the adaptations of the unique lineages of the cyanobacterium *Prochlorococcus* found there (**Ulloa et al. 2021**). Complementing this issue, **AI Vargas, von Dassow**, and **Ulloa** have been collaborating on a meta-analysis and review led by former IMO postdoc Jane Wong suggesting that most phytoplankton may be limited by every low O_2 , while IMO MSci student Edson Piscocoya and postdoc Monserrat Aldunate conducted a study, co-supervised by **Vargas** and **von Dassow**, that provided the first experimental evidence supporting the role of low pH/low O_2 conditions on the vertical distribution of eukaryotic phytoplankton (**Piscocoya et al. submitted**).

Directing similar strategies towards ecologically and economically important animals, **PI Vargas** was involved in a study looking at how environmental variability that includes natural OA and DO events impact coastal shellfish farming (**Saavedra et al. 2021**) and he also participated in a study published in *Sci. Tot. Environ.* (**Jahnsen-Guzmán et al. 2021**) that evaluated the potential of 'environmental refuges' to OA in an estuarine system of southern Chile, which provides conditions (high pH and carbonate saturation state), which favor the fitness of some marine organisms. These works significantly advanced the discussion of how and where human society can apply ocean acidification management efforts, including applying the diversity of conditions found in the Chilean natural laboratory towards the innovative idea of identifying refuges.

Meanwhile, von Dassow initiated a collaboration with Italian researchers to conduct the first culture-based study establishing the species and toxicity of the ecologically important diatom genus *Pseudo-nitzschia* present in the coastal and open ocean waters of the Southeast Pacific. *Pseudo-nitzschia* is a

Harmful Algal Bloom genus well known from the Northern Hemisphere but almost unstudied previously in the Southeast Pacific. Several species have been particularly responsive to previous climate events in the North Pacific, but it is impossible to distinguish *Pseudo-nitzschia* by light microscopy, so the culture-based database is the first step in permitting studies of its responses to environmental gradients in Chilean coastal, estuarine, and offshore waters.

It continues to be a technical challenge to count and distinguish marine microbes. Ulloa and von Dassow separately advanced the application of flow cytometry for discrimination and quantification of marine micro-organisms (**Henríquez et al. 2021; Mardones et al. 2022**).

IMO researchers also addressed the question *How does biogeochemical function differ among normoxic, OMZ, and AMZ marine systems?* A high-impact study led by **Dr. Vargas** with the participation of several associate and adjunct researchers (**Schneider, Sepulveda, and D'Ottone**) was published in *Nature Communications*. The study reported geochemical and stable isotope measurements from the anoxic marine zone (AMZ) off northern Chile during periods of contrasting oceanographic conditions (Cruise LowpHOX 1 in late austral 2015, and LowpHOX 2 in middle austral summer of 2018), indicating that microbial processes mediated sulfur and nitrogen cycling impact carbonate chemistry conditions in this AMZ. An isotope mass-balance model demonstrated that variations in the rates of sulfur- and nitrogen-mediated carbon fixation in AMZ waters contributed to ~7–35% of the particulate organic carbon (POC) exported to deeper waters. This study received high digital media coverage at national and international levels.

We continued analyzing the physical drivers of the variability of the Oxygen Minimum Zone (OMZ) at different time and spatial scales. During 2021 we incorporated the analysis of fine and microscales combining ocean glider observations with microstructure measurements. Our results showed that diapycnal O₂ fluxes toward the OMZ from below –i.e., from the Antarctic Intermediate Water– are related to double diffusion instabilities (particularly salt fingers) that contribute significantly to ventilate and shape the lower boundary of the OMZ. The analysis of glider observations identified and characterized subsurface intensified mesoscale eddies and their impact on the OMZ. Together with the direct eddy transports, stirring by mesoscale eddies generates thermohaline intrusions of fine scale that largely contribute to increase iso- and diapycnal mixing in the OMZ. These studies formed part of an undergraduate thesis (now graduate student in oceanography M. Pinto guided by IMO AIs O. Pizarro and O. Ulloa) and developed in collaboration with national (CEAZA) and international (ULPGC) partners.

Along with IMO PhD student L. Ortis, we analyzed the transport and evolution of the O₂ and the main components of the nitrogen cycle (NO₃⁻, NO₂⁻, NH₄⁺, N₂O) inside subsurface eddies. In addition, the different physical terms that contribute to the oxygen balance inside the eddy as it moves from its formation zone were analyzed. In general, the terms related to horizontal oxygen advection are the ones that contribute most to the oxygen balance, however, during the early stages of the eddies (first months) vertical advection is also relevant. The latter also appears to play an important role when eddies interact with relevant topographic features like seamounts. With the former PhD Student M. Pizarro-Koch (graduate, July 2021) we analyze the interannual variability of the OMZ using also a coupled physical/biogeochemical simulation. This study complements the study at seasonal scale already published (Pizarro-Koch et al. 2019). Interannual variation of both the Peru-Chile Undercurrent and a set the zonal cross-shore flows that alternate their direction eastward and westward are the main drivers of the interannual variability of the core of the OMZ (Pizarro-Koch et al., submitted).

During 2021 a new research grant led by **Vargas** began, aiming to understand the natural variability regime of oxygen, pH, and pCO₂ in the coastal upwelling area of Arauco Gulf in Central Chile. The study involves the deployment of a series of sensors and loggers along different coastal sites, as well modeling approaches in collaboration with the **AI Pizarro**, and experimental work starting in year

2022 in the new micro-mesocosm facility at the coastal laboratory in Dichato. The study also involves an IMO graduate student guided by both researchers.

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Research Line II: The Deep Ocean

During 2021 we continued our work focused on the deep and offshore region of the eastern South Pacific. At the oceanic region off the Chilean coast important progress was made for understanding key factors structuring biological communities and modulating the distribution and diversity of planktonic species. A basic task was the identification of dominant plankton species at the ultra-

oligotrophic area within the South Pacific central gyre (Medellín-Mora et al. 2021), and the significant role that the coastal-oceanic oceanographic gradient has as influencing the biodiversity pattern of a key zooplankton group amphipods (Espinosa-Leal et al., 2021). Physical mesoscale processes were also identified as a key factor influencing the zooplankton distribution and biological productivity of the seamount region (Parada et al., 2021)

Regarding the ultra-deep (>1000 m) waters in the region, one of the key questions we have focused our attention on is related to the source of organic C available for deep biological communities. We proposed the hypothesis that most C available for deep species is produced as plankton in the near-shore upwelling zone and it becomes transported by mesoscale activity to oceanic regions in which is preyed by carnivorous zooplankton entering in a food-web dominated by vertically migrating zooplankton and fish which in turn promote the downward C flux. The source and pathways of C and N contributing to this process were traced by the analysis of isotopes composition of these bio-elements (González et al. submitted). In the same context, a model involving the biological demand of C for maintaining respiration rates of zooplankton in the deep and ultra-deep Atacama Trench allowed us to conclude that passive sinking of C from the highly productive euphotic zone may satisfy such demands (Fernández-Urruzola et al. 2021).

Deep ocean circulation plays a central role in it by carrying heat, fresh water, carbon, and dissolved substances that are essential for life. Nevertheless, the mean deep circulation and its variability in the Southeast Pacific is poorly understood. Historical evidence suggests that in this region an important component of the Pacific outflow takes place. During 2021 we analyzed the four repetitions of the east part of the P06 line, a transpacific oceanographic section carried out along 32.5°S during years 1992, 2003, 2010 and 2017, to get a consistent view of the deep flow and its sensitivity to the level of no motion selected. Our results showed a robust southward deep flow of about 5.6 ± 0.69 Sv (1 Sv = $106 \text{ m}^3 \text{ s}^{-1}$) between about 1000 and 3600 m depth near the Chilean coast (between the continental slope and 89°W). These results were part of M. Torres' thesis recently defended.

With respect to one of our major challenges dealing with the knowledge and exploration of deep ocean communities, we continued the analysis of samples and data from the ATACAMEX and SONNE Cruises carried out during the summer 2018. From Lander deployments at both cruises down to >8000 m, and in collaboration with our international partners, we discovered and described a new species of the most abundant scavenger amphipod, which was named as *Eurythenes atacamensis* in honor to ATACAMEX cruise (Weston et al., 2021). In addition, molecular approaches, based on environmental DNA (eDNA) have revealed novel and surprisingly high diversity in the deep and ultra-deep water of the Atacama Trench located below the highly productive upwelling zone of northern Chile, in comparison with the Kermadec Trench located underneath a much lower productive zone off the New Zealand coast (Ramírez-Flandes et al. submitted). Zooplankton metabarcoding analyses is also revealing an increase diversity of zooplankton with deep after samples obtained with the MOCNESS net above the Atacama Trench (Gonzalez et al. work in progress)

During 2021, IMO has joined forces with the geophysics/geology community and secured funds to deploy the first Integrated Deep-Ocean Observing System (IDOOS) at the Atacama Trench and continental slope, linking cutting-edge monitoring technology for data acquisition within a novel transdisciplinary framework. The overarching goal of IDOOS is to detect and quantify a wide range of poorly understood deep-ocean processes ranging from the characterization of the structure and temporal variability of physical, geochemical, and biological conditions, up to detecting seafloor deformation associated with the build-up of strain leading to a great earthquake, over several years. Moreover, the implementation of biogeochemical sensors (O_2 , pH/p CO_2) will improve our understanding about how climate change, and specifically global warming and ocean acidification,

can impact the deep-ocean habitat of this unique reservoir of biodiversity for the Earth. Our observing system will have two principal elements (Fig. 2):

- A deep ocean moored system composed of two lines anchored to the bottom of the sea with a set of oceanographic sensors located at different depths that allow the recording of different physical and biogeochemical parameters, such as water movement, temperature, salinity, pressure, dissolved oxygen, and CO₂. The hadal line will include sediment traps to collect sinking material substances that sediments through the water column.
- A set of three sea-floor pressure and tilting sensors with the new capacity of removing instrumental drift and measuring vertical displacements related to inter-seismic locking, seismic deformation and slow slip or transient events. These sensors will be integrated with a dense network of ocean-bottom and onshore seismometers.

IDOOS will be deployed during 2022.

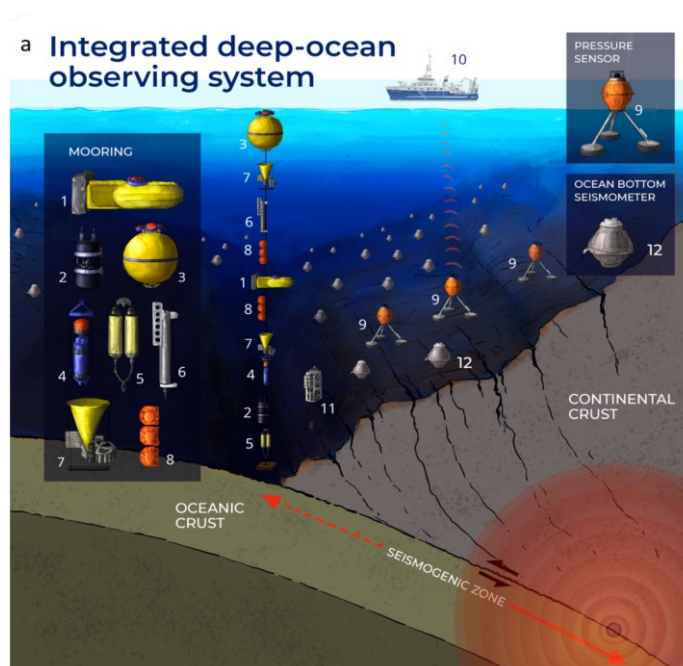


Fig. 2. IMO's Integrated Deep-Ocean Observing System (IDOOS) to be deployed in the Atacama Trench.

Finally, during the second half of 2021, we worked on getting the official permits from the Chilean authorities and preparing a new international expedition to the Atacama Trench. IMO was invited by the American entrepreneur and explorer Victor Vescovo and his team to lead the scientific component of the first human descent submersible expedition to the deepest part of the trench (off Antofagasta, Chile). The expedition took place in early 2022; the results will therefore be given in the next annual report.

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Espinosa-Leal, L, Escribano, R. Riquelme-Bugueño, R., Corredor-Acosta, A. 2021. Distribution and biodiversity patterns of hyperiid amphipods across the coastal-offshore gradient of the sub-tropical Southeast Pacific. *Marine Diversity* 51:13. <https://doi.org/10.1007/s12526-020-01152-x>

Fernández-Urruzola, I., Ulloa, O., Glud, R.N., Pinkerton, M.H., **Schneider, W.,** Wenzhöfer, F., **Escribano, R.** 2021. Plankton respiration in the Atacama Trench region: Implications for particulate organic carbon flux into the hadal realm. *Limnology & Oceanography*. 1-15. doi: 10.1002/lno.11866.

González, C.E., Bode, A., **Fernández-Urruzola, I., Hidalgo, P., Escribano, R.** 2021. Trophic and taxonomic structure connectivity of zooplankton assemblages over the zonal gradient off central Chile (submitted *Journal of Marine Systems*).

Medellín-Mora, J., Escribano, R., Corredor-Acosta, A., **Hidalgo, P., Schneider, W.** 2021. Diversity and distribution of pelagic copepods in the oligotrophic blue water of the south Pacific subtropical gyre. *Frontiers in Marine Science*. Volume 8 | Article 625842. doi: 10.3389/fmars.2021.625842

Parada, C., Ernst, B, Cornejo-Guzmán, S., Santa Cruz, F., Sandoval-Belmar, M., Rivara, P., Tapia, B., Gauthier, S., Pino-Aguilera, J., **Escribano, R., Morales, C.E.** 2021. Chlorophyll-a and zooplankton variability around the Robinson Crusoe Island forced by mesoscale and sub-mesoscale features: A multidisciplinary approach. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 31:253–272. <http://DOI:10.1002/aqc.3499>

Ramírez-Flandes, S., González, C.E., Aldunate, M., Poulain, J., Wincker, P., Glud, R.N., **Escribano, R.,** Arnaud Haond, S., **Ulloa, O.** 2021. High genetic diversity in the pelagic deep-sea fauna of the Atacama Trench revealed by environmental DNA. *eLife* (submitted).

Weston, J.N.J., **Espinosa-Leal, L.,** Wainwright, J.A., Stewart, E.Cd. **González, C.E.,** Linley, T.D., Reid, W., **Hidalgo, P., Oliva, M.E., Ulloa, O.,** Wenzhöfer, ., Glud, R., **Escribano, R.,** Jamieson, A.J. 2021. *Eurythenes atacamensis* sp. nov. (Crustacea: Amphipoda) exhibits ontogenetic vertical stratification across abyssal and hadal depths in the Atacama Trench, eastern South Pacific Ocean *Marine Biodiversity*. 51:51. <https://doi.org/10.1007/s12526-021-01182-z>.

b) Productivity:

A total of 23_ articles were published in peer-reviewed journals in 2021, 56.5% in Q1 journals and 34.8% in journal within the 10%, with 34.8% associated to RL 1, 43.5% to RL 2, and 21.7% to both lines. Of the total, 14 articles were authored or co-authored by the six current IMO associate researchers (2.3 articles per associate researcher). Many of the studies published in 2021 involved collaboration between IMO and other national research centers. For examples, the IMO-led study of Vargas et al. 2021 involved collaborators from the *Coastal Social-Ecological Millennium Institute (SECOS)* and the Center for Climate and Resilience Research (CR)², while IMO-led the study by von Dassow et al. 2021 involved collaborators from Centro de Investigación Dinámica de Ecosistemas Marinos de Altas Latitudes (*IDEAL*). In several other cases (e.g. Jahnsen-Guzmán et al, Mardones et al., Henríquez-Castillo et al.), researchers from other centers invited the participation of IMO researchers for their unique expertise. Although all publications in RL1 and 90% of the studies in RL2 were led by Chileans, several studies involved international collaboration, and we highlight the example of the Vargas et al. study because it illustrates the impact of the international IMO adjunct researcher Sepúlveda. It is also notable the that 11 studies involved the collaboration of two or more (associate) investigators bridging between the disciplines of biological and physical oceanography, and, finally, that 6 studies were led by current or former IMO students or postdocs and such young researchers also participated in most of the IMO publications.

Open Access policy: IMO finances publication costs. If only a single Associate is listed as co-author, requested funds come from that investigator's yearly assigned funds. However, if two or more Associates are involved, publication fees including open access fees come from central IMO funding, a policy which encourages both collaboration among associate investigators and Open Access.

c) **Outstanding publications:**

1. **Ulloa et al. 2021**, published in *PNAS*, used frontier single-cell genome sequencing technology to investigate a topic within the question *How does biogeochemical function differ among norm-oxic, OMZ, and AMZ marine systems?* of RL1 at the organism level. Specifically, they identify the adaptations of the planktonic cyanobacterium *Prochlorococcus* to life in sunlit but anoxic layers of the open ocean.
2. **Vargas et al. 2021**, published in *Nature Communications*, tackled the same question, but at the systems level, detecting the interactions of ultra low O₂ levels, chemioautotrophy, and sinking C fixed by surface photoautotrophy on the distinct C flows in OMZ and AMZ systems.
3. **Fernández-Urruzola et al. 2021**, published in a top disciplinary journal *Limnology and Oceanography*, represents the first study of physiological rates within the abyssal and hadal zones of Chile, showing the technical and scientific advances of IMO to study the deep sea. This study demonstrates that IMO can go beyond descriptive study of the deep sea to produce knowledge on biogeochemical function even in the deepest most inaccessible zones of the ocean.
4. **Medellín-Mora et al. 2021**, published in a top disciplinary journal *Frontiers in Marine Science*, shows the IMO operating very far from shore. In particular, this study focused on copepods, one of the most important animal grazers in the ocean, in the oligotrophic center of the South Pacific where the bluest waters on Earth are found.
5. **Díaz-Rosas et al. 2021**, published in the top disciplinary journal *Biogeosciences*, managed to sample a large portion of the range of surface environments in the Southeastern Pacific, using the entire region as a natural laboratory to ask what carbonate chemistry parameters matter to calcifying phytoplankton (the coccolithophores) and whether there are indications of which might be resilient generalists and which might be less tolerant specialists to changes in the environment.

All papers listed here are included in Annex 3.

Summary table

<u>Category of Publication</u> ¹	<u>MSI Center Members</u>	<u>Number of Publications co-authored by students</u>	<u>Total Number of Publications</u>
ISI/WOS Publications or Similar to ISI/WOS Standard	Principal Researchers	6	14
	Other Researchers	1	9
SCOPUS Publications or Similar to SCOPUS Standard	Principal Researchers	0	0
	Other Researchers	0	0
SCIELO Publications or Similar to SCIELO Standard	Principal Researchers	0	0
	Other Researchers	0	0
Scientific Books and chapters	Principal Researchers	0	0
	Other Researchers	0	0
Other Scientific Publications	Principal Researchers	0	0
	Other Researchers	0	0
<u>Total of Publications</u>		6	23

¹ Note: Categorization of publications according to Web of Science (www.webofscience.com)

d) Congress Presentations:

P. von Dassow “Microevolutionary variability of a complex life cycle in a cosmopolitan microalgae.” Keynote speaker. SYM10: Life history trait variation: evolutionary and ecological consequences (organizers Marie-Laure Guillemin, Stacy Krueger-Hadfield). 12th International Phycology Congress IPC2021. On-line. 25-03-2021.

P. von Dassow “Looking at phytoplankton evolution and adaptation from the natural labs of the Southeast Pacific.” Invited seminar. Spring 2021. OIMB Seminar Series. Oregon Institute of Marine Biology. University of Oregon, Charleston, OR, USA (realizado por video conferencia). 23-04-2021.

Summary Table

Type of presentation	Type of presentation	National Events [Number]	International Events [Number]
Principal Researchers	Conferences, oral communications, poster communications, others (specify)	9	2
	Invited presentations (not included in the above row)	0	0
Other researchers (Adjunct, Senior, Young, Postdoctoral Researchers)	Conferences, oral communications, poster communications, others (specify)	8	1
	Invited presentations (not included in the above row)	1	0
Students	Conferences, oral communications, poster communications, others (specify)	1	0
	Invited presentations (not included in the above row)	0	0

Other achievements:

- **Patents:**
No patents to report this period.
- **Intellectual property:**
Book: “*Travesía al Inframundo. La Fosa de Atacama*” by Osvaldo Ulloa Quijada e Ilustraciones de Felipe Gamonal, ISBN 978-956-9114-26-7, Intellectual Property 2021-A-2304.
- **Organization of Scientific Events:**
The information about Scientific events is listed in **Annex 4**.
- **Scientific Editorial Boards:** *Presentación de los principales comités editoriales en los que participan los Investigadores y su relevancia según tipo de medio.*
 - **R. Escribano:** Associate Editor of *Frontiers in Marine Science*, a top 10% (IF=4.912 in 2020) international journal of marine sciences.
 - **O. Ulloa:** Associate Editor of *Limnology and Oceanography*, a top 10% (IF=4.745 in 2020) international journal of aquatic sciences.
- **Awards:**
No awards for this period.

Detailed information on lines of research throughout the development of the center is in Annex 2.

2. **Education and Capacity Building** (3 páginas para Núcleos / 4 páginas para Institutos)

a) **Education, Training and Capacity Building:**

In 2021, under a pandemic situation from 2020, IMO continued to support and develop education and training activities at the Postdoctoral, PhD, MSc, and Undergraduate levels. Graduate level activities were associated with 5 graduate programs on oceanography and marine sciences in Chile: i) Doctoral Program in Environmental Sciences (UdeC), ii) Doctoral Program in Ecology (PUC), and iii) Doctoral Program in Oceanography (UdeC), iv) Master's Program in Oceanography (PUCV) and v) Master's Program in Oceanography (UdeC). Support for undergraduate careers and degrees was mostly developed through 4 undergraduate professional careers: Marine Biology at PUC and UdeC, Oceanography at PUCV and Geophysics at UdeC. In addition, our program for Early Career Scientists (IECS), implemented in 2019 continued supporting young scientists. Two IECS were maintained by IMO during 2021.

The recruitment of graduate students was decreased because of the pandemic but also the majority of our students had to postpone some activities. As a result, the number of students did not considerably change from 2020 to 2021. We focused on supporting the students to maintain their status and not abandon studies, making every effort to provide financial aid to our students, although our PhD students were very successful in obtaining scholarships from ANID. The following graph (Fig. a1) illustrates the different funding sources (scholarships) for students doing thesis work with IMO in 2021.

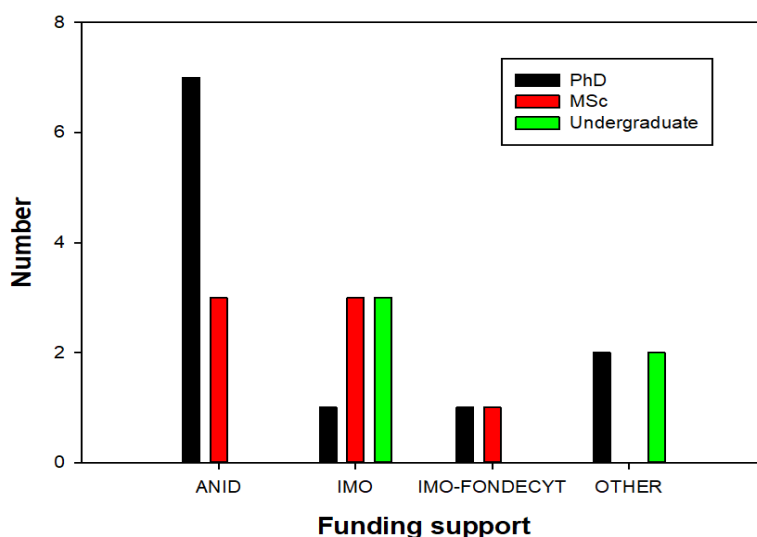


Figure a1: The different sources of funding to support undergraduate and graduate students carrying on their thesis at IMO during 2021. IMO/Fondecyt are concurrent grants complemented with IMO funding.

● Postdoctoral researchers

IMO supported 7 postdoctoral fellows during 2021. Continuing their work from previous years included IMO fully funded to postdocs Carolina González, and new postdocs Andrés Mesas and Reinaldo Rivera. And gave partial economical support to those who got external funding, such as Natalia Osma, Igor Fernández-Urruzola, and Vera Oerder, who gained governmental funds from ANID/FONDECYT and Paula Ruz, who has been founded by PUCV too.

b) Achievements and Results

The IMO’s primary educational achievements during 2021 were the following:

- In graduate and undergraduate programs. During 2021, IMO researchers participated in 5 undergraduate and 6 graduate programs, including lecturing basic and advanced courses, practical work, and thesis supervision and co-supervision: Undergraduate Programs in Marine Sciences: Marine Biology at UdeC, PUC, and UCN, Geophysics at UdeC, and Oceanography at PUCV. Graduate Programs in Marine Sciences: M.Sc. in Oceanography at UdeC, M.Sc. In Oceanography at PUCV, M.Sc. in Ecology of Aquatic Systems at U. Antofagasta, Ph.D. in Oceanography at UdeC, Ph.D. in Environmental Sciences at UdeC, and Ph.D. in Biological Sciences at PUC. The total number of students directly linked to IMO has fluctuated year-after-year and is shown in the following Figure:

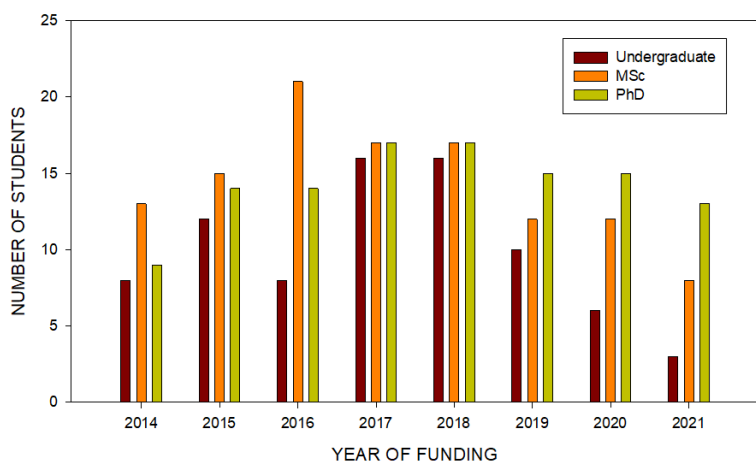


Figure b1: Total number of students since 2014 doing their thesis work at IMO. In 2021 there were 2 undergraduates, 8 in M.Sc., and 13 in Ph.D. Programs. IMO Associate Researchers are or were co-tutoring 50% or more students in each of these categories.

Three PhD students and 2 MSc students associated with IMO graduated in 2021. The evolution of graduating students each year shows a positive tendency through the years (Figure b2). In total, IMO has graduated 14 PhD and 17 MSc students from 2014 to 2021.

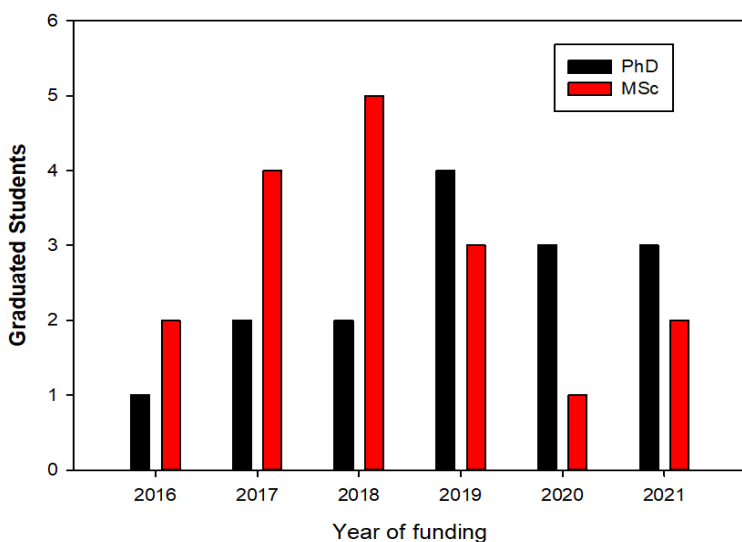


Figure b2: the number of new graduated students per year after doing their thesis at IMO.

All PhD students who graduated while associated with IMO are currently active young scientists.

The present position and destination of these students is shown in the Table below.

PhD	Current Position
Montserrat Aldunate	Postdoctoral position at IMO
Valeria Anabalón	Researcher in another project in Chile
July Corredor	Researcher in another Chilean Center
Carolina González	ANID-funded postdoctoral position at IMO
Johanna Medellín	Academic at Universidad de Valparaíso
Valentina Valdés	Postdoctoral position at UdeC
Paula Ruz	Postdoctoral position at UdeC
Sonia Yañez	Postdoctoral position at UdeC
Salvador Ramírez	Engineer-Researcher at UdeC and IMO
Pritha Tutasi	Researcher at INOCAR Ecuador
Freddy Hernández	Researcher at INOCAR Ecuador
Lady Liliana Espinosa	Early Career Scientist at IMO
Francisco Javier Díaz	Postdoctoral Position at PUC
Matías Pizarro Koch	Postdoctoral position at the UPWELL Nucleus

Table b1: PhD students graduated at IMO 2015-2021 and their present working situation.

Regarding MSc graduated while at IMO, several of them have started PhD programs in Chile or abroad, while some are working as highly qualified technicians at Chilean universities or research centers (Table b2)

New MSc	Current Position
Katerín Aniñir	Technician at a Center
Richard Cobo	Back in Ecuador
Marcela Contreras	PhD Student LEGOS/OMP Université Paul Sabatier Toulouse, France
Pamela Fierro	Undertaken PhD in France
Rosario Díaz	Profesional at the Industry
Javiera Pavez	Technician
Paula Ruiz	Undertaken PhD in Chile
Belén Franco	Undertaken PhD in Denmark
Leissing Frederick	Undertaken PhD in Chile
Guillermo Feliú	Undertaken PhD in France
Constanza Merino	Unknown situation
Luis Valencia	Technician
Braulio Fernandez	Applying to a PhD
Edson Piscocoya	Applying to a PhD

Table b2: New MSc graduated at IMO during 2015-2021 and their present position.

Sources for IMO students

IMO offers a call for undergraduate scholarships twice a year. The selection criteria are based on the academic records of the candidates, the needs of each IMO research theme, and the potential for

interaction through co-tutoring their thesis work and/or professional qualification. In the case of graduate students, IMO associate researchers are asked twice a year to propose candidates, including first year and advanced students with a thesis proposal already approved. First year students who applied to an ANID scholarship but were not awarded are also considered for support if they have very good academic records and, in some cases, they are linked to IMO from their undergraduate formation. IMO support extends for up to 1 year and these students are asked to apply again for external funds. Graduate students finishing their thesis work are also supported for periods of less than 1 year if they have completed an important part of their thesis requirements. IMO also supports students with partial grants when IMO researchers can make contributions to these grants through other funding sources available to them. In 2021, IMO awarded new scholarships to a total of 12 students including 3 undergraduates 7 M.Sc. and 2 PhDs. In addition, 11 graduate students working at IMO received ANID scholarships during 2021, whereas the rest had full or partial support from other funding sources (e.g. institutional scholarships or associated grants from IMO researchers).

Graduate theses completed in 2021:

Francisco Javier Díaz Rosas. PhD Thesis “Environmental and biotic controls on coccolithophores assemblages and *Emiliania huxleyi* populations: integrating cell traits, population dynamics and community structure”. Doctoral Program. Faculty of Biological Sciences, Pontificia Universidad Católica de Chile. Supervisor: Dr. P. von Dassow.

Matias Pizarro-Koch. Ph.D. thesis “Variabilidad de la zona de mínimo oxígeno frente a la costa central de Chile”. PhD. Program in Oceanography, University of Concepcion. Supervisor: Dr. O. Pizarro.

Pritha Tutasi, Ph.D. Thesis “Downward C flux into the deep ocean by active transport of C mediated by zooplankton vertical migration” Supervisor: Dr. R. Escribano.

Braulio Fernández, MSc. Thesis “The community structure of deep-sea gelatinous zooplankton in the Southeast Pacific at the Atacama trench”. Co-supervisors: Dr. P. Hidalgo and I. Fernández.

Edson Piscoya, MSc. Thesis “Influencia de factores físico-químicos en la distribución vertical del pico-nanoplancton en la Zona de Mínimo Oxígeno (ZMO) del norte de Chile: La influencia relativa del bajo pH/bajo O₂”. Co-supervisor: C. Vargas and P. von Dassow. Thesis defense in January 2022

Theses in progress:

Edgart Flores, Ph.D. Thesis, “Characterization of the organic matter in the Atacama Trench using lipid markers”. Co-supervisors: Dr. O. Ulloa and Dr. J. Sepúlveda.

Lenna Ortiz. Ph.D. thesis “Evolución biogeoquímica de los remolinos de mesoescala frente a la costa de Chile”. PhD Program in Oceanography, UNiversity of Concepción. Supervisor: Dr. O. Pizarro.

María Carla Marín M. PhD. Thesis. “Impacto de las ondas de Rossby extratropicales en la circulación profunda de la cuenca de Chile”. PhD. Program in Oceanography, University of Concepcion. Supervisor: Dr. O. Pizarro.

Cristina Carrasco M. Ph.D. Thesis. “Deep circulation in the Chilean basin” PhD. Program in Oceanography, University of Concepcion. Supervisor: Dr. O. Pizarro.

Ana Belén Venegas. Ph.D. Thesis "Interacciones físicas-biológicas que determinan la variabilidad en biomasa y producción del zooplancton en la zona de surgencia de Chile - Centro Sur: el rol de procesos advectivos y la interacción fitoplancton-zooplancton". PhD. Program in Oceanography, University of Concepcion. Co-supervisors: Dr. R. Escribano, Dr. C. Parada.

Manuela Pérez. Ph.D. Thesis “Vertical-layered biogeographic patterns of pelagic copepods in the South Pacific Ocean. Ph.D. Program in Oceanography, University of Concepción. Supervisor: Dr. Rubén Escribano

Macarena Díaz Ph.D. Thesis “The role of predatory interactions and environmental variability over euphausiid community structure and biomass: Control mechanisms underlying interannual fluctuations in the northern Humboldt Current System”. Co-supervisors: R. Riquelme-Bugueño and R. Escribano

Susana Cabrera Ph.D. Thesis “Interacciones tróficas y migración vertical como mecanismos de transferencia de C hacia el océano profundo.” Ph.D. Program in Oceanography, University of Concepción. Supervisor: Dr. Rubén Escribano

Leissing Frederick Ph.D. Thesis “The effects of deoxygenation and in coastal upwelling systems: Adaptive Molecular Response to hypoxia in zooplankton. Ph.D. Program in Oceanography, University of Concepción. Co-supervisors: Dr. Mauricio Urbina and Dr. Rubén Escribano

Francisca Olivares, M.Sc. Thesis, “The planktonic microbiome of the Atacama Trench”. Supervisor: Dr. O. Ulloa. Thesis defense pending (expected mid 2022)

Nadín Ramirez R. MSc thesis, “Estudio de la variabilidad de submesoescala en Chile central (~36°30’S) y de eventos de oxigenación de la zona de mínimo de oxígeno mediante observaciones realizadas con planeadores submarino”. Master Program in Oceanography, University of Concepción. Supervisor: Dr. O. Pizarro.

Enrique Ascencio, MSc. Thesis, “Respuesta fisiológica de dinoflagelados mixotróficos del género *Alexandrium* y *Prorocentrum* frente a condiciones de alto pCO₂/bajo pH”; Supervisor: Dr. Cristian A. Vargas, co-supervisor: Dr. Patricia Gómez (Departamento de Botánica, UdeC).

c) **Destination of students:**

Student name	Study Program level - milestone	Approval date	Current labor position	Academic route (Institution and funding)
Francisco Javier Díaz	PhD Program in Ecology	25-06-2021	Postdoctoral Researcher (part time)	Pontificia Universidad Católica de Chile
Pritha Tutasi	PhD Program in Oceanography	15-02-2021	Researcher	INOCAR Ecuador
Matias Pizarro-Koch	PhD Program in Oceanography	20 March 2021	Postdoctoral position	UPWELL Chilean Center
Braulio Fernández	MSc Oceanography	15 June 2021	Technician at UdeC applying to PhD Program	
Edson Piscocoya	MSc Oceanography	January 2022	Applying to a PhD program	

3. Networking and other collaborative work (2 páginas para Núcleos / 3 páginas para Institutos)

a) **Redes Formales de Colaboración:**

During 2021, IMO has been participating and consolidating different national and international collaboration networks in the framework of our research lines.

Some of these collaborations have been resulting from a continuous process along the whole life of IMO, such as our participation as main leading actor in the ***Latin-American Ocean Acidification Network (LAOCA)***, a regional network for synthesis, standardization of chemistry techniques, capacity building, outreach and communication, and policy issues, constituting the regional node for the articulation and communication between local, regional, and global research programs (e.g. GOA-ON and IOCCP), where during 2021 **Dr. Vargas** has been acting as Co-chair.

During 2021 IMO also signed a formal agreement with the **Instituto Milenio de Socio-Ecología Costera (SECOS)**, and **PI Vargas** leads the relations between IMO and SECOS. As part of the agreement, both IMO and SECOS agreed to organize an annual training course for its respective graduate students, as well as, participants from *LAOCA*. The first of these courses has already taken place, during 25 October and 1 November 2021 ("*Ocean Acidification and Climate Change: Perspective from Evolutionary Ecology*"). This formal agreement between IMO and SECOS also considers the analysis of the national ocean policy for Chile. Furthermore, as a result from this agreement among IMO-SECOS and in partnership with *LAOCA*, a Webinar Series through YouTube was also organized during whole 2021, which includes the participation of early career scientists from whole the Latin-American region (See: <https://www.youtube.com/channel/UCOi5g0d1HrBoYYaGGdj6Tig/videos>).

During 2021, IMO was continuing the partnership established with the "***Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andrés***" (***INVEMAR***) - **COLOMBIA** in the framework of the network project "*Strengthening of technical-scientific capacities of new methods for the study of marine biodiversity in Colombia and Chile - BIOMACC*", led by the young researcher, **Dr. Johanna Medellín**. During March 9 – 11th was organized an international course on "*Methods and Applications for the study of deep ocean benthic communities*". Similarly, our postdoctorate **Dr. Natalia Osma** was continuing her participation as a full member of the recent **SCOR Working Group 161 (2021-2024)**, "***Respiration in the Mesopelagic Ocean (ReMO): Reconciling ecological, biogeochemical and model estimates***", aiming to identify, quantify and priorities gaps in scientific knowledge about this issue, develop a global dataset of mesopelagic respiration estimates, produce a new synthesis of open ocean mesopelagic respiration, and produce a best practice manual of techniques and approaches to determine mesopelagic respiration.

In connection with Research Line 1 of IMO **R. Escribano** has continued co-chairing the SCOR WG 155 on Eastern Boundary Upwelling Systems (EBUS) dynamics and climate change. This SCOR WG gathering researchers from the four major EBUS during 2021 organized the EBUS International Conference to be held in Lima by September 2022. Other actions of the WG are related to compiling specialized literature on EBUS dynamics and databases, all of them to be compiled and made available to the public in a web portal. The WG has also been writing a review paper on vulnerability and ecosystem services of EBUS upon ongoing global warming.

The ocean knowledge action network (KAN) of the Future Earth Program continued its work in the framework of the UN Ocean Decade and during 2021 **R. Escribano** continued as a member of the Ocean KAN Development Team.

Regarding network activities associated with Research Line 2 of IMO, **R. Escribano** and the young researcher **Carolina Gonzalez** maintained a very active collaborative work within the SCOR WG 157 on MetazooGene. R. Escribano is an associate member of MetaZoogene. This WG organized a special session at the Open Science Conference of ASLO and AGU in Hawaii by February 2022. This WG has also been connecting our Metabarcoding work on deep samples from the Atacama Trench with other international partners to solve some methodological problems.

During 2021 we also continued the collaborative work with the Instituto Español de Oceanografía (IEO) at A Coruña, Spain in the framework of our TROPHONET Project funded by ANID. Collaborative work with the Spanish partners and our young researcher **Igor Fernández** was focused on data analysis and writing a scientific paper from the EPIC Cruise performed during March 2019 onboard the Japanese R/V MIRAI.

During 2021 **P. von Dassow** continued to be associated with the larger CNRS (France)-funded International Research Network Diveristy and Biotechnology of Marine Algae (DABMA, the successor to the previous French-led network DEBMA), However he left the Binational CNRS research unit within DABMA to become a Research Fellow affiliated with the Stazione Zoologica Anton Dohrn, where in 2021 he spent 2.5 months initiating collaborations to study the oceanography, evolution, and genomics of the diverse toxic marine diatom genus *Pseudo-nitzschia*.

In 2021 a memorandum of understanding between the Center for Advanced Studies in Arid Zones (CEAZA) and IMO was signed. In the frame of this collaboration two oceanographic campaigns led by Dr. Pizarro were carried out off Concepcion (~36.5°S) and Coquimbo (~30°S) during 2021. The objective of these cruises was to study turbulence and finescale variability and their role in the oxygen fluxes in the Oxygen Minimum Zone.

At national level, IMO has a permanent participation in different expert groups providing services to public and governmental agencies. *Dr. Vargas* has been continuing as a permanent member of the “**Technical Advisory Committee on Climate Change (GTA-Cambio Climático Subpesca)**” at the Undersecretary of Fisheries, where he provides guidance and advice on different issues related with the impact of climate change on marine resources in Chile.

b) **Redes de Colaboración:**

The majority of publications provide evidence of a large number of informal collaborations of IMO researchers at national and international levels. For examples, the IMO-led study of Vargas et al. 2021 involved the formal collaboration mentioned above with *SECOS* as well as the *Center for Climate and Resilience Research (CR)2*, and the IMO-led the study by von Dassow et al. 2021 involved collaborators from the Chilean *Centro de Investigación Dinámica de Ecosistemas Marinos de Altas Latitudes* as well as the *Algal Resources Collection* of the *University of North Carolina Wilmington* in the USA. In several other cases (e.g. Jahnsen-Guzmán et al, Mardones et al., Henríquez-Castillo et al.), researchers from other centers or institutions (e.g., the *Instituto de Fomento Pesquero*) invited the participation of IMO researchers for their unique expertise.

4. **Outreach and connections with other sectors** (3 páginas para Núcleos / 4 páginas para Institutos)

a) **Outreach:** (More details about this subject in **Annexes 7.1 a 7.3.**)

The general objective of outreach activities is to spread knowledge about Marine Sciences and IMO investigations through the larger society and the educational community in particular. The criteria to enhance these activities are rooted in identifying needs in the target audience, using diverse technological resources (ICTs) to reach audiences that are diverse in terms of interests and learning methods. Among the Outreach activities developed during 2021 are the following:

Book release “Journey to the Underworld: The Atacama Trench” (In Spanish): During 2021 we completed and released a science book to the public — aimed at both youth and adult readers — inspired by the IMO's explorations of the Atacama Trench. The book, entitled "Travesía al Inframundo" (or “Journey to the Underworld”), was written by Osvaldo Ulloa with support from the Extension Team in research, editing, communication and illustration and addresses topics related to deep ocean exploration in general, with special emphasis on the morphology, ecosystem and fauna of the Atacama Trench.

Talks and lectures: During 2021 we continued to respond to pandemic-related challenges and needs by developing a variety of online talks, conferences and lectures. These permit both our researchers and the Extension Team to bring the wider community in contact with a variety of topics related to Marine Sciences.

Teacher Training: The Extension Team continued to provide teacher training courses, whose main objective is to update concepts and provide new tools to teachers. This is intended to contribute to the educational and scholastic sphere, with the goal of making the approach to Marine Sciences in the classroom both as fun and as accurate as possible.

“Ruka's Fantastic Travels”: The 13 episodes that comprise the second season of the successful children's series "Ruka's Fantastic Travels" were released. It was produced by GVG Producciones with contributions from the National Television Council, and co-produced by Fundación Ciencia y Vida, Señal Colombia and IMO. The series premiered with great success on TVN's children's block and was also broadcasted on TV Educa and CNTV Play.

“Explorers, from the atom to the cosmos”: The sixth season of this series was made, wherein the research conducted in our country's centers of excellence is presented. With an average impact of 400,000 viewers per episode and a total of 5,600,000 viewers for the season's 14 episodes. In the episode about the Center, the following topics were addressed:

- *What is it like to be a woman in Chile whose livelihood is Oceanography?*
- *The exploration of the deep ocean*
- *"Travesía al Inframundo": Discovering the deep ocean.*

Video documentation: <https://www.youtube.com/watch?v=HKSCWyuUGM8>

<https://www.youtube.com/watch?v=gsUQxp76Tg0>

https://www.youtube.com/watch?v=5uS_ek6toNc

Science and Art Workshop: The IMO Extension Team has aimed in recent years, through multiple initiatives, to promote the link between Science and Art. In 2021, we addressed this through a virtual workshop on illustration and short stories about the ocean. In this workshop, the young participants learned different literary techniques, as well as artistic styles, from which to create short stories inspired by the ocean.

RedPop Presentation: The IMO Outreach Team presented the conference "Transmedia Strategies in Science Outreach" at RedPop. It explained the successful strategy implemented by the IMO, based on the tremendous milestone of the Atacamex expedition, to demonstrate how different

products (documentaries, books, exhibitions, and video games) can reach different audiences and very heterogeneous targets.

Bichitos 2 (second season): During 2021, the second season of the children's series "Bichitos" was co-produced with Fundación Ciencia & Vida, CNTV Children and GVG producciones. This series stars children answering different questions on topics related to the environment. Among the topics are climate change, ecosystems, fresh water, pollination, and the greenhouse effect, among others that make up the 16 episodes of the second season.

In the field of communications, the main objective has been to consolidate the Institute as a national reference in the study of the deep and open ocean, with special emphasis on the Southeast Pacific. To this objective and given the current health crisis in which the possibilities of holding in-person events have been very limited, a strategic plan was designed to enable the IMO to continue to have an active presence in the media.

In this sense, we have implemented a multilevel communication and dissemination plan, focused on distinct targets and including several actions aimed at:

- Child audiences: Distributing and promoting our audiovisual productions for children, as well as the Art and Science workshops.
- The general public: Presentation, release and distribution of the book "Travesía al Inframundo: La Fosa de Atacama" (Journey to the Underworld: The Atacama Trench). In addition, we have disseminated all the activities (conferences, lectures, workshops, talks, audiovisual programs, etc.) and relevant research of the Institute.
- Educational sphere: We always maintain a special interest in the educational world, through the dissemination of our teacher training sessions and activities focused on schoolchildren.

b) **Connections with other sectors:**

Since 2017, when IMO led the scientific community in expressing the risks and problems inherent in a foreign proposal to conduct commercial ocean iron fertilization (OIF) in marine waters of Chile, IMO researchers have repeatedly been asked to provide scientific advice related to ocean geoengineering policy for Chilean governmental agencies. In September 2021, IMO associate investigator von Dassow and former IMO associate investigator Dr. Carmen Morales (retired in 2020) were asked to present and participate in a round table meeting or various Chilean ministries organized by the Chilean Ministry of Foreign Affairs (MINREL). A MINREL working group has been evaluating whether Chile should ratify the 2013 Amendment to the London Protocol, the first proposed international mechanism to regulate ocean geoengineering. Dr. von Dassow and Dr. Morales presented "Antecedentes Científicos sobre Fertilización del Océano – OIF Elementos de Análisis sobre sa Enmienda Lp.4(8) y Gobernanza de la Geoingeniería Marina", where we reviewed not just the issues about OIF, but marine geoengineering more broadly. We emphasized that ocean geoengineering included many proposed technologies, and sometimes overlapped with "Blue Carbon" initiatives, and a range of viewpoints exists in the scientific community, with many respected groups suggesting that other geoengineering proposals must be considered and there must be an international regulatory framework to evaluate adequately these proposals from both scientific and ethical standpoints. We made a series of recommendations of the institutional needs that Chile faces in order to prepare to respond to such initiatives.

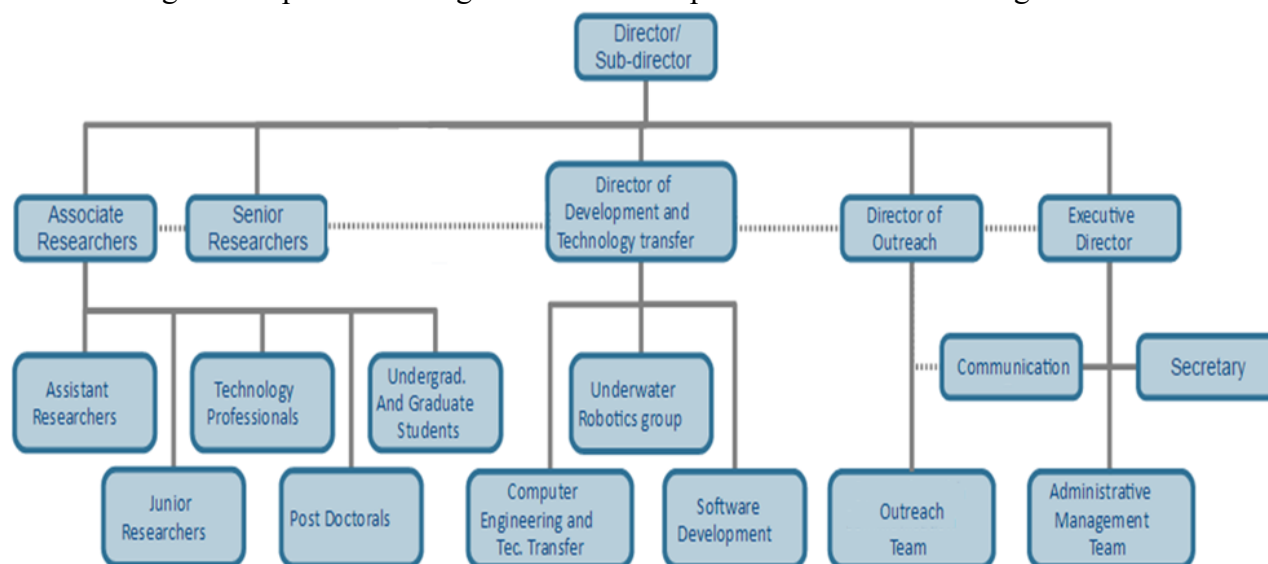
A summary is shown in Annex 8.

c) **Other achievements:** No other achievements to show here.

5. Administration and Financial Status (1 página incluyendo tabla)

a) Organization and administration:

The following chart represent the organizational and operational structure during 2021:



Regarding the relationships with the host institutions, mainly with the University of Concepción, it has been very cooperative and complementary, actively participating and coordinating both with the Vice-Rector for Research and Development and with the faculties of Natural and Oceanographic Sciences, Physical Sciences and Mathematics, Environmental Science, and the Postgraduate and International Affairs Directorates, especially for project development, human capital formation (building capacity) and use of infrastructure.

The following table is a summary of technical and administrative staff during this period:

Category	Female	Male	TOTAL
Assistant & Technicians	6	10	16
Administrative Staff	3	2	5
TOTAL	9	12	21

b) Financial Status:

Our financial status was mainly based on the operational Annual Fund of approx. USD 1,000,000. from the Science Ministry. This fund was used in 50% for personnel (Salaries and scholarships), 30% for operational expenses (16% of total budget in expendables), 10% in equipment and infrastructure adequations, 7% in administration costs, and approx. 3% in overhead for host universities.

Further, at the beginning of 2021, IMO received the funds (App. USD 1,115,000) specifically to build up a deep-sea observation platform, which we called IDOOS (Integrated Deep-Ocean Observing System for geoscience research). We have been in the procurement process of the different devices included in the system, ending the year using approx. 70% of the total budget, despite the pandemic restrictions to international commerce.

A summary of the funds from different sources is shown in **Annex 9**.

6. Annexes

Annex 1.- Institute / Nucleus Researchers

1.1 Tabla resumen de investigadores del centro

category of researcher	Quantity	Average age	Nationality		Distribution Gender		
			National	International	Male	Female	Not stated
Director	1	60	1	0	1	0	0
Alternate Director	1	64	1	0	1	0	0
Principal Researcher	6	57	4	2	6	0	0
Adjunt Researcher	12	50	12	0	11	1	0
Senior Researcher	3	69	2	1	3	0	0
Young Researcher	4	41	4	0	1	3	0
Postdoctoral	7	36	4	3	3	4	0

1.2 Principal Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Oswaldo Ulloa Quijada	2	Chilean	M	21-05-61	Marine Biologist	D	Universidad de Concepción	Responsible Director	2
Oscar Pizarro Arriagada	1 and 2	Chilean	M	28-03-63	Oceanographer	D	Universidad de Concepción	Research Associate	2
Rubén Escribano Veloso	1 and 2	Chilean	M	16-04-57	Marine Biologist	D	Universidad de Concepción	Substitute Principal	2
Peter Von Dassow	1	American	M	31-03-74	Bachelor of Science in Cellular and Molecular Biology	D	Pontificia Universidad católica de Chile	Research Associate	2

Wolfgang Schneider	1	German	M	16-02-54	M.Sc Oceanographer	D	Universidad de Concepción	Research Associate	2
Cristian Vargas Gálvez	1 and 2	Chilean	M	26-12-1972	Marine Biologist	D	Universidad de Concepción	Research Associate	2

1.3 Adjunt Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Víctor Miguel Aguilera Ramos	1	Chilean	M	01-11-1976	Marine Biologist	D	CEAZA- Universidad Católica del Norte	Assistant Professor	2
Marcos Simón Moreno Switt	2	Chilean	M	27-08-1974	Geologist	D	Universidad de Concepción	Assistant Professor	2
Ramiro Antonio Riquelme Bugueño	1,2	Chilean	M	07-09-1978	Marine Biologist	D	Universidad de Concepción	Assistant Professor	2
Julio Cesar Sepúlveda Arellano	1	Chilean	M	25-02-1977	Marine Biologist	D	University of Colorado Boulder	Assistant Professor	2
Marcelo Enrique Oliva Moreno	1,2	Chilean	M	17-03-1952	Biologist	D	Universidad de Antofagasta	Full Professor	2

Pablo Rosenblatt Guelfenbein	1,2	Chilean	M	06-01-1955	Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2
Pamela del Carmen Hidalgo Diaz	1,2	Chilean	F	07-06-1966	Aquaculture Engineer	D	Universidad de Concepción	Adjunct Professor	2
Giancarlo Troni Peralta	2	Chilean	M	06-10-1975	Electric civil engineer	D	Pontificia Universidad Católica de Chile	Assistant Professor	2
Mauricio Andrónico Urbina Foneron	1	Chilean	M	22-09-1979	Aquaculture Engineer	D	Universidad de Concepción	Assistant Professor	2
Víctor Enrique Villagrán Orellana	1,2	Chilean	M	02-03-1973	Electronic Engineer	M	Universidad de Concepción	Chief MIDGEO Laboratory	2
Atilio Edison Morgado Malebrán	1,2	Chilean	M	23-05-1960	Marine Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2
Nadín Cristóbal Ramirez Riveros	1, 2	Chilean	M	12-02-1983	Oceanographer	M	Millennium Institute of Oceanography	Adjunct Researcher	2

1.4 Young Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Montserrat Aldunate Chinchón	1, 2	Chilean	F	10-02-1984	Marine Biologist	D	Millennium Institute of Oceanography	Young Researchers	1
Marcela Alejandra Cornejo D'Ottone	1	Chilean	F	20-07-1977	Oceanographer	D	Pontificia Universidad Católica de Valparaíso	Associate Professor	2
Matías Esteban Castro González	1, 2	Chilean	M	28-12-1981	Molecular Biotechnology engineer	D	Universidad de Chile, Santiago	Young Researchers	2
Diana Johanna Medellín Mora	1	Colombiana	F	23-08-1977	Marine Biologist	B	Millennium Institute of Oceanography	Young Researchers	2

1.5 Senior Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Juan Carlos Castilla Zenobi	1,2	Chilean	M	19-08-40	Biologist	D	Pontificia Universidad Católica de Chile	Professor	2
Gerrit van den Engh	1,2	Holland	M	06-03-49	Biophysicist expert in cytometry	D	Becton Dickinson	Senior researcher	2
Samuel Hormazábal Fritz	1	Chilean	M	08-12-67	Oceanographer	D	Pontificia Universidad Católica de Valparaíso	Associate Professor	2

1.6 Postdoctoral Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Vera Oerder Gautron	1	French	F	22-07-1987	Oceanographer	D	Pontificia Universidad Católica de Valparaíso	Postdoctoral fellow	2
Paula Mariela Ruz Moreno	1	Chilean	F	06-07-1983	Marine Ecologist with mention in Resource Management.	D	Pontificia Universidad Católica de Valparaíso	Postdoctoral fellow	2

					Bachelor of Ecological Sciences.				
Ígor Fernández Urruzola	1,2	Spanish	M	18-08-1983	Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	2
Natalia Osma Prado	1	Spanish	F	29-01-1983	Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	2
Carolina Andrea González Espiniza	1,2	Chilean	F	20-06-1990	Marine Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Andrés Alberto Mesas Palma	1	Chilean	M	13-05-1988	Marine Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Reinaldo Javier Rivera Jara	1,2	Chilean	M	30-11-1984	Licenciado de Recursos Naturales	D	Millennium Institute of Oceanography	Postdoctoral fellow	1

<u>NOMENCLATURE:</u> [Gender] [M] Male [F] Female [ND] Does not Declare	[Academic Degree] [U] Undergraduate [M] Master [D] Doctoral	[Relation with Center] [1] Full time [2] Part time
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Annex 2.- Research Lines

Here we present our research lines since the beginning of the center. In progress first.

Nº	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/y]	Ending Date [dd/mm/y]	Status
1	A Variable and Changing Ocean	The goals of this theme I will be organized around three grand questions: A: How well do biogeochemical flows, community composition, and even population structure of key species correlate with physical oceanographic drivers? B: How does biogeochemical function differ among norm-oxic, OMZ, and AMZ marine systems? C: What is the resilience of key communities and organisms to a changing ocean, and can that be predicted by their origin?	Dominant environmental drivers, such as naturally high pCO ₂ /low pH conditions partially coupled to naturally low O ₂ or anoxic waters, must be crucial in shaping ecosystem and biogeochemical functioning in the ESP. Additionally, as the global ocean is both acidifying (due to absorption of anthropogenic CO ₂) and losing O ₂ (due to warming and increased stratification), the ESP also provides one of the most important natural laboratories for predicting future ocean function in the Anthropocene by understanding how biological systems adapt to and function under these conditions. The first period showed us the need to more effectively integrate the physical and chemical oceanographic understanding of the drivers of ocean variability, at the (sub)mesoscale (former Line 1) and on inter-annual to longer time scales (former line 2), with investigation of the consequences and responses at biogeochemical, ecological, and even organismal levels (former line 3). While the physical drivers are relatively well understood, the frontier of investigation is to understand the consequences for chemical, biogeochemical, and biological function, including potential adaptive responses.	Oscar Pizarro Arriagada. Wolfgang Schneider. Samuel Ernesto Hormazábal Fritz. Peter von Dassow. Víctor Miguel Aguilera Ramos. Heraclio Rubén Escribano Veloso. Víctor Enrique Villagrán Orellana. Pablo Rosenblat Guelfenbein. Montserrat Gabriela Aldunate Chinchón. Diana Johanna Medellín Mora. Juan Carlos Castilla Zenobi. Gerrit van den Engh. Ramiro Riquelme Antonio Bugueño. Julio César Sepúlveda Arellano. Marcelo Enrique Oliva Moreno. Pamela del Carmen Díaz Hidalgo. Mauricio Andrónico Urbina Ferrón. Atilio Edison Morgado Malebrán.	Biología marina. Ecología y ciencias ambientales. Oceanografía. Biología molecular. Física. Geoquímica. Química del ambiente.	02-01-2019		In progress

2	The Deep Ocean	<p>The goal of this theme II will be organized around a single grand question: What are the physical and biogeochemical characteristics of deep and ultra-deep waters of the eastern South Pacific, and which of those determine the diversity and functional structure of their pelagic communities?</p>	<p>In spite of the inexperience and logistical challenges in deep-sea oceanography, initiating the exploration and studying of the deep and ultra deep waters of the South Pacific proved to be extremely rewarding, and constitute one of the most promising research goals for the next phase. As for Research Theme I, the first period showed us the need to more effectively integrate the physical, chemical and biological aspects of the study of the deep ocean.</p>	<p>Heraclio Rubén Escribano Veloso. Osvaldo Iván Ulloa Quijada. Marcelo Enrique Oliva Moreno. Pamela del Carmen Hidalgo Diaz. Wolfgang Schneider. Oscar Roberto Pizarro Arriagada. Peter von Dassow. Cristián Antonio Vargas Galvez. Pablo Rosenblatt Guelfenbein. Ramiro Antonio Riquelme Bugueño. Víctor Enrique Villagrán Orellana. Gerrit van den Engh. Montserrat Gabriela Aldunate Chinchón. Juan Carlos Castilla Zenobi. Samuel Ernesto Hormazábal Fritz. Marcos Simón Moreno Switt. Giancarlo Troni Peralta. Atilio Edison Morgado Malebrán. Andrés Alberto Mesas Palma. Reinaldo Javier Rivera Jara. Matías Estebán Castro González.</p>	<p>Biología marina. Biología molecular. Ecología y ciencias ambientales. Geofísica. Bioquímica. Genética y evolución. Geoquímica. Ingeniería. Ingeniería electrónica. Ingeniería mecánica. Ingeniería oceánica. Oceanografía. Tectónica. Zoología.</p>	<p>02-01- 2019</p>		<p>In progress</p>
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1	Mesoscale processes	What is the role of mesoscale activity in governing energy and matter transfer and ecosystem dynamics in open ocean ecosystems	<p>Mesoscale eddies are characteristic of the southeastern Pacific (SEP) and connect areas with coastal upwelling with oligotrophic oceanic waters, as well as meso- and epipelagic domains. Eddies create unique and relatively isolated environments with distinct biological communities and chemical conditions, depending on the nature of the water trapped, the characteristics and path of eddies and their interactions with winds and topography. Seamounts, submarine mountain ranges and oceanic islands in the southeastern Pacific can also create or strengthen mesoscale activity and consequently increase biological production around them.</p> <p>Our hypothesis is that mesoscale eddies generated in the coastal area create conditions of deficient O₂/low pH in the open sea (or the opposite in areas with minimal oxygen), with corresponding changes in the structure of communities and biochemical cycles, and that differ significantly from those found in adjacent oceanic waters.</p> <p>To address this research theme, we will carry a field experiment to study the characteristics and evolution of mesoscale eddies generated in the sea beyond central Chile (~36 °S) and that are propagated to the northwest, reaching to around the Juan Fernández Archipelago. The field experiment will include time-series observations by satellite teledetection (e.g. ocean altimetry and color), an anchorage in the vicinity of the Juan Fernández Archipelago, and sections with a sailplane, as well as cruises oriented to processes.</p>	<p>Carmen Morales Samuel Hormazábal Carolina Parada. Marcela Cornejo. Juan C. Castilla. Oscar Pizarro. Peter von Dassow Cristian Vargas Heraclio Rubén Escribano Ramiro Riquelme Pierre Amael Auger Víctor Villagrán Pablo Rosenblatt</p>	<p>Ecology and environmental sciences. Oceanography Meteorology and climatology. Marine biology. numerical methods and computer science.</p>	26-12-2013	31-12-2018	Reformulated
2	Ocean Variability and Change	How large scale perturbations impact the transport and gradients in physical chemical water properties	<p>The subtropical cell controls the large-scale transport of heat, freshwater, carbon, nutrients and dissolved O₂ through the southeastern Pacific basin. These processes modulate chemistry and biology and the regional component of the climate variability.</p> <p>Models and field observations have shown that in the context of climate warming, the subtropical celda of the South Pacific is reinforced as a response to changes in surface winds on a large scale on the tropical Pacific. As well, it is expected that global warming directly affects the</p>	<p>Oscar Pizarro Arriagada. Wolfgang Schneider Ricardo Hernán De Pol Holz. Carolina Eugenia Parada Veliz. Samuel Ernesto Hormazábal Fritz Carmen Morales Van de Wyngard Peter von Dassow</p>	<p>Biochemistry. Ecology and environmental sciences. Oceanography Meteorology and climatology. Marine biology.</p>	26-12-2013	31-12-2018	Finished

			<p>South Pacific by strengthening the degree of productivity.</p> <p>As the temperature of the upper layers increases, the stratification of oceanic water is reinforced, affecting the mixing of water masses and vertical diffusiveness in subtropical regions. In contrast, stronger coastal winds could increase vertical mixing and upwellings of eastern currents. It has been argued that coastal upwelling and transport by the Humboldt Current have intensified in recent decades and has been getting stronger on the scale of decades. This in turn has been modifying the properties of waters that participate in the subtropical cell and in an increase in the physical, biochemical and ecological gradients between the coastal and oceanic environments. The lower O₂ content of the warmer ocean waters and the higher gradients between upwelling and stratified oceanic waters contributes to expanding waters low in O₂/pH and high in pCO₂, which affects biological communities and the biogeochemical cycles in these waters.</p>	<p>Víctor Miguel Aguilera Ramos. Aldo Manuel Montecinos Gula Heraclio Rubén Escribano Veloso. Víctor Enrique Villagrán Orellana Pierre Amael Auger Frauke Albrecht Pablo Rosenblatt</p>	<p>numerical methods and computer science.</p>			
3	Adapting to a Changing Ocean	How Key functional plankton groups adapt to changing ocean chemistry and impact biogeochemical cycling	<p>The strong and dynamic horizontal chemical gradients in the southeastern Pacific (SEP), from ultra-oligotrophic waters to coastal upwelling, exhibit highly variable combinations of low O₂ and pH/high pCO₂ and include strong vertical changes in O₂ concentrations, from saturation levels at the surface to undetectable levels in the nucleus of minimum oxygen zone (MOZ). These gradients cover a wide range of spatial-temporal scales.</p> <p>The responses of plankton communities and the feedback between community function and biogeochemical dynamics can depend in large measure on adaptations and capacities of acclimatization of key components, which can vary significantly among oceanic habitats. Moreover, the biological responses to multiple stress factors can be additive, synergetic or antagonistic.</p> <p>Our hypothesis is that the genomic variability among marine species is related to the differential functional responses to multiple stress factors and these determine the persistence or the</p>	<p>Peter von Dassow. Oswaldo Iván Ulloa Quijada. Cristian Antonio Vargas Galvez. Pamela del Carmen Hidalgo Diaz. Víctor Miguel Aguilera Ramos. Ricardo Hernán De Pol Holz. Alvaro Alfredo Muñoz Plominsky. Heraclio Rubén Escribano Veloso. Gerrit van den Engh. Víctor Enrique Villagrán Orellana Pedro Echeveste De Miguel. Pablo Rosenblatt</p>	<p>Numerical methods and computer science.</p> <p>Biochemistry.</p> <p>Marine biology.</p> <p>Biophysics.</p> <p>Microbiology</p> <p>Oceanography</p>	26-12-2013	31-12-2018	Finished

			<p>modification of ecological/biogeochemical functions as the chemistry of the ocean changes. It is postulated that community functioning in highly stable environments like the South Pacific gyre is less robust in the context of changes in chemical conditions compared to that of highly variable environments, such as the oceanic coasts. Field and laboratory work will be undertaken to address this theme. In the first fieldwork undertaking, key representatives of functional plankton from areas with gradients of pCO₂, pO₂ and nutrients will be isolated. In association with this activity, a new collection of phytoplankton will be initiated at the PUC in coordination with the Roscoff Culture Collection.</p> <p>Perturbation experiments will be conducted with single stress factors on selected species, focusing on physiological variability in response to variations in pCO₂/pH, and O₂, and allow for improving the design of experiments with multiple stress factors. Based on these results, we conduct genomic analysis of species/genera (e.g. low O₂ – Prochlorococcus; low pH/high pCO₂ – Coccolithophore).</p>					
4	the deep Ocean	what are the community structures and the biogeochemical characteristics of the deep and abyssal waters of the ESP	<p>The ecosystems of deep ESP waters are practically unknown. Exploration of mesopelagic (>500 m) and abyssopelagic communities (>3000 m) represent unique opportunities to discover new forms of life, species and genes for science, as well as a major challenge for oceanography in the South Pacific basin.</p> <p>This initiative will allow for identifying the mechanism through which communities are able to distribute themselves widely and colonize unique habitats like the Atacama Trench and the Nazca, Salas & Gómez and Juan Fernández ranges. Our hypothesis is that the ranges contribute significantly to the dispersion of species and the gene flows in the coast-ocean direction, driven by the circulation of water masses and mixing associated with the meso and large scale physical dynamics.</p> <p>To address this theme we will carry out deep water samplings, including a MOCNESS net (maximum depth of 6,500 m) with an underwater video profiler (UVP), conductivity, temperature</p>	<p>Heraclio Rubén Escribano Veloso. Oswaldo Iván Ulloa Quijada. Marcelo Enrique Oliva Moreno. Pamela del Carmen Hidalgo Diaz. Wolfgang Schneider. Oscar Roberto Pizarro Arriagada. Peter von Dassow Cristian Antonio Vargas Galvez. Pablo Rosenblatt Guelfenbein. Ramiro Antonio Riquelme Bugueño. Víctor Enrique Villagrán Orellana. Pablo Rosenblatt Gerrit van den Engh.</p>	<p>Numerical methods and computer science. Biochemistry. Marine biology. Biophysics. Microbiology Oceanography Ecology and Environmental Sciences</p>	26-12-2013	31-12-2018	Reformulated

			<p>and fluorescence sensors and stratified sampling nets.</p> <p>The underwater video profiler provides profiles of the distributions of particle sizes, while the net samplings will be divided into fractions for examining live animals, DNA analysis and taxonomic studies.</p> <p>Water samples will also be taken for molecular and genomic analyses of microbial communities (viruses to protists). In situ incubation systems will be developed to estimate microbiological activity/rates. Quantitative and qualitative assessments will also be made of fish parasites and plankton as biomarkers of the dispersion of host species and the colonization of habitats. Individual and biogeochemical models will be used to analyze the mechanisms that contribute to maintaining endemic communities and the connectivity among different islands, seamounts and other oceanic regions.</p> <p>Molecular analysis of selected plankton will be centered on DNA microsatellites and mitochondrial DNA to relate sampled populations and species in the coast-ocean direction and in the vertical dimension.</p>					
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Annex 3.- Publications (Total or partially financed by MSI)**3.1.- ISI/WOS Publications or Similar to ISI/WOS Standard****3.1.1 Principal Researchers:**

N°	Title	Quartile*	Authors	Researcher Principal associated with the publication	DOI	Lines of Research	N° principal researchers of the center	Number of researchers of the center another category	N° students	Date of publication
1	Do Differences in Latitudinal Distributions of Species and Organelle Haplotypes Reflect Thermal Reaction Norms Within the <i>Emiliana/Gephyrocapsa</i> Complex?	Q1	Von Dassow PETER., Muñoz P., Pinon S., Velaco-Senovilla E., Anguita-Salinas S..	Von Dassow PETER	10.3389/fmars.2021.785763	A Variable and Changing Ocean. The Deep Ocean.	1	0	0	02-12-2021
2	Abundances and morphotypes of the coccolithophore <i>Emiliana huxleyi</i> in southern Patagonia compared to neighbouring oceans and Northern Hemisphere fjords	Q1	Díaz-Rosas FRANCISCO JAVIER., Alves-de-Souza C., Alarcón E., Menschel E., González H.E., Torres R., Von Dassow PETER	Von Dassow PETER	10.5194/bg-18-5465-2021	A Variable and Changing	1	0	1	08-10-2021
3	Local and remote physical processes driving variability of the planktonic system in the Juan Fernández Archipelago: A multidisciplinary framework providing conservation insights	Q1	Parada CAROLINA EUGENIA., Escribano R., Morales C.E., Ernst B., Cornejo-Guzmán S., Santa Cruz F., Sandoval-Belmar M., Rivara P.,	Escribano Rubén	10.1002/aqc.3499	The Deep Ocean	1	1	0	25-02-2021
4	A source of isotopically light organic carbon in a low-pH anoxic marine zone	Q1	Vargas C.A., Sepúlveda JULIO CÉSAR., De Pol-Holz RICARDO HERNÁN., Schneider WOLFGANG.,	Vargas Cristián Schneider WOLFGANG	10.1038/s41467-021-21871-4	A Variable and Changing Ocean. The Deep Ocean.	2	2	1	18-03-2021

			Cornejo MARCELA ALEJANDRA., Cantarero S., Galán A., Farias L.,							
5	Eurythenes atacamensis sp. nov. (Crustacea: Amphipoda) exhibits ontogenetic vertical stratification across abyssal and hadal depths in the Atacama Trench, eastern South Pacific Ocean	Q3	Weston J.N.J., Espinosa LADY LILIANA., Wainwright J.A., Stewart E.C.D., González C.E., Hidalgo PAMELA DEL CARMEN., Oliva M.E., Escribano R., Ulloa OSVALDO IVÁN	Escribano Rubén, Ulloa OSVALDO IVÁN	10.1007/s12526-021-01182-z	A Variable and Changing Ocean. The Deep Ocean.	2	2	1	14-05-2021
6	Distribution-and-biodiversity-patterns-of-hyperiid-amphipods-across-the-coastal-offshore-gradient-of-the-sub-tropical-southeast-pacific	Q3	Espinosa LADY LILIANA., Escribano R., Riquelme-Bugueño RAMIRO ANTONIO., Corredor-Acosta JULY ANDREA.	Escribano Rubén	10.1007/s12526-020-01152-x	The Deep Ocean.	1	1	1	16-01-2021
7	The cyanobacterium Prochlorococcus has divergent light-harvesting antennae and may have evolved in a low-oxygen ocean	Q1	Ulloa OSVALDO IVÁN., Henríquez CARLOS ANDRÉS., Ramírez-Flandes SALVADOR FRANCISCO., Murillo A.A., M. Plominsky A., Morgan-Lang C., Hallam S.J.	Ulloa OSVALDO IVÁN	10.1073/pnas.2025638118	The Deep Ocean.	1	0	0	16-03-2021
8	Flow cytometry with cell sorting and sequencing as a tool for the study of the stomach microbiota of the Humboldt Current krill (Euphausiacea)	Q3	Henríquez CARLOS ANDRÉS., Franco-Cisterna BELÉN ANAÍ.S., Murillo A.A., Ulloa OSVALDO IVÁN., Riquelme-Bugueño RAMIRO ANTONIO.	Ulloa OSVALDO IVÁN	10.1093/jcbiol/rwab006	The Deep Ocean.	1	1	0	02-04-2021
9	Ocean acidification induces distinct metabolic responses in subtropical zooplankton under oligotrophic conditions and after simulated upwelling	Q1	Osma NATALIA., Vargas C.A., Algueró-Muñiz M., Bach L.T., Gómez M., Horn H.G., ... , Fernández-Urruzola IGOR .	Vargas Cristián	10.1016/j.scitotenv.2021.152252	A Variable and Changing Ocean.	1	2	0	04-12-2021
10	Plankton respiration in the Atacama Trench region: Implications for particulate organic carbon flux into the hadal realm	Q1	Fernández-Urruzola IGOR ., Ulloa OSVALDO IVÁN., Glud R.N., Pinkerton M.H., Schneider WOLFGANG., Wenzhöfer F., Escribano R..	Ulloa OSVALDO IVÁN. Escribano Rubén.	10.1002/Ino.11866	A Variable and Changing Ocean.	2	1	0	11-06-2021
11	Uncovering the Composition and Diversity of Pelagic Copepods in the Oligotrophic Blue Water of the South Pacific Subtropical Gyre	Q1	Medellín-Mora JOHANA., Escribano R., Corredor-Acosta A., Hidalgo PAMELA DEL CARMEN., Schneider WOLFGANG.	Schneider WOLFGANG. Escribano Rubén	10.3389/fmars.2021.625842	The Deep Ocean.	2	2	0	26-07-2021

12	The community structure of hyperiid amphipods associated with two seamount regions in the South-east Pacific	Q3	Espinosa LADY LILIANA., Medellín-Mora JOHANA., Corredor-Acosta JULY ANDREA., Escribano R..	Escribano Rubén	10.1017/S0025315420001344	The Deep Ocean.	1	1	1	14-01-2021
13	Potential virus-mediated nitrogen cycling in oxygen-depleted oceanic waters	Q1	Gazitúa M.C., Vik D.R., Roux S., Gregory A.C., Bolduc B., Winder B., Mulholland M.R., Hallam S.J., Ulloa OSVALDO IVÁN., Sullivan M.B.	Ulloa OSVALDO IVÁN	10.1038/s41396-020-00825-6	The Deep Ocean	1	0	1	01-04-2021
14	Genome-resolved viral ecology in a marine oxygen minimum zone	Q1	Vik D., Gazitúa M. C., Sun C.L., Zayed A. A., Aldunate MONTSERRAT GABRIELA., Mulholland M.R., Ulloa OSVALDO IVÁN., Sullivan M.B.	Ulloa OSVALDO IVÁN	10.1111/1462-2920.15313	A Variable and Changing Ocean.	1	1	0	01-06-2021

**Q5: Ingresar esta opción para aquellos artículos que no posean cuartil.*

3.2.- SCOPUS Publications or Similar to SCOPUS Standard

3.2.1 Principal Researchers:

N°	Title	Quartile	Authors	Researcher Principal associated with the publication	DOI	Lines of Research	N° principal researchers of the center	Number of researchers of the center another category	N° students	Date of publication
1										
2										
3										

3.3.- SCIELO Publications or Similar to SCIELO Standard

3.3.1 Principal Researchers:

N°	Title	Quartile	Authors	Researcher Principal associated with the Publication	DOI	Lines of Research	N° principal researchers of the center	Number of researchers of the center other category	N° students	Date of publication
1										
2										
3										

3.4.- Scientific Books and Chapters

3.4.1 Principals Researchers:

N°	Title	Quartile	Principal Researcher	Source	Volume	Number	Initial page	ISBN	Lines of Research	N° principal researchers of the center	Number of researchers of the center another category	N° students	Date of publication
1													
2													
3													

3.5.- Other Publications

3.5.1 Principals Researchers:

N°	Title	Publication Category	Other Category	Quartile	Authors	Principal Researcher	Lines of Research	N° principal researchers of the center	Number of researchers of the center another category	N° students	Date of publication
1											

2													
3													

3.6.- “ISI/WOS Publications or Similar to ISI/WOS Standard”, “SCOPUS Publications or Similar to SCOPUS Standard” “SCIELO Publications or Similar to SCIELO Standard”, “Books and chapters in books” y “Other Publications [Other Researchers]”:

3.6.1 Other researchers:

N°	Publication Category	Other Category	Quartile	Authors	Title	Source	Volume	Number	Initial page	ISSN	DOI	Lines of Research	N° principal researchers of the center	N° students	Date of publication
1	ISI/WOS o Similar a ISI/WOS standard		Q2	Espinola-Novelo J.F., Oliva M.E..	Spatial and Temporal Variability of Parasite Communities: Implications for Fish Stock Identification	Espinola-Novelo J., Oliva M. (2021) Spatial and Temporal Variability of Parasite Communities: Implications for Fish Stock Identification. MDPI Journal fishes 6 (4): 71-82	6	4	71	2410-3888	10.3390/fishes6040071	The Deep Ocean	1	0	03-12-2021
2	ISI/WOS o Similar a ISI/WOS standard		Q1	Díaz MACARENA., S. Saldías G., Letelier J., Riquelme-Bugueño RAMIRO ANTONIO	Spatial and interannual variability in the distribution of euphausiid life stages in the permanent upwelling system off northern Chile	Díaz-Astudillo, M., Saldías, G.S., Letelier, J., y Riquelme-Bugueño, R. (2022). Spatial and interannual variability in the distribution of euphausiid life stages in the permanent upwelling system off northern Chile. ICES Journal of Marine Science, 79(1), 61-75.	79	1	61	1054-3139	10.1093/icesjms/fsab241	The Deep Ocean	1	1	06-12-2021
3	ISI/WOS o Similar a ISI/WOS standard		Q2	Toro-Chacón J., Tickell F., González R., Victoriano	Aerobic and anaerobic metabolic scaling in the burrowing freshwater	Toro-Chacón J., Tickell F., González R., Victoriano P., Fernández-Urruzola I., Urbina M. (2021) Aerobic and anaerobic metabolic scaling in the	191	4	617	0174-1578	10.1007/s00360-021-01374-w	The Deep Ocean. A Variable and			04-05-2021

			P.F., Fernández- Urruzola IGOR., Urbina MAURICIO ANDRÓNICO.	crayfish <i>Parastacus pugnax</i>	burrowing freshwater crayfish <i>Parastacus pugnax</i> . <i>J Comp Physiol B</i> . 2021 Jul;191(4):617-628.						Changing Ocean.			
4	ISI/WOS o Similar a ISI/WOS standard	Q3	Riquelme- Bugueño RAMIRO ANTONIO., Luppi T., Saldías G. S., Lagos M. E., Urbina MAURICIO ANDRÓNICO., Retamal M. A..	Annual cycle of growth and population structure of the estuarine crab <i>Hemigrapsus crenulatus</i> (Brachyura: Varunidae) off central Chile	Riquelme-Bugueño R., Luppi T., Saldías G., Lagos M., Urbina M., Retamal M. (2021) Annual cycle of growth and population structure of the estuarine crab <i>Hemigrapsus crenulatus</i> (Brachyura: Varunidae) off central Chile.. <i>Journal of the Marine Biological Association of the United Kingdom</i> 1: 343-357.	1	0	343	0025-3154 eISSN:146 9-7769<	10.1017/S0025 315421000333	Variable and Changing Ocean.	2	0	02-06-2021
5	ISI/WOS o Similar a ISI/WOS standard	Q1	Lagos M.E., Castillo NICOLE CECILIA., Albarrán- Mélzer N., Pinochet J., Gebauer J., Urbina MAURICIO ANDRÓNICO.	Age dependent physiological tolerances explain population dynamics and distribution in the intertidal zone: A study with porcelain crabs	Lagos M., Castillo N., Albarrán-Mélzer N., Pinochet J., Gebauer J., Urbina M. (2021) Age dependent physiological tolerances explain population dynamics and distribution in the intertidal zone: A study with porcelain crabs. <i>Marine Environmental Research</i> 169: 1-8.	169	0	1	01411136 eissn:1879 -0291	10.1016/j.mare nvres.2021.10 5343	Variable and Changing Ocean.			01-07-2021
6	ISI/WOS o Similar a ISI/WOS standard	Q1	Aimon C., Simpson S.D., Hazelwood R.A., Bruintjes R., Urbina	Anthropogenic underwater vibrations are sensed and stressful for the shore crab <i>Carcinus maenas</i> *	Aimon C., Simpson S., Hazelwood R., Bruintjes R., Urbina M. (2021) Anthropogenic underwater vibrations are sensed and stressful for the shore crab <i>Carcinus maenas</i> *. <i>Environmental Pollution</i> 285: 1-9.	285	0	1	0269-7491 eISSN:187 3-6424	10.1016/j.envp ol.2021.11714 8	Variable and Changing Ocean.	1	0	15-09-2021

			MAURICIO ANDRÓNICO.											
7	ISI/WOS o Similar a ISI/WOS standard	Q4	Ogawa K., Itoh N., OLIVA M.E..	Emendation of the genus <i>Neoheterobothrium</i> and a proposal of a new genus <i>Paraheterobothrium</i> (Monogenea: Diclidophoridae) for five species of diclidophorids from Pleuronectiform fishes	Ogawa K., Itoh N., Oliva M. (2021) Emendation of the genus <i>Neoheterobothrium</i> and a proposal of a new genus <i>Paraheterobothrium</i> (Monogenea: Diclidophoridae) for five species of diclidophorids from Pleuronectiform fishes. <i>Systematic Parasitology</i> 98: 515-533.	285	0	1	0165-5752 eISSN:1573-5192	10.1007/s11230-021-09993-1	. A Variable and Changing Ocean.	1	0	05-08-2021
8	ISI/WOS o Similar a ISI/WOS standard	Q2	Donoso F., Moreno MARCOS., Ortega-Culaciati F., Bedford J.R., Benavente R.	Automatic Detection of Slow Slip Events Using the PICCA: Application to Chilean GNSS Data	Donoso F., Moreno M., Ortega-Culaciati F., Bedford J., Benavente R. (2021) Automatic Detection of Slow Slip Events Using the PICCA: Application to Chilean GNSS Data. <i>Frontiers in Earth Science</i> 9: 1-12.	9	0	1	EISSN 2296-6463	10.3389/feart.2021.788054	A Variable and Changing Ocean. The Deep Ocean.	1	0	24-12-2021
9	ISI/WOS o Similar a ISI/WOS standard	Q2	Edgar Fernando Dorado-Roncancio, JOHANNA Medellín-Mora & José Ernesto Mancera-Pineda	Taxonomic diversity and ecological attributes of copepods of the Colombian Caribbean Sea	Edgar Fernando Dorado-Roncancio, Johanna Medellín-Mora & José Ernesto Mancera-Pineda (2021) Taxonomic diversity and ecological attributes of copepods of the Colombian Caribbean Sea, <i>Neotropical Biodiversity</i> , 7:1, 491-502,	7	1	491	2376-6808	10.1080/23766808.2021.2000295	0	1	1	01-12-2021

3.5.- Collaborative publications:

Category of Publication	1 researcher		2 researchers		3 researchers		4 or more researchers	
	Nº	%	Nº	%	Nº	%	Nº	%
<i>ISI/WOS Publications or Similar to ISI/WOS Standard</i>	11	47,82 %	7	30,43%	1	4,35%	4	17,39%
<i>SCOPUS Publications or Similar to SCOPUS Standard</i>	0	0,00%	0	0,00%	0	0,00%	0	0,00%
<i>SCIELO Publications or Similar to SCIELO Standard</i>	0	0,00%	0	0,00%	0	0,00%	0	0,00%
<i>Books and chapters</i>	0	0,00%	0	0,00%	0	0,00%	0	0,00%
<i>Other Publications</i>	0	0,00%	0	0,00%	0	0,00%	0	0,00%
<u>Total of publications</u>	11	47,82 %	7	30,43%	1	4,35%	4	17,39%

Annex 4.- Organization of Scientific Events

Scope	Title	Type of Event	City	Country	Responsible Researcher	URL
Internacional	Curso Acidificación del océano y otros estresores asociados al cambio climático: Una mirada desde la ecología evolutiva	Curso	Chile	Concepción	Cristian Vargas Gálvez	https://socioecologiacostera.cl/2021/07/26/acidificacion-del-oceano-y-otros-estresores-asociados-al-cambio-climatico-una-mirada-desde-la-ecologia-evolutiva/
Internacional	Tercer curso BIOMACC “Colecciones Biológicas Marinas y procesos curatoriales”,	Video Conferencia	Colombia-Chile	Concepción	Heraclio Rubén Escribano	https://www.naturalesudec.cl/tercer-curso-biomacc-colecciones-biologicas-marinas-y-procesos-curatoriales/
Internacional	Acidificación del Océano y otros Estresores asociados al cambio climático: Una Mirada desde la Ecología Evolutiva	Seminario	Chile	Concepción	Cristian Vargas Gálvez	

Annex 5.- Education and capacity building**5.1 Capacity Building inside MSI Centers**

MSI RESEARCHER	NUMBER												TOTAL NUMBER PER MSI RESEARCHER		
	Undergraduate students			Graduate students						Postdoctoral researchers					
				Masters			Doctoral								
	F	M	T	F	M	T	F	M	T	F	M	T			
Oscar Pizarro	2	1	3	0	4	4	3	2	5	0	0	0	5	7	12
Samuel Ernesto Hormazábal Fritz Marcela Alejandra Cornejo D'Ottone	0	0	0	4	0	4	0	0	0	0	0	0	4	0	4
Peter von Dassow	1	0	1	0	1	1	0	1	1	0	0	0	1	2	3
Oswaldo Iván Ulloa Quijada	1	0	1	1	0	1	1	1	2	0	0	0	3	1	4
Heraclio Rubén Escribano Veloso	0	0	0	0	0	0	4	0	4	1	2	3	5	2	7
Samuel Ernesto Hormazábal Fritz	0	1	1	3	2	5	0	0	0	1	0	1	4	3	7
Heraclio Rubén Escribano Veloso Marcelo Enrique Oliva Moreno	0	1	1	0	0	0	0	1	1	0	0	0	0	2	2
Pamela del Carmen Hidalgo Diaz	0	2	2	0	1	1	0	0	0	0	0	0	0	3	3
Mauricio Andrónico Urbina Foneron	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
Oscar Roberto Pizarro Arriagada Carolina Eugenia Parada Veliz	1	0	1	0	1	1	0	0	0	0	0	0	1	1	2
Cristian Antonio Vargas Galvez	0	0	0	0	2	2	0	0	0	1	1	2	1	3	4
Wolfgang Schneider	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
Heraclio Rubén Escribano Veloso Ramiro Antonio Riquelme Bugueño	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
Ramiro Antonio Riquelme Bugueño	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1
Mauricio Andrónico Urbina Foneron Heraclio Rubén Escribano Veloso	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1

Julio César Sepúlveda Arellano	0	0	0	0	0	2	0	1	1	0	0	0	0	1	1
Heraclio Rubén Escribano Veloso Pamela del Carmen Hidalgo Diaz	1	1	2	0	0	0	0	0	0	0	0	0	1	1	2
Samuel Ernesto Hormazábal Fritz Oscar Roberto Pizarro Arriagada	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
TOTAL	6	6	12	10	12	22	10	6	16	4	3	7	30	27	57

Annex 5.2. - Short-term Traineeships of MSI students

Listado de Pasantías

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Macarena Paz Díaz Astudillo	Oregon State University	United States of America	Kim Bernard	The main objective was implement additive models spatially explicit that allow explain the variability of abundance of krill in response to multiple factors environmental (local and climatic) and biological (predatory pressure), working with large databases. In addition, this visit will allow establishing collaboration networks between laboratories who study the dynamics of zooplankton populations using the krill as an object of study, as the “Krillab” of Dr. Ramiro Riquelme (UdeC), and the “Krill Seeker Lab”, of the Dr Kim Bernard	12-10-2021	31-01-2022

Listado de Pasantías Externas

Intern Type	Intern Name	Academic Degree	Home Institution	Destination Institution	Country	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Student	Felix Cuello	PhD Student	Universidad de Magdalena	Pontificia Universidad Católica de Valparaíso	Colombia	Obtaining physical and biological satellital data, for compilation of fish catching strategies and data of fish capture for fishing strategy analysis from artisanal fishermen	01-05-2021	31-12-2021

Annex 6.- Networking and other collaborative work**6.1 Formal Collaboration networks**

Network Name	Network Scope	Researchers				Institutions
		From the Center		External		
		Resear chers	Postdo cs/ Stude nts	Resear chers	Postdo cs/ Studen ts	
TROPHIC WEB IN THE DEEP OCEAN: UNDERSTANDING CARBON AND NITROGEN FLOW IN THE MARINE ECOSYSTEM (TROPHO-NET)	I	4	2	0	0	Instituto Español de Oceanografía (IEO) A Coruña, SPAIN
Improving estimates of marine zooplankton production through the neutral red method (ZOOPE-NET)", REDES 180141	I	3	3	0	0	University of Swansea, UK
Technical-scientific Capacity building for new methods for the study of biodiversity BIOMACC	LA	3	16	19	0	Agencia Chilena de Cooperación Internacional (AGCI) Agencia Para la Colaboración de Colombia (APC) Instituto de Investigaciones Marinas y Costeras INVEMAR (Colombia) Universidad de Concepción (UdeC) Instituto Milenio de Oceanografía (IMO)
<i>Latin-American Ocean Acidification Network (LAOCA)</i> , a regional network for synthesis, standardization of chemistry	LA	2	3	27	14	IOC-UNESCO- The Ocean Acidification International Coordination Centre (OA-ICC), the Center for the Study of Multiple-Drivers on Marine Socio-

techniques, capacity building, outreach and communication, and policy issues						Ecological Systems (MUSELS), and the Millennium Institute of Oceanography (IMO), Universidad Santo Tomas, in Chile, Universidad de Buenos Aires, CONICET, in Argentina, Universidade Federal do Rio Grande, Universidade do Estado do Rio de Janeiro, in Brasil
--	--	--	--	--	--	---

NOMENCLATURE:
[Network Scope]
 [N] National [I] International [LA] Latin American

Annex 6.2.- Collaboration Networks

Activity Name	Objective	Description	Co-Participants Institutions	Number of Research from the Center	Number of Postdocs/Students from the Center	Number of External Research	Number of External Postdocs/Students	Product	Name of the Center Principals Researchers Participating in the activity
“Trans media strategies in scientific communication” talk in RedPOP congress	To present IMO’s experience in the development of transmedia platforms.	We carried out a virtual conference at the XVII Congress of RedPOP, as part of our active participation as partners of the network.	RedPOP (Network for the Popularization of Science and Technology in Latin America and the Caribbean)	0	0	0	0	Conference	Network for the Popularization of Science and Technology in Latin America and the Caribbean

Annex 7. - Outreach**7.1. - Outreach activities throughout the period**

Event Title	Type of Event	Scope	Target Audience	Date	Country	Region	N° of Student from the Center	N° of Attendees	Duration in days	Participating Researchers	Responsible for the activity
Atacama school camp	Scientific camp	National	Primary students	21-01-21	Chile	Atacama	0	80	2		Bárbara Léniz Genta
Conference at Pto Ideas science festival	Conference	National	General publ Primary students Secondary students	16-04-21	Chile	Antofagasta	0	60	1	Heraclio Rubén Escribano Veloso.	Rubén Escribano
Book presentation "Travesía al Inframundo"	Conference	National	General publ	28-05-21	Chile	Bío Bío	0	70	1	Oswaldo Ulloa	Oswaldo Ulloa
Oceanic culture activity	Conference	National	Primary students Secondary students	08-06-21	Chile	Bío Bío	0	170	1		Bárbara Léniz Genta
Book launching "Travesía al Inframundo"	Conference	National	General publ	08-06-21	Chile	Bío Bío	0	100	1	Oswaldo Ivá Ulloa Quijada.	Oswaldo Ulloa

Conversatory "DOCE"	Conference	National	General publ	09-06-21	Chile	Bío Bío	0	30	1	Oswaldo Ulloa	Oswaldo Ulloa
"Open science" talk	Conference	National	Secondary students General publ	22-06-21	Chile	Bío Bío	0	80	1		Felipe Gamonal
"Open Science" talk	Conference	National	General publ	29-06-21	Chile	Bío Bío	0	80	1		Bárbara Léniz Genta
"Ocean acidification" talk	Conference	National	Secondary students	29-06-21	Chile	Bío Bío	0	25	1		Bárbara Léniz Genta
"Open Science" Talk	Conference	National	General publ	01-07-21	Chile	Bío Bío	0	30	1		Bárbara Léniz Genta
Teacher training	Seminar	National	Primary teachers Secondary teachers	20-08-21	Chile	Bío Bío	0	60	1		Felipe Gamonal
IMO chapter in "Exploradores" serie	Interview	National	General publ	25-08-21	Chile	Metropolitan de Santiago	0	5000	1		Bárbara Léniz Genta
"The taste of knowledge" (El sabor del saber)	Conference	National	General publ	26-08-21	Chile	Bío Bío	0	50	1		Bárbara Léniz Genta
Teacher training	Seminar	National	High school teachers	27-08-21	Chile	Bío Bío	0	60	1		Bárbara Léniz Genta

			Primary students								
Illustration and stories workshop	Workshop	National	Primary students	21-10-21	Chile	Bío Bío	0	20	1		Felipe Gamonal
Conference in Red POP	Conference	International	General publ	24-10-21	Chile	Bío Bío	0	50	1		Pablo Rosenblatt

7.2.- Articles and Interviews

Type of media and scope	Local/Regional		National		International		TOTAL
	N° Interviews	N° Articles	N° Interviews	N° Articles	N° Interviews	N° Articles	
Written	3	5	3	2	0	1	14
Internet	5	10	2	13	0	13	43
Audiovisual	4	2	7	4	1	1	19
TOTAL	12	17	12	19	1	15	76

Annex 8. - Connections with other sectors:

Activity	Type of Connection [Number]	Type of Activity [Number]	Institution Country	Agent Type [Number]	Economic Sector
Participation in Round Table about OIF and London Protocol	2	7	Chilean Ministry of Foreign Affairs (MINREL)	2	Public Service - Government

Note: Dr. Von Dassow and Dr. Morales presented in a round table meeting with various Chilean ministries organized by MINREL, as part of the working group to evaluate scientific data to make decisions about OIF and the 2013 Amendment “London Protocol”.

NOMENCLATURE:

[Type of Connection] [1] Services Contract [2] Cooperation Agreement

[Type of Activity] [1] Development of Studies [2] Project Implementation [3] Training [4] Prospective Activity [5] Scientific Training [6] Installation of Scientists [7] Others (specify at the table foot other types of activity)

[Agent Type] [1] Industry and Services [2] Organizations and Public Services [3] Educational Sector

Annex 9.- Total Funding:¹

Funds	2021 Sources of Funding	
	Amount [\$]	Percentage of resources used by the Center [%]
MSI Funds *	852.799.100	91,26
Other Public Funds to IMO**	988.869.445	67,89
Concurrent Public and private Funds not managed by IMO	811.253.000	19,96
Income from services and other	54.006.963	80,86
Private funds - Donations	20.000.000	100
TOTAL	2.726.928.508	61,43

*: Include PME (Projection to External Medium) funds

** : FONDEQUIP MAYOR (Funds from Science Ministry to build up and install a Deep-Sea Observation System)

¹ Para aquellas fuentes de financiamiento con el mismo origen, se debe realizar sólo un ingreso con el valor total de la fuente de financiamiento y no ingresar uno a uno estos montos.

Annex 10.- Outstanding Activities

Name of the activity relevant in your discipline	Type of activity relevant in your discipline carried out	Description of the relevant activity in your discipline	Importance in your discipline of the activity	Possibility to maintain or replicate this activity
First popular science book "Journey to the Underworld: The Atacama Trench"	Science divulgation - Outreach	introduces scientific exploration of the deep sea and emphasizes the knowledge of the Atacama Trench	This is a milestone in our discipline, because it is the first book about deep ocean in the country	It is difficult because of time demand of writing a book, but possible