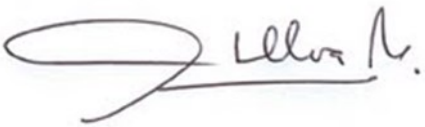



<b>Name of the Center:</b> <b>Millennium Institute of Oceanography - Instituto Milenio de Oceanografía</b>	
Type (Institute or Nucleus)	INSTITUTE ICN12_019
Acronym	IMO
Reported period	January 1 to December 31, 2022
Starting date of the Center	DECEMBER 26, 2013
Web Page	<a href="http://www.imo-chile.cl">http://www.imo-chile.cl</a>
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 \$ 969.977
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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**

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. In 2022, IMO completed its 9th year carrying out research of excellence on oceanography in the Eastern South Pacific, contributing to education and building capacity to promote the formation of new scientists and professionals involved in marine sciences in Chile, and communicating scientific findings to the Chilean society.

IMO has focused the investigation on two research lines: Adaptation to a Changing Ocean (Line 1) and the Deep Ocean Ecosystem (Line 2). In Line 1 the key scientific questions relate to how the biogeochemical flows, community composition, and population structure of key species correlate with physical oceanographic drivers, comparing how biogeochemical processes are affected in norm-oxic, the oxygen minimum zone (OMZ), and the anoxic marine zone (AMZ), and how key communities and organisms respond to a changing ocean. Line 2 deals with the physical, geophysical and biogeochemical characteristics of deep and ultra-deep waters of the Eastern South Pacific, and how these can affect the diversity and functional structure of pelagic communities. Since 2022 IMO has also added a geoscience program (within Research Line 2) by linking oceanography with geology and geophysics.

During 2022, IMO consisted of 33 researchers: 6 associate researchers, 3 senior researchers, 12 adjunct researchers, 4 young researchers, 7 postdocs and 1 early career scientist. 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). There were also 16 professionals/technicians and assistants, 5 administrative staff, and 34 students (8 undergraduate, 12 M.Sc., and 14 Ph.D.). During this period, there was 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. Regarding organization of research actions, Drs. Cristian Vargas and P. von Dassow lead Research Line 1 while Drs. R. Escribano and O. Ulloa lead Research Line 2. Also, 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.

For research line 1, important progress has been made in understanding the functioning of anoxic (AMZ) and oxygen minimum zones (OMZ), regarding microbial communities. For instance, we found that when a secondary Chlorophyll maximum (SCM) occurred below the oxycline, the basal anoxic lineages of *Prochlorococcus* were the most important contributors to carbon cycling, while in the absence of the SCM, chemoautotrophic activity driven by anammox or sulfur-oxidizing bacteria could be more important in the carbon cycle. Also low pH/low O<sub>2</sub> conditions influence the vertical distribution of phototrophic pico-nanoplankton and these algal cells cannot survive being exposed to low pH/low O<sub>2</sub>. We further developed the testable hypotheses that most modern ocean phytoplankton have a higher-than-expected requirement for O<sub>2</sub>. On the other hand, the biogeochemical role of zooplankton may decrease under future ocean conditions, evidenced by a significant decline in the role of this group in remineralization of organic matter and nitrogen regeneration in the ocean. However, our research

reinforces the idea that local adaptation to high-pCO<sub>2</sub> environments allows organisms to develop compensatory mechanisms to maintain fitness, and therefore, the present pCO<sub>2</sub> natural variability needs to be considered while interpreting experimental results.

With respect to Research Line 2, we found that freshly produced C in the coastal upwelling zone can be physically transported offshore and becoming available for the deep layers through passive and active downward fluxes of C and N. In the same context, we found that zonal gradients regulate the pathways of C and N through the pelagic food web from shallow coastal towards oceanic deep-ocean waters. We revealed a high diversity of pelagic metazoan from surface to deep and ultradeep (>6000 m) waters in the Atacama and Kermadec trenches, while a novel and highly structured diversity of zooplankton inhabits the water column above the Atacama Trench. We also found that intact cell membrane polar lipids (IPLs) in hadal sediments from the Atacama Trench derive predominantly from in situ microbial biomass and production, while the export of the more labile lipid component from organic matter produced in the euphotic zone and in the zone of minimum oxygen in the mesopelagic zone it is negligible.

In 2022 IMO researchers, along with their students and collaborators, published 19 scientific articles, including 1 book and 1 book chapter, and gave more than 30 presentations in national and international conferences. Regarding educational activities, a total number of 34 students (graduate and undergraduate) carried on their thesis at IMO in 2022 of which 2 PhDs and 3 MSc's graduated. 7 postdoc positions and 1 early career scientist conducted research at IMO during 2022, either funded by IMO or with external funding.

IMO researchers actively participated in several collaborative international networks during 2022 through which training courses, workshops, and conferences were organized and held, as well as the realization of intercalibrations experiments on modern methods to study biogeochemical processes and biological diversity in the ocean. Networking activities also promoted and prioritized the participation and involvement of our students in international initiatives and projects. A key collaboration was established with Victor Vescovo (USA) to carry out a joint expedition at the Atacama Trench aboard the R/V Pressure Drop and to perform human-tripulated immersions to the bottom of the trench.

With respect to technological development and linking to society, IMO established the Center for Oceanographic Instrumentation (CIO) at University of Concepción which is led by IMO researcher O. Pizarro. This Center will help IMO strengthen links with partners at national and international levels by providing oceanographic advice and service.

IMO continued developing outreach activities in 2022. Various outstanding activities and projects complemented the “Atacamex” documentary and the book “A Journey into the Underworld”. Among them the “Atacamex: Deep-Sea Science exhibit”, launched by IMO in cooperation with the University of Concepción's Interactive Center of Sciences, Arts, and Technology (CICAT), was very successful. Between its opening in May 2022 and March 2023, it received 15,500 visits by children of all ages, university students, and families. IMO also continued developing video games, stories and documentaries for public media. All these activities and products have become successful and popular in Chilean society, touching all age groups.

## **1.2 Resumen Ejecutivo**

El Instituto Milenio de Oceanografía (IMO) es un centro de excelencia establecido a fines de 2013, con el objetivo de explorar e investigar el océano abierto y profundo. En 2022, IMO cumplió 9 años desde su fundación, dedicando esfuerzos, tiempo y recursos para llevar a cabo nuestra investigación de excelencia en oceanografía en el Pacífico Sur Oriental, contribuyendo en la educación y la creación de capacidades para promover la formación de nuevos científicos y profesionales involucrados en la marina, ciencias en Chile, y comunicando sus hallazgos científicos a la sociedad chilena.

IMO ha enfocado la investigación en dos líneas de investigación: Adaptación a un Océano Cambiante (Línea 1) y el Ecosistema del Océano Profundo (Línea 2). En la Línea 1, las preguntas científicas clave se relacionan con cómo los flujos biogeoquímicos, la composición de la comunidad y la estructura de la población de especies clave se correlacionan con los forzantes oceanográficos físicos, comparando cómo los procesos biogeoquímicos se ven afectados en normoxia, en la zona mínima de oxígeno (OMZ) y en la zona anóxica marina (AMZ), y cómo las comunidades y organismos clave responden a un océano cambiante. La línea 2 trata sobre las características físicas, geofísicas y biogeoquímicas de las aguas profundas y ultraprofundas del Pacífico Sur Oriental, y cómo éstas pueden afectar la diversidad y estructura funcional de las comunidades pelágicas. Desde 2022, IMO también ha agregado un programa de geociencias (dentro de la Línea de investigación 2) mediante la vinculación de la oceanografía con la geología y la geofísica.

Durante 2022, IMO consistió en 33 investigadores: 6 investigadores asociados, 3 investigadores senior, 12 investigadores adjuntos, 4 investigadores jóvenes, 7 postdoctorados y 1 científico de carrera temprana. Los investigadores asociados: Dres. Osvaldo Ulloa (Director), Rubén Escribano (Subdirector), Oscar Pizarro, Wolfgang Schneider y Cristian Vargas (de la Universidad de Concepción, UdeC) y Peter von Dassow (de la Pontificia Universidad Católica de Chile, PUC). También hubo 16 profesionales/técnicos y auxiliares, 5 administrativos y 34 estudiantes (8 de pregrado, 12 de maestría y 14 de doctorado). Durante este período se contó con un equipo de extensión (liderado por Pablo Rosenblatt, Director de Extensión), una oficina administrativa central con sede en la UdeC (liderada por Atilio Morgado, Director Ejecutivo) y un equipo de desarrollo y transferencia de tecnología (establecido en 2016) liderado por Ing. Víctor Villagrán. En cuanto a la organización de las acciones de investigación, los Dres. Cristian Vargas y P. von Dassow lideran la Línea de Investigación 2, mientras que los Dres. R. Escribano y O. Ulloa lideran la Línea de Investigación 1. Además, cada año, los investigadores asociados se reúnen al inicio para definir las prioridades de investigación anuales de cada línea, así como para la educación, la divulgación y el desarrollo y transferencia de tecnología, y el presupuesto es asignado de acuerdo con estas prioridades.

Para la línea de investigación 1, se ha logrado un importante progreso en la comprensión del funcionamiento de las zonas anóxica (AMZ) y mínima de oxígeno (OMZ), con respecto a las comunidades microbianas. Por ejemplo, encontramos que cuando ocurre una clorofila máxima secundaria (SCM) bajo la oxiclina, los linajes anóxicos basales de *Prochlorococcus* fueron los más importantes contribuyentes al reciclaje de carbono, mientras que, en ausencia de tal SCM, la actividad quimioautotrófica impulsada por Anammox o bacterias oxidantes de azufre sería más importante en el reciclaje del carbono. Además, que las condiciones de pH bajo/O<sub>2</sub> bajo influyen en la distribución vertical del pico-nanoplancton fototrófico y que estas células algales no pueden sobrevivir a la exposición a pH bajo/O<sub>2</sub> bajo. Desarrollamos aún más las hipótesis testeable de que la mayoría del fitoplancton oceánico moderno tiene un requerimiento de O<sub>2</sub> más alto de lo esperado. Por otra parte, el

rol biogeoquímico del zooplancton puede decrecer bajo las condiciones oceánicas futuras, evidenciado por una disminución significativa del papel de este grupo en la remineralización de la materia orgánica y la regeneración de nitrógeno en el océano. Sin embargo, nuestra investigación refuerza la idea de que la adaptación local a ambientes de alta pCO<sub>2</sub> permite a los organismos desarrollar mecanismos compensatorios para mantener la aptitud y, por lo tanto, la variabilidad natural actual de pCO<sub>2</sub> debe tenerse en cuenta al interpretar los resultados experimentales.

Con respecto a la Línea de investigación 2, encontramos que el C recién producido en la zona de surgencia costera puede transportarse físicamente mar adentro y llegar a estar disponible para las capas profundas a través de flujos descendentes pasivos y activos de C y N. En el mismo contexto, se encontró que los gradientes zonales regulan las vías de C y N a través de la trama trófica pelágica desde las aguas costeras poco profundas hacia las aguas oceánicas profundas. Revelamos una alta diversidad de metazoos pelágicos desde aguas superficiales hasta aguas profundas y ultraprofundas (>6000 m) en las fosas de Atacama y Kermadec, y a su vez una nueva y altamente estructurada diversidad de zooplancton como habitantes de la columna de agua sobre la Fosa de Atacama. También encontramos que los lípidos polares de membrana celular intacta (IPL), en los sedimentos hadales de la Fosa de Atacama, derivan predominantemente de la producción y biomasa microbiana in situ, mientras que la exportación de componentes lipídicos más lábiles de la materia orgánica producida en la zona eufótica y en la zona de mínimo oxígeno en la zona mesopelágica es insignificante.

En 2022 los investigadores del IMO, junto con sus estudiantes y colaboradores, publicaron 19 artículos científicos y realizaron más de 30 presentaciones en conferencias nacionales e internacionales. En cuanto a las actividades educativas, un total de 34 estudiantes (graduados y de pregrado) realizaron su tesis en IMO en 2022, de los cuales se graduaron 2 PhDs y 3 MSc. Mientras que 7 investigadores postdoctorales y 1 científico joven (científico de carrera inicial), realizaron sus investigaciones en IMO durante 2022, ya sea financiado por IMO o con financiamiento externo.

Los investigadores de IMO participaron activamente en varias redes internacionales de colaboración durante 2022, a través de las cuales se organizaron y realizaron cursos de entrenamiento, talleres y conferencias, así como realizaron experimentos de intercalibración sobre métodos modernos para estudiar procesos biogeoquímicos y diversidad biológica en el océano. Las actividades de redes también promovieron y priorizaron la participación y compromiso de nuestros estudiantes en iniciativas y proyectos internacionales. Se estableció una colaboración clave con Victor Vescovo (EE. UU.) para llevar a cabo una expedición conjunta a la Fosa de Atacama a bordo del R/V Pressure Drop y realizar inmersiones tripuladas por humanos hacia el fondo de la fosa.

Con respecto al desarrollo tecnológico y la vinculación con la sociedad, IMO estableció el Centro de Instrumentación Oceanográfica (CIO) en la Universidad de Concepción, el cual es liderado por el investigador de IMO O. Pizarro. Este Centro ayudará a fortalecer los vínculos de IMO con socios a nivel nacional e internacional proporcionando asesoramiento y servicios oceanográficos.

IMO continuó desarrollando actividades y acciones para llegar a la sociedad en general en 2022. Varias actividades y proyectos destacados complementaron el documental “Atacamex” y el libro “Un viaje al inframundo”. Entre ellos, la “Exhibición Atacamex: Ciencia del Océano Profundo” fue muy exitosa, lanzada por IMO en cooperación con el Centro Interactivo de Ciencias, Artes y Tecnología (CICAT) de la Universidad de Concepción. Entre su apertura en mayo de 2022 y marzo de 2023, fue visitado más de 15.500 niños de todas las edades, universitarios y familias. IMO también continuó desarrollando videojuegos, historias y documentales para medios públicos. Todas estas actividades y productos se han vuelto muy exitosos y populares en la sociedad chilena, llegando a todas las edades.

### **1.3. Outstanding Achievements**

Highly significant scientific achievements were obtained regarding responses and potential adaptations of key species to ocean acidification and deoxygenation, as described in recently published works in high-impact journals. Also, important progress has been made in describing and understanding the metazoan and microbial diversity and their functioning in the deep ocean ecosystem of the Southeast Pacific.

A collaboration was established with Victor Vescovo (USA) to carry out a cruise, which was originally planned for December 2022, but conducted in January 2023, in which two human-tripulated immersions at the deepest points of the Atacama Trench were executed. This is certainly a major achievement for IMO from scientific and historical viewpoints.

The establishment of a Center for Oceanographic Instrumentation (CIO) at UdeC associated with IMO and led by IMO researcher O. Pizarro should also be considered a significant achievement in the framework of technological development for ocean research. CIO will strengthen our interactions and links with public institutes and universities in Chile and the region which require our services for maintenance and calibration of oceanographic equipment.

During 2022 IMO was granted ship time funding from the ANID to carry out a cruise during 2023. The main goal of this expedition will be the installation of our deep ocean mooring at the Atacama Trench which constitutes the key objective of our IDOOS Project.

## **2- Introduction**

### ***a) Description of the Institute/Nucleus:***

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 ninth 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 2022, its ninth 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 includes 16 professionals/technicians and assistants, 5 administrative staff, as well as 38 students (8 undergraduate, 16 M.Sc., and 14 Ph.D.).

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 led Research Line 1.

During 2022 the Center of Oceanographic Instrumentation (CIO) was established as funded by ANID and led by IMO associate Researcher O. Pizarro. This Center became a key component of IMO in the framework of Technological Development and links with other Centers and Universities in Chile and the region.

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.

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

#### a) **Current status of research lines:**

Significant progress has been made in both research lines during 2022 to achieve the scientific goals. However, as for difficulties and challenges, during 2022 we were still emerging from the pandemic lockdowns of 2020 and 2021. While we continued to be productive relying largely on data and samples collected in 2019 and before, we also dedicated time and resources to re-activate lab and field activities, which in many cases involve training or retraining personnel. This situation is reflected in our scientific productivity of 2022 which we firmly believe will significantly increase in the upcoming year. Detailed achievements and status of both research lines are as follow:

**Research Line 1: Adaptation to Changing Ocean.** IMO engaged our graduate students and postdocs with interdisciplinary approaches to confront complex problems associated with this research line. We achieved important progress in understanding the functioning of anoxic (AMZ) and oxygen minimum zones (OMZ), especially with regards to the study of microbial communities. For instance, during 2022 IMO postdoctoral researcher **Montserrat Aldunate** lead a study, together with associates, **Ulloa, Vargas,** and **Von Dassow,** focused on evaluating the carbon assimilation by the picoplanktonic community inhabiting the secondary chlorophyll maximum (SCM) below the oxycline of the Anoxic Marine Zones (AMZ) of North and South Pacific Ocean. We found that when the SCM was developed, the basal anoxic lineages of *Prochlorococcus* (**Ulloa et al. 2021**) were important contributors to carbon cycling. When the SCM was not developed, chemoautotrophic activity driven by anammox or sulfur-oxidizing bacteria could be more important in the carbon cycle, highlighting the importance of understanding the phototrophic versus chemoautotrophic processes in these oceanic areas (**Aldunate et al. 2022**), and expanding on results previously reported by **Vargas et al. (2021)**.

IMO MSci student **Edson Piscoya**, under the supervision of associates **Vargas** and **von Dassow**, as well as **Aldunate**, published a study evaluating the relative influence of environmental factors that might control the coexistence and vertical distribution of pico-nanoplankton associated with the OMZ off northern Chile (**Piscoya et al. 2022**). The study combined fieldwork with experiments upon low pH/low O<sub>2</sub> conditions at the laboratory, and evidenced that temperature, oxygen, and carbonate chemistry parameters (pH and dissolved inorganic carbon, DIC) might influence significantly the vertical distribution of phototrophic pico-nanoplankton. Moreover, laboratory experiments with the nanophytoplankton *Imantonia* sp., isolated from the OMZ of northern Chile, demonstrated that these algal cells did not survive exposure to low pH/low O<sub>2</sub> levels mimicking conditions in the OMZ oxycline. Recent IMO postdoc **Jane C. Y. Wong** and associate **von Dassow** led a study (**Wong et al. 2023**) reviewing information on photosynthetic organisms in the oxycline, and, to explain the existence of the chlorophyll minimum in the oxycline above the SCM, developed testable hypotheses that most modern ocean phytoplankton have a higher-than-expected requirement for O<sub>2</sub>. Additionally, (former) postdoctoral researcher **Carlos Henríquez-Castillo** led a “metaomics” study that revealed the contribution of the *Alteromonas* bacteria to the carbon cycling in OMZs.

Our postdoctoral researchers also participated in international initiatives aiming to understand the future impact of ocean acidification (OA) on zooplankton communities by using mesocosm approaches. For instance, **Natalia Osma** published a mesocosm study evaluating the combined effects of OA and nutrient availability on the physiology of micro-and mesozooplankton communities in the subtropical northeast Atlantic Ocean. The study was carried out in the framework of the BIOACID Program (Biological Impacts of Ocean ACIDification), hosted by the Plataforma Oceánica de Canarias (PLOCAN). Overall, the results of this study indicate a potential decline in the biogeochemical role of

zooplankton under future ocean conditions, evidenced by a significant decline in the role of this group in remineralization of organic matter and nitrogen regeneration in the ocean (**Osma et al. 2022**).

The year 2022 was also a year for the consolidation of high-impact studies published by some of our associates. For instance, associate **Vargas** and international collaborators Dr. Juan Diego Gaitán-Espitia from the University of Hong Kong, together with a group of Chilean and Swedish scientists, published a novel article in *Nature Climate Change* focused on evaluate how upper environmental pCO<sub>2</sub> levels in coastal ocean can determine the sensitivity to future ocean acidification (OA) scenarios in different populations of marine invertebrates at global scale. For such purposes, scientists compiled and analyzed pCO<sub>2</sub> data from global repositories and oceanographic buoys, as well as results from experimental studies examining the effects of pCO<sub>2</sub> on biological traits in marine invertebrates. The article reinforces the idea that local adaptation to high-pCO<sub>2</sub> environments allows organisms to develop compensatory mechanisms to maintain fitness, and therefore, the need to consider present pCO<sub>2</sub> natural variability while interpreting experimental results (**Vargas et al. 2022**). IMO associate **von Dassow** published an invited commentary in *PNAS* synthesizing results from decades of research with new electrophysiological results to explain why coccolithophore calcification is more sensitive to low pH/high CO<sub>2</sub> than predicted from the calcium carbonate saturation state of seawater.

In the framework of understanding the ocean carbon cycle in the Southeast Pacific Region, in the past year associate **Vargas** collaborated on an international study aiming to characterize the isotopic signature of the dissolved inorganic carbon pool (DIC). Results from this study had significant implications for the interpretation of paleoceanographic records, which are typically collected from the continental margin rather close to the coast. The study was published in *Journal of Geophysical Research, Oceans* (**Reyes-Macaya et al. 2022**).

Our ECLIPSE (El Niño and Climate Change) Project led by IMO researcher V. Aguilera has shown that at the tropical convergence (30° S), coastal upwelling persists throughout the year, promoting the ascent of CO<sub>2</sub> saturated (>700 uatm) subsurface water lowering the pH (<7.7) and reaching near surface waters. These continuous observations will be highly relevant as current predictions suggest an El Niño is developing this year.

In terms of ocean deoxygenation, Urbina and international collaborators (Verberk et al. 2022) have published a high impact manuscript describing how the interaction between temperature and cell size shapes hypoxia tolerance on fish globally. On a local scale, Urbina and co workers have successfully measured hypoxia tolerance on 12 organisms (from gelatinous plankton, copepods, crustaceans to fish) inhabiting in the boundaries of the oxygen minimum zone, allowing an a more ecological and broader scale evaluation of the impacts of ocean deoxygenation on Chilean pelagic communities (paper in prep.).

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**Aldunate, M.; von Dassow, P.; Vargas, C.A.; Ulloa, O.** 2022. Carbon assimilation by the picoplanktonic community inhabiting the secondary chlorophyll maximum of the Anoxic Marine Zones of the Eastern Tropical North and South Pacific. *Frontiers in Marine Science* 9:858308. doi: 10.3389/fmars.2022.858308

**Henríquez-Castillo, C., Plominsky, S. Ramírez-Flandes, S. Bertagnolli, A.D., Stewart F. J., O. Ulloa, O.** (2022). Metaomics unveils the contribution of alteromonas bacteria to carbon cycling in marine oxygen minimum zones. *Frontiers in Marine Science*, 9: 993667. doi: 10.3389/fmars.2022.993667.

**Osma, N.; Vargas, C.A.;** Algueró-Muñiz, M.; Bach, L.T.; Gómez, M.; Horn, H.GG.; Ludwig, A.; Packard, T.T.; Riebesell, U.; Romero-Kutzner, V.; Taucher, J.; **Fernández-Urruzola, I.** (2022) Ocean acidification induces distinct metabolic responses in subtropical zooplankton under oligotrophic conditions and after simulated upwelling. *Science of the Total Environment* 810, 152252.

**Piscoya, E.; von Dassow, P.; Aldunate, M.; Vargas, C.A.** 2022. Physical-chemical factors influencing the vertical distribution of phototrophic pico-nanoplankton in the Oxygen Minimum Zone (OMZ) off Northern Chile: The relative influence of low pH/low O<sub>2</sub> conditions. *Marine Environmental Research* 180, 105710

**Vargas, C.A.;** Cuevas, L.A.; Broitman, B.R.; San Martin, V.A.; Lagos, N.A.; **Gaitán-Espitia, J.D.;** Dupont, S. 2022. Upper environmental pCO<sub>2</sub> drives sensitivity to ocean acidification in marine invertebrates. *Nature Climate Change*, 12, 200-207. <https://doi.org/10.1038/s41558-021-01269-2>

Verberk, W. C. E. P., Sandker, J.F., van de Pol, I.L.E., **Urbina, M.A.**, Wilson, R.W., McKenzie, D.J., Leiva, F.P. 2022. Body mass and cell size shape the tolerance of fishes to low oxygen in a temperature-dependent manner

**von Dassow, P.** Voltage-gated proton channels explain coccolithophore sensitivity to ocean acidification. *Proceedings of the National Academy of Sciences USA*. 119 (25) e2206426119. <https://doi.org/10.1073/pnas.2206426119>

**Wong, J. C.-Y.,** Raven, J. A., **Aldunate, M.**, Silva, S., Gaitán-Espitia, J. D., **Vargas, C., Ulloa, O., von Dassow, P.** 2023. Do phytoplankton require oxygen to survive? A hypothesis and model synthesis from Oxygen Minimum Zones. *Limnology and Oceanography*. doi: 10.1002/lno.12367

**Research Line 2: The Deep Ocean.** Research efforts on the deep ocean system during 2022 were mostly devoted to complete analysis of data and samples collected during the expeditions ATACAMEX (February 2018), SONNE (February-March 2018) and EPIC (February 2019) along with occasional captures of deep-sea fishes at northern Chile. Much time was also devoted to preparing the proposal for funding for ship-time to carry out the IDOOS expedition. The proposal was approved for funding by ANID and the expedition will be carried out during September 2023.

One of the key questions that IMO research has addressed in the last few years relates to the main sources of organic Carbon fueling the deep ocean ecosystem in the Southeast Pacific. Previous work by **Fernández-Urruzola et al. (2021)** suggested that passive vertical fluxes of C may satisfy the C demand of planktonic communities at deep and ultra-deep (>4000 m) waters in the upwelling zone. In the same context, using data on isotopic signatures in N and C of zooplankton from a previous cruise performed in 2016 at central-Chile, we showed that freshly produced C in the coastal upwelling zone carried on by primary and secondary producers can be laterally transported offshore by physical processes and then becoming available for the deeper layers through passive and active downward flux of C and N (**González et al. 2022**). A complementary finding, also using isotopic signatures of C and N from zooplankton samples obtained during the EPIC cruise, showed how the zonal oceanographic gradient can regulate the pathways of C and N through the pelagic food web from shallow coastal vs oceanic deep-ocean waters (**Fernández-Urruzola et al., 2022**)

By means of molecular markers applied on eDNA samples from the Atacama and Kermadec trenches, we have revealed a high diversity of pelagic metazoan from surface to deep and ultradeep (>6000 m) waters, particularly in the Atacama Trench, much of it represented by unknown species or even higher taxonomic categories (**Ramírez-Flandes et al. submitted**). We have also continued with the analysis of the hadal pelagic microbial communities, using a combination of metabarcoding, metagenomics and single-cell genomics.

The composition and distribution of intact cell membrane polar lipids (IPLs) extracted from surface sediments around the deepest points of the Atacama Trench and the adjacent bathyal margin were analyzed. The results show (**Flores et al., 2022**) that the lipid characteristics —such as the degree of saturation— in the Atacama Trench sediments are more related to those found in bathyal sediments than to those previously reported for the near-surface ocean water column in the region. These results, therefore, indicate that IPLs in hadal sediments from the Atacama Trench derive predominantly from in situ microbial biomass and production, while the export of the more labile lipid component from organic matter produced in the euphotic zone and in the zone of minimum oxygen in the mesopelagic zone it is negligible.

Based on molecular approaches, we applied metabarcoding analysis to net-tow samples down to 5000 m, revealing a novel, highly structured, and unknown diversity of zooplankton inhabiting above the Atacama Trench (**González et al., submitted**).

Regarding the functioning of the deep-sea food web, we have used biochemical markers to assess trophic interactions of pelagic organisms. In particular, stable isotope signatures from deep-sea fishes captured by the large MOCNESS net during the R/V Sonne cruise revealed the food web structure and prey-predator relationships of carnivore fishes (Ñacari et al. accepted). We have continued characterizing and describing symbiotic species associated with deep-sea fishes, such as those related to the scavenger “grenadiers” (Ñacari et al. 2022), and also describing the genetic diversity of demersal (>200 m) hakes (**Oliva et al., 2022**).

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**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.

**Fernandez-Urruzola, I., Bode, A., Loick-Wilde, N., Schneider, W., Lindsay, D., Escribano, R.** 2022. Trophic ecology of midwater zooplankton along a productivity gradient in the Southeast Pacific. *Frontiers in Marine Science*. 10:1057502. DOI [https://10.3389/fmars.2023.1057502](https://doi.org/10.3389/fmars.2023.1057502)

**Flores, E., Cantarero, S. I., Ruiz-Fenández, P., Dildar, N., Zabel, M., Ulloa O., Sepúlveda, J.** (2022). Bacterial and eukaryotic intact polar lipids point to in situ production as a key source of labile organic matter in hadal surface sediment of the Atacama Trench. *Biogeosciences*, 19: 1395-1420. <https://doi.org/10.5194/bg-19-1395-2022>

**González, C.E., Bode, A., Fernández-Urruzola, I., Hidalgo, P., Oerder, V., Escribano, R.** 2022. The lateral transport of zooplankton explains trophic and taxonomic similarities over the zonal gradient of central Chile. *Journal of Marine Systems*. <https://doi.org/10.1016/j.jmarsys.2022.103840>

**González, C.E.,** Blanco-Bercial, L., **Escribano, R.,** **Fernández-Urruzola, I.,** **Rivera, R.,** **Ulloa, O.** 2023. Biodiversity of zooplankton in the midnight zone. Proceeding of the National Academy of Sciences (under revision).

Ñacari, L., **Escribano, R. Oliva, M.E,** 2022. Endoparasites and diet of the “bigeye grenadier” *Macrourus holotrachys* Günther, 1878 from the deep sea in the Southeastern Pacific Ocean. Deep Sea Research, Part-I 103903. <https://doi.org/10.1016/j.dsr.2022.103903>

**Oliva, M.E.;** Cárdenas, L.; Valdivia, I.M.; Bruning, P.; Figueroa-Fabrega, L.; **Escribano, R.** 2022. Spatial Pattern of Genetic Diversity in the Blood Fluke *Aporocotyle argentinensis* (Digenea, Aporocotylidae) from South American Hakes (Pisces: Merluccidae). Diversity 2022, 14, 772. <https://doi.org/10.3390/d14090772>

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

#### b) **Productivity:**

This period we published 19 articles, 17 in journals, 1 chapter of book and a Guide-book. The 17 articles were published in peer-reviewed journals in 2022, 76% in Q1 journals and 60% were related to Line 1, 30% to Line 2 and 10% to both lines. From the total, 12 articles were authored or co-authored by IMO Associate Researchers, resulting in 2 articles per researcher. Several works were published with international collaborators, but others were led by IMO researchers and constituted 100% IMO works, such as Monserrat et al., Ñacari et al., von Dassow and Piscoya et al. Other works were published in collaboration with other national centers, such that of Benítez et al. with SECOS Center, Buchan et al. with IDEAL Center, and Henríquez et al. with CEAZA Center.

Most publications in 2022 included IMO young researchers, postdocs and students. In fact, 3 publications were led by IMO postdocs, Osma et al., González et al. and Aldunate et al. while 3 publications were led by IMO students Piscoya et al., Ñacari et al., and Flores et al.

IMO in accordance with its policy finances publications costs and open access when 2 or more Associate Researchers are co-authors in a given article. This is to promote collaborative and multidisciplinary work inside IMO. When only a single Associate Researcher is author, publications expenses are to be covered by operational funding yearly assigned to that researcher.

#### c) **Outstanding publications:**

**Vargas, C.A.;** Cuevas, L.A.; Broitman, B.R.; San Martin, V.A.; Lagos, N.A.; Gaitán-Espitia, J.D.; Dupont, S. 2022. Upper environmental pCO<sub>2</sub> drives sensitivity to ocean acidification in marine invertebrates. Nature Climate Change, 12, 200-207. <https://doi.org/10.1038/s41558-021-01269-2>

The publication of this article in the prestigious journal Nature Climate Change received high coverage in various national and international media. The article was highly valued by the international community working on OA, since it highlights the importance of local biological adaptation and the need to consider present pCO<sub>2</sub> natural variability.

**Von Dassow, P.** Voltage-gated proton channels explain coccolithophore sensitivity to ocean acidification. *Proceedings of the National Academy of Sciences USA*. 119 (25) e2206426119. <https://doi.org/10.1073/pnas.2206426119>

Von Dassow was invited to submit this commentary in the prestigious journal PNAS to introduce important new electrophysiological results on coccolithophore calcification. Coccolithophore calcification is much more sensitive to ocean acidification than seawater and carbonate chemistry considerations alone would predict. To address this mystery, Von Dassow synthesized over a decade-and-a-half of results on the membrane physiology underlying coccolithophore calcification, the effects of ocean acidification on this process, and he also explained how these electrical and molecular processes in cellular membranes have global biogeochemical consequences.

**Aldunate, M., Von Dassow, P., Vargas, C.A., Ulloa, O.** 2022. Carbon Assimilation by the Picoplanktonic Community Inhabiting the Secondary Chlorophyll Maximum of the Anoxic Marine Zones of the Eastern Tropical North and South Pacific. *Frontiers in Marine Science*. 10.3389/fmars.2022.858308.

This work led by IMO Postdoc M. Aldunate provides key clues on the biogeochemical role of the picoplankton community when responding and adapting to subsurface anoxic waters in the upwelling zone of Chile in the context of our Research Line 1.

**González, C.E., Bode, A., Fernández-Urruzola, I., Hidalgo, P., Oerder, V., Escribano, R.** 2022. The lateral transport of zooplankton explains trophic and taxonomic similarities over the zonal gradient of central Chile. *Journal of Marine Systems*. <https://doi.org/10.1016/j.jmarsys.2022.103840>

This work led by one of our postdocs proposes a mechanism mediated by physical processes and biological interactions by which organic C produced in the photic zone of the nearshore upwelling band can be transported to the offshore and eventually taken downward to sustain deep ocean communities, including the Atacama trench system. Identifying the sources of organic C supporting deep-ocean communities is one of the key questions being addressed by IMO regarding functioning of the deep ocean ecosystem.

### Summary table

<b><u>Category of Publication</u></b> <sup>1</sup>	<b><u>MSI Center Members</u></b>	<b><u>Number of Publications co-authored by students</u></b>	<b><u>Total Number of Publications</u></b>
ISI/WOS Publications or Similar to ISI/WOS Standard	Principal Researchers		
	Other Researchers	1	1
SCOPUS Publications or Similar to SCOPUS Standard	Principal Researchers	3	12
	Other Researchers		4
SCIELO Publications or Similar to SCIELO Standard	Principal Researchers		
	Other Researchers		
Scientific Books and chapters	Principal Researchers		1
	Other Researchers		
Other Scientific Publications	Principal Researchers	1	1
	Other Researchers		
<b><u>Total of Publications</u></b>		<b>4</b>	<b>19</b>

<sup>1</sup> Nota: indicar la metodología o fuente utilizada para la categorización de las publicaciones

d) **Congress Presentations:****Summary Table**

Type of presentation	Type of presentation	National Events [Number]	International Events [Number]
Principal Researchers	Conferences, oral communications, poster communications, others (specify)	18	15
	Invited presentations (not included in above row)	1	1
Other researchers (Adjunct, Senior, Young, Postdoctoral Researchers)	Conferences, oral communications, poster communications, others (specify)	8	4
	Invited presentations (not included in above row)	1	0
Students	<i>Conferences, oral communications, poster communications, others (specify)</i>	3	3
	Invited presentations (not included in above row)	0	0

**Other achievements:**

- **Patents:** No patents during this year.
- **Intellectual property:** No intellectual properties during this year.
- **Organization of Scientific Events:**

Two major scientific events were co-organized by IMO researchers and national/international collaborators. The “Open Science Conference on Eastern Boundary Upwelling Systems (EBUS): Past, Present and Future & Second International Conference on the Humboldt Current System”, held in Lima, Peru on September 19 - 23, 2022. The Conference was sponsored and organized by the SCOR EBUS WG 157 co-chaired by IMO Researcher R. Escribano and IMO also was co-sponsor. This conference covered a wide range of disciplines and research lines for coastal upwelling systems, and our both main lines of research were involved in the meeting through oral and panel presentations of our researchers and students. IMO also organized and convened two sessions: Session #13 on “zooplankton dynamics” related to our Research Line 1 (co-convened by IMO researcher P. Hidalgo) and Session #17 on deep-ocean Ecosystems (convened by IMOR postdocs I. Fernandez, J. Medellín, C. González).

The second event was at a national level The “6th Congress on Physical Oceanography, Meteorology and Climate of the Eastern South Pacific” held in Puerto Montt, Chile in November 2022, which was co-organized and co-sponsored by IMO researchers O. Pizarro and V. Villagrán. In this event several works presented by IMO researchers and students were closely related to both research lines of IMO in the field of ocean variability and climate forcing (on various time-spatial scales) for Research Line 1, and deep ocean circulation and dynamics for Research Line 2.



- **Scientific Editorial Boards:**

The Associate Researchers C. Vargas, R. Escibano, and P. von Dassow are Associate Members of the Editorial Board of the highly prestigious journal *Frontiers in Marine Science*.

While our Associate Researcher and IMO Director O. Ulloa is Associate Editor of the highly-ranked Journal *Limnology and Oceanography*.

Participation of IMO researchers in these well-known and highly recognized journals in the field of oceanography reflect the strong connection and involvement of our researchers in the state of the art of oceanography at international level.

A detailed Scientific Editorial Boards table with the information is presented in **Annex 13**.

- **Awards:**

A detailed of Awards table is presented in **Annex 14**.

#### 4. Education and Capacity Building

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

Since IMO officially initiated by December 2013, the Educational and Building Capacity actions were considered as key tasks in which all researchers must become involved. These actions have been always strongly linked to our academic involvement at undergraduate and graduate duties in our host Universities. Furthermore, we have promoted the involvement of our students, technicians, postdocs and young researchers in our networking activities, such that all of them have the opportunity for increasing their capacities at the highest possible level and can also enhance their visibility for future participation in international projects and appointments. For instance, IMO has been exploring the expansion of the student base and human capacity to train them. We have built a model where we formally engage young professors and postdocs, together with our solid group of associate and adjunct researchers, into annual training events in the form of short graduate courses. In the framework of a formal agreement with SECOS, this year, **Dr. Vargas** organized for the first time an international course entitled, **“Quality control and management of carbonate chemistry data for studies of ocean natural variability and long-term ocean acidification monitoring programs in Latin America”**. The course included the participation of 20 researchers, including some from both institutes (IMO and SECOS), as well as lab technicians and senior scientists from seven countries in the region (Argentina, Brazil, Colombia, Ecuador, México, Perú, and Chile).

**SHORT ONLINE COURSE**  
**QUALITY CONTROL AND MANAGEMENT OF CARBONATE CHEMISTRY DATA FOR STUDIES OF OCEAN NATURAL VARIABILITY AND LONG-TERM OCEAN ACIDIFICATION MONITORING PROGRAMS IN LATIN AMERICA**  
 FROM 09TH TO 11TH NOVEMBER 2022  
 BETWEEN 09AM & 12PM (GMT-4)

**DEADLINE FOR APPLICATION**  
**November 2, 2022**  
 Participants interested will be informed during the week 2 days after the deadline of submission.

**APPLICATION FORM**  
<https://bit.ly/CaravelLAOCA>

**PROFESSOR:**  
**DR. CRISTIAN A. VARGAS**  
 Department of Aquatic Systems,  
 Faculty of Oceanographic Sciences,  
 Universidad del Bío-Bío, Chile  
 cristian.vargas@ubiobio.cl

**DR. VICTOR H. AGUILERA**  
 Centro de Estudios Avanzados en Zonas  
 Azules (CEAZA), Universidad de Chile

**COURSE OBJECTIVES AND CONTENT**

Upon completion of the training course, participants will have gained increased knowledge in the following topics:

- Measuring natural variability in carbonate chemistry using microprobes, continuous and discrete methods, from observations to models.
- Sharing carbonate chemistry data: Validation and data reporting standards.
- Properly installed, integrated, and to enable data processing for scientific data management.
- Interpolation and quality control (QC) of pH data collection. Application to the 2017-18 winter long cruise in the IOP, and data management.
- Data collection and analysis for the time series.
- Data visualization and data access. Reporting of data: challenges for international monitoring of ocean acidification status.

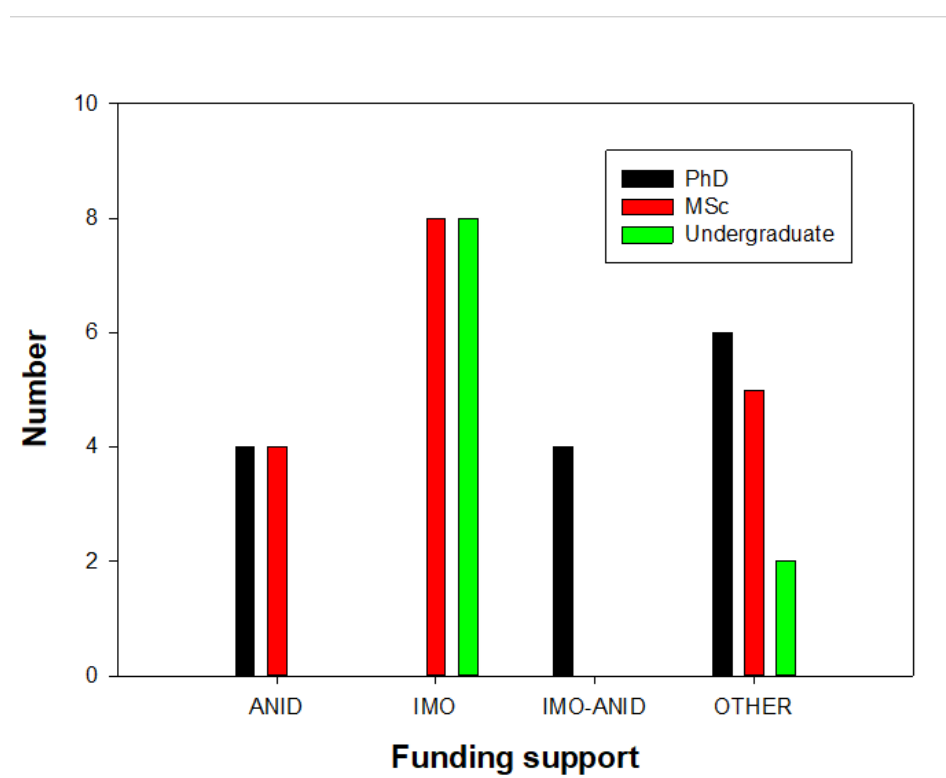
**INSTRUCTORS**

- Dr. Richard Kelly, NOAA Pacific Marine Environmental Laboratory, United States
- Dr. Andrés Salas, National Center for Environmental Information, University of Buenos Aires, Argentina
- Dr. Liang Wang, South System, Environmental Information Systems, University of Toronto, Canada
- Dr. John Pitt, Institute for Coastal Ocean Research, UCL, Great Britain
- Dr. María J. Calvo-Pedraza, Department of Oceanography, University of Algarve, Portugal
- Dr. Eugenio Cuevas, Coastal Ocean and Environmental Change Group (COEC), Department of Oceanography, Faculty of Environmental Sciences, Universidad de Concepción, Chile

Regarding our actions at the local level, during 2022 IMO continued supporting education and capacity building activities at the Postdoctoral, PhD, MSc, and Undergraduate levels. Sponsored activities and graduate student support were associated with 5 programs in oceanography and marine sciences in Chile: i) Doctoral Program in Environmental Sciences (UdeC), ii) Doctoral Program in Ecology (PUC), iii) Doctoral Program in Oceanography (UdeC), iv) Master Program in Oceanography (PUCV), and v) Master Program in Oceanography (UdeC). Sponsoring and support for undergraduate careers and degrees were mostly provided to 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 some young scientists. Two IECS were supported by IMO during 2022, J. Medellín-Mora (until March

2022) and Francisco Díaz (from December 2022). An IECS position was approved for L. Espinosa (Colombia) during 2022, but the migration process took too long and then she decided to decline the offer. In 2022, IMO also recruited the young scientist Dr. Matias Castro, who became involved in the study of microbial ecology in deep waters and sea floor of hadal systems (Theme 2 of IMO).

The total number of IMO students in 2022 was 32 (graduate and undergraduate), indicating an increase of 8 students compared to 2021 (5 new undergraduate + new 4 MSc), although no new PhD's were incorporated. Our efforts continued to support the students, and in 2022 we mostly provided support to new MSc and undergraduate students, while providing complementary support to PhD students who had not finished their thesis and whose ANID scholarship ended during 2022, so that their funding was combined IMO-ANID. The following graph (Fig. a1) illustrates the different sources of funding (scholarships) for students doing their thesis at IMO during 2022.



*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 positions

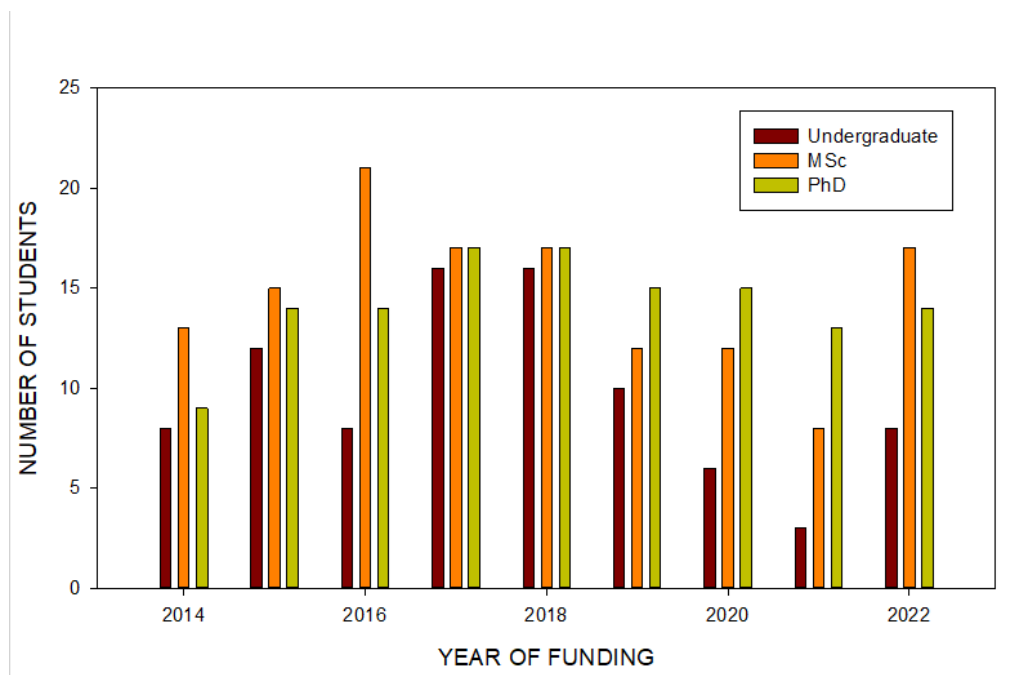
IMO supported 7 postdoctoral positions during 2022: Carolina González was IMO funded until March 2022 and then she continued at IMO funded by ANID. In March 2022 and open call for two postdoctoral positions was made. After the selection process two new postdoctoral were appointed Reinaldo Rivera and Andrés Mesa. Monserrat Aldunate continued at IMO funded by ANID and IMO fully supported Natalia Osma until October 2022 and then she took an academic position at Universidad de Antofagasta and continued linked to IMO as a Young Researcher, while Igor

Fernández continued as fully supported by IMO. Finally, Francisco Díaz continued working at IMO, funded in part by IMO, ANID, and internal funds of the PUC.

## b) Achievements and results:

The main IMO's educational and building capacity achievements during 2022 were the following:

- In graduate and undergraduate programs. During 2022, IMO researchers invested time and resources through 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 associated with IMO has fluctuated year-after-year and is shown in the following Figure b1:



*Figure b1: Total number of students since 2014 doing their thesis work at IMO. In 2022 there were 8 undergraduates, 12 in M.Sc., and 12 in Ph.D. Programs. IMO Associate Researchers are or were co-tutoring 50% or more students in each of these categories.*

With respect to graduation, in 2022 IMO graduated 1 PhD and 3 MSc students. The evolution of graduating students each year does not show a clear trend through the years and (Figure b2). The main outcome indicates that IMO has graduated 15 PhD and 20 MSc students since 2014 and up to 2022.

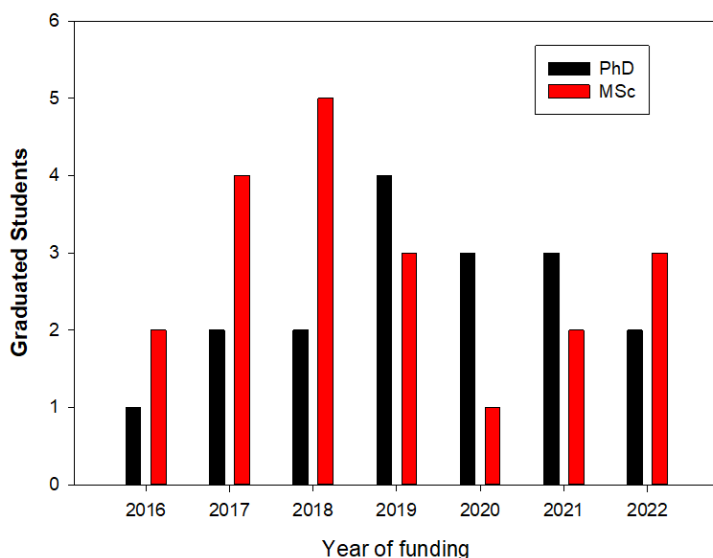


Figure b2: the number of new graduated students per year after carrying on their thesis at IMO. All PhD students graduated at IMO are currently active scientists in Chile. The present position and destination of newly graduated PhD from IMO is shown in the Table below.

New PhD	Current Position
Monserrat Aldunate	Postdoctoral position at IMO
Valeria Anabalón	Researcher in another project in Chile
July Corredor	Researcher in the Chilean Center IDEAL
Carolina González	Postdoctoral position at IMO funded by ANID
Johanna Medellín	Academic Position at Universidad de Valparaíso, Chile
Valentina Valdés	Postdoctoral position at UdeC
Paula Ruz	Academic Position at Universidad Católica de Valparaíso, Chile
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	Researcher at INVEMAR, Colombia
Francisco Javier Díaz	Early Career Scientist at IMO
Matías Pizarro Koch	Postdoctoral position at the UPWELL Center, Chile
Macarena Díaz	Postdoctoral position at Universidad del Bio Bio, Chile, funded by ANID

Table b1: PhD students graduated at IMO 2015-2022 and their present position.

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

New MSc	Current Position
Katerin Anifir	Technician at CEAZA Center, Chile
Richard Cobo	Back in Ecuador

Marcela Contreras	Technician at Universidad Católica Valparaíso, Chile
Pamela Fierro	Undertaken PhD in France
Rosario Díaz	Undertaken PhD Programa at Universidad Católica del Norte, Chile
Javiera Pavez	Technician at Universidad Católica Valparaíso, Chile
Paula Ruiz	Undertaken PhD in Chile
Belén Franco	Postdoctoral position in Denmark
Leissing Frederick	Undertaken PhD in Chile
Guillermo Feliú	Researcher at the Fishery Research Institute of Chile
Constanza Merino	Unknown position
Luis Valencia	Unknown position
Braulio Fernandez	Starting PhD at Southampton, UK
Edson Piscoya	Back in Peru in unknown position
Francisca Olivares	Undertaken PhD at Universidad de Antofagasta, Chile
Cristóbal Aguilera	Unknown position
Sybillé Améstica	Technician at PUC
Katherine Gómez	Unknown position
Laura Latorre	Technician at Universidad de Valparaíso
Darinka Pecarevic	Professional working as consulting

*Table b2: New MSc graduated at IMO during 2015-2022 and their present position.*

### ***The sources for recruitment of IMO students.***

IMO conducts an open call for undergraduate scholarships twice a year (March and August). 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 IMO support if they have a high academic record and, in some cases, they are already 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 2022, IMO awarded new scholarships to a total of 17 students, 8 at undergraduate level and 9 at graduate level (5 M.Sc. and 4 Ph.D.). In addition, 9 graduate students working at IMO received ANID scholarship during 2022, whereas the rest had full or partial support from other funding sources (institutional scholarships or associated grants from IMO researchers).

### ***Graduate theses completed in 2022:***

*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 (thesis defense in March 2023).*

*Macarena Díaz PhD. 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 (thesis defense in August 2022)*

*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. (thesis defense in July 2022)*

*Francisca Olivares, M.Sc. Thesis, “The planktonic microbiome of the Atacama Trench”. Supervisor: Dr. O. Ulloa. (thesis defense in August 2022)*

*Edson Piscoya, M.Sc. Thesis “Influencia de factores físico-químicos en la distribución vertical del piconanoplancton en la Zona de Mínimo Oxígeno (ZMO) del norte de Chile: La influencia relativa del bajo pH/bajo O<sub>2</sub>” Supervisors Dr. C. Vargas and Dr. P. von Dassow. (thesis defense in January 2022)*

### **Theses in progress during 2022:**

*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.*

*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 Concepción. 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*

*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*

*Luis Ñacari Ph.D. Thesis at University of Antofagasta “Trophic ecology of deep-sea fishes above the Atacama Trench”. Co-supervisors Dr. M. Oliva, Dr. R. Escribano.*

*Cristina Carrasco Ph.D. Thesis at UdeC “Deep-ocean circulation processes in the eastern South Pacific” Supervisor Dr. O.Pizarro.*

*Paula Ruiz, PhD. Thesis at UdeC “Quimiotaxis en el océano profundo”. Supervisor Dr. O. Ulloa, co-supervisor Dr. P. Hidalgo.*

*Esteban Fernández Ph.D. Thesis at UdeC “Modelling the global climate-carbon cycle across the Eocene-Oligocene Transition using a new Earth System Model”. Supervisor Dr. O. Pizarro*

*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”. Supervisor: Dr. O. Pizarro.*

*Enrique Ascencio, MSc. Thesis, “Respuesta fisiológica de dinoflagelados mixotróficos del género Alexandrium y Prorocentrum frente a condiciones de alto pCO<sub>2</sub>/bajo pH”; Supervisor: Dr. Cristian A. Vargas, co-supervisor: Dr. Patricia Gómez (Departamento de Botánica, UdeC).*

*Mauro Pinto, MSc Thesis “Mezcla diapicna en la zona de mínimo oxígeno frente a Chile central: el rol de los dedos de sal”. Supervisor Dr. O. Pizarro.*

*Sibille Daniela Améstica Guzmán: MSc Thesis “Efecto de los Remolinos de mesoescala y Ondas Rossby sobre la variabilidad de las corrientes y la distribución vertical de las propiedades físico-*

*químicas de las aguas adyacentes a la Isla Robinson Crusoe durante el periodo Septiembre 2015- Noviembre 2016". Supervisor Dr. S. Hormazábal.*

*Valerie Alejandra Villegas Gamboa: MSc Thesis "Efecto de las rutas preferidas de remolinos de mesoescala sobre la distribución de propiedades biogeoquímicas en el Pacífico Sur Oriental frente a Chile central (24° - 43° S)". Supervisor Dr. S. Hormazábal.*

*Darinka Pecarevic Estay: MSc Thesis "Efecto de las ondas atrapadas a la costa y los remolinos de mesoescala sobre la surgencia costera frente a Chile central (32-34°S)". Supervisor Dr. S. Hormazábal.*

### c) **Destination of students:**

The information about the current position and situation of students graduated at IMO from their MSc and PhD programs is presented in the following table.

<b>Student name</b>	<b>Study Program level - milestone</b>	<b>Approval date</b>	<b>Current labor position</b>	<b>Academic route (Institution and funding)</b>
Macarena Díaz	PhD Program in Oceanography	August 2022	Postdoctoral position at Universidad del Bio Bio, Chile	University of Bio Bio, Chile. Funded by ANID
Braulio Fernández	MSc in Oceanography	15 June 2021	PhD Program at UK	Funded by ANID Abroad Scholarship
Edson Piscoya	MSc in Oceanography	January 2022	Currently in Peru applying to a PhD program	

*Table c1: Current position and situation of students graduated at IMO from their MSc and PhD programs.*

## 5. **Networking and other collaborative work**

### a) **Redes Formales de Colaboración:**

During 2022, IMO researchers have engaged in different national and international networks. For instance, during 2022, Dr. Vargas has been continuing acting as Co-chair of the Latin-American Ocean Acidification Network (LAOCA). As part of a formal agreement signed between LAOCA, IMO and the Coastal Social-Ecological Millennium Institute (SECOS), both millennium institutes got engaged and supported different actions led by LAOCA Network. In this sense, during 2022, our institute worked in close connection with SECOS, in which our associate Dr. Vargas also participated. As part of the previously mentioned agreement, both IMO and SECOS compromised to organize annually a training course for its respective graduate students, as well as participants from this regional network. IMO also continues supporting the organization of a webinar through YouTube led by LAOCA, which includes the participation of early career scientists from the whole Latin-American region.

(See: <https://www.youtube.com/channel/UCOi5g0d1HrBoYYaGGdj6Tig/videos>)

IMO researchers have explored additional funding for networking work with national and international research centers. For instance, adjunct researcher Victor Aguilera, together with associate Vargas were awarded the REDES-ANID Project FOVI210058 entitled "International Alliance for the generation of knowledge and capacities to detect Remote and Local processes of Ocean Acidification on the coasts of Chile (INRELOAD)", which enhance the collaboration with European institutions, including the Lyell Centre in United Kingdom and the Center for Marine Environmental Sciences MARUM in Bremen, Germany. Dr. Von Dassow continued as research fellow in the Stazione Zoologica Anton Dohrn de Napoli (SZN), Italy, being appointed as external supervisor of a new PhD student of the Open



University-SZN program investigating the genomics and evolution of sex determination in the toxic diatom *Pseudo-nitzschia*.

The SCOR Working Group EBUS 155 continued its activities in 2022 as co-chaired by IMO researcher R. Escribano, and one of the main actions was the organization and realization of the Open Science Conference on Eastern Boundary Upwelling Systems (EBUS): Past, Present and Future & Second International Conference on the Humboldt Current System held in Lima by September 2022. Near 400 people from the 5 continents attended the Conference (<https://www.ebus-lima2022.com/>). IMO sponsored the Conference and organized Session 17 “Shedding light in the darkness: New insights on the deep-ocean ecosystems of the major EBUS” (co-chaired by IMO postdocs I. Fernández-Urruzola and C. González). Also 1 or 2 Special Issues of the works presented at the meeting are in the submission process for publication in the Journal Deep-Sea Research Part II.

The SCOR WG MetaZooGene 157 (<https://metazoogene.org/>) in which R. Escribano is an associate member, started a worldwide experiment on intercalibration of methods for application of metabarcoding in the study of zooplankton diversity. IMO Postdoc Carolina González is an active participant of this project.

Additionally, during 2022, 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", funded by the Chilean and Colombian International Collaboration Agencies, and led by the young researcher, Dr. Johanna Medellín. From this network an electronic Guide on Methods for Studying the Marine Biodiversity was produced and became available for researchers and students at both parts (<https://alfresco.invemar.org.co/share/s/V3njFoQISza-fcLhAhoJkw>).

In late 2022, our associate Vargas was invited to participate as a member of the SCOR Project “Changing Ocean Biological Systems (COBS)”. The purpose of the project is to promote new methods for assessing the effects of multiple environmental factors acting on organisms at the same time. The project resulted from the realization by scientists working on single environmental factors (e.g. pH, temperature, oxygen) that single-factor experiments were not realistic to changes occurring in the ocean. More details can be found at: <https://scor-int.org/project/changing-ocean-biological-systems-cobs/>.

IMO researcher von Dassow was appointed a Research Fellow at the Stazione Zoologica Anton Dohrn (SZN) in Napoli, Italy. He completed a research stay in June 2022, and was appointed External Supervisor with Dr. Mariella Ferrante (SZN) of a co-supervised PhD student of the Open University PhD program. SZN has initiated the process of making a formal collaboration agreement with the PUC and, if IMO continues, envisions to do that also with IMO.

A significant part of our researchers continue working in connection with governmental agencies, especially within the framework of climate change and global change issues. For instance, our associate Dr. Vargas has been working actively 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 on issues including the use of information resulting from IMO’s research and the evaluation of ocean acidification impact in the marine populations.

Workshops and collaborations with national and international research centers are expected to continue during 2023.

**b) Redes de Colaboración:**

A collaboration between Dr. von Dassow and Dr. Jorge Mardones of the Center for Harmful Algae Studies (CREAN) of the Fisheries Development Institute (Instituto de Fomento Pesquero; IFOP) grew to an international level, involving researchers from Chile, Japan, Germany, and the US and resulted in a book chapter on new and classical approaches to phytoplankton identification in monitoring of harmful algae (Mardones et al. 2022).

IMO researchers O. Ulloa and R. Escribano became members of the Southeast Pacific committee for the 150 Challenger program of the UN Ocean Decade. The committee has been preparing a proposal for submission to the Schmidt Ocean Institute’s Open Call for Expressions Of Interest to carry out an expedition on the R/V Falkor in the Southeast Pacific focused on the deep ocean.

During 2022 we established collaboration with researchers from the Bermuda Institute of Ocean Sciences (BIOS) and Wood Hole Oceanographic Institute (WHOI) focused on molecular methods and informatic analysis of deep-sea fauna. IMO postdoctoral C. González carried out a 2-months research visit to BIOS in the framework of a joint study to assess diversity of deep-sea zooplankton from the Atacama Trench.

## **6. Outreach and connections with other sectors**

**a) Outreach:**

The general goal we seek to achieve through our outreach activities is to disseminate knowledge related to marine science and the research carried out by the Millennium Institute of Oceanography (IMO) among our community. To enhance these activities, we must identify the needs of our target audience and use various teaching and technological resources (ICTs) adapted to several groups with widely different interests and learning methods.

In 2022, one of our most important goals was to strengthen the transmedia strategy developed to raise awareness about the crucial milestone our researchers reached by exploring the Atacama Trench. During last year, we carried out several high impact activities and projects that complement the “Atacamex” documentary and the book “A Journey into the Underworld,” including:

**The “Atacamex: Deep-Sea Science” Exhibit:** Developed with funding from the 2020 Public Science Contest and sponsored by private companies, “Atacamex: Deep-Sea Science” is an exhibit launched by IMO in cooperation with the University of Concepción’s Interactive Center of Sciences, Arts, and Technology (CICAT). This interactive exhibit about ocean exploration and especially the Atacama Trench is still available at CICAT, featuring experiments, drawings, and scale models of submarine organisms and vehicles as well as a sensory booth with virtual reality glasses allowing visitors to experience what it is like to be at a depth of over 8,000 meters. “Atacamex: Deep-Sea Science” offers an immersive experience inviting people to be surprised and marvel at the mysteries of the deep sea. Between its opening in May 2022 and March 2023, it received over 15,500 visits by children of all ages, university students, and families.

**[YouTube video \(in Spanish\): CICAT launches new interactive room “Atacamex: Deep-Sea Science”.](#)**

**The “Audacity: Hadal Challenge” video game:** Seeking to bring the deep sea closer to school students and families, “Audacity: Hadal Challenge” allows users to discover the fascinating organisms living in hadal depths, as well as their formation, the peculiar characteristics found in those inhospitable ecosystems, and the challenges posed by their exploration. This video game was developed by the Millennium Institute of Oceanography and funded by the 2021 Public Science Contest of the Science and Society Department of Chile’s Ministry of Science, Technology, Knowledge, and Innovation.

Launched in November 2022, “Audacity: Hadal Challenge” has been downloaded over 3,500 times.

Website (in Spanish): [Audacity: Hadal Challenge \(audaciagame.cl\)](http://audaciagame.cl)

**We also worked on other projects, such as:**

The third season of “Invisible Bugs”: In 2022, we produced the third season of the children’s TV series “Invisible Bugs,” this time focusing on the ocean. “Invisible Bugs” features boys and girls from different regions of Chile who ask questions and express their opinions and insight about the ocean, its importance, its role on global climate, and its impact on climate change and society.

This series seeks to explain what boys and girls think and feel about the topics discussed through interviews where children answer questions and tell their experiences with the contents. The new season, to be released in April 2023, was financed in cooperation with CNTV Infantil and the Millennium Scientific Initiative’s Outreach Fund.

Produced in cooperation with CNTV Infantil, “Invisible Bugs” already has three seasons (the fourth one currently being developed) and has been screened on seventy Chilean TV channels as well as various digital platforms.

**Tony Tonina Ocean Stories:** In 2022, we developed a series of eight short stories written and illustrated by some of our team members under the title “Ocean Stories: The Scientific Recipe of Tony Tonina.” The stories recount the adventures of famous chef Tony Tonina, who, along with his faithful team, sets out to explore and discover new environments, species, and amazing facts about our oceans. We also decided to expand our reach and promote inclusion by making the tales available as audio stories. The eight stories with their audio recordings will be released, propagated, and disseminated in 2023 through the main virtual audio and social media platforms.

These products complement the children’s animated series “The Scientific Recipe of Tony Tonina,” made up of ten episodes, and the puppet show with the same name, where the main characters become puppets in a very amusing presentation for boys and girls. In this way, as years go by, Tony Tonina and his friends have managed to keep delighting and educating children with their various presentations, products, and formats.

**The Ocean Film Festival:** As part of the first Puerto de Ideas Biobío Festival, IMO and Puerto Ideas organized the first version of the Ocean Film Festival in Chile. Over a thousand documentaries **from** around the world entered the contest, twenty of which were selected for the final round. The winning film was “Stolen Fish” (from Poland-The Gambia, 2020).

**“Researchers: from Atom to Cosmos”:** The TV series “Researchers: from Atom to Cosmos” completed its seventh season in 2022. This series features interviews and reports on Chile’s research centers of excellence across different fields of knowledge.

During the episode featuring IMO, Dr. Osvaldo Ulloa, director of the Millennium Institute of Oceanography, discussed the manned expedition into the Atacama Trench, the development of outreach science projects such as the “Atacamex” exhibit and the children’s TV series “Invisible Bugs,” and IMO’s research about ocean acidification.

IMO’s episode has achieved over 300,000 views, and all episodes in the series can be accessed (in Spanish) at the following link: [Researchers: from Atom to Cosmos – YouTube](#).

**Regarding communications,** our primary aim has been to position IMO as a national model of open and deep-sea research, with particular emphasis on the western South Pacific.

**The “Atacama Hadal” expedition** was the pinnacle of our communication efforts in 2022, as it required an extensive communication campaign. After Atacama Hadal, our communication plan focused on the different projects of IMO’s transmedia strategy, as well as on lectures, workshops, and science fairs. By these means, we have brought attention to IMO’s descent into the Atacama Trench even after mainstream media stopped covering the news.

**b) Connections with other sectors:**

The establishment and installation of the Center for Oceanographic Instrumentation (CIO) is one of the most important achievements of IMO in 2022 and connects with other sectors. This Center, which is funded by ANID and led by IMO researcher O. Pizarro, will allow us to expand and strengthen the collaboration and links with other institutes and universities in Chile and the region which require maintenance, service and calibration of oceanographic equipment. CIO services will open connections with various sectors in Chile in the context of oceanographic research, consulting and services, such as the Oceanographic and Hydrographic Service of the Chilean Navy (SHOA), the Fishery Research Institute (IFOP), environmental consulting companies, and others.

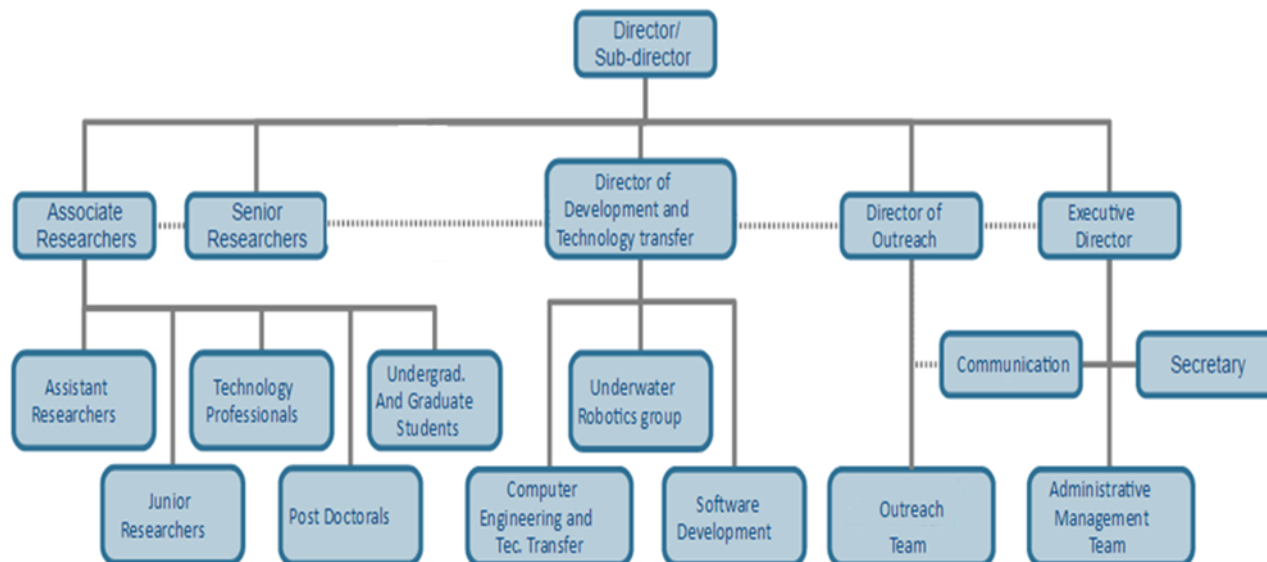
The informal collaboration involving IMO researcher von Dassow that lead to the chapter in a new leading book reviewing harmful algae (Mardones et al. 2022) involved researchers from universities, as well as government and private research institutions (IFOP in Chile, Japan Fisheries Research and Education Agency, Japan and the Alfred Wegener Institut-Helmholtz Zentrum für Polar- und Meeresforschung, Germany) and Chilean private companies providing environmental analysis services (Plancton Andino).

**c) Other achievements:** No other achievements to report this period.

## 7. Administration and Financial Status

### a) **Organization and administration:**

The following chart shows the IMO organization during 2022:



*Organization chart IMO 2022.*

During this period, 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, focusing in 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
<b>Assistant &amp; Technicians</b>	6	8	14
<b>Administrative Staff</b>	3	3	6
<b>TOTAL</b>	9	11	20

### b) **Financial Status:**

The financial status was mainly based on the operational annual fund of approx. USD 970,000. received from Develop and Research National Agency (ANID in Spanish), from the Science Ministry. This fund was used in 49% for personnel (Salaries and scholarships), 28% for operational expenses (20% of total budget in expendables), 13% in infrastructure adequations and equipment, 7% in administration costs, and approx. 3% in overhead for host universities.

By other hand, during 2022, IMO finished the equipment procurement to build up a deep-sea observation platform, from a project called IDOOS (Integrated Deep-Ocean Observing System for

geoscience research). And at the end of 2022 we could apply with a project to a bid for paying research ship time, which was successful to have an app. 12 ship days, the minimum ship time to deploy the observation platform at Atacama Trench. The funds to pay ship time will be transferred to IMO in 2023.

This year IMO include as income different funds, but managed directly just three funds, with one being the main. The other funds, not managed by IMO, were connected to other related projects and the amount “used” detailed in the Annex 9, are estimates from the responsible researchers leading those projects. A summary of all the funds from different sources is shown in Annex 9.

## 8. Annexes:

### Annex 1.- Institute / Nucleus Researchers

#### 1.1 Tabla resumen de investigadores del centro

Researcher Category	Number	Average age	Nationality		Gender Distribution		
			Chilean	Foreign	Male	Female	Not declared
Director	1	61	1	0	1	0	0
Deputy Director	1	65	1	0	1	0	0
Principal or Associate Researchers	6 (all)	64,2	4	2	6	0	0
Adjunct Researchers	11	51,8	11	0	9	2	0
Senior Researchers	3	70	2	1	3	0	0
Young Researchers	8	40.6	5	3	3	5	0
Postdoctoral Researchers	7	28,4	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
Osvaldo Ulloa Quijada	2	Chilean	M	21/05/61	Marine Biologist	D	University of Concepción	Responsible Director	2
Oscar Pizarro Arriagada	1 and 2	Chilean	M	28/03/63	Oceanographer	D	University of Concepción	Research Associate	2
Rubén Escribano Veloso	1 and 2	Chilean	M	16/04/57	Marine Biologist	D	University of Concepción	Substitute Principal	2
Peter Von Dassow	1	American	M	31/03/74	Bachelor of Science in Cellular and Molecular Biology	D	Pontifical Catholic University of Chile	Research Associate	2
Wolfgang Schneider	1	German	M	16/02/54	Oceanographer	D	University of Concepción	Associate Professor	2
Cristian Vargas Galvéz	1	Chilean	M	26/12/72	Marine Biologist	D	University of Concepción	Research Associate	2

## 1.3 Adjunct 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	01/11/76	Marine Biologist	D	CEAZA- Northern Catholic University	Assistant Professor	2
Marcela Alejandra Cornejo D'Ottone	1	Chilean	F	20/07/77	Oceanographer	D	Pontifical Catholic University of Valparaíso	Associate Professor	2
Marcos Simón Moreno Swit	2	Chilean	M	24/08/74	Geologist	D	University of Concepción	Assistant Professor	2
Ramiro Antonio Riquelme Bugueño	1,2	Chilean	M	07/09/78	Marine Biologist	D	University of Concepción	Assistant Professor	2
Julio Cesar Sepúlveda Arellano	1	Chilean	M	25/02/77	Marine Biologist	D	University of Colorado Boulder	Assistant Professor	2
Marcelo Enrique Oliva Moreno	1,2	Chilean	M	17/03/52	Biologist	D	University of Antofagasta	Full Professor	2
Pablo Rosenblatt Guelfenbein	1,2	Chilean	M	06/01/55	Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2
Pamela del Carmen Hidalgo Díaz	1,2	Chilean	F	07/06/66	Aquaculture Engineer	D	University of Concepción	Adjunct Professor	2
Mauricio Andrés Urbina Fonerón	1	Chilean	M	07/09/78	Aquaculture Engineer	D	University of Concepción	Assistant Professor	2
Víctor Enrique Villagrán Orellana	1,2	Chilean	M	02/03/73	Electronic Engineer	M	University of Concepción	Chief MIDGEO Laboratory	2
Atilio Edison Morgado Malebrán	1,2	Chilean	M	23/05/60	Marine Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2

## 1.4 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	Pontifical Catholic University of Chile	Professor	2
Gerrit van den Engh	1,2	Dutch	M	06/03/49	Biophysicist expert in cytometry	D	Becton Dickinson	Senior researcher	2
Samuel Ernesto Hormazábal Fritz	1	Chilean	M	08/12/67	Oceanographer	D	Pontifical Catholic University of Valparaíso	Associate Professor	2



## 1.5 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	10/02/84	Marine Biologist	D	Millennium Institute of Oceanography	Young Researchers	1
Natalia Osma Prado	1,2	Spanish	F	29/01/83	PhD in Biological Oceanography	D	Millennium Institute of Oceanography	Young Researcher	1
Vera Oerder Gautron	1,2	French	F	22/07/87	PhD in Oceanography and Climatology	D	University of Concepción	Associate Professor	1
Marcela Alejandra Cornejo D'Ottone***	1	Chilean	F	20/07/77	Oceanographer	D	Pontifical Catholic University of Valparaiso	Associate Professor	2
Diana Johanna Medellín Mora	1	Colombian	F	18/01/83	Marine Biologist	D	Millennium Institute of Oceanography	Young Researcher	2
Matías Esteban Castro González	1,2	Chilean	M	28/12/81	Molecular Biotechnology engineer	D	University of Chile, Santiago	Young Researchers	2
Salvador Francisco Ramírez Flandes	1,2	Chilean	M	07/01/75	Engineer	D	Millennium Institute of Oceanography	Young Researchers	1
Francisco Javier Díaz Rosas	1,2	Chilean	M	24/12/80	Marine Biologist	D	Pontifical Catholic University	Young Researchers	1

## 1.6 Postdoctoral Researchers

Name	Last Name	Qualification	Nationality	Gender	Rut	Mail	Guide Researcher
Paula Mariela	Ruz Moreno	Doctor in Oceanography	Chilean	F	15501869-0	paularuz@gmail.com	Dr- Samuel Hormazábal
Igor	Fernández Urruzola	Doctor in Oceanography	Spanish	M	25931998-6	igor.fernandez@imo-chile.cl	Dr. Rubén escribano
Carolina Andrea	González Espinoza	Doctor in Oceanography	Chilean	F	17318249-k	caru.019@gmail.com	Dr. Rubén Escribano
Andrés Alberto	Mesas Palma	Doctor of Science mention Ecology and Evolution	Chilean	M	16651189-5	andresmesasp@gmail.com	Dr. Cristian Vargas
Reinaldo Javier	Rivera Jara	PhD in Systematics and Biodiversity	Chilean	M	15852652-2	reijavier@gmail.com	Dr. Rubén Escribano
***Natalia	Osma Prado	Dr. En Oceanografía biológica	Spanish	F	25931958-7	nat.osma@gmail.com	Dr. Cristian Vargas
***Vera	Oerder Gautron	Dr. En Oceanografía y climatología	French	F	25689896-9	vera.oerder@imo-chile.cl	Dr. Rubén Escribano

\*\*\*: Researcher who changed category from Postdoctoral to Young during this period

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

Nº	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
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 <sub>2</sub> /low pH conditions partially coupled to naturally low O <sub>2</sub> 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 <sub>2</sub> ) and losing O <sub>2</sub> (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 Bugeño. 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	

2	The Deep Ocean	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?	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.	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 Buguño. 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.	Biología marina. Biología molecular. Ecología y ciencias ambientales. Geofísica. Bioquímica . Genética y evolución. Geoquímica. Ingeniería. Ingeniería electrónica . Ingeniería mecánica. Ingeniería oceánica. Oceanografía. Geología. Tectónica. Zoología.	02/01/20 19	
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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	Source (Name of the Journal) <sup>1</sup>	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											

***\*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:**

<sup>1</sup> El campo “Name of Journal” corresponde al campo “Source” de acuerdo a la nomenclatura de los reportes de productividad científica que se extraen de la plataforma de gestión Milenio.

N°	Title	Quartile	Authors	Researcher Principal associated with the publication	Source (Name of the Journal)	DOI	Lines of Research	N° principal researchers of the center	Number of researchers of the center another category	N° students	Date of publication
1	Upper environmental pCO <sub>2</sub> drives sensitivity to ocean acidification in marine invertebrates	Q1	Cristian A. Vargas, L. Antonio Cuevas, Bernardo R. Broitman, Valeska A. San Martín, Nelson A. Lagos, Juan Diego Gaitán-Espitia and Sam Dupont	Cristian Vargas	Nature Climate Change	10.1038/s41558-021-01269-2	1. A Variable and Changing Ocean	1	0	0	03-02-2022
2	Ocean acidification induces distinct metabolic responses in subtropical zooplankton under oligotrophic conditions and after simulated upwelling	Q1	Osma N, Vargas CA, Algueró-Muñiz M, Bach LT, Gómez M, Horn HG, Ludwig A, Packard TT, Riebesell U, Romero-Kutzner V, Taucher J, Fernández-Urruzola I	Cristian Vargas	Science of the Total Environment	10.1016/j.scitotenv.2021.152252	1. A Variable and Changing Ocean	1	2	0	01-03-2022
3	Carbon Assimilation by the Picoplanktonic Community Inhabiting the Secondary Chlorophyll Maximum of the Anoxic Marine Zones of the Eastern Tropical North and South Pacific	Q1	Montserrat Aldunate, Peter Von Dassow, Cristian A. Vargas, Osvaldo Ulloa	Peter Von Dassow, Cristian A. Vargas, Osvaldo Ulloa	Frontiers in Marine Science	10.3389/fmars.2022.858308	1. A Variable and Changing Ocean	3	1	0	19-05-2022
4	Physical-chemical factors influencing the vertical distribution of phototrophic pico-nanoplankton in the Oxygen Minimum Zone (OMZ) off Northern Chile: The relative influence of low pH/low O <sub>2</sub> conditions	Q1	Edson Piscocoya; Peter von Dassow; Montserrat Aldunate; Cristian A.Vargas	Peter Von Dassow, Cristian A. Vargas	Marine Environmental Research	10.1016/j.marenvres.2022.105710	1. A Variable and Changing Ocean	2	1	1	01-06-2022
5	Voltage-gated proton channels explain coccolithophore sensitivity to ocean acidification	Q1	Peter Von Dassow	Peter Von Dassow	Proceeding of the National Academy of Sciences	10.1073/pnas.2206426119	1. A Variable and Changing Ocea	1	0	0	10-06-2022
6	Metaomics unveils the contribution of Alteromonas bacteria to carbon cycling in marine oxygen minimum zones	Q1	Carlos Henríquez-Castillo, Alvaro M. Plominsky, Salvador Ramírez-Flandes, Anthony D. Bertagnolli, Frank J. Stewart and Osvaldo Ulloa	Osvaldo Ulloa	Frontiers in Marine Science	10.3389/fmars.2022.993667	1. A Variable and Changing Ocean	1	1	0	11-09-2022
7	Spatial Pattern of Genetic Diversity in the Blood Fluke <i>Aporocotyle argentinensis</i> (Digenea, Aporocotylidae) from South American Hakes (Pisces: Merlucciidae)	Q2	Marcelo E. Oliva, Leyla Cárdenas, Isabel M. Valdivia, Paulina Bruning, Luis Figueroa-Fabrega and Rubén Escribano.	Rubén Escribano	Diversity	10.3390/d14090772	1. A Variable and Changing Ocean.	1	1	0	19-09-2022

8	Distribution of blue and sei whale vocalizations, and temperature-salinity characteristics from glider surveys in the Northern Chilean Patagonia mega-estuarine system	Q1	Buchan, S. J., Gutiérrez Cabello, L., Baumgartner, M., Stafford, K. M., Ramirez, N., Pizarro, O., & Cifuentes, J.	Oscar Pizarro	Frontiers in Marine Science	10.3389/fmars.2022.903964	1. A Variable and Changing Ocean	1	0	0	07-10-2022
9	The lateral transport of zooplankton explains trophic and taxonomic similarities over the zonal gradient of central Chile	Q1	González, C. E., Bode, A., Fernández-Urruzola, I., Hidalgo, P., Oerder, V., & Escribano, R.	Rubén Escribano	Journal of Marine Systems	10.1016/j.jmarsys.2022.103840	1. A Variable and Changing Ocean	1	3	0	14-11-2022
10	Differential gene expression analysis in the scallop <i>Argopecten purpuratus</i> exposed to altered pH and temperature conditions in an upwelling-influenced farming area	Q3	Samanta Benítez, Alvaro Figueroa, Nelson A. Lagos, Andrea X. Silva, Cristian Duarte, Cristian A. Vargas, Marco A. Lardies, Leyla Cardenas	Cristian Vargas	Comparative Biochemistry and Physiology	10.1016/j.cbcd.2022.101046	1. A Variable and Changing Ocean	1	0	0	01-12-2022
11	Endoparasites and diet of the "bigeye grenadier" <i>Macrourus holotrachys</i> Günther, 1878 from the deep sea in the Southeastern Pacific Ocean	Q1	Luis A. Ñacari; Rubén Escribano and Marcelo E. Oliva.	Rubén Escribano	Deep-Sea Research	10.1016/j.dsr.2022.103903	2. The Deep Ocean	1	1	1	22-12-2022
12	Bacterial and eukaryotic intact polar lipids point to in situ production as a key source of labile organic matter in hadal surface sediment of the Atacama Trench	Q1	Edgart Flores, Sebastian I. Cantarero, Paula Ruiz-Fernández, Nadia Dildar, Matthias Zabel, Osvaldo Ulloa, and Julio Sepúlveda	Osvaldo Ulloa	Biogeosciences	10.5194/bg-19-1395-2022	2. The Deep Ocean	1	1	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	Source (Name of the Journal)	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 (Name of the Journal)	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	Guía para el estudio de la biodiversidad marina en Colombia y Chile.	N/A	Rubén Escribano	<p>Escribano Rubén, Dorado-Roncancio, E.F., Medellín-Mora, J. y C. Arteaga-Flórez Edgart (Eds.). 2022. Guía para el estudio de la biodiversidad marina en Colombia y Chile. Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andrés, Santa Marta. Serie de publicaciones generales N° 121. 315 p. (Libro)</p>	121	121	1	978-958-8935-74-4	<p>1. A Variable and Changing Ocean. 2. The Deep Ocean</p>	1	3	1	05-10-2022



2	From molecules to ecosystem functioning: insight into new approaches to taxonomy to monitor harmful algae diversity in Chile.	Jorge I. Mardonesa, Bernd Krockd, Lara Marcusc, Catharina Alves-de-Souzaf , Satoshi Nagaig, Kyoko Yarimizuh, Alejandro Clémenti , Nicole Correac, Sebastian Silva , Javier Paredes-Mellaa, and Peter Von Dassow	Peter Von Dassow	Jorge I. Mardonesa, Bernd Krockd, Lara Marcusc, Catharina Alves-de-Souzaf , Satoshi Nagaig, Kyoko Yarimizuh, Alejandro Clémenti , Nicole Correac, Sebastian Silva , Javier Paredes-Mellaa, and Peter Von Dassow. Chapter 4 – Advances in Phytoplankton Ecology (pp.119-154)			119	978-0-12-822861-6	1. A Variable and Changing Ocean	1	0	0	01-01-2022
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### 3.5.- Other Publications

#### 3.5.1 Principals Researchers:

N°	Title	Publication Category	Other Category	Quartile	Authors	Source (Name of the Journal)	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 (Name of the Journal)	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		Q1	Julio Sepúlveda and Sebastián Cantarero	Phytoplankton response to a warming ocean	Sepúlveda J, Cantarero S, Phytoplankton response to a warming ocean. Science Oceanography (2022), V:376, N: 6600, 1378-1379	376	6600	1378	1476-4687	10.1126/science. Abo5235	2. The Deep Ocean	1	1	23-06-2022
2	SCOPUS Publications or Similar to SCOPUS Standard		Q1	Ndjamba, Tchimanda Simeão Imbo and Araya, Miguel and Oliva Marcelo Enrique	Otolith Weight as an Estimator of the Age of <i>Seriola lalandi</i> Valenciennes, 1833 (Carangidae), in the Southeastern Pacific Animals	Ndjamba T.S.I, Araya Moliva, M.E. Otolith Weight as an Estimator of the Age of <i>Seriola lalandi</i> Valenciennes, 1833 (Carangidae), in the Southeastern Pacific Animals. MDPI: Animals 2022, V: 12, N:1640, 1-8.	12	1640	1	2076-2615	10.3390/ani12131640	1. A Variable and Changing Ocean	1	0	26-06-2022
3	SCOPUS Publications or Similar to SCOPUS Standard		Q2	Victor M. Aguilera and Nina Bednaršek	Variations in phenotypic plasticity in a cosmopolitan copepod species across latitudinal hydrographic gradients	Aguilera VM, Bednaršek N, Variations in phenotypic plasticity in a cosmopolitan copepod species across latitudinal hydrographic gradients. Front. Ecol. Evol(2022). V:10, N: 925648, 1-19.	10	925648	1	2296-701X	10.3389/fevo.2022.925648	1. A Variable and Changing Ocean	1	0	20-10-2022

4	SCOPUS Publications or Similar to SCOPUS Standard		Q1	Wilco C. E. P. Verberk, Jeroen F. Sandker, Iris L. E. van de Pol, Mauricio A. Urbina, Rod W. Wilson, David J. McKenzie, Félix P. Leiva	Body mass and cell size shape the tolerance of fishes to low oxygen in a temperature-dependent manner	Verberk W., Sandker J., Van de Pol I., Urbina M., Wilson R, McKenzie D., Leiva F. Body mass and cell size shape the tolerance of fishes to low oxygen in a temperature-dependent manner. Wiley Global Change Biology (2022). V: 28, N: 19, 1-13.	28	19	1	13652486-13541013	10.1111/gcb.16319	1. A Variable and Changing Ocean	1	0	22-05-2022
5	SCOPUS Publications or Similar to SCOPUS Standard		Q2	Dorado-Roncancio, F., J Medellin-Mora, J. E Mancera-Pineda and M. Pizarro-Koch.	Copepods of the off-shore waters of Caribbean Colombian Sea and their response to oceanographic regulators	Dorado-Roncancio, F., J Medellin-Mora, J. E Mancera-Pineda and M. Pizarro-Koch. 2022. Copepods of the off-shore waters of Caribbean Colombian Sea and their response to oceanographic regulators. Journal of the Marine Biological Association of the United Kingdom, 101(8), 1129-1143.	101	8	1129	0025-3154, 1469-7769	10.1017/S0025315422000133.	2. The Deep Ocean	1	0	14-09-2022

**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>	1	5						
<i>SCOPUS Publications or Similar to SCOPUS Standard</i>	8	42	4	21	2	11	2	11
<i>SCIELO Publications or Similar to SCIELO Standard</i>								
<i>Books and chapters</i>	2	11						
<i>Other Publications</i>								
<b><u>Total of publications</u></b>	11	58	4	21	2	11	2	11

**Annex 4.- Organization of Scientific Events**

Scope	Title	Type of Event	City	Country	Responsible Researcher	URL
National	6to. Congress of Physical Oceanography, Meteorology and Climate of the Eastern South Pacific	Exhibition	Puerto Montt	Chile	Oscar Pizarro Arriagada, Víctor Enrique Villagrán Orellana	<a href="https://ofmc2019.squarespace.com/">https://ofmc2019.squarespace.com/</a>
international	International EBUS Conference	Exhibition	Lima	Perú	Rubén Escribano	<a href="https://www.ebus-lima2022.com/es/outcomes">https://www.ebus-lima2022.com/es/outcomes</a>

**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	F	M	T
Samuel Hormazábal Fritz, Marcela Cornejo D'Ottone	0	0	0	2	0	2	0	0	0	0	0	0	2	0	2
Oswaldo Iván Ulloa Quijada	1	0	1	1	0	1	1	1	2	0	0	0	3	1	4
Heracio Rubén Escribano Veloso	1	0	1	0	0	0	4	0	4	1	2	3	6	2	8
Samuel Hormazábal Fritz	0	1	1	2	0	2	0	0	0	1	0	1	3	0	3
Heracio Rubén Escribano Veloso Marcelo Oliva Moreno	0	1	1	0	0	0	0	1	1	0	0	0	0	2	2
Mauricio Andrónico Urbina Foneron	0	0	0	0	0	0	2	0	2	0	0	0	2	0	2
Oscar Pizarro Arriagada Carolina Parada Veliz	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
Oscar Roberto Pizarro Arriagada	1	1	2	0	2	2	1	1	2	0	0	0	2	4	6
Cristian Antonio Vargas Galvez	0	0	0	0	2	2	0	0	0	0	1	1	0	3	3
Pamela del Carmen Hidalgo Diaz	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
Heracio Rubén Escribano Veloso Ramiro Antonio Riquelme Bugueño	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
Peter von Dassow	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
Ramiro Antonio Riquelme Bugueño	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1
Mauricio Andrónico Urbina Foneron Heracio 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	0	0	1	1	0	0	0	0	1	1
Heracio Rubén Escribano Veloso Pamela del Carmen Hidalgo Diaz	1	1	2	0	0	0	0	0	0	0	0	0	1	1	2
Víctor Enrique Villagrán Orellana Oscar Roberto Pizarro Arriagada	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
<b>TOTAL</b>	<b>5</b>	<b>6</b>	<b>11</b>	<b>7</b>	<b>6</b>	<b>13</b>	<b>9</b>	<b>4</b>	<b>13</b>	<b>2</b>	<b>3</b>	<b>5</b>	<b>23</b>	<b>18</b>	<b>41</b>

**Doctorate Students 2022**

Name	Last Name	Qualification	Nationality	Gender	Rut	Researcher	Email
Lenna Oriana	Ortiz Castillo	Bachelor of Physics Master of M.C Physical Oceanography	Mexican	F	25689993-0	Oscar Pizarro	lennaortiz@udec.cl
Esteban Javier	Fernández Villanueva	Geophysical	Chilean	M	16711759-7	Oscar Pizarro	<a href="mailto:efvillanueva7@gmail.com">efvillanueva7@gmail.com</a>
Edgart Elvis	Flores Rafael	MSc in Marine Sciences	Peruan	M	25971931-3	Osvaldo Ulloa	edgardt.flores@imo-chile.cl
Rocío del Pilar	Barrios Figueroa	Marine Biology	Chilean	F	18644024-2	Mauricio Urbina	rdp.barrios.figueroa@gmail.com
Leissing Eugenia	Federick Figueroa	MSc in Science mention Oceanography	Chilean	F	16140232-k	Rubén Escibano	leissing.frederick@gmail.com
Ana Belén	Venegas Ramos	MSc in Applied Mathematics	Chilean	F	17215982-6	Rubén Escibano	ana.venegas.ramos@gmail.com
Luis Angel	Ñacari Enciso	Marine Biology	Peruan	M	24575171-0	Rubén Escibano / Marcelo Oliva	bh_luis@hotmail.com
Macarena Paz <sup>4</sup>	Díaz Astudillo	Marine Biology	Chilean	F	17994667-K	Rubén Escibano/ Ramiro Riquelme	macarenapaz.da@gmail.com
Manuela Isabel	Pérez Aragón	Marine Biologist, MSc in Marine Biodiversity & Conservation	Chilean	F	15879492-6	Rubén Escibano	maispear@gmail.com
Paula Sofía	Ruiz Fernández	MSc Science mention Oceanography	Chilean	F	17021810-8	Osvaldo Ulloa	sofpaula@gmail.com
Susana	Cabrera Nuñez	MSc with mention in Management in Marine Resources	Mexican	F	G32560735	Rubén Escibano	bm.cabrerususana@gmail.com
Sebastián Ignacio	Cantarero	MSc of Geology	Estado Unidense	M	506272839	Julio Sepulveda / Peter Von Dasow	canta003@d.umn.edu
Erika	Jorquera Paegelow	MSc Marine Biology and Ecology	Chilean	F	15907216-9	Ramiro Riquelme	Erika.a.jorquera@gmail.com

*Note: <sup>4</sup>: Student graduated in August 2022*

**MSc Students 2022**

Name	Last Name	Qualification	Nationality	Gender	Rut	Researcher	Mail
Francisca Ignacia <sup>5</sup>	Olivares Mendoza	Marine Biology	Chilena	F	17616723-8	Oswaldo Ulloa	fraan.olivares@gmail.com
Sibille Daniela	Améstica Guzmán	Marine Biology	Chilena	F	18357613-5	Samuel Hormazábal	sdaestica@uc.cl
Valerie Alejandra	Villegas Gamboa	Oceanography	Chilena	F	17656474-1	Samuel Hormazábal/ Marcela Cornejo	valvilgam@gmail.com
Darinka	Pecarevic Estay	Oceanography	Chilena	F	17754456-6	Samuel Hormazábal	darinka.pecarevic@hotmail.cl
Edson Alexis <sup>5</sup>	Piscoya Campos	Fisheries Biology	Peruano	M	26743810-2	Cristian Vargas	edpiscoya@gmail.com
Constanza Yissell	Hernández Urbano	Oceanography	Chilena	F	18541784-0	Samuel Hormazábal / Marcela Cornejo	constanza.hernandez.u@gmail.com
Enrique Alonso	Ascencio Vargas	Marine Biology	Chileno	M	17637149-8	Cristian Vargas	eaascenc@gmail.com
David Ignacio	Carrasco Flores	Geophysical	Chileno	M	19294127-k	Oscar Pizarro	davcarrasco@udec.cl
Iván Alejandro	Almendra Gajardo	Geophysical	Chilena	M	19333865-8	Carolina Parada- Oscar Pizarro	ialmendra@udec.cl
Tomás Ignacio	Llona Brunet	Marine Biology	Chilean	M	19245587-1	Peter von Dassow	t.llona.brunet@gmail.com
Mauro Alonso	Pinto Juica	Geophysical	Chilean	M	19889583-8	Oscar Pizarro	mauro.pinto@imo-chile.cl
Jocelyn Tamara <sup>5</sup>	Silva Aburto	Marine Biology	Chilean	F	16348244-4	Ramiro Riquelme	jocsilva@udec.cl
Constanza Valentina	Larson Paredes	Marine Biology	Chilean	F	18361493-2	Heraclio Rubén Escribano- Mauricio Urbina	conbstanza.larson@imo-chile
Andrea	Castro	Bachelor in Geophysics	Chilean	F	19090118-1	Oscar Pizarro	andrecastro@udec.cl
Manuel Ignacio	Torres Godoy	Geophysical	Chilean	M	20022457-4	Oscar Pizarro	manuel99torres@gmail.com
Tomás Ignacio	Llona Brunet	Marine Biology	Chilean	M	19245587-1	Peter von Dassow	t.llona.brunet@gmail.com
Mauro Alonso	Pinto Juica	Geophysical	Chilean	M	19889583-8	Oscar Pizarro	mauro.pinto@imo-chile.cl
Jocelyn Tamara	Silva Aburto	Marine Biology	Chilean	F	16348244-4	Ramiro Riquelme	jocsilva@udec.cl

*Note: 5: Students graduated during 2022.*



**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]
Esteban Fernández Villanueva	University of Southern Denmark	Dinamarca	Donald Canfield	Doctoral thesis	01/10/2022	30/03/2023
Paula Sofía Ruiz Fernández	Bigelow Single Cell Genomics Center	Estados Unidos de America	Ramunas Stepanauskas	Three-month internship to analyze data from doctoral thesis.	08/04/2022	23/04/2022
Mauro Pinto Juica	University of the Palmas de Gran Canaria	España	Ángel Rodríguez	Improvement study mixing processes in the ocean	01/07/2022	05/08/2022
Vicente Pelen Araneda	CTECMA	Chile	Marcelo Gutiérrez	Environmental Reports (INFAs) in Cooke concessions consisted of analyzes of organic matter and sediment and water column parameters. Underwater inspection with aquatic robot, and extraction and refloating of other material.	03/01/2022	07/03/2022
Edgart Elvis Flores Rafael	University of Colorado, Boulder	Estados Unidos de America	Julio Sepulveda	Isotopic analysis of sediment samples from the Atacama Trench	14/06/2022	23/08/2022

**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]
Magister	Chloé Höllerer	Magister	AgroCampus Oeste Rennes-Angers	Pontifical Catholic University of Chile- IMO	Francia	Work on the host-range of EhVs with strains of <i>Emiliana huxleyi</i> and its close relatives from the waters of the Southeast Pacific off Chile.	21/09/2022	22/12/2022

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

Network Name	Network Scope	Researchers				Institutions
		From the Center		External		
		Researchers	Postdocs / Students	Researchers	Postdocs / Students	
Strengthening of technical-scientific capacities of new methods for the study of marine biodiversity in Colombia and Chile BIOMACC	international	2	16	19	0	Chilean Agency for International Cooperation (AGCI) Agency for Collaboration of Colombia (APC) Institute of Marine and Coastal Research INVEMAR (Colombia) University of Concepción (UdeC) Millennium Institute of Oceanography (IMO)
Niche Analysis	international	2	0	0	0	Millennium Institute of Oceanography; Algal Resources Collection, MARBIONC, Center for Marine Science, University of North Carolina Wilmington, Wilmington, USA
Study the production of particulate inorganic carbon (PIC) by coccolithophores	international	2	0	0	0	Millennium Institute of Oceanography (; Bigelow Laboratory
Carbon fluxes in the Atacama trench	National	2	0	0	0	Millennium Institute of Oceanography; Center for Dynamics Research of High Latitudes Marine Ecosystems
Latin American Ocean Acidification Network (Laoca)	International	3	1	50	10	Autonomous University of Baja California, Mexico, Federal University of Rio Grande, Brazil, University of Concepción, National Institute for Fisheries Research and Development" (INIDEP), Argentina, Santo Tomás University,
METAZOOGENE	International	3	2	25	15	IMO-Chile, SCOR WG-157, Universidad de Connecticut, USA
EBUS SCOR	International	2	1	12	10	IMO-Chile, SCOR WG-155, Institute of Geophysics of Peru, University of Las Palmas de Gran Canarias, Spain, MBARI USA,

**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

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

Event Title	Type of Event	Scope	Target Audience	Date	Country	Región	N° of Student from the Center	N° of Attendees	Duration in days	Participating Researchers	Responsible for the activity
Walk through Science	Exhibition	National	General public	21-04-2022	Chile	Antofagasta	0	350	4	Pablo Rosenblatt Guelfenbein.	Felipe Gamonal
Marine Science Carnaval Workshops	Workshop	National	Secondary students	23-05-2022	Chile	Bío Bío	0	55	1		Bárbara Léniz Genta
Marine Science Carnaval	Workshop	National	Primary and secondary students	26-05-2022	Chile	Bío Bío	0	70	1		Daniel Toledo
VI Symposium in marine science outreach	Conference	National	Professionals	27-05-2022	Chile	Bío Bío	0	45	1		Felipe Gamonal
Talk: "Revealing the mysteries of the deep ocean"	Conference	National	Secondary students	28-09-2022	Chile	Bío Bío	0	30	1		Bárbara Léniz Genta
Talk: "Revealing the mysteries of the deep ocean"	Conference	National	General public	19-10-2022	Chile	Bío Bío	0	32	1		Bárbara Léniz Genta
Science in a meter	Exhibition	National	General public	06-10-2022	Chile	Metropolitana de Santiago	0	1500	4		Bárbara Léniz Genta
Osvaldo Ulloa's talk	Conference	National	General public	06-10-2022	Chile	Bío Bío	0	120	1	Osvaldo Ulloa Quijada.	Osvaldo Ulloa
Talk: "Revealing the mysteries of the deep ocean"	Conference	National	Primary and secondary students	25-08-2022	Chile	Bío Bío	0	65	1		Bárbara Léniz Genta
Talk "Revealing the mysteries of the deep ocean"	Conference	National	Secondary students	24-08-2022	Chile	Bío Bío	0	60	1		Bárbara Léniz Genta
Marine Film Festival	Contest	International	General public, Professionals, Communication media	28-08-2022	Chile	Bío Bío	0	450	7	Pablo Rosenblatt Guelfenbein, Osvaldo Ulloa Quijada	Pablo Rosenblatt
Submarine robotic workshops	Workshop	National	Primary students	10-09-2022	Chile	de la Araucanía	0	120	1	Osvaldo Ulloa Quijada	Bárbara Léniz Genta

Oswaldo Ulloa's talk	Conference	National	Secondary students, Teachers, Public sector	28-03-2022	Chile	Bío Bío	0	115	1	Oswaldo Ulloa Quijada	Oswaldo Ulloa
Workshop: "Audiovisual format and transmedia: new strategies for science communication"	Workshop	Nacional	Public sector, Private, Professionals	09-11-2022	Chile	Metropolitana de Santiago	0	65	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt
Scientific school fair	Exhibition	National	Primary and secondary students	28-10-2022	Chile	Bío Bío	0	350	1		Bárbara Léniz Genta
Christmas party UdeC	Exhibition	National	General public	16-12-2022	Chile	Bío Bío	0	890	1		Bárbara Léniz Genta
Christmas party ENAP	Exhibition	National	Private sector	17-12-2022	Chile	Bío Bío	0	850	1		Bárbara Léniz Genta
"Atacamex: Science of the deep ocean" Exhibition launch	Exhibition	National	General public	03-05-2022	Chile	Bío Bío	0	74	1	Pablo Rosenblatt Guelfenbein, Oswaldo Ulloa Quijada, H. Rubén Escribano V.	Bárbara Léniz Genta
Videogame presentation: "Audacity: Hadal challenge"	Exhibition	National	Primary students, Teachers	08-11-2022	Chile	Bío Bío	0	45	1		Edwin Rodríguez
"Audacity: Hadal challenge" Launch	Exhibition	National	General public	22-11-2022	Chile	Bío Bío	0	50	1	Oswaldo Ulloa Quijada, Pablo Rosenblatt Guelfenbein.	Edwin Rodríguez

## **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	2	6	1	13	1	5	<b>28</b>
Internet	2	9	2	27	3	18	<b>61</b>
Audiovisual	3	4	6	2	1	1	<b>17</b>
<b>TOTAL</b>	<b>7</b>	<b>19</b>	<b>9</b>	<b>42</b>	<b>5</b>	<b>24</b>	<b>106</b>

**Annex 8. - Connections with other sectors:**

Activity	Type of Connection [Number]	Type of Activity [Number]	Institution Country	Agent Type [Number]	Economic Sector
Training to other Scientific research center by CIO-IMO	1	5	Chile	3	Educational: Public Universities
Calibrations of oceanographic equipment by CIO-IMO	1	7.a	Chile	1,2,3	Educational, Research and Industry services: Public and private universities, Public and private research centers, and Services companies (Consultants)
Collaboration to produce a harmful algal book	2	7.b	Chile, Japan, Germany	3	Educational, Scientific research: Public Universities and research centers, and private lab,

7.a: Domestic calibration service of CTD

7.a: Collaboration to produce an educational product.

**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:**

Funds	2022 Sources of Funding	
	Amount[\$]	Percentage of resources used by the Center [%]
Public Funds: MSI IMO	Managed By IMO 840.000.000	51.6
Public funds: MSI PME	10.000.000	0
Other international Funds	60.620.000	59.7
	Funds no managed by IMO	
Public funds: Other ANID Centers	1.312.620.000	5.4
Public funds: FONDECYT	746.158.010	9.3
Public Funds: CONICYT ANILLO	15.000.000	33.3
Public Funds: CONICYT OTRO	16.000.000	31.3
Public Funds: "Public Science" Program	35.040.000	4.3
Private funds	8.000.000	50
<b>TOTAL</b>	<b>3.043.438.010</b>	<b>20.6</b>

**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



**Annex 11.- Negative or positive aspects that you would like to address in order to understand the context in which the center developed its work during the reported period.**

**Relevant Positive and Negative Aspects**

IMO has been successful in positioning oceanography as a highly relevant discipline in Chile through outreaching activities, such as documentaries and talks at all levels. This view is reflected by numerous requests for talks, press releases and interviews to IMO researchers. During 2022 we have prioritized the participation of our young researchers in all these activities.

The scientific excellence of IMO is reflected in the recognition of three of its Associate Researchers as Chilean highest ranked scientists by Research.com. This recognition has promoted a closer approach with university authorities and their support to accomplish our mission and goals.

Regarding difficulties, during 2022 we were still attempting to overcome the consequences of the Covid pandemic which affected our research activities mostly during 2020 and 2021. There were many constraints during those entire years to perform field and experimental work at the university laboratories. Those limitations resulted in delayed results of pre-planned activities which are reflected in a lower scientific productivity for this period. Most of our students were also affected by this situation and some of them have had difficulties making progress on their theses, especially if their scholarships come to an end. That is why we decided to prioritize supporting students and young researchers during 2022. The negative effects of the pandemic on our research we think started to be overcome in 2022 and in the upcoming year, and then the scientific productivity should significantly increase for 2023. This is clearly reflected in the status of the research lines in which we cite several works which were produced in 2022, but then became published in early 2023.

A summary of negative and positive aspects visualized during 2022 are as follow:

Negative: A negative aspect is how slow it has been to resume face-to-face activities in educational institutions, in other communes. We haven't been able to get back to our normal pre-pandemic performance in this kind of activity.

On the other hand, it has been difficult to establish a methodology that allows us to evaluate the impact of our activities and products in the long term.

a) Challenging to re-initiate lab and field activities and recruit new students in 2022 after pandemic disruption in 2020-2021 and civil strife after 2019:

- Re-establishing human capacity in the lab and at sea has been slow (see below).
- Field activities in the sea must be re-activated with changing sanitary protocols
- Equipment that was unused for two years has to be re-conditioned prior to being functional in the field, and this can be costly and time-consuming.

b) Challenging to re-establish physical links and collaborations between Concepción and Santiago. Two years of remote collaborations led to loss of synchrony in collaborations between the host institutions.

Co-host institution PUC put IMO below research centers it principally hosts in prioritizing resources. As a result, associate investigator von Dassow did not have a functioning lab during 2021-2022 and access to infrastructure promised by the PUC was seriously diminished during this time.

- Greater difficulty for students or personnel incorporating in IMO in 2020-2022 to become productive.
- Younger students in particular have much less practical training, and it was still difficult to organize presentational training when needed for personnel.
- Other collaborations could not be maintained, such as the collaboration of von Dassow with France.

Positive:

- In the positive aspects, we can stand out the great scope in number of participants and/or viewers of our products such as the Atacamex exhibition, the documentary, Exploradores series, the children's series and the video game.
- Also, the collaborative alliances established and maintained along the years, and the consolidation of the multidisciplinary team that we have formed, which develops each project. During 2022, Edwin Rodríguez, informatic y Carolina Moena, writer, joined the team.
- The formation of this multidisciplinary team, along with the established alliances, have allowed us to develop the transmedia strategy in which our activities and products are framed. This science communication methodology has been widely valued, even leading us to carry out a workshop in this regard for all ANID's research centers of excellence.
- Strong and increasing national and international reputation
- Generally good administrative support, can be agile in responding to needs

International collaborations

- At the end of 2022, with return to presentational learning in the universities, there was an increase in interest from younger students from the pent-up demand for research experiences from 2020-2021.
- Some collaborative networks established earlier in IMO thrived.

New collaborations, both formal networks and bilateral exchanges (e.g. von Dassow with Italy) could be established.

**Other Annexes.****Annex 12. Scientific Editorial Boards table:**

N°	Nombre Publicación	Categoría Publicación	Otra Categoría	Miembro(s) del Comité	Año Inicio	Año Término
1	Frontiers in Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Víctor Miguel Aguilera Ramos.	2018	
2	Frontiers in Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Cristian Antonio Vargas Galvez.	2019	
3	Journal of Plankton Research	ISI/WOS standard o Similar a ISI/WOS standard		Peter von Dassow.	2015	
4	Frontiers in Physiology	ISI/WOS standard o Similar a ISI/WOS standard		Cristian Antonio Vargas Galvez.	2019	
5	Frontiers in Microbiology	ISI/WOS standard o Similar a ISI/WOS standard		Osvaldo Iván Ulloa Quijada.	2018	
6	Frontiers in Marine Sciences	ISI/WOS standard o Similar a ISI/WOS standard		Marcela Alejandra Cornejo D'Ottone.	2022	
7	Frontiers in Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Víctor Miguel Aguilera Ramos.	2020	
8	Revista Acta Oceanográfica del Pacífico	Otras Publicaciones	Dialnet	Pamela del Carmen Hidalgo Diaz.	2020	
9	Environmental Science and Technology, Editorial Advisory Board Members of ES&T	Otras Publicaciones	WOS-SCOPUS	Mauricio Andrónico Urbina Foneron.	2020	
10	Limnology and Oceanography Asociación de Ciencias de Limnología y Oceanografía	ISI/WOS standard o Similar a ISI/WOS standard		Osvaldo Iván Ulloa Quijada.	2020	
11	Frontiers in Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Peter von Dassow .	2022	
12	Frontiers in Microbiology	ISI/WOS standard o Similar a ISI/WOS standard		Matías Esteban Castro González.	2017	
13	Extremophiles, Springer	ISI/WOS standard o Similar a ISI/WOS standard		Matías Esteban Castro González.	2019	

14	Revista de Biología Marina y Oceanografía	ISI/WOS standard o Similar a ISI/WOS standard		Marcelo Enrique Oliva Moreno.	2017	
15	AGU Advances	ISI/WOS standard o Similar a ISI/WOS standard		Marcos Simón Moreno Switt.	2022	
16	Frontiers in Marine Sciences	ISI/WOS standard o Similar a ISI/WOS standard		Heraclio Rubén Escribano Veloso.	2019	
17	Frontiers Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Igor Fernández Urruzola.	2019	
18	Frontiers Marine Science	ISI/WOS standard o Similar a ISI/WOS standard		Natalia Osma Prado.	2019	
19	Latin American Journal of Aquatic Research	Otras Publicaciones	WOS-SCOPUS	Paula Ruz Moreno.	2018	
20	Ocean Dynamics	Otras Publicaciones	WOS-SCOPUS	Paula Ruz Moreno.	2022	

### Annex 13. Awards table

N°	Investigador	Premio	País	Institución Otorgante	Contribución del Investigador	Fecha
1	Cristian Antonio Vargas Galvez	Ranking Research	Inglaterra	Research.com 2022, medición internacional	Se basa en la producción científica de un investigador, s que también contempla el impacto de la investigación generada, ya que se cuenta el número de citas”	19-12-2022
2	Heraclio Rubén Escribano Veloso	Ranking Research 2022	Inglaterra	Research.com 2022, medición internacional	Se basa en la producción científica de un investigador, s que también contempla el impacto de la investigación generada, ya que se cuenta el número de citas”	19-12-2022
3	Osvaldo Iván Ulloa Quijada	Ranking Research 2022	Inglaterra	Research.com 2022, medición internacional	Se basa en la producción científica de un investigador, s que también contempla el impacto de la investigación generada, ya que se cuenta el número de citas”	19-12-2022