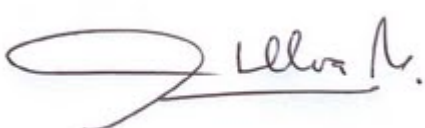





<b>Name of the Center:</b>	
<b>Instituto Milenio de Oceanografía</b>	
Type (Institute or Nucleus)	Institute
Acronym	IMO
Reported period	January 1 to December 31, 2018
Starting date of the Center	December 26, 2013
Web Page	<a href="http://www.es.imo-chile.cl">www.es.imo-chile.cl</a>
Host Institution(s)	Universidad de Concepción and Pontificia Universidad Católica de Chile
Address	Cabina 7, Barrio Universitario UdeC S/N°, Concepción, Chile
Stage	Renewal
End date of the Center	December 26, 2023
Total amount	USD \$6.869.443 for 5 years
Total amount for the reported period	USD \$1.310.452

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<i>Institute / Nucleus Principal Researcher Name</i>	<i>Institute / Nucleus Deputy Principal Researcher Name</i>
Dr. Osvaldo Ulloa Quijada	Dr. H. Rubén Escribano Veloso
<i>Principal Researcher's Signature</i>	<i>Deputy Principal Researcher's Signature</i>
	

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## 1. 1.1 Executive Summary

Chile forms the southeastern border of the Pacific Ocean, the largest ocean basin, whose circulation is a major controlling element of global climate. It is also the largest biome on the planet, accounting for most of the biological production in the oceans. Ocean-atmosphere dynamics in the Pacific, such as the El Niño-La Niña alternation, cause substantial changes in ecosystem structure and functioning in the Eastern South Pacific (ESP), with global ecological and economic impacts. Ongoing climate change is increasingly impacting ecosystems, socio-economic systems, food availability, human health, and even governance. Chile, as a Pacific rim country, is particularly susceptible to these changes, yet the ESP region is still much less explored and understood than the rest of the Pacific Ocean.

**The Millennium Institute of Oceanography (IMO)** seeks to help place Chilean science at the forefront of developing an integrated scientific understanding of the ESP and of short and long-term changes affecting the structure and functioning of ESP ecosystems. IMO is organized around four interconnected research lines each with ambitious goals:

- 1) **Mesoscale processes:** To characterize physical mesoscale (and sub-mesoscale) structures and processes in the ESP and their impact on open-ocean and transitional (coast-ocean) ecosystems;
- 2) **Ocean variability:** To determine how large-scale perturbations impact the transport and gradients in physical-chemical water properties and the dynamics of the ESP;
- 3) **Adaptations to a changing ocean:** To gain new understanding about the adaptations of key planktonic groups to chemical changes taking place in the ocean (eg. acidification, deoxygenation, desertification) and the impact of such changes on biogeochemical cycling;
- 4) **The deep ocean.** To explore the pelagic environment of the deep and ultra-deep ocean.

As well as physical, chemical, and biological oceanographers, IMO scientists include ecologists, microbiologists, ecosystem modelers, science-outreach specialists, and special equipment-developers. IMO also has a global network of scientific collaborators. During 2018, IMO included 35 researchers in different categories, 31 research technicians and assistants, and 6 administrative staff. In addition to ICM funds, the IMO was funded externally by projects awarded to IMO members from national (e.g. FONDECYT, FONDEF) and international agencies (e.g., Agouron, Gordon and Betty Moore Foundation), and individual grants or external fellowships to postdocs and students. At the end of 2018, the IMO was awarded MSI financing for a second five year period (2019-2023).

*Activities during 2018 (year 5):*

### Scientific and technological achievements:

The most important IMO achievement to highlight in 2018 was the repeated exploration of the Atacama Trench onboard back-to-back national and international cruises, reaching record depths with innovative deep sea technology. Thus, we achieved the most ambitious goal laid out for the first five year period.

IMO additionally continued to lead or participate in field activities as well as experimental and modelling work in year 5. However, a major focus was on processing data and publishing results from field work in prior years. This resulted in the highest publication output, highest average Impact Factor (IF) of journals IMO researchers published in, and highest intra-IMO collaboration level to date, as well as the first patent and registered intellectual properties:

- 34 journal articles were published in 2018, of which 28 indexed (Web of Knowledge) articles were authored or co-authored by IMO associate researchers (3.5 articles per associate researcher).
- Of the 28 indexed articles authored by IMO associate researchers, 71% were in Q1 journals and 25% in the top 10% of the IF distribution for disciplines.
- 29% of indexed articles included more than one IMO associate investigator as author, and 11% were co-authored by 3 or more.
- The first IMO patent was accepted and two intellectual properties were registered in Chile in 2018.

#### Education and capacity building achievements:

IMO continued to recruit and maintain students at undergraduate, Masters, and Ph.D levels as well as Postdocs, offering competitive fellowships and participating graduate and undergraduate programs at 3 universities. IMO continued to organize or participate in educational and training activities ranging from short training courses at the local level to international advanced training courses in Costa Rica and Ecuador. During Year 5, IMO had 9 postdocs, 50 undergraduate and graduate students, while one PhD, two Masters, and three undergraduate thesis were successfully completed by IMO students during that year.

#### Networking:

As well as continuing established formal collaborations at national and international levels, (e.g., SCOR, GOA-ON), two new research networks including IMO were formed, TROPHONET between IMO and the Spanish Oceanographic Institute (IEO), and ZOOPE-NET between IMO and the Bioscience Department of Swansea University, UK. Also, the SCOR-financed Working Group Eastern Boundary Upwelling Ecosystems (EBUS), which is co-chaired by an IMO researcher, began functioning in 2018, and IMO researchers have become incorporated in other SCOR Working Groups.

#### Outreach:

IMO's outreach team continued highly successful activities previously implemented, such as an educational website ([www.sumergete.cl](http://www.sumergete.cl)), travelling scientific experiences and shows, and 3 television series which reached millions of viewers in Chile and neighboring countries. Likewise, IMO continued to work at local levels with visits to schools, participating in scientific fairs, and hosting visits from school classes to marine labs. A highlighted new achievement for the Outreach team in 2018 was the project "**ExploSub: Science and technology for underwater exploration**" (Ciencia y Tecnología para la Exploración Submarina)" where students and teachers from Penco, Coihueco, Quillon and San Pedro were guided in the construction of small-scale prototypes of an underwater vehicle for the exploration of the ocean.

## **1.2 Resumen Ejecutivo**

Chile forma la frontera sureste del Océano Pacífico, la cuenta oceánica más grande, cuyo circulación es un elemento mayor del control global de la clima. También es el bioma más grande de la planeta, representando la mayor parte de la producción biológica de los océanos. Dinámicos océano-atmosféricos en el Pacífico, como la alternación El Niño-La Niña, resultan en cambios sustanciales de la estructura de ecosistemas y el funcionamiento del Pacífico Sur Oriental (PSO), con impactos ecológicos y económicos globales. El cambio climático en curso afecta cada vez más ecosistemas, sistemas socio-económicos, disponibilidad de alimentos, salud humana, y aun gobernanza. Chile, como un país del borde del Pacífico, es especialmente susceptible a estos cambios, sin embargo la región del PSO es todavía menos explorado y entendido que el resto del Océano Pacífico.

El Instituto Milenio de Oceanografía (IMO) apunta a posicionar la ciencia Chilena en la frontera del desarrollo de conocimiento científico integrado del PSO y de los cambios de corto y largo término que afectan la estructura y funcionamiento de los ecosistemas del PSO. IMO se encuentra organizado en torno a cuatro líneas de investigación interconectadas, cada una de las cuales con metas ambiciosas:

- 1) **Procesos de mesoscala:** Caracterizar las estructuras y procesos de mesoscala (y sub-mesoescala) en el PSO y sus impactos en los ecosistemas del océano abierto y transicional (costa-océano);
- 2) **Variabilidad oceánica:** Determinar cómo las perturbaciones de gran escala impactan el transporte y gradiente de propiedades físicas y químicas del agua y la dinámica del PSO;
- 3) **Adaptaciones a un océano cambiante:** Alcanzar una nueva comprensión acerca de las adaptaciones de grupos planctónicos claves a los cambios químicos que toman lugar en el océano (Ej. Acidificación, desoxigenación, desertificación) y el impacto de tales cambios sobre los ciclos biogeoquímicos;
- 4) **El océano profundo:** Explorar el ambiente pelágico del océano profundo y ultra-profundo.

Además de oceanógrafos físicos, químicos, y biológicos, investigadores del IMO incluyen ecólogos, microbiólogos, modeladores de ecosistemas, especialistas de divulgación científica, y desarrolladores de equipamiento especializado. El IMO también tiene un red global de colaboraciones científicas. Durante 2018, el IMO incluía 35 investigadores en distintas categorías, 31 técnicos-profesionales y asistentes técnicos, y 6 funcionarios administrativos. En adición al fondos ICM, el IMO recibió financiamiento externo por proyectos adjudicados a investigadores IMO de agencias nacionales (ej. FONDECYT, FONDEF) e internacionales (ej. Agouron, Gordon and Betty Moore Foundation), además de becas individuales externas a postdocs y estudiantes. Al final de año 2018, a IMO se adjudicó financiamiento ICM por un segundo periodo de 5 años (2019-2023).

*Actividades durante 2018 (año 5):*

### Logros científicos y tecnológicos:

El más importante logro IMO de 2018 a destacar fue la exploración repetitivamente de la Fosa Atacama a borde cruceros nacionales e internacionales adosados, logrando profundidades record con tecnología innovadora para el mar profundo. Así logramos la meta más ambiciosa planteada para el primer periodo de cinco años.

Además, el IMO continuó de liderar o participar tanto en actividades de terreno como en trabajos experimentales y de modelación en año 5. Sin embargo, un enfoque mayor fue en el procesamiento de datos y la publicación de resultados obtenidos en trabajo de campo en años previos. Este dio lugar a la más alta producción de publicaciones, más alto Factor de Impacto (FI) promedio de revistas en las

cuales investigadores IMO publicaron, y más alto nivel de colaboración interna IMO hasta la fecha, además de la primera patente y los primeros registros de propiedad intelectual otorgados:

- 34 artículos fueron publicados en revistas en 2018, de los cuales 28 artículos indexados (Web of Knowledge) tenían investigadores asociados IMO como autores o co-autores (3,5 artículos por investigador asociado).
- De los 28 artículos indexados escritos por investigadores asociados IMO, 71% fueron en revistas Q1 y 25% fueron en el primer 11% de revistas por distribución FI por disciplina.
- 29% de los artículos indexados incluyeron más de un investigador asociado IMO como autor, y 11% incluyeron 3 o más.
- Al IMO le fue aceptada su primera patente y dos registros de propiedad intelectual fueron inscritos en Chile en 2018.

#### Educación y formación de capacidad:

El IMO continuó de reclutar y mantener estudiantes a niveles de pregrado, Masters, y Ph.D además de Postdocs, ofreciendo becas competitivas y participando en programas postgrado y pregrado en 3 universidades. IMO continuó de organizar o participar en actividades educacionales o de formación desde cursos cortos de formación al nivel local a cursos avanzados internacionales en Costa Rica y Ecuador. Durante año 5, el IMO tenía 9 postdocs, 50 estudiantes pregrado y postgrado, mientras se completaron exitosamente un tesis doctorado, dos tesis Masters, y tres tesis pregrados por estudiantes IMO durante ese año.

#### Redes:

Además de continuar colaboraciones formales a niveles nacionales y internacionales (ej. SCOR, GOA-ON), se formaron dos nuevas redes de investigación incluyendo IMO, TROPHONET entre IMO y el Instituto Español de Oceanografía (IEO), y ZOOP-NET entre IMO y el Departamento de Biociencias de la Universidad de Swansea, UK. También, el Grupo de Trabajo Sistemas de Surgencia de Bordes Orientales (EBUS) financiado por SCOR, lo cuál es co-presidiado por un investigador IMO, comenzó a funcionar en 2018, y investigadores IMO han sido incorporados en otros Grupos de Trabajo de SCOR.

#### Divulgación:

El equipo de divulgación de IMO continuaba con actividades altamente exitosas previamente implementado, como un sitio web educativa ([www.sumergete.cl](http://www.sumergete.cl)), experiencias y espectáculos itinerantes científicos, y 3 programas de televisión que alcanzaron millones de espectadores en Chile y países vecinos. Igualmente, IMO continuó de trabajar a niveles locales con visitas a colegios, participación en ferias científicas, y patrocinando visitas de colegios a laboratorios marinos. Un nuevo logro destacado del equipo de Divulgación en 2018 fue el proyecto **“ExploSub: Ciencia y Tecnología para la Exploración Submarina”**, donde se guiaron estudiantes y profesores de Penco, Coihueco, Quillón, y San Pedro en la construcción de prototipos de pequeña escala de vehículos submarinos para la exploración del océano.

### 1.3. Outstanding Achievements

IMO's researchers were able to repeatedly explore the Atacama Trench, from the surface to a record depth of 8081 m, first in a national cruise aboard the *R/V Cabo de Hornos* and then an international cruise aboard the German *R/V Sonne*. This involved implementing highly advanced technologies, including the MOCNESS plankton net system and a novel lander design permitting water-column sampling in the ultra-deep ocean, as well as video observations and trap studies on the ocean floor (Hardy and Ulloa 2018, cover of Marine Technology Reporter). Plankton samples during the *Sonne* were obtained with MOCNESS from the record depth of 5,158 m.



## 2. Introduction

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

The Millennium Institute of Oceanography (IMO, Instituto Milenio de Oceanografía) is a center of excellence, established at the end of 2013, with the aim of exploring and researching the open and deep ocean. Its vision is to become an internationally recognized institute in oceanographic research and education, leading exploration in the central and eastern area of the South Pacific Ocean, with impact on the country and society in general. IMO's commitment is to provide an intellectually stimulating environment for the production and dissemination of scientific knowledge that generates new understanding about the ocean, from a creative, daring and collaborative perspective.

IMO's mission is: i) to conduct pioneering and interdisciplinary research in oceanography, addressing scientific problems in an integrative and collaborative manner; ii) to develop and apply new technologies and platforms for observational and experimental work in the ocean, including the use of the new Chilean research vessel Cabo de Hornos, and to reach unexplored areas of the South Pacific; iii) to increase human resources in ocean sciences in Chile and South America, through higher education and training in research based on direct observation and experimentation in the sea, and by attracting ocean scientists from all over the world to work in Chile; and iv) to inform and create awareness among the general public and decision-makers about the importance of the ocean, its conservation and its relationship to humans and global change.

This Annual Report is a summary of the fifth year of activities and the third as a legal Non-Profit Private Corporation.

### b) **Research Lines:**

IMO established the following 4 initial research lines:

**I. Mesoscale Processes:** The focus of this research line is the characterization of physical mesoscale (and sub-mesoscale) structures and processes in the eastern South Pacific Ocean (ESP) and their impact on open-ocean and transitional (coast-ocean) ecosystems. Mesoscale structures include eddies and fronts of different types, but probably other types of poorly characterized structures associated with seamounts, ridges, and oceanic islands. The research strategy is based on field observations, satellite data, and modeling work.

**II. Ocean Variability:** The main focus of this research theme is to analyze the impact climate variability and change has on the circulation, transport of volume, heat and freshwater, stratification of the upper water column of the South Pacific Ocean, especially the ESP and the Humboldt Current system, which includes coastal upwelling and the oxygen minimum zone. The research strategy is based on field and satellite observations as well as on numerical models. Since large-scale physical variability and change also impact meso- and sub-mesoscale physical processes and the chemical and biological characteristics of the ocean, this research theme is also a cross-sectional one.

**III. Adaptation to a Changing Ocean:** This research line seeks to gain new understanding about the adaptations (at the genomic, physiological, behavioral and community-structure level) of key planktonic groups to chemical and physical changes taking place in the ocean (e.g., acidification, deoxygenation, ocean warming, desertification) and the impact of such changes on biogeochemical cycling. The research strategy is based on laboratory and fieldwork. For lab work, isolation of selected species of key plankton functional groups across environmental gradients and single-stressor



(perturbation) experiments reveal responses to variations in pCO<sub>2</sub>/pH, O<sub>2</sub> and nutrients, followed by genome analysis or multi-stressor experiments on selected species. Field observations and experiments are conducted in IMO-organized and other oceanographic expeditions.

**IV. The Deep Ocean:** The objective of this research line is to explore the deep and ultra-deep ocean, determining the pelagic-community ecology and physical/biogeochemical characteristics of the bathyal (> 1000 m), abyssal (>4,000 m) and hadal (>6,000 m) waters of the eastern South Pacific. Special emphasis will be on mechanisms that contribute to the maintenance of endemic communities and the connectivity among the different deep biomes (i.e., islands, seamounts, trenches, etc.). IMO will organize as well as participate in major research expeditions to study the deep and ultra-deep waters of the eastern South Pacific, including the Atacama Trench. Appropriate sampling, observational, and experimental technology will be implemented and developed, accordingly.

The original research lines were maintained during 2018, with line 2 being a more cross-sectional theme, as it permeates and underpins the other three research lines.

**c) Organization of researcher's team:**

During 2018, its fifth year, IMO consisted of 35 researchers: the 8 original associate researchers, 2 senior researchers, 8 adjunct researchers, 4 young researchers and 13 postdocs. The associate researchers: Drs. Osvaldo Ulloa (Director), Rubén Escribano (Deputy Director), Carmen Morales, Oscar Pizarro, Wolfgang Schneider, and Cristian Vargas (from University of Concepción, UdeC), Peter von Dassow (Pontifical Catholic University of Chile, PUC) and Samuel Hormazábal (Pontifical Catholic University of Valparaíso, PUCV). They are distributed in Concepción, Santiago, and Valparaíso, respectively. IMO also worked with 31 professionals/technicians and assistants, 6 administrative staff, as well as 59 students (22 undergraduate, 20 M.Sc., and 17 Ph.D.).

During this period, the IMO has been organized around the 4 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 also has two senior researchers: Prof. Juan Carlos Castilla, (PUC) and Dr. Gerrit van den Engh (MarCy, USA), both as advisors to the institute. Scientific and technical personnel, laboratories, and equipment are shared across the research lines, and also contribute to outreach and technology development. Drs. C. Morales and S. Hormazabal lead Research Line 1; W. Schneider and O. Pizarro lead Research Line 2; P. von Dassow, C. Vargas and O. Ulloa lead Research Line 3; and R. Escribano and O. Ulloa lead Research Line 4.

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. Central to IMO's research activities are the organization of and participation in oceanographic expeditions and field experiments. To date, IMO has lead 4 large scale cruises and played a leading role on 2 other cruises on the R/V Cabo de Hornos, as well as conducting or participating in large international cruises, as on RV Sonne, smaller national cruises, and other field expeditions at the both national and international levels.

### 3. Scientific and technological research:

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

##### **I. Mesoscale Processes**

Understanding physical and ecological processes at mesoscale (10-1000 km) and sub-mesoscales (1-10 km) in the ESP is the main focus of this research line. This focus has links with Research Lines 2 and 3 through subjects such as mesoscale variability in the Oxygen Minimum Zone (OMZ) and meso- to submesoscale features influencing the response of planktonic communities. Results which were reported in 2017 and have been published during 2018, as well as those analysed and prepared or in preparation for submission, include the following, separated into three main topics:

#### a) Mesoscale and submesoscale processes and features:

##### - Coastal fronts

1) A new method to automatically identify the front and define its main characteristics (position, width, intensity) from high resolution SST data was developed. The spatio-temporal variability of front characteristics was analysed in a region off central-southern Chile (2003 to 2016). The probability of detecting a front, as well as the front width and intensity are driven by coastal wind conditions and increased over the 2007-2016 period compared to the 2003-2006 period. The highly variable front position is related to the coastal jet configuration and does not depend on the atmospheric forcing (**Oerder et al., 2018**).

##### - mesoscale and submesoscale features and processes around oceanic islands

1) The oceanographic cruise carried out during October 2018 around Robinson Crusoe Island (Juan Fernandez Archipelago) followed the generation of a Von Karman eddy from the atmospheric formation to the coupling to the ocean layer. Physical and biogeochemical measurements were undertaken at the start and end of the event. The evolution of oceanographic properties was followed by high frequency biogeochemical measurements undertaken with a sea glider. Currently, we are finishing data analysis from the cruise (**Parada et al., in preparation**).

##### - Eddy tracks

1) A physical-biogeochemical ROMS-PISCES simulation off central-Chile shows that the organization of the mesoscale eddy field in preferred eddy tracks structures the distribution of biogeochemical tracers. This is mostly done through the eddy trapping of water masses from the coastal and offshore side of the upwelling front by cyclones and anticyclones, respectively, but also through eddy stirring (filaments arising from eddy-eddy interaction) in the first 200 km from the coast (**Villegas et al., in preparation**).

#### b) Mesoscale processes influencing the OMZ distribution:

1) The influence of intra-thermocline eddies (ITEs) on the vertical variability of the oxygen minimum zone (OMZ) in the eastern South Pacific (0-40°S) is spatially characterized using in situ CTD-O profiles. Results indicate that ITEs drive the upper oxycline variability in coastal waters off Chile and southern Peru, and appear to be the dominant mechanism of vertical OMZ variability everywhere offshore outside of the equatorial band. ITEs are suggested to shape the borders of the OMZ so that ITE variability may drive the shape of the large-scale OMZ. Mesoscale variations of the upper oxycline being mostly due to ITEs south of 8°S may affect the food web in a different manner than north of this latitude (**Auger et al. re-submitted in early 2019 to Journal of Geophysical Research**).

#### c) Impact of mesoscale and submesoscale processes on planktonic communities:

- Remote detection of phytoplankton community structure at the submesoscale and mesoscale levels
- 1) A new approach (PHYSTWO) that improves the spectral-based PHYSAT method for identifying phytoplankton functional types (PFT) was developed and applied/calibrated with in situ data including meso- and submesoscale features in the region off central-southern Chile. We found that this method increases the accuracy of PFT identification, extending the application of this tool to waters with high Chl-a concentration, and significantly decreases (~60%) undetermined retrievals when compared with PHYSAT (**Correa-Ramirez et al., 2018**).
- 2) A satellite-based application of a phytoplankton size-class model, fitted with in situ size fractionated Chl-a data, was tested and variability in phytoplankton size classes (PSC) in surface waters associated with mesoscale variability was assessed. The largest changes in size structure took place during the early life of eddies (~2 months), with a higher contribution of the microplankton fraction when eddies were located closer to the coast, while nanoplankton was dominant and picoplankton almost constant (<20%) throughout the lifetime of eddies (**Corredor-Acosta et al., 2018**).
- 3) Biophysical modelling in the area of oceanic seamounts and islands in the Juan Fernandez Archipelago suggest that submeso- and mesoscale activity coupled to biological behavior (i.e. diel vertical migration) may promote aggregation of spiny lobster larvae, likely increasing retention and survival. (**Medel et al., 2018**).
- 4) An analysis of the influence of submesoscale-mesoscale activity on phytoplankton size distribution in an area of interaction between an upwelling front (CUF) and an intrathermocline eddy (ITE) off Concepción focused on a cross-shore assessment of diapycnal nutrient fluxes. Maximum surface (10-20 m) and subsurface (30-60 m) upward injection of nutrients were found in the CUF and ITE areas, respectively, in association with the underlying nutrient field and high turbulent mixing. Maxima in diapycnal nutrient fluxes were associated with high Chl-a contribution (40-70%) by the microplankton, as well as with maxima in micro-diatom abundance (**Corredor-Acosta et al., submitted in 2019 to Frontiers in Marine Science**).
- 5) Relevant mesoscale and submesoscale processes leading to Chl-a increases in the Juan Fernandez Archipelago (JFA) were analysed, including local and remote hydrodynamic processes in a Regional Ocean Modeling System (ROMS) simulation with satellite Chl-a and Sea Level Height (STL) data (2001-2008). Results show that the remote influence on Chl-a increases due to mesoscale eddies in the study zone is restricted to small regions close to the islands (<10 km). In addition, the permanent presence of submesoscale structures and the occurrence of Von Kármán vortex - Ekman pumping - around the islands, as well as the advection of coastal waters from the upwelling zone through a meandering flow, are shown to be main contributors to Chl-a variability in the region (**Cornejo-Guzmán et al., submitted in early 2019 to Deep-Sea Research Part I**).
- 6) The characterization of small planktonic eukaryotes in an area of intense mesoscale and submesoscale activity off Valparaiso (MOPEX cruise, 2016) was achieved through implementation of the molecular technique CARD-FISH (catalyzed reporter deposition - fluorescence in situ hybridization). Molecular probes targeted phototrophic organisms such as the phyla Haptophytes, Chlorophytes, the specific order Mamiellales within Chlorophytes, as well as heterotrophic organisms in different orders of the phylum Stramenopiles. Results indicate that Haptophytes were prevalent in coastal waters and constituted most of the nanoplankton, whereas nanoplanktonic Chlorophytes were rare. The biomass of phototrophic picoplankton was generally low and represented by Mamiellales. Heterotrophic Stramenopiles were less well represented than their phototrophic counterparts, but showed differential distributions among different clades within this group. Further analyses will assess the factors leading to the different patterns observed (**Potvin et al., in preparation**).
- 7) A physical-biogeochemical ROMS-PISCES simulation off Peru-Chile shows that cyclones (anticyclones) host positive (negative) anomalies of primary productivity, in line with trapping of nutrient and plankton-rich (poor) surface waters from the coastal (offshore) side of the upwelling front

in coastal upwelling regions. The lower productivity of cyclones off northern Chile, caused by a stronger iron limitation (triggered by a narrow continental shelf), may then explain a minimum offshore extension of the coastal productivity in this area. Anticyclones tend to enhance the zonal extension of the OMZ, while cyclones shoal the upper oxycline (**Berger et al., in preparation**).

8) Phytoplankton phenology in the waters around the Juan Fernández Archipelago was characterized using satellite data (2003-20013). The cycle lagged between coastal and oceanic waters. Max. Chl-a concentrations occurred at the coast of the islands closer to the continent. The phenology of SST and wind stress were not coupled to that of Chl-a. Results suggest that the mechanisms driving phytoplankton phenology is similar among the islands and that the cycle in the coastal area would be affected by local processes (island mass effect) and remote influences (mesoscale eddies generated in the continental region), which produce submesoscale variability in the waters around the islands (**Salas et al., in preparation**).

## II. Ocean Variability

During 2018, integrated IMO research on these themes was dedicated to:

**1. La Niña 2010 originated in the Amundsen and Bellingshausen Seas.** La Niña or the cold phase of the ENSO is referred to an anomalous inter-annual cooling of SST in the central Equatorial Pacific. In such an event the easterly trade winds accelerate which in turn strengthen the Equatorial Upwelling, which lifts deeper and colder water to the surface. The velocity of the trade winds is determined by the pressure gradient at sea surface between the South Pacific High (SPH) and the Indonesian Low (IL), meaning that an extraordinary intense SPH is needed to initiate a strong La Niña event. This additional air mass is ought to be supplied by the IL by means of the Southern Oscillation (SO). This century's strongest La Niña scenario with maximum SST anomalies  $< -1.5^{\circ}\text{C}$  initiated in June 2010. We showed that the air-mass needed to intensify the SPH in 2010 and consequently the trade winds as well, which initiated the La Niña event at the end of this year was not supplied by the IL but rather by the Sub Polar Low, located in the Amundsen and Bellingshausen Seas, most likely via the Ferrel Cell which connects the Polar Cell with the Hadley Cell. This study was presented at the IV international Conference on El Niño Southern Oscillation: ENSO in a warmer Climate, 16-18 October 2018, Guayaquil, Ecuador, by **W. Schneider & R. Garreaud**.

**2.- The impact ENOS has on the Humboldt Current System.** For 7 El Niño (70 months in total) and 7 La Niña (83 months in total) periods starting 1993, Sea Surface Temperature (SST), Absolute Dynamic topography (ADT), surface winds, sea air pressure, and the temperature of the upper water column were analyzed in order to determine the impact ENSO has on the Humboldt Current System. During El Niño events SST and also the upper 40 m of the water column, were  $0.6^{\circ}\text{C}$  warmer and ADT about 5 cm higher than during La Niña events. Equatorward and upwelling favourable winds intensified during La Niña events but were weaker during El Niños, increasing coastal upwelling in the former events and decreasing upwelling during the latter events, explaining observed differences in SST and ADT. Further, the mean meridional component of geostrophic velocity, averaged for the Humboldt Current System, was about 20% stronger during La Niña events compared to El Niño ones. This resulted in an increase of eddy kinetic energy during La Niña episodes. Research on this topic is related to the **Doctoral Thesis of IMO PhD student Freddy Hernandez**.

**3. Decadal modulation of the relationship between ENSO and the Pacific Meridional Modes.** The so-called Pacific Meridional Modes (PMMs) are climate modes that originate in the extra-tropical regions and propagate to the equatorial region, potentially influencing El Niño event development. The issue of whether or not the PMMs are precursors of El Niño events has remained debated all the more

so as El Niño events are of two types, one with a center of action in the eastern Pacific and the other in the central Pacific. Here we show that the precursor signal of the PMMs with regards to El Niño experiences a decadal variability, which partly explains the difficulty in detecting a selection mechanism of the El Niño types which frequency of occurrence has varied over time. The analysis of a long-term climate mode simulations suggests that the precursor signal of the PMM of the Northern Hemisphere is obscured by natural variability, while PMMs of the South Hemisphere have no predictive value with regards to El Niño but instead are forced during El Niño development. This work was submitted to **Journal of Geophysical Research (manuscript 2018JC014579)** and is led by Dr. B. Dewitte from CEAZA, and IMO researchers **O. Pizarro** and **A. Montecinos** and IMO student **D. Saavedra** participate as coauthors.

**4. Understanding Sea Level Change in the South Pacific during the late 20th and early 21st Century.** Sea level change is important in the context of climate change. The global mean sea level has risen about 20cm in the last century. However, sea level change is not globally uniform but varies regionally due to different factors. These factors are a mixture of natural and human induced contributions. Satellite data provide a global picture of sea level change. These observations started in the early 1990s. During the period 1993 to 2015 for which the satellite data is available, a spatial non-uniform trend has been observed in the South Pacific, with a maximum in the western part, east of New Zealand. The main objective of this work is to analyze whether this trend can be explained with natural climate variability or whether it is human influenced. Apart from the observations, model data that simulate the climate of the past century is used in order to answer that question. The results of this work indicate that the observed sea level pattern during 1993 to 2015 cannot be explained by natural variability alone. This work, was submitted to **Journal of Geophysical Research (manuscript 2018JC014828RR)** and is led by **Dr. F. Albrecht** postdoc IMO and participate as coauthor from IMO researchers **O. Pizarro** and **A. Montecinos**.

**5. Subsurface mesoscale eddy generation in the ocean off central Chile.** Subsurface mesoscale eddies are swirling masses of water observed below the surface layer of the ocean (around 100 to 400 meters depth). Off central Chile, these eddies play a central role in the variability of the Oxygen Minimum Zone. They have typical diameters of few tens of kilometers. They are formed near the coast, where an intense subsurface poleward flow, namely the Peru-Chile Undercurrent (PCUC), interacts with the continental slope and the seaward border of the continental shelf. These eddies can travel long distances, toward the open ocean, transporting coastal waters with low dissolved oxygen and high nutrient concentrations and impacting the regional marine ecosystems. We use a high-resolution numerical oceanic model (~0.3 km) to analyze the formation of an eddy near 33.5°S off Chile. We showed that the eddy formation process requires the undercurrent to destabilize and detach from the coast, promoting the generation of submesoscale eddies (diameters ~10 km). This means that in regions of eddy formation, initially the PCUC drifts offshore transferring momentum to submesoscale eddies. Later on, these eddies begin to coalesce to form an eddy with larger dimensions. We also showed that the spatial resolution of the numerical model can impact the mechanism of transfer of momentum as well as the vertical structure of eddies. This work was submitted to **Journal of Geophysical Research (manuscript 2018JC014723R)** and is led by the IMO student **M. Contreras** and participate as coauthor the IMO researcher and Thesis supervisor **O. Pizarro**.

**6.- Seasonal variability of the Oxygen Minimum Zone in the eastern South Pacific: A modeling study.** Dissolved oxygen in the ocean strongly impact most marine ecosystems. Its distribution depends mainly of physical and biogeochemical processes. In the eastern south Pacific, water with very low oxygen is present at intermediate depths (100-800 m). This oxygen minimum zone (OMZ) is

associated with a regional water mass called Equatorial Subsurface Water which is transported southward along the coast by the Peru-Chile Undercurrent. Here, using a physical/biogeochemical model we investigate the main mechanisms controlling the seasonal variability of the OMZ off central Chile. We observed that the total volume of the low-oxygen waters is reduced by 25% during spring. This seasonal change is closely related to changes in the water mass composition and is mainly driven by changes in the undercurrent transport, but zonal currents and eddy fluxes, largely related to mesoscale variability, play also a major role in the seasonal and spatial variability of the OMZ, while biogeochemical processes and small scale mixing play only a secondary role. This work was just submitted to **Journal of Geophysical Research (manuscript 2019JC015201)** and is led by the IMO student **M. Pizarro** and participate as coauthor the IMO researcher and Thesis supervisor **O. Pizarro**.

#### **New research projects:**

1. FONDECYT: The impacts of mesoscale eddies in the dynamics of the oxygen minimum zone off Chile. PI: O. Pizarro. Co-I: B. Dewitte. Period: 2018-2020.
2. FONDECYT: Non-linear response of the South Eastern Pacific Oxygen Minimum Zone to ENSO. PI: B. Dewitte co-I IMO: O. Pizarro. Period: 2019-2021

### **III. Adaptations to a Changing Ocean**

The main objective of this research line is to gain new understanding about the adaptations (at different levels) of key marine groups to physical-chemical changes taking place in the ocean, including processes such as ocean acidification (OA), deoxygenation (DO), and ocean warming (OW), as well as, the impact of such changes on biogeochemical cycling. In this framework, during 2018 IMO researchers were focused mostly on data and sample analysis from research cruises (*LowpHOX 2*), from time series observations, and from experimental results conducted in controlled laboratory conditions. During 2018 we also focused on publishing some of the information recorded during 2017. Moreover, our new adjunct researcher Dr. Julio Sepúlveda has been working on lipid analyses aiming to understand adaptation of microbial communities associated to low pH/low O<sub>2</sub> conditions. Major scientific achievements are summarized as:

- A major accomplishment was the *LowpHOX 2* cruise in Jan-Feb 2018, where we were able to re-visit three of the stations first visited in the *LowpHOX 1* cruise off the coast of Iquique, northern Chile in 2015. We have carried out a complete analysis of different carbon pools including, the carbonate system (pH, A<sub>T</sub>, DIC, PIC), the dissolved and particulate organic fraction (DOC, POC), and a detailed isotopic analysis of each carbon pool (d<sup>13</sup>C<sub>DIC-DOC</sub> and d<sup>14</sup>C<sub>DIC-DOC</sub>) for both years. As expected, anoxic (NO<sub>2</sub>-accumulating) waters were deeper in the El Niño year (2015). However, unexpectedly, subsurface pH and DIC values were more extreme during the El Niño year (Fig. 1).
- In the framework of FONDECYT Project 1170065 lead by *Drs. Vargas* and *Von Dassow*, our adjunct researcher, *Dr. Sepúlveda* and his PhD student, *Mr. Cantarero* are analyzing vertical distributions of intact polar lipids (IPLs) through the OMZ.
- *Dr. Vargas* and *Ms. L. Arias* also participated in an expedition, organized together with researchers from ESPOL, Ecuador, University of Palermo, Italy, and colleagues from the National Oceanic and Atmospheric Administration (NOAA), to a volcanic CO<sub>2</sub>-seep recently discovered in Roca Redonda, in Galapagos Island. This expedition provides valuable data for understanding the adaptation of benthic communities exposed to naturally occurring corrosive low pH/high pCO<sub>2</sub> conditions.
- *Drs. von Dassow* and *Aguilera* started work in the context of FONDECYT 1181614 studying in parallel the cosmopolitan coccolithophore *Emiliania huxleyi* and the toxic diatom genus *Pseudo-*

*nitzschia*, with the hypothesis that these represent respectively a generalist strategy versus a specialist/diversification strategy for adapting to new or changing environments. Their program in 2018-2019 is to obtain culture isolates of the two groups from the same sites across a range of oceanographic conditions, for studies of how genetic and physiological characters reflect habitats.

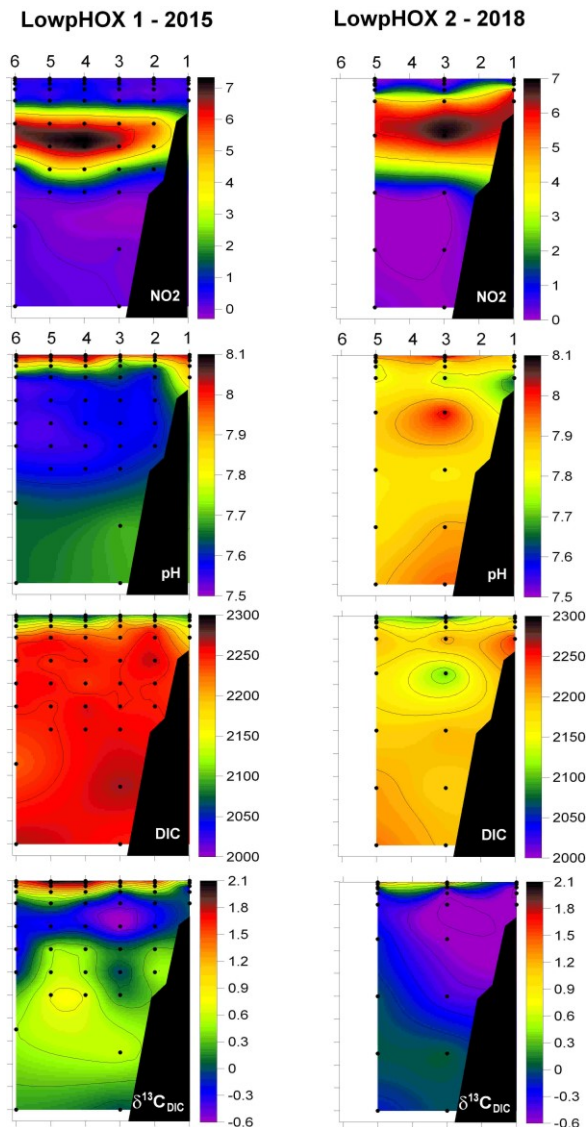


Fig. 1. A preliminary comparison between carbonate chemistry along a coast-offshore transect between LowpHOX 1 in 2015, and LowpHOX 2 in 2018.

- *Dr. von Dassow* continues to participate in the Moore Foundation international effort to develop new Experimental Model Systems in marine microbial eukaryotes (Waller et al. 2018). This has led to his participation with Dr. Fernán Federici of the Instituto Milenio de Biología Integrativa y Sintética and collaborators from the JCVI in the USA and CNRS in France to develop and test a new uLoop open-source toolkit for permitting rapid and efficient combinatorial assembly of DNA for genetic manipulation of diatoms. This is essential for being able to explore the genetic and cell biological underpinnings of phytoplankton adaptations.

- The group of *Dr. Vargas* published evidence that the exposure of parents to high  $p\text{CO}_2$ , induces a transgenerational effect on larval stages of *M. chilensis* to withstand high  $p\text{CO}_2$  scenarios (Díaz et al. 2018). The article was one of the 15% most viewed in in the Aquatic Animal Health section of *Frontiers in Physiology* of 2018.

- The group of *Dr. Vargas* also published the first evidence in Chile about the impact of the melting of glaciers on the chemistry of seawater. These results showed that meltwater, cold and with low alkalinity, are corrosive to calcium carbonate (Vargas et al. 2018), with potential negative effects on calcifiers, such as mollusks, echinoderms, and cold-water corals.

- Drs. Vargas, Escribano and Aguilera, working on the analysis of data collected off Antofagasta (23°S), showed that “warm-acid” upwelling conditions during El Niño modulate the functional traits (egg production, egg size and growth) of a dominant neritic copepod in northern Chile (Aguilera et al. 2019).

- *Dr. von Dassow*’s group published, in three articles, how *E. huxleyi* exhibits high variability in response to copper-toxicity (Echeveste et al. 2018; Mella-Flores et al. 2018) and in response to ocean acidification (von Dassow et al. 2018), but that patterns of physiological variability versus environmental exposure are not simple.
- In a collaborative work between Drs. P. von Dassow and O. Ulloa, and using single-cell genomics and transcriptomics, it was found that certain previously uncharacterized bacteria and archaea are significantly more abundant and transcriptionally more active in anoxic marine zones (AMZs) than previously described phylogenetically related microbial groups; they thus appear to be new key microbial players in AMZ biogeochemistry (Plominsky et al. 2018).

- Analysis of nearly 4 years of monthly molecular data on pelagic microbial community composition in continental shelf waters off Concepción revealed that dissolved oxygen was the best variable explaining their spatial and temporal variability in comparison to other environmental variables. Moreover, taxonomic evidence was provided for an active sulfur cycle in the water column during anoxic conditions (**Aldunate et al. 2018**).
- A new Fondecyt project 118-1682 lead by Dr. R. Escribano started research activities by mid 2018. This project is focused on zooplankton dynamics under a changing ocean and its scientific goals aim at seasonal and interannual variability of zooplankton biomass, production and size structure under the impact of variable upwelling forced by climatic changes. Time series work and experiments are based at the upwelling zone off Concepción and new methods based on automated analysis of zooplankton are being tested to assess zooplankton responses to wind-driven upwelling.

#### IV. The deep ocean ecosystem

During 2018 a major effort was realized to explore and study the deep and ultra-deep waters in the Atacama trench off Chile. The ATACAMEX expedition on January 2018 constituted a key national initiative supported by IMO and CONICYT providing resources, equipment and ship time to uncover environmental conditions and marine life inhabiting abyssal and hadal waters of the trench. A second initiative was the SO-261 cruise conducted in March 2018 onboard the German R/V Sonne, which also targeted the Atacama Trench. IMO had a very active participation in this international cruise by providing equipment and researchers to sample and study the water-column and bottom-associated fauna at the deepest points of the trench. We are currently characterizing the pelagic fauna and assessing C flow and metabolisms of deep-sea zooplankton and fishes inhabiting deep and ultra-deep waters above the trench. In this year, we also continued processing data and samples from previous cruises and occasional samples of deep sea fishes and their parasites in collaboration with local fishermen.

##### *Key findings:*

- A new species of an extremely voracious scavenger inhabiting the near-bottom realm in the Atacama trench has been found and it is currently subjected to molecular and morphological analysis. Although some species of this group have been previously described, this seems an endemic species at the deepest point (>8000 m) of the Atacama trench.
- Deep and oceanic waters in the eastern south Pacific appear strongly subsidized by water mass properties, nutrients and plankton originated in the coastal upwelling zone in sub-tropical and temperate areas off Chile (**Frederick et al. 2018, González et al. 2019, Aníñir et al. submitted to Plos One**).
- In oligotrophic waters of the central south Pacific gyre N cycling is mediated by zooplankton as to fuel regenerated primary production. This occurs in areas where diazotrophic processes are the main sources for N (**Valdés et al., 2018**).
- A significant ecological zonation from the coastal upwelling to the ultra-oligotrophic water in the South Central Pacific Gyre can be distinguished on the basis of biogeochemical regions, zooplankton community structure and their C and N isotopes signals, revealing variable sources of nutrients across the zonal gradient (**González et al., 2019**).
- Planktonic copepods dominate the blue waters of the south Pacific gyre (Medellin-Mora et al. MS in preparation) and pelagic amphipods appear as the most abundant predators in the planktonic food web (**Espinosa et al., submitted to Deep Sea Res. I**).
- Over the zonal gradient of the eastern south Pacific, ecological barriers, such as oceanographic discontinuities, may prevent genetic flow between zooplankton populations and so promoting



higher genetic diversity, but also unexpected high endemism, revealing cryptic speciation (**Gonzalez et al., submitted Nature Sci. Rep.**).

- Morphological and molecular analyses have allowed us to uncover new species and clarify taxonomic status of parasites of deep-water fishes of the Eastern South Pacific region (**Espínola-Novelo et al. 2018, Ñacari et al. 2018, Oliva et al. 2018**).

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

A total of 34 journal articles were published in year 5, of which 28 indexed (Web of Knowledge) were authored or coauthored by IMO associate researchers (3.5 publications per associate researcher). From the latter, 71% were in Q1 journals and 25% in the top 10% of the Impact Factor (IF) distribution for the disciplines (Annex 3). Furthermore, 52% of these publications were open access, reflecting our continued commitment to publish in highly ranked open-access journals or to pay the required fee to make them open access.

From the 28 total indexed articles published by the associate researchers, 29% included more than one researcher. Moreover, 11% of the total were co-authored by 3 or more researchers, reflecting the collaborative work among IMO researchers. Also, the relative number of publications co-authored by students was 46%. Hence, the publication record in year 5 evidenced the collaborative effort of IMO associate researchers to publish high-quality and multidisciplinary research in top-level journals. A complete detail of publications is shown in Annex 3.

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

The following publications are considered to be among the most relevant for 2018, because they are examples of the synergy among associate researchers and they involve the participation of graduate students and/or postdocs:

1. Oerder V., Berto J., Morales C., Hormazábal S., Pizarro O. (2018) Coastal upwelling front detection off Central Chile (36.5–37°S) and spatio-temporal variability of frontal characteristics. Remote Sensing 10: 690. (Research Lines 1 and 2). This study describes and quantifies at high resolution the spatial and temporal variability of an upwelling front using a new automatic method, which is applicable to other upwelling regions.

2. Plominsky A., Trefault N., Podell S., Blanton J., De la Iglesia R., Allen E., Von Dassow P., Ulloa O. (2018) Metabolic potential and in situ transcriptomic profiles of previously uncharacterized key microbial groups involved in coupled carbon, nitrogen, and sulfur cycling in anoxic marine zones. Environmental Microbiology 20: 2727-2742. (Research Line 3). Results in this paper provide new understanding about the biogeochemical role of microorganisms in anoxic marine zones in the large ecosystem of the eastern South Pacific.

3. González C., Escribano R., Bode A., Schneider W. (2019) Zooplankton taxonomic and trophic community structure across biogeochemical regions in the Eastern South Pacific. Frontiers in Marine Science 5: 498. (Research Line 4). This paper represents a pioneer work connecting plankton zooplankton communities and biogeochemical processes in the oligotrophic and ultraoligotrophic systems surrounding the south Pacific central gyre.

**Summary table**

<b><u>Category of Publication</u></b> <sup>1</sup>	<b><u>MSI Center Members</u></b>	<b><u>Number of Publications coauthored by students</u></b>	<b><u>Total Number of Publications</u></b>
ISI/WOS Publications or Similar to ISI/WOS Standard	Associate Researchers	<u>13</u>	<u>28</u>
	Other Researchers	<u>0</u>	<u>3</u>
SCOPUS Publications or Similar to SCOPUS Standard	Associate Researchers		
	Other Researchers		
SCIELO Publications or Similar to SCIELO Standard	Associate Researchers	<u>0</u>	<u>1</u>
	Other Researchers	<u>0</u>	<u>1</u>
Scientific Books and chapters	Associate Researchers		
	Other Researchers		
Other Scientific Publications	Associate Researchers	<u>0</u>	<u>1</u>
	Other Researchers		
<b><u>Total of Publications</u></b>		<b><u>13</u></b>	<b><u>34</u></b>

*Note: All the publications were categorized according to the values given in the Incite Journal Citation Report webpage, from the Clarivate Analytics group (former Thomas Reuters). The Impact factor values for each journal and year were considered, as well as the JIF percentile values (Journal Impact Factor), which were used to determine the corresponding quartile for each publication.*

**d) Congress Presentations:**

- In relation with Research Line 3, and in particular with deoxygenation, Dr. O. Ulloa was an invited speaker at the the 16th International Symposium on Photosynthetic Prokaryotes (Vancouver), the Gordon Conference on Ocean Biogeochemistry (Hong Kong), and the Ocean Deoxygenation Conference (Kiel). At these meetings, results were presented about the new understandings of the biogeochemical role of microorganisms in anoxic marine zones.
- In the context of Research Line 3, related to ocean warming and climate change, Drs. C. Vargas and R. Escribano were invited to an international colloquium on the impact of climate change in the upwelling systems. The event held in Lima, Peru on September 2018 was organized by IMARPE (Peru), IRD (France) and the French Embassy. Both presentations summarized recent findings on how the plankton system and marine life are adapting to ocean variability in the upwelling zone off Peru and Chile.
- Recent observations and findings on ocean variability linked to the upwelling process and its ecological impact in the Humboldt Current were summarized by Dr. R. Escribano in the invited opening conference of the IV Ibero-American Symposium on Reproductive Ecology, Recruitment and fishery, event held on October 2018 in Iquique CHILE, organized by SIBERCOR and University Arturo Prat of Chile.
- "GOOS South American Regional Workshop: regional projects and national strategies on marine monitoring", Santa Marta, COLOMBIA, 12 June 2018. The main objective of this meeting was engaging partners around end-to-end delivery from observations to users, the review status of the observing system, and the implementation plan development. IMO has an active participation through Dr. C.A. Vargas invited as representative of LAOCA in this event.

- "Gordon Research Conference: 2018 Ocean Global Change Biology Conference", Waterville Valley, New Hampshire, USA, 19 July 2018. Dr. C. Vargas participated in this highly reputed multidisciplinary meeting, which includes investigators working in numerous marine ecosystems. The field also integrates numerous techniques and approaches to understand how populations of marine organisms will respond to the complex, multiple stressor scenarios emerging in the contemporary world ocean.
- "11th International Conference on the Applications of Stable Isotope Techniques to Ecological Studies (IsoEcol 2018)", Viña del Mar, CHILE, 31 July and 1 August 2018. Dr. C. Vargas participated in this international meeting by presenting results on the application of isotope technique in studies focused on the impact of ocean acidification in carbonate chemistry and marine organisms.

### Summary Table

Type of presentation	National Events [Number]	International Events [Number]
<b>A. Associate Researchers</b>		
Conferences, oral communications, poster communications, others (specify)	40	29
Invited presentations (not included in above row)	1	7
<b>B. Other researchers (Adjunct Researchers, Senior Researchers, Young Researchers, Postdoctoral Researchers and Students)</b>		
Conferences, oral communications, poster communications, others (specify)	28	16
Invited presentations (not included in above row)	0	0

### Other achievements:

- **Patents:**

On June 14 2018, the National Institute for Industrial Property (Instituto Nacional de Propiedad Industrial) accepted the first patent from IMO and Universidad de Concepción, registered under number 224-2018, and published by the Official Journal of Chilean Republic on August 24 2018. It is an Automatic Titrator for Dissolved Oxygen. This portable device allows high throughput, high precision, and high accuracy processing of water samples for determining dissolved O<sub>2</sub> content using the Winkler's titration gold standard method, with uses in scientific expeditions and laboratories, analytical laboratory services, and industries as aquaculture, agriculture, wine, treatment of industrial and agricultural waste, etc. A technological, market and economical potential evaluation from Tekcapital (Invention Evaluator) in Sept. 2018 stated: *"Development of an automatic titrator for dissolved oxygen would be immensely useful, especially one that is portable, efficient, accurate, and can be stowed on research vessels. Various commercialized methods for the assessment of dissolved*

oxygen are currently available and these organizations could make excellent partners in future endeavors”.

- **Intellectual property:**

At the end of year 2017, in December, IMO officially registered before the Department of Libraries and Archives, Department of Intellectual Property, granted number 285.813, the puppet theater called "*TONY TONINA, ALETAS EN ACCIÓN*" (“Tony Tonna, fins in action”).

On August 2018, IMO officially registered before the Department of Libraries and Archives, Department of Intellectual Property, granted number 294.232, the activity called "*MUESTRA AUDIOVISUAL CIENTÍFICA ITINERANTE (MACI)*", Itinerant Scientific Audiovisual Exhibiton.

- **Organization of Scientific Events:**

- **Scientific Editorial Boards:**

- O. Ulloa, Associate Editor for “Frontiers Microbiology” and “Frontiers in Marine Science” (since January 2018).
- R. Escribano, member of the editorial board of the Mexican Journal Oceanides. This participation serves as a link to regional collaboration
- R. Escribano, co-editor of a Special Topic in the Journal Frontiers in Marine Sciences. The topic is “El Niño under climate change” and the issue has become very relevant to IMO in the context of Research theme 3.

- **Awards:**

- In September 2018, R. Escribano was awarded the 2018 Municipal Award of Science by the Municipality of Concepción City. This award is a recognition to outstanding scientists who have greatly contributed to develop science and education of excellence on the name of the city and region of Concepción, Chile.

**Other outstanding recognitions are:**

- C. Vargas was nominated for third period as member of the Executive Council for the Global Ocean Acidification Observing Network (GOA-ON).
- C. Vargas was nominated as Member for third period of the Executive Council of the International Ocean Carbon Coordination Project (IOCCP).
- R. Escribano was for appointed for a second period (2018-2021) as member of the Scientific Steering Committee of the Integrated Marine Biosphere and Ecosystem Research Program (IMBeR) and chair of the Upwelling Working Group

#### 4. Education and Capacity Building

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

During 2018, IMO continued activities training young scientists at the Postdoctoral, Ph.D, masters and undergraduate levels. In this regard, IMO has continued to actively participate in 5 graduate programs and in 4 undergraduate programs.

- Postdoctoral researchers

During 2018, IMO hosted 13 postdocs, 7 of which were previously incorporated and continued their work in 2018. Two new postdocs were incorporated in 2018. Katty Donoso was incorporated, supported by a concurrent Project FONDECYT 188-1682, and Elise Van Meerssche was incorporated, supported by FONDEF IF17F10011. Natalia Osma started in 2017 and she was funded by IMO, but she was awarded a FONDECYT Grant and will continue her work as funded by CONICYT/FONDECYT starting in March 2019. Igor Fernandez, Vera Oerder, Carlos Henríquez and Frauke Albrecht were all CONICYT/FONDECYT funded and continued their work last year, whereas Eric Potvin and Johanna Medellin were fully supported by IMO in 2018. Among the 8 postdocs working full time with IMO researchers during 2018, 6 of them came from foreign countries (France, Spain and Germany).

The main IMO's educational activities, achievements and results during 2018 were the following:

- IMO involvement in graduate and undergraduate Programs

During 2018, IMO continued to be linked to different undergraduate (5) and graduate programs (6), including teaching basic and advanced courses, practical work, and thesis guidance.

- 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 and 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.

A total number of 59 students were directly linked to IMO: 22 in undergraduate, 20 in M. Sc., and 17 in Ph.D. Programs. IMO Associate researchers are or were co-tutoring 50% or more students in each of these categories.

IMO offers a call for undergraduate scholarships twice a year. The selection criteria is strongly 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 a CONICYT scholarship but did not get it are strongly considered for support if they have very good academic records and, in some cases, they were linked to IMO from their undergraduate formation. IMO support extends for up to 1 year and these students are asked to apply again to 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 make a contribution to these grants through other funding sources available to them.

In 2018, IMO awarded scholarships to a total of 18 students, 6 of undergraduate level and to 12 of graduate level (10 M.Sc. and 2 Ph.D.). In addition, 7 of the 34 graduate students from IMO received a CONICYT scholarship during 2018, whereas the rest had full or partial support from other funding sources (e.g. institutional scholarships or through projects from IMO researchers).

- IMO organization of training

Short-Course; “Carbonate system in the ocean: Laboratory techniques, use and validation of autonomous sensors”, 15 - 18 January 2018, Facultad de Ciencias Ambientales, Universidad de Concepción, Concepción, Chile. This course was focused on laboratory technicians, professionals, and PhD students and Post-Docs involved in fieldwork and chemical analyses in laboratory at their respective institutions. The course was organized by the associate Dr. Vargas, and the assistant, Ms. Lorena Arias (Chemist).

Short-Course, “Application of stable isotopes for Ocean Acidification Studies”, 26 - 28 November 2018, Centro de Investigación en Ciencias del Mar y Limnología, Universidad de Costa Rica, San José, Costa Rica. This is an international course funded by the Pier2Peer Program of the Global Ocean Acidification Observing Network (GOA-ON) and The Ocean Foundation, through a specific grant to our associate, C. Vargas. The course was given by Dr. Vargas to graduate students and professionals from Costa Rica, Panamá, and Perú.

Advanced training course on Ocean Biogeographic Information System (OBIS) was carried out at University of Concepción on August 2018 as organized by IMO and sponsored by University of Concepción. This course was lectured by Dr. Ana Peralta who provides the technical assistance to the international OBIS portal. The course was attended by 20 students from different institutions of Chile as to become trained to compile, integrate and build data bases on marine diversity which can be upload at the OBIS Portal. P. Hidalgo (IMO Adjunct Researcher) coordinated and organized the course.

IMO also organized short courses in the University of Concepcion to train graduate students and technicians in programming languages ("R" Software and MatLab) and statistical analysis applied to IMO themes. In addition to courses, a special cycle of seminars was conducted by graduate students and post-docs in order to share research experiences and to inform to the IMO community about their research activities and achievements.

## **b) Achievements and results:**

### Theses completed:

Valeria Anabalón. PhD. Thesis in Oceanography at Universidad Las Palmas de Gran Canaria, Spain “Spatio-temporal variability in the structure of planktonic communities in eastern boundary systems: influence of coastal upwelling, mesoscale activity and nutrient concentration”. Co-tutors: Dr. Morales, C. and Dr. Javier Aristegui (Las Palmas, Spain, December 2018).

Paula Ruiz. MSc. thesis, Universidad de Concepción “Fijación autotrófica del Carbono a lo largo del gradiente de oxígeno en zonas marinas anóxicas: una aproximación metagenómica”. Tutor O. Ulloa (November 2018).

Sebastián Cornejo-Guzmán, undergraduate thesis. Geophysics at UdeC “Mecanismos de mesoescala y variables biogeoquímicas que determinan la variabilidad de la clorofila-a en el Archipiélago de Juan Fernández”; Tutor: Dr. Carolina Parada, co-tutor: CE. Morales; (March 2018).

Felipe Gamonal. Undergraduate Thesis Marine Biology UdeC "Comunicación Científica a través del arte y la tecnología, descubriendo las maravillas del zooplancton marino". Tutor R. Escribano (December 2018).

Felipe Moscoso. Undergraduate Thesis. Universidad Andrés Bello "Cambios en la estructura comunitaria y variación de tamaños en Chaetognatha en la zona de transición costera frente a Chile central (28°-33°S)". Tutor R. Escribano (December 2018).

Theses in progress:

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". Co-tutors: R. Escribano and C. Parada.

Montserrat Aldunate. Ph.D Thesis "Metabolismos alternativos del carbono y del nitrógeno en la pico cianobacterias que habitan las zonas marinas anóxicas" project and candidacy approved 22 Jan. 2016. Co-tutors: O. Ulloa and P. von Dassow. Thesis defense by June 2019.

Francisco Javier Díaz Rosas. Faculty of Biological Sciences, Pontificia Universidad Católica de Chile. Ph.D Thesis "Environmental and biotic controls on coccolithophores assemblages and *Emiliania huxleyi* populations: integrating cell traits, population dynamics and community structure" project and candidacy approved 3 Jul. 2017. Tutor: P. von Dassow.

Andrea Corredor-Acosta, Ph.D. thesis, "Influencia de los procesos físicos de mesoescala en la estructura de tamaños de la comunidad fitoplanctónica en Chile central"; Tutors: CE. Morales, S. Hormazabal; Thesis defense (mid-2019).

Carolina González, Ph.D. thesis "Variabilidad oceanográfica espacial y su impacto sobre la filogeografía de copépodos pelágicos en el Pacífico Sur Oriental". Co-tutors R. Escribano and Pedro Victoriano. Thesis defense mid 2019.

Lady Liliana Espinosa, Ph.D. thesis "Factores oceanográficos que modulan la estructura comunitaria de anfípodos hipéridos en la región oriental del Pacífico Sur". Tutor R. Escribano. Thesis defense mid 2019.

Salvador Ramírez Flandes Ph.D. thesis Program Complex Systems Engineering, University Adolfo Ibañez "Study on the use of functional traits to characterize microbial communities". Tutor O. Ulloa. Thesis defense May 2019.

Sonia Yañez. PhD. Thesis in Oceanography at Universidad de Concepción, Chile "Mortalidad y degradación bacteriana de copépodos pelágicos asociadas a las Zonas de Mínimo de Oxígeno (ZMOs)". Tutors P. Hidalgo and O. Ulloa. Thesis defense early 2019.

Freddy Hernandez, Ph.D. thesis in Oceanography at Universidad de Concepcion, Chile "Impacto de la variabilidad climática durante la última década sobre la dinámica del giro subtropical en el Pacífico Sur Oriental y el volumen del Agua Intermedia del Pacífico Sur Oriental". Tutor W. Schneider. Thesis defense 2019.

Katerin Aniñir. MSc. Thesis Universidad de Concepción, Chile "Genetic connectivity of a pelagic copepod between two seamounts zones in the eastern South Pacific". Co-tutors: R. Escribano, S. Hormazabal. Thesis defense early 2019.

Pamela Fierro. MSc. Thesis Universidad de Concepción, Chile "Estructura comunitaria de copépodos pelágicos asociados a montes submarinos de la Dorsal Juan Fernández (32-34°S) en el Pacífico sur oriental". Tutors P. Hidalgo and R. Escribano. Thesis defense early 2019.

Marcela Contreras. MSc. Thesis Universidad de Concepción, Chile "Subsurface mesoscale eddy generation in the ocean off central Chile". Tutors: O. Pizarro, B. Dewitte (CEAZA and LEGOS, Toulouse, France). Thesis defense early 2019.

Victoria Salas, MSc. thesis, “Mesoscale eddies and upwelling filaments around Seamount O'Higgins, Juan Fernandez Ridge”; Tutor: S. Hormazabal, CE. Morales: co-tutor. Defense by mid 2019.

Diego Saavedra. Undergraduate Thesis. Geophysics at UdeC. "Modo dominante no-ENOS de variabilidad océano-atmósfera en el Pacífico Suroriental".Tutors: O. Pizarro, B. Dewitte (CEAZA and LEGOS, Toulouse, France) (defense early 2019).

Dario Torres. Undergraduate Thesis. Geophysics at UdeC. "Caracterización de la respuesta transiente en sensores ópticos de oxígeno disuelto".Tutors: V. Villagran co-tutor O. Pizarro. (defense early 2019).

Valerie Villegas, MSc. thesis, “Efecto de los caminos preferidos de remolinos de mesoescala en la distribución de la productividad primaria y de la zona de mínimo oxígeno en el Pacífico sur-oriental frente a Chile”; Tutor: S. Hormazabal, co-tutor: PA. Auger; thesis defense (early-2019).

Luis Valencia, MSc. Thesis, Oceanography PUCV, “Mixing processes on seamounts along the Juan Fernández Ridge off central Chile” Tutor S. Hormazabal; Ángel Rodríguez-Santana; Wolfgang Schneider.

Darinka Pecarevic, 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)”; Tutor: S. Hormazabal; co-tutor: C.E. Morales; Thesis defense (early-2019).

- **Destination of students:**

Ph.D. Valeria Anabalón and Sonia Yañez are currently preparing applications to Postdoctoral funding of CONICYT/FONDECYT. MSc. Paula Ruiz, started a Research Assistant position in Centro de Biotecnología, UdeC. Undergraduate Felipe Moscoso has been accepted at the M.Sc. Program of Oceanography UdeC. Undergraduate Felipe Gamonal has taken a position at IMO as assistant to outreach activities. Sebastián Cornejo is currently doing an assistantship for a FONDECYT project under supervision of C. Parada.



## 5. Networking and other collaborative work

### a) **Networking:**

This year 2018, IMO also sustained collaboration with the OA-ICC (Ocean Acidification International Coordination Centre) Adaptations to a Changing Ocean program. OA-ICC supported the organization of the **2018 Galapagos Ocean Acidification School**. This school involved the assistance of 12 participants from 7 countries, including *Argentina, Brazil, Colombia, Costa Rica, Chile, Ecuador, and Mexico*. Funding from SCOR and IOC-UNESCO (International Oceanographic Committee) was the main initial support for searching additional funding for the organization of this course, with additional support from IMO and the Millennium Nucleus MUSELS.

The collage consists of several elements:

- Top Left:** A flyer for the "2018 Galapagos Ocean Acidification School" held from August 19-26th, 2018, at the Charles Darwin Research Station in Puerto Ayora, Galapagos, Ecuador. The theme is "CO<sub>2</sub> Vents at Roca Redonda, Galapagos Islands: A Natural Laboratory for Long-Term Multidisciplinary Ocean Acidification Experiments and Capacity Building".
- Top Middle:** A map of the Galapagos Islands with a red dot indicating the location of Roca Redonda.
- Top Right:** A list of "Target participants" with criteria for selection based on current roles, laboratory involvement, and research interests in natural CO<sub>2</sub> vents.
- Middle Left:** A list of "Lecturers" including Dr. Rafael Bermudez, Dr. Cristian A. Vargas, Dr. Lorena Ariza, Dr. Sebastian Vignati, Dr. Nelson A. Lagos, and Dr. Nancy Goveas.
- Middle Right:** A list of "Organizers" including Dr. Rafael Bermudez, Dr. Cristian A. Vargas, and Dr. Nelson A. Lagos.
- Bottom Left:** A list of "Objectives" for the course, including training in different aspects of OA research, measuring parameters, and data analysis.
- Bottom Middle:** A list of logos for partner organizations: IAEA, IOC-UNESCO, SCOR, MUSELS, IMO, and the University of Palermo.
- Bottom Right:** A grid of photographs showing participants in a classroom, a red table with samples, a rocky coastline, and underwater scenes with divers and coral reefs.

During the course we were using natural CO<sub>2</sub> gradients around Roca Redonda to conduct in situ observations using a wide range of techniques for long term capacity building (chemistry, biology, geology, etc) and data collection. In order to achieve this we conducted an advance training course, using natural CO<sub>2</sub> seeps as experimental units. All participants were selected based on their current role in their laboratories indicating their active, full-time involvement with relevant analytical duties in the field and in their laboratories. Thus an extended collaboration based on mutual interests was set-up after the training course. As a result of this capacity building action, and the expedition to Roca Redonda CO<sub>2</sub>-seep site, the research group at the Galapagos Marine Research and Exploration Program (GMaRE) and Chilean researchers aim to implement an OA observatory at oceanic islands.

During 2018, Dr. Vargas continued his participation in the Executive Council of two highly relevant international programs. He serves as a member of the Executive Council of the **Global Ocean Acidification Observing Network, (GOA-ON)**, and as member of the **Scientific Committee of the International Ocean Carbon Coordination Program (IOCCP)**. During 2018, Dr. Vargas was also actively working in the international network program CO<sub>2</sub> Pier2Peer from GOA-ON. Pier2Peer is a scientific mentorship program that matches senior researchers with early career scientists to facilitate an exchange of expertise and to provide a platform for international collaborations. During 2018, Dr. Celeste Sánchez Noguera from University of Costa Rica was conducting a research stay at Dr.

Vargas's Lab in Concepcion, Chile, involving training on different techniques, including the analyses of Dissolved Inorganic Carbon (DIC), Total Alkalinity ( $A_T$ ), and in the framework of this Pier2Peer program, Dr. Vargas was conducting a Short-Course on the *Application of Stable Isotopes in Ocean Acidification Studies* at the Universidad de Costa Rica in San José. The researchers of RL1 and RL2 were also carrying out groundbreaking work in capacity building in other Latin-American countries (e.g. Peru, Ecuador, and Costa Rica), focused in monitoring and understanding the rates and effects of OA.

Dr. von Dassow continues to be an associate investigator in the CNRS international research unit UMI 3614 “Evolutionary Biology and Ecology of Algae”, which includes partners in the CNRS, Sorbonne Université, PUCCh, and UACH. This resulted in the project FONDECYT 1181614, which began in November 2018 and involves von Dassow as principal investigator, with Dr. Sylvain Faugeron (chilean leader of UMI 3614) and Dr. Aguilera (IMO adjunct researcher) as co-investigator. Also, the new culture collection of micro- and macroalgae “South Eastern Pacific Algae” (SEPA) now has a public website at <http://sepa.bio.puc.cl/> where over 350 strains of microalgae and over 1600 strains of macroalgae can be ordered by any researcher in Chile.

During 2018 two new networking projects were funded by CONICYT/Chile through the Program International Collaborative Networks between research Centers. The new **TROPHONET network** was established between IMO and the Spanish Oceanographic Institute (IEO) located at La Coruña, Spain. TROPHONET at IMO is lead by R. Escribano and it is focused on trophodynamics and food webs of deep ocean pelagic communities. Spanish and IMO researchers will collaborate to develop science, training and education in this topic during 2018 2019 and 2020. A second network between IMO and the Bioscience Department of Swansea University, UK, named as **ZOOP-NET** will focus on collaborative research for improving estimates of marine zooplankton production through the neutral red method. This network project is lead by P. Hidalgo (IMO adjunct researcher) and R. Escribano, and it will begin activities by early 2019 by a Methodology-focused workshop to calibrate and establish protocols to estimate natural mortality of zooplankton in the ocean, in the context of responses and adaptation to a changing ocean.

In 2017 a new SCOR (Scientific Committee for Oceanic Research) Working Group was approved on **Eastern Boundary Upwelling Ecosystems (EBUS)**. Activities of this WG 155 began during June 2018 after a first face-to-face meeting hosted at Washington DC, during the International Conference on the Impact of Climate Change on Marine Ecosystems organized by PICES. R. Escribano is co-chairing this SCOR WG 155 which is targeting collaborative research, training and education on the responses and dynamics of the four major EBUS under a changing ocean.

In the context of international networking for studying deep ocean and high seas zooplankton a new SCOR WG was also approved during 2018 which is focused of a worldwide network to assess genetic diversity based on metagenomics of zooplankton. The WG has been named as **METAZOOGENE** and is lead by Ann Bucklin of Connecticut University, USA. R. Escribano has become associate member of this WG.

IMO also continued to be member of the RON (Regional Nodes) Managers and Steering Committee of OBIS (Ocean Biogeographic Information System). This worldwide networking focused on integrated data of marine biodiversity is comprised by a series of regional nodes hosted at different institutions in the five continents, the regional node of OBIS of the eastern South Pacific, **ESPOBIS**, is hosted at University of Concepción and managed by IMO by P. Hidalgo and R. Escribano.

## b) Other collaborative activities:

In the context of networking IMO has continued to be an active participant of international networking programs and panels, such as the Ocean KAN (Knowledge Action Network) of the international program Future Earth and IMBeR (Integrated Marine Biosphere Research). In both panels R. Escribano has continued to be member of the scientific steering committees.

With internal financing from his university (PUCCh), Dr. von Dassow visited Dr. Uwe John of the Alfred Wegener Institute in Germany in June 2018 to analyze phylogenomic data on the evolutionary relationships between the cosmopolitan phytoplankton *Emiliana huxleyi*, which is the globally most abundant coccolithophore, and its close relatives in the genus *Gephyrocapsa*, which are not cosmopolitan. Whole genome re-sequencing data was analyzed to construct a time-calibrated species tree of the evolutionary divergence between these organisms. Analysis is ongoing in the two labs to determine the roles of introgressive hybridization, life cycle modification, gene loss, and positive selection in the evolutionary history resulting in *E. huxleyi* as cosmopolitan while the other species are not.

The project FONDEF IT17F10011 began in 2018 with Dr. Chris Aiken (PUCCh) as Director and Dr. von Dassow is Sub-Director. It seeks to develop an operational model for phytoplankton monitoring using ships of opportunity for automated sample collection and imaging flow cytometry for rapid through-put of sample analysis. This collaborative project also involves co-investigators Dr. Giancarlo Troni (PUCCh) and Dr. Catharina Alves-de-Souza (UNC-Wilmington, USA) and relies on collaboration with the government agency SERNAPESCA as associated entity.

## 6. Outreach and connections with other sectors

### a) Outreach:

The multi-disciplinary Outreach team of IMO aims to promote a meaningful learning and a major awareness and empowerment of how we must care about our Ocean. During 2018, the team worked in several initiatives:

#### 1. PME projects:

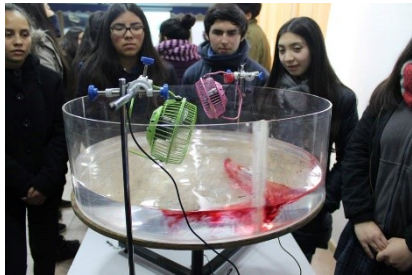
*i. “Inmerse: A journey through the Pacific Ocean” (“Sumérgete: una travesía por el Océano Pacífico”)* ([www.sumergete.cl](http://www.sumergete.cl))

A Web platform which began the year 2015 to approach the general community, mainly schools, in a fun way by informing and motivating with the wonders of the different marine environments of our country. In 2018, “Sumérgete” was finalist in the Comkids Interactive Festival, Brasil, Platform category; and it was nominated to best Antarctic Education project by Instituto Antártico Chileno (INACH).



Also, in 2018 it was held the third version of "Dive to Explore" competition, in association with The Ministry of Cultures, Arts and Heritage. Students worked in illustration and poetry, which were exhibited later, along with an Award Ceremony at the Estación de Biología Marina de la Universidad de Concepción (the Marine Biology Station of the University of Concepción), located in Dichato.

*ii. Itinerant Scientific Audiovisual Exhibiton (Muestra Audiovisual Científica Itinerante MACI)*



MACI is one of the most emblematic activity, whose main purpose is to "bring the ocean to school" for one day. The activity consists in a display of audiovisual material, followed by practical work and playful activities with the students from first and second grade of elementary school and high school education. In 2018, there were a total of 15 events, in Biobio Region, with more than 1.800 students.

*iii. IMO at the School (IMO en la Escuela)*

This initiative consists of theoretical and practical workshops focused on students from elementary and high school. During 2018 it were carried out more than 13 workshops, among which the most outstanding were “Biogeography” and “Deep Ocean”, and with more than 700 students participating.



*iv. Oceanic culture and marine science workshop for teachers (Taller de Cultura Oceánica y Ciencias del Mar para docentes)*



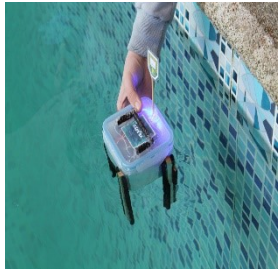
In December 2018, it was held once more this workshop for teachers from Coihueco commune, with the aim of update and strengthen their knowledge about marine sciences. It took place in the Estación de Biología Marina de la Universidad de Concepción (Marine Biology Station of the University of Concepción). "Biodiversity" and "How the ocean moves?" were the topics addressed.

## 2. Puppet show "Tony Tonina: Fins In Action (*Función de títeres Tony Tonina: Aletas en Acción*)

During 2018, the execution of the show, inspired by the animated TV series "The Scientific Recipe of Tony Tonina", was continued, with CONICYT auspice. It were carried out 10 performances, in Biobio, Ñuble and Metropolitan Regions. For more than 800 primary students.



## 3. ExploSub

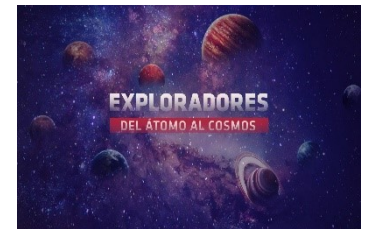


In 2018, it was executed the Explora Project for Valuation and Outreach of Science and Technology, called: "ExploSub: Science and technology for underwater exploration" (Ciencia y Tecnología para la Exploración Submarina)".

This consisted in applied technological development workshops, where students and teachers from Penco, Coihueco, Quillon and San Pedro County participated. They worked in the construction of a small-scale prototype of an underwater vehicle for the exploration of the ocean.

## 4. Explorers: From the Atom to the Cosmos (*Exploradores: del Átomo al Cosmos*)

It is from 2016 that IMO opened this new windows for science, creating and producing "Exploradores del Átomo al Cosmos" (Explorers: From the Atom to the Cosmos). In 2018 it was produced the third season, with 32 new episodes that portrait the research of the Chilean centers of excellence. The 32 episodes reached more than 12 million viewers. In this season one episode was dedicated to IMO, with the exploration to the Atacama Trench.



(<https://www.youtube.com/channel/UCJx7VStRwfK7UrcmVbhcjxg/videos>).

## 5. The Scientific Recipe of Tony Tonina (*La Receta Científica de Tony Tonina*)

Our children's series produced thanks to Explora Program of CONICYT, it has been spread through BIOBIO TV channel, NOVASUR channel for all over the country, reaching more than 7,200 schools, and the public television of Peru, Ipaev. Thereby, reaching a million of kids from Chile and Peru ([www.tonytonina.cl](http://www.tonytonina.cl)).

## 6. Experiment: Children's Science (*Experimenta: Ciencia de Niños*)

This new TV series for kids, with its first season released in 2018, aims to bring Science close to girls and boys, in an entertaining way, showing them the diversity of people doing science in laboratories, motivating, that way, more children with science. It was broadcasted by the Chilean public educational television network Novasur. One of the episodes was about IMO's researcher Rubén Escribano with zooplankton. "Experimenta" was awarded at "XXVII Festival Internacional de Cine para Niños y Jóvenes", Divercine 2018, in Uruguay.



## 7. The Fantastic Ruka trips (*Los Fantásticos Viajes de Ruka*)

It was produced this animated television series that tells the story of Ruka, a curious child who travels to the seabed with Nuna a unique turtle, where they discover amazing creatures and phenomena of the ocean. 13 chapters. Broadcasted in Chile and Colombia. Top 5 among the most watched series in Colombia. Produced by the support of the Chilean Council of Television (CNTV), Señal Colombia, Fundación Ciencia & Vida and IMO. Ruka was awarded at the III Festival Internacional de Cine Infantil y Juvenil Zinetxiki Zinemaldi.

### 8. Other significant events

During 2018, we participated and organized several others outreach activities, for school and general community, such as: national and communal scientific fairs; support for school science academies to scholar research and participation in Explora Congress; we received visits of delegations of students at the Marine Biology Station UdeC, in Dichato; scientific talks about Atacamex and the exploration of Atacama Trench, in massive events like Puerto de Ideas Festival, in Antofagasta, scientific coffee in Concepcion and in educational establishments; scientific illustration workshops; among others.



In the other hand, we have continued strengthening the alliances established all this years, and adding new ones, like: PAR Explora Biobío, Centro Interactivo de Ciencias, Artes y Tecnologías (CICAT), Pontificia Universidad Católica de Valparaíso, PAR Explora RM Sur Oriente, Ecology and Sustainable Management of Oceanic Islands (ESMOI), Instituto Antártico Chileno (INACH), Centro de Investigación en Ecosistemas de la Patagonia (CIEP), RedPOP, Ministry of Cultures, Arts and Heritage, Cultural Corporation “Artistas del Acero”.

We also experimented for the first time organizing seminars directed at undergraduate students organized by IMO researcher von Dassow in collaboration with the Asociación de Estudiantes de Ciencias del Mar de Chile (AECMAR). This collaboration organized a seminar of IMO Director Ulloa “Explorando Nuestro Mar Profundo: La Fosa de Atacama” on 22/11/2018 in the PUC. The auditorio reached over capacity, with undergraduates principally from the marine biology programs of the PUC and the Universidad Andres Bello. Based on the positive experience and high interest from AECMAR, these seminars will be repeated in 2019.

#### b) Connections with other sectors:

IMO offers calibration of oceanographic instruments (e.g. CTDs) to external users, covering a lack of such services. In relation to this, IMO signed a Memorandum of Understanding with the French company NKE Instruments to cooperate in maintenance, equipment calibration, and eventual technological development in ocean sensors. So we are extending our technical capabilities to scientific and industrial areas.

#### c) Other achievements:

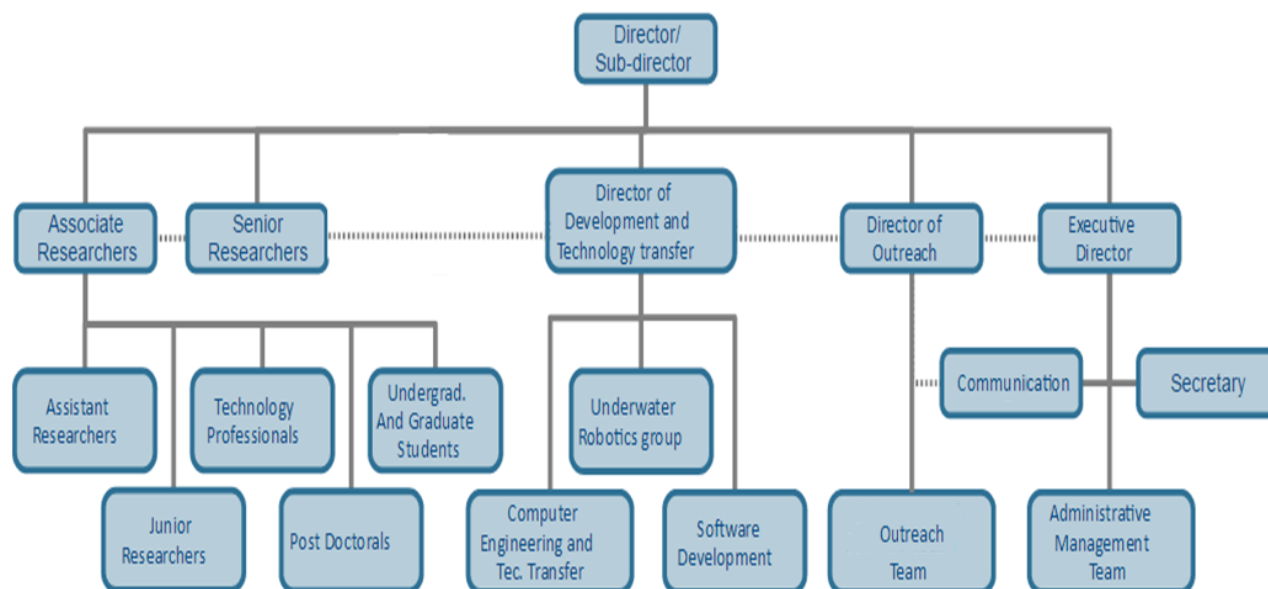
At the meeting organized by the ministries of foreign affairs, where participates the member countries of GRASP-GOOS and the CPPS (Peru, Colombia, Chile and Ecuador), it was agreed to analyze the possibility of adopting POMeO, the computer system for operational oceanography/meteorology

(developed by IMO researchers), as a basis for the development of the systems operational oceanography / meteorology of the member countries of the alliance.

## 7. Administration and Financial Status

### a) Organization and administration:

The following chart represent the organizational and operational structure during 2018.



The administration team for 2018 was comprised of Mr. Mario Baltazar as Chief Accountant, and Mrs. Olga Pérez as the Assistant Accountant, and IMO's Executive Secretary, Mrs. Francisca Osses, The three of them full time, a Housekeeper Assistance, Mrs Paola Torres and the Executive Director Mr. Atilio E. Morgado, both of them part time. The number of professionals (Assistant and Technician) ranged between 24 to 31, working in laboratory, sample and data analysis, field task, including cruises and marine operations and equipment operation. Some of them contributed also to R&D and Outreach activities.

During 2018, administrative demand was comparable to the year before, explained by factors such as turnover of staff, as well as new professionals, new Explora, Fondecyt and International Networking projects, obtained by professionals and researchers from the Institute, and other reported activities. During this year IMO continued renting a house to satisfy the needs for meeting room, outreach team and administrative offices, oceanographic equipment warehousing, maintenance facilities, etc., starting with the "Casa IMO" (*IMO Home*).

A summary of administrative and technical staff by gender is presented below.

Category	Female	Male	TOTAL
Assistant & Technicians	13	18	31
Administrative Staff	4	2	6
TOTAL	17	20	37

**b) Financial Status:**

The financial status, in terms of fund sources, income, leverage and percentage of use of that funds are detailed as required in Annex 9.



## 8. Annexes

### **Annex 1.- Institute / Nucleus Researchers**

#### 1.1 Associate Researchers

Full Name	Research Line	Nationality	Gender	Date of birth	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Oscar Roberto Pizarro Arriagada	1,2,4	Chilean	M	28-03-1963	Oceanographer	D	UdeC	Full Professor	2
Peter von Dassow	All	American	M	31-03-1974	Oceanographer	D	PUC	Assistant Professor	2
Oswaldo Iván Ulloa Quijada	3,4	Chilean	M	21-05-1961	Marine Biologist	D	UdeC	Full Professor	2
Heraclio Rubén Escribano Veloso	All	Chilean	M	16-04-1957	Marine Biologist	D	UdeC	Full Professor	2
Carmen Morales Van De Wyngard	1,2	Chilean	F	16-07-1955	Biologist	D	UdeC	Associate Professor	2
Wolfgang Schneider	2,4	German	M	16-02-1954	Oceanographer	D	UdeC	Full Professor	2
Cristian Antonio Vargas Galvez	1,3,4	Chilean	M	26-12-1972	Marine Biologist	D	UdeC	Assistant Professor	2
Samuel Ernesto	1,2	Chilean	M	08-12-1967	Oceanographer	D	PUCV	Associate	2

Hormazábal Fritz								Professor	
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## 1.2 Young 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	2,3	Chilean	M	01-11-76	Marine Biologist	D	CEAZA	Assistant Professor	2
Marcela Alejandra Cornejo D'Ottone	1	Chilean	F	20-07-77	Oceanographer	D	Pontifical Catholic University of Chile	Associate Professor	2
Pierre Amael Auger	1	French	M	07-09-1984	Engineer	D	Mllennium Institute of Oceanography	Postdoctoral fellow	1
Ramiro Antonio Riquelme Bugueño	1, 3, 4	Chilean	M	07-09-1978	Marine Biologist	D	University of Concepción – IMO	Assistant Professor	2

## 1.3 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	All	Chilean	M	19-08-40	Biologist	D	PUC	Professor	2
Gerrit van den Engh	All	Holland	M	06-03-49	Biologist	D	MarCy	Senior researcher	2

## 1.4 Others

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Carolina Eugenia Parada Veliz	1	Chilean	F	02-10-1970	Oceanographer	D	University of Concepción	Assistant Professor	2
Julio Sepúlveda Arellano	2, 3:	Chilean	M	25-02-1977	Marine Biologist	D	University of Colorado Boulder	Assistant Professor	2
Marcelo Enrique Oliva Moreno	4	Chilean	M	17-03-1952	Biologist	D	University of Antofagasta	Full Professor	2
Pablo Rosenblatt Guelfenbein	All.	Chilean	M	06-01-1955	Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2
Pamela del Carmen Hidalgo Diaz	3	Chilean	F	07-06-1966	Other	D	University of Concepción	Adjunct Professor	2
Mauricio Andrónico Urbina Foneron	1, 3, 4	Chilean	M	07-09-1978	Aquaculture Engineer	D	University of Concepción	Assistant Professor	2
Víctor Enrique Villagrán Orellana	All.	Chilean	M	02-03-1973	Electronic Engineer	M	University of Concepción	Chief MIDGEO Laboratory	2
Paulina Andrea Aguayo Venegas	3	Chilean	F	31-12-1980	Marine Biologist	D	Millennium Institute of Oceanography	postdoctoral fellow	1
Carlos Andrés Henríquez Castillo	3, 4	Chilean	M	06-05-1983	Biochemist	D	University of Concepción – IMO	postdoctoral fellow	2
Pedro Echeveste De Miguel	3, 4	Spanish	M	03-08-1981	Biologist	D	Pontifical Catholic University of Chile	postdoctoral fellow	1
Frauke Albrecht	2	German	F	02-01-1980	Geoscientist	D	University of Hamburg Germany	Postdoctoral fellow	1
Eric Potvin	1,3	Canadian	M	07-06-1983	Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Vera Oerder	1,3	French	F	22-07-1987	Oceanographer	D	PUCV-IMO	Postdoctoral fellow	1

Paula Ruz Moreno	2,4	Chilean	F	06-07-1983	Marine Biologist	D	PUCV-IMO	Postdoctoral fellow	2
Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Ígor Fernández	2, 4	Spanish	M	11-11-2015	Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Natalia Osma	3	Spanish	F	29-01-1983	Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Diana Medellín Mora	3	Colombian	M	23-08-1977	Marine Biologist	D	Millennium Institute of Oceanography	Postdoctoral fellow	1
Katty Donoso	3	Chilean	F	12-05-1982	Marine Biologist	D	University of Concepción – IMO	Postdoctoral fellow	2
Elise Van Meerssche	3	French	F	02-07-1986	Chemist	D	Pontifical Catholic University of Chile	Postdoctoral fellow	2
Atilio Morgado	All	Chilean	M	23-05-1960	Marine Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2

**NOMENCLATURE:**

<b>[Gender]</b> [M] Male [F] Female	<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

N°	Research Line	Research Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date	Ending Date
1	Mesoscale processes	What is the role of mesoscale activity in governing energy and matter transfer and ecosystem dynamics in open ocean ecosystems	<p>Mesoscale eddies are characteristic of the southeastern Pacific (SEP) and connect areas with coastal upwelling with oligotrophic oceanic waters, as well as meso- and epipelagic domains. Eddies create unique and relatively isolated environments with distinct biological communities and chemical conditions, depending on the nature of the water trapped, the characteristics and path of eddies and their interactions with winds and topography. Seamounts, submarine mountain ranges and oceanic islands in the southeastern Pacific can also create or strengthen mesoscale activity and consequently increase biological production around them.</p> <p>Our hypothesis is that mesoscale eddies generated in the coastal area create conditions of deficient O<sub>2</sub>/low pH in the open sea (or the opposite in areas with minimal oxygen), with corresponding changes in the structure of communities and biochemical cycles, and that differ significantly from those found in adjacent oceanic waters.</p> <p>To address this research theme, we will carry a field experiment to study the characteristics and evolution of mesoscale eddies generated in the sea beyond central Chile (~36 °S) and that are propagated to the northwest, reaching to around the Juan Fernández Archipelago. The field experiment will include time-series observations by satellite teledetection (e.g. ocean altimetry and color), an anchorage in the vicinity of the Juan Fernández Archipelago, and sections with a sailplane, as well as cruises oriented to processes.</p>	<p><b>Carmen Morales</b>  <b>Samuel Hormazábal</b>            Carolina Parada.            Marcela Cornejo.            Juan C. Castilla.            Oscar Pizarro.            Peter von Dassow            Cristian Vargas            Heraclio Rubén            Escribano            Ramiro Riquelme            Pierre Amael Auger            Víctor Villagrán            Pablo Rosenblatt</p>	<p>Ecology and environmental sciences.            Oceanography            y            Meteorology and climatology.            Marine biology.            numerical methods and computer science.</p>	26-12-2013	31-12-2018

2	Ocean Variability and Change	How large scale perturbations impact the transport and gradients in physical chemical water properties	<p>The subtropical cell controls the large-scale transport of heat, freshwater, carbon, nutrients and dissolved O<sub>2</sub> through the southeastern Pacific basin. These processes modulate chemistry and biology and the regional component of the climate variability. Models and field observations have shown that in the context of climate warming, the subtropical celda of the South Pacific is reinforced as a response to changes in surface winds on a large scale on the tropical Pacific. As well, it is expected that global warming directly affects the South Pacific by strengthening the degree of productivity.</p> <p>As the temperature of the upper layers increases, the stratification of oceanic water is reinforced, affecting the mixing of water masses and vertical diffusiveness in subtropical regions. In contrast, stronger coastal winds could increase vertical mixing and upwellings of eastern currents. It has been argued that coastal upwelling and transport by the Humboldt Current have intensified in recent decades and has been getting stronger on the scale of decades. This in turn has been modifying the properties of waters that participate in the subtropical cell and in an increase in the physical, biochemical and ecological gradients between the coastal and oceanic environments. The lower O<sub>2</sub> content of the warmer ocean waters and the higher gradients between upwelling and stratified oceanic waters contributes to expanding waters low in O<sub>2</sub>/pH and high in pCO<sub>2</sub>, which affects biological communities and the biogeochemical cycles in these waters.</p>	<p><b>Oscar Pizarro Arriagada.</b>  <b>Wolfgang Schneider</b>                  Ricardo Hernán De Pol Holz.                  Carolina Eugenia Parada Veliz.                  Samuel Ernesto Hormazábal Fritz                  Carmen Morales Van de Wyngard                  Peter von Dassow                  Víctor Miguel Aguilera Ramos.                  Aldo Manuel Montecinos Gula                  Heraclio Rubén Escribano Veloso.                  Víctor Enrique Villagrán Orellana                  Pierre Amael Auger                  Frauke Albrecht                  Pablo Rosenblatt</p>	<p>Biochemistry.                  Ecology and environmental sciences.                  Oceanography                  Meteorology and climatology.                  Marine biology.                  numerical methods and computer science.</p>	26-12-2013	31-12-2018
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3	Adapting to a Changing Ocean	How Key functional plankton groups adapt to changing ocean chemistry and impact biogeochemical cycling	<p>The strong and dynamic horizontal chemical gradients in the southeastern Pacific (SEP), from ultra-oligotrophic waters to coastal upwelling, exhibit highly variable combinations of low O<sub>2</sub> and pH/high pCO<sub>2</sub> and include strong vertical changes in O<sub>2</sub> concentrations, from saturation levels at the surface to undetectable levels in the nucleus of minimum oxygen zone (MOZ). These gradients cover a wide range of spatial-temporal scales.</p> <p>The responses of plankton communities and the feedback between community function and biogeochemical dynamics can depend in large measure on adaptations and capacities of acclimatization of key components, which can vary significantly among oceanic habitats. Moreover, the biological responses to multiple stress factors can be additive, synergetic or antagonistic.</p> <p>Our hypothesis is that the genomic variability among marine species is related to the differential functional responses to multiple stress factors and these determine the persistence or the modification of ecological/biogeochemical functions as the chemistry of the ocean changes.</p> <p>It is postulated that community functioning in highly stable environments like the South Pacific gyre is less robust in the context of changes in chemical conditions compared to that of highly variable environments, such as the oceanic coasts.</p> <p>Field and laboratory work will be undertaken to address this theme. In the first fieldwork undertaking, key representatives of functional plankton from areas with gradients of pCO<sub>2</sub>, pO<sub>2</sub> and nutrients will be isolated. In association with this activity, a new collection of phytoplankton will be initiated at the PUC in coordination with the Roscoff Culture Collection.</p> <p>Perturbation experiments will be conducted with single stress factors on selected species, focusing on physiological variability in response to variations in pCO<sub>2</sub>/pH, and O<sub>2</sub>, and allow for improving the design of experiments with multiple stress factors. Based on these results, we conduct genomic analysis of species/genera (e.g. low O<sub>2</sub> – Prochlorococcus; low pH/high pCO<sub>2</sub> – Coccolithophore).</p>	<p><b>Peter von Dassow.</b>  <b>Oswaldo Iván Ulloa Quijada.</b>  <b>Cristian Antonio Vargas Galvez.</b>                  Pamela del Carmen Hidalgo Diaz.                  Víctor Miguel Aguilera Ramos.                  Ricardo Hernán De Pol Holz.                  Alvaro Alfredo Muñoz Plominsky.                  Heraclio Rubén Escribano Veloso.                  Gerrit van den Engh.                  Víctor Enrique Villagrán Orellana                  Pedro Echeveste De Miguel.                  Pablo Rosenblatt</p>	<p>Numerical methods and computer science.</p> <p>Biochemistry.</p> <p>Marine biology.</p> <p>Biophysics.</p> <p>Microbiology</p> <p>Oceanography</p>	26-12-2013	
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4	the deep Ocean	<p>what are the community structures and the biogeochemical characteristics of the deep and abyssal waters of the ESP</p>	<p>The ecosystems of deep SEP waters are practically unknown. Exploration of mesopelagic (&gt;500 m) and abyssopelagic communities (&gt;3000 m) represent unique opportunities to discover new forms of life, species and genes for science, as well as a major challenge for oceanography in the South Pacific basin.</p> <p>This initiative will allow for identifying the mechanism through which communities are able to distribute themselves widely and colonize unique habitats like the Atacama Trench and the Nazca, Salas &amp; Gómez and Juan Fernández ranges. Our hypothesis is that the ranges contribute significantly to the dispersion of species and the gene flows in the coast-ocean direction, driven by the circulation of water masses and mixing associated with the meso and large scale physical dynamics.</p> <p>To address this theme we will carry out deep water samplings, including a MOCNESS net (maximum depth of 6,500 m) with an underwater video profiler (UVP), conductivity, temperature and fluorescence sensors and stratified sampling nets.</p> <p>The underwater video profiler provides profiles of the distributions of particle sizes, while the net samplings will be divided into fractions for examining live animals, DNA analysis and taxonomic studies.</p> <p>Water samples will also be taken for molecular and genomic analyses of microbial communities (viruses to protists). In situ incubation systems will be developed to estimate microbiological activity/rates. Quantitative and qualitative assessments will also be made of fish parasites and plankton as biomarkers of the dispersion of host species and the colonization of habitats. Individual and biogeochemical models will be used to analyze the mechanisms that contribute to maintaining endemic communities and the connectivity among different islands, seamounts and other oceanic regions.</p> <p>Molecular analysis of selected plankton will be centered on DNA microsatellites and mitochondrial DNA to relate sampled populations and species in the coast-ocean direction and in the vertical dimension.</p>	<p><b>Heraclio Rubén Escribano Veloso. Osvaldo Iván Ulloa Quijada.</b> Marcelo Enrique Oliva Moreno. Pamela del Carmen Hidalgo Diaz. Wolfgang Schneider. Oscar Roberto Pizarro Arriagada. Peter von Dassow Cristian Antonio Vargas Galvez. Pablo Rosenblatt Guelfenbein. Ramiro Antonio Riquelme Bugueño. Víctor Enrique Villagrán Orellana. Pablo Rosenblatt Gerrit van den Engh.</p>	<p>Numerical methods and computer science.</p> <p>Biochemistry.</p> <p>Marine biology.</p> <p>Biophysics.</p> <p>Microbiology</p> <p>Oceanography</p> <p>Ecology and Environmental Sciences</p>	<p>26-12-2013</p>	
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**Annex 3.- Publications (Total or partially financed by MSI)****3.1.- ISI/WOS Publications or Similar to ISI/WOS Standard:****3.1.1 Associate Researchers:**

1. Ruz P., Hidalgo P., Escribano R., Keister J., Yebra L., Franco-Cisterna B. (2018) Hypoxia effects on females and early stages of *Calanus chilensis* in the Humboldt Current ecosystem (23°S). *Journal of Experimental Marine Biology and Ecology* 498: 61-71. Q2, IF: 1.99, Research Line 3
2. Valdés V., Fernández C., Molina V., Escribano R.(2018) Nitrogen excretion by copepods and its effect on ammonia-oxidizing communities in a coastal upwelling zone. *Limnology and Oceanography* 63: 278-294. Q1\*, IF: 3.794, Research Line 4
3. Vargas C., Cuevas L., Silva N., González H., De Pol-Holz R., Narváez D. (2018) Influence of glacier melting and river discharges on the nutrient distribution and DIC recycling in the Southern Chilean Patagonia. *Journal of Geophysical Research: Biogeosciences*123: 256-270. Q1, IF: 3.487, Research Line 3
4. Medel M., Parada C., Morales C., Pizarro O., Ernst B., Conejero C. (2018) How biophysical interactions associated with sub- and mesoscale structures affect planktonic larvae of the spiny lobster in the Juan Fernández Ridge: A modeling approach. *Progress in Oceanography*162: 98-119. Q1\*, IF: 4.27, Research Line 2
5. Ñacari L., Sepulveda F., Escribano R., Oliva M. (2018) *Acanthocotyle gurgesiella* n. sp. (Monogenea: Acanthocotylidae) from the deep-sea skate *Gurgesiella furvescens* (Rajidae) in the south-eastern Pacific. *Journal of Helminthology*92: 223-227. Q2, IF: 1.63, Research Line 4
6. Von Dassow P., Díaz-Rosas F., Bendif E., Gaitán-Espitia J., Mella-Flores D., Rokkita S., John U., Torres R. (2018) Overcalcified forms of the coccolithophore *Emiliania huxleyi* in high CO2 waters are not pre-adapted to ocean acidification. *Biogeosciences*15: 1515-1534. Q1, IF: 3.978, Research Line 3
7. Correa-Ramírez M., Morales C., Letelier R., Anabalón V., Hormazábal S.(2018) Improving the remote sensing retrieval of phytoplankton functional types (PFT) using empirical orthogonal functions: A case study in a coastal upwelling region. *Remote Sensing*10: . Q1, IF: 3.406, Research Line 1
8. Oliva M., Valdivia I., Cárdenas L., Muñoz G., Escribano R., George-Nascimento M. (2018) A new species of *Proctoeces* and reinstatement of *Proctoeces humboldti* George-Nascimento and Quiroga 1983 (Digenea: Fellodistomidae) based on molecular and morphological evidence. *Parasitology International* 67: 159-169. Q2, IF: 2.055, Research Line 4
9. Frederick L., Escribano R., Morales C., Hormazábal S., Medellín-Mora J. (2018) Mesozooplankton respiration and community structure in a seamount region of the eastern South Pacific. *Deep-Sea Research Part I: Oceanographic Research Papers*135: 74-87. Q1, IF: 2.684, Research Line 4
10. Ñacari L., Sepúlveda F., Escribano R., Bray R., Oliva M. (2018) Morphological and molecular characterization of digenean parasites of the Galapagos sheephead *Semicossyphus darwini* (Jenyns) with the re-description of *Labrifer secundus* Manter 1940 (Lepidapedidae) from the Humboldt Current Large Marine Ecosystem. *Systematic Parasitology* 95: 391-401. Q3, IF: 1.273, Research Line 4
11. Oerder V., Bento J., Morales C., Hormazábal S., Pizarro O. (2018) Coastal upwelling front detection off Central Chile (36.5–37°S) and spatio-temporal variability of frontal characteristics. *Remote Sensing*10: . Q1, IF: 3.406, Research Line 1

12. Echeveste P., Croot P., Von Dassow P. (2018) Differences in the sensitivity to Cu and ligand production of coastal vs offshore strains of *Emiliania huxleyi*. *Science of The Total Environment* 625: 1673-1680. Q1, IF: 4.61, Research Line 3
13. Saavedra L., Parra D., San Martín V., Lagos N., Vargas C. (2018) Local habitat influences on feeding and respiration of the intertidal mussels *Perumytilus purpuratus* exposed to increased pCO<sub>2</sub> levels. *Estuaries and Coasts* 41: 1118-1129. Q1, IF: 2.659, Research Line 3
14. Corredor-Acosta J., Morales C., Brewin R., Auger P., Pizarro O., Hormazábal S., Anabalón V. (2018) Phytoplankton size structure in association with mesoscale eddies off Central-Southern Chile: the satellite application of a phytoplankton size-class model. *Remote Sensing* 10: . Q1, IF: 3.406, Research Line 1
15. Dornelas M., Antão L., Moyes F., Bates A., Magurran A., Adam D., ..., Escribano R., ..., Hidalgo P., ..., Zettler M. (2018) BioTIME: A database of biodiversity time series for the Anthropocene. *Global Ecology and Biogeography* 27: 760-786. Q1\*, IF: 5.958, Research Line 4
16. Waller R., Cleves P., Rubio-Brotons M., Woods A., Bender S., Edgcomb V., Gann E., Jones A., Teytelman L., Von Dassow P., Wilhelm S., Collier J. (2018) Strength in numbers: collaborative science for new experimental model systems.. *PLOS Biology* 16: . Q1\*, IF: 9.163, Research Line 3
17. Plominsky A., Trefault N., Podell S., Blanton J., De la Iglesia R., Allen E., Von Dassow P., Ulloa O. (2018) Metabolic potential and in situ transcriptomic profiles of previously uncharacterized key microbial groups involved in coupled carbon, nitrogen, and sulfur cycling in anoxic marine zones. *Environmental Microbiology* 20: 2727-2742. Q1\*, IF: 6.201, Research Line 3
18. Plominsky A., Henríquez C., Delherbe N., Podell S., Ramírez-Flandes S., Ugalde J., Santibañez J., Van Den Engh G., Hanselmann K., Ulloa O., De la Iglesia R., Allen E., Trefault N. (2018) Distinctive archaeal composition of an artisanal crystallizer pond and functional insights into salt-saturated hypersaline environment adaptation.. *Frontiers in Microbiology* 9: . Q1, IF: 4.165, Research Line 3
19. Crowe S., Cox R., Jones C., Fowle D., Santibañez-Bustos J., Ulloa O., Canfield D. (2018) Decrypting the sulfur cycle in oceanic oxygen minimum zones. *ISME Journal* 12: 2322-2329. Q1\*, IF: 9.52, Research Line 3
20. Aldunate M., De la Iglesia R., Bertagnolli A., Ulloa O. (2018) Oxygen modulates bacterial community composition in the coastal upwelling waters off central Chile. *Deep-Sea Research Part II: Topical Studies in Oceanography* 156: 68-79. Q1, IF: 2.451, Research Line 3
21. Díaz R., Lardies M., Tapia F., Tarifeño E., Vargas C. (2018) Transgenerational effects of pCO<sub>2</sub>-driven ocean acidification on adult mussels *Mytilus chilensis* modulate physiological response to multiple stressors in larvae. *Frontiers in Physiology* 9: . Q1, IF: 3.394, Research Line 3
22. Iriarte J., Cuevas L., Cornejo F., Silva N., González H., Castro L., Montero P., Vargas C., Daneri G. (2018) Low spring primary production and microplankton carbon biomass in Sub-Antarctic Patagonian channels and fjords (50-53°S). *Arctic, Antarctic, and Alpine Research* 50: . Q3, IF: 2.231, Research Line 3
23. • Valdés V., Carlotti F., Escribano R., Donoso K., Pagano M., Molina V., Fernandez C. (2018) Nitrogen and phosphorus recycling mediated by copepods and response of bacterioplankton community from three contrasting areas in the western tropical South Pacific (20° S). *Biogeosciences* 15: 6019-6032. Q1, IF: 3.978, Research Line 4
24. • Duarte C., Navarro J., Quijón P., Loncon D., Torres R., Manríquez P., Lardies M., Vargas C., Lagos N. (2018) The energetic physiology of juvenile mussels, *Mytilus chilensis* (Hupe): The prevalent role of salinity under current and predicted pCO<sub>2</sub> scenarios. *Environmental Pollution* 242: 156-163. Q1, IF: 4.358, Research Line 3

25. • Espínola-Novelo J., Escribano R., Oliva M. (2018) Metazoan parasite communities of two deep-sea elasmobranchs: the southern lanternshark, *Etmopterus granulosus*, and the largenose catshark, *Apristurus nasutus*, in the Southeastern Pacific Ocean. *Parasite* 25: . Q2, IF: 2.069, Research Line 4
26. • Ganesh S., Bertagnolli A., Bristow L., Padilla C., Blackwood N., Aldunate M., Bourbonnais A., Altabet M., Malmstrom R., Woyke T., Ulloa O., Konstantinidis K., Thamdrup B., Stewart F. (2018) Single cell genomic and transcriptomic evidence for the use of alternative nitrogen substrates by anammox bacteria. *ISME Journal* 12: 2706-2722. Q1\*, IF: 9.52, Research Line 3
27. • Jacob B., Tapia F., Quiñones R., Montes R., Sobarzo M., Schneider W., Daneri G., Morales C., Montero P., González H. (2018) Major changes in diatom abundance, productivity, and net community metabolism in a windier and dryer coastal climate in the southern Humboldt Current. *Progress in Oceanography* 168: 196-209. Q1\*, IF: 4.27, Research Lines 1, 3
28. • Mella-Flores D., Machon J., Contreras-Porcía L., Mesa-Campbell S., Von Dassow P. (2018) Differential responses of *Emiliana huxleyi* (Haptophyta) strains to copper excess. *Cryptogamie, Algologie* 39: 481-509. Q3, IF: 1.114, Research Line 3

### 3.1.2 Other researchers:

- 1 Gómez-Gutiérrez J., Batchelder H., Riquelme-Bugueño R. (2018) William Thornton Peterson, “Bill”, 1942–2017, Zooplankton, *Climate Change. Journal of Plankton Research* 40: 503-508. Q2, IF: 1.897, Research Line 4
- 2 Santa Cruz F., Ernst B., Arata J., Parada C. (2018) Spatial and temporal dynamics of the Antarctic krill fishery in fishing hotspots in the Bransfield Strait and South Shetland Islands. *Fisheries Research* 208: 157-166. Q2, IF: 1.874, Research Line 1
3. Parada C., Gretchina A., Vásquez S., Belmadani A., Combes V., Ernst B., Di Lorenzo E., Porobic J., Sepúlveda A. (2017) Expanding the conceptual framework of the spatial population structure and life history of jack mackerel in the eastern South Pacific: an oceanic seamount region as potential spawning/nursery habitat. *ICES Journal of Marine Science* 74: 2398-2414. Q1, IF: 2.906, Research Line 1

### 3.2.- SCOPUS Publications or Similar to SCOPUS Standard:

- 3.2.1 Associate Researchers: No publications
- 3.2.2 Other researchers: No publications

### 3.3.- SCIELO Publications or Similar to SCIELO

#### 3.3.1 Associate Researchers:

1. Medellín-Mora J., Escribano R., Schneider W., Correa-Ramírez M. (2018) Spatial variability of zooplankton community structure in Colombian Caribbean waters during two seasons. *Revista de Biología Tropical* 66: 688-708. Q2, IF: 0.33, Research Line 3

#### 3.3.2 Other researchers:

1. Sandoval M., Parada C., Torres R. (2018) Proposal of an integrated system for forecasting Harmful Algal Blooms (HAB) in Chile. *Latin American Journal of Aquatic Research* 46: 424-451. Q4, IF: 0.482, Research Line 1

### 3.4.- Scientific Books and Chapters

- 3.4.1 Associate Researchers: No publications
- 3.4.2 Other researchers: No publications

### 3.5.- Other Publications

#### 3.5.1 Associate Researchers:

1. Hardy, K. & O. Ulloa (2018). Lander depth record set for the Peru Chile/Atacama Trench. Marine Technology Reporter 61(3): 34-41

#### 3.5.2 Other researchers:

### 3.5.- Collaborative publications:

Category of Publication	1 researcher		2 researchers		3 researchers		4 or more researchers	
	Nº	%	Nº	%	Nº	%	Nº	%
<i>ISI Publications or Similar to ISI Standard</i>	13	42	11	35	3	10	4	13
<i>SCIELO Publications or Similar to SCIELO Standard</i>	1	50			1	50		
<i>Books and chapters</i>								
<i>Other Publications</i>								
<b><u>Total of publications</u></b>	14	42	11	33	4	12	4	12

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

N°	Título Evento	Tipo Evento	Alcance	Publico Objetivo	Duración en días	País	Ciudad	Fecha inicio	Fecha Término	N° Asistentes	N° Expositores Milenio	N° Expositores Nacionales	N° Expositores Extranjeros	Investigador Responsable de la Actividad
1	Curso OBIS	Workshop	Internacional	Profesores Universitarios. Estudiantes de Postgrado.	5	Chile	Concepción	02-10-18	06-10-18	20	0	2	1	Pamela Hidalgo
2	Sistema de carbonato en el océano: Técnicas de laboratorio, uso y validación de sensores autónomos	Workshop	Nacional	Estudiantes de Postgrado	4	Chile	Concepción	15-01-18	18-01-18	20	1	0	0	Cristian Vargas
3	Aplicación de Isótopos Estables en Estudios de Acidificación del Océano	Workshop	Nacional	Estudiantes de Postgrado.	3	Chile	Concepción	26-11-18	28-11-18	25	1	1	0	Cristian Vargas
4	Simposio "Microbial Symposium in the Marine Environment	Conferencia	Internacional	Estudiantes de Postgrado. Profesores Universitarios Comunidad Científica	1	Chile	Concepción	12-01-18	12-01-18	100	0	0	4	Oswaldo Ulloa
	Ecology and Diversity of Marine Microorganisms (ECODIM)	Workshop	Internacional	Profesores Universitarios. Estudiantes de Postgrado	22	Chile	Concepción Dichato	07-01-18	28-01-18	30	0	1	7	Rubén Escribano

**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
O. Ulloa	1	1	2	1		1		2	2		2	2	2	5	7
R. Escribano	1	1	2	1		1	4		4	2	1	3	8	2	10
S.Hormazábal	1	1	2	2	2	4			0			0	3	3	6
O. Pizarro		1	1	1	2	3	1	1	2			0	2	4	6
W. Schneider			0			0		1	1			0	0	1	1
C. Vargas			0	1	1	2			0	2		2	3	1	4
P. Von Dassow			0			0		1	1		2	2	0	3	3
C.Morales		1	1			0	1		1	1		1	2	1	3
O.Ulloa/P.V.Dassow			0			0	1		1			0	1	0	1
O.Ulloa/R.Riquelme	1		1			0			0			0	1	0	1
C.Morales/ P. Von Dassow			0			0			0		1	1	0	1	1
C.Morales/ C.Parada		1	1			0			0			0	0	1	1
C.Morales/ S. Hormazábal			0			0	1		1			0	1	0	1
O.Pizarro/S.Hormazabal	1		1			0			0			0	1	0	1
O.pizarro/ C. Parada	1	1	2			0			0			0	1	1	2
O.Pizarro/V. Villagrán	1		1			0			0			0	1	0	1
Pablo Rosenblatt			0	1		1			0			0	1	0	1
Pamela Hidalgo	1		1			0			0			0	1	0	1
P. Von Dassow/ J. Sepúlveda			0		1	1			0			0	0	1	1
R. Escribano/ M.Oliva			0	1		1		1	1			0	1	1	2
R. Escribano/ P.Hidalgo	1	1	2	1		1	1		1			0	3	1	4

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
R. Escribano/ P.Hidalgo/ V́ctor Aguilera			0		1	1			0			0	0	1	1
R. Escribano/ R. Riquelme	1	1	2			0			0			0	1	1	2
R. Escribano/ P.Hidalgo/ V́ctor Aguilera			0			0			0			0	0	0	0
R. Escribano/ P.Hidalgo/ V́ctor Aguilera			0			0			0			0	0	0	0
R. Escribano/ P.Hidalgo/ V́ctor Aguilera			0			0			0			0	0	0	0
R. Escribano/ P.Hidalgo/ V́ctor Aguilera			0			0			0			0	0	0	0
S. Hormazábal/ C. Morales	1		1	1		1	2		2			0	4	0	4
S. Hormazábal/ C.Parada			0			0			0			0	0	0	0
S. Hormazábal/ C. Morales / Oscar Pizarro			0			0			0	1		1	1	0	1
S. Hormazábal/ M.Cornejo		1	1	2	1	3			0			0	2	2	4
W. Schneider/ O. Pizarro			0			0			0	1		1	1	0	1
V. Villagrán		1	1										0	1	1
<b>Total</b>	11	11	22	12	8	20	11	6	17	7	6	13	41	31	72

**Annex 5.2. - Short-term Traineeships of MSI students**

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Montserrat Aldunate	Pontificia Universidad Católica de Chile	Chile	Peter von Dassow	Escritura artículo científico de tesis	07-05-2018	27-05-2018
Lady Liliana Espinosa	Instituto Español de Oceanografía (IEO)/	España	Antonio Bode	Factores que modulan la estructura comunitaria de anfípodos hipéridos en la región oriental del pacífico sur.	05-09-2018	05-11-2018
Luis Valencia Castro	Universidad de Las Palmas de Gran Canaria	España	Ángel Rodríguez-Santana	investigación de procesos de mezcla en sistemas de afloramiento (desarrollo de algoritmos de procesamiento y análisis en MatLAB de registros de microestructura).	01-10-2018	30-11-2018



**Annex 6.- Networking and other collaborative work****6.1 Networking****NOMENCLATURE:****[Network Scope]**

[N] National [I] International [LA] Latin American

Network Name	Network Scope	Network Participants [Number]				Institutions
		From the Center		External		
		Resear chers	Postdocs/ Students	Researc hers	Postdocs/ Students	
Evolutionary Biology and Ecology of Algae, Unité Mixte de Investigation 3614 (CNRS, PUCCh, UACH)	I	1		7	1/5	PUC
						UACH
						CNRS
						Sorbonne Universités
International Research Network "Diversity, Evolution and Biotechnology of Marine Algae" (GDRI N° 0803)	I	1		>50		CNRS (France), Sorbonne Université UPMC Paris VI, 6 universities in Chile (PUCCh, U de Conc, U. Lagos, UCSC, U Mag, UACH), 2 universities in Brazil

**Annex 6.2.- Other collaborative activities**

Activity Name	Co-Participant Institution(s)	Participants [Number]				Products [Type & Number]
		MSI center		External		
		Researchers	Postdocs/ Students	Researchers	Postdocs/ Students	
Collection of Micro- and Macroalgas	Pontificia Universidad Católica de Chile	1		1		South Pacific East Algae culture collection <a href="http://sepa.bio.puc.cl/">http://sepa.bio.puc.cl/</a>

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

<i>Event Title</i>	<i>Type of Event</i>	<i>Scope</i>	<i>Target Audience</i>	<i>Date</i>	<i>Country</i>	<i>Region</i>	<i>N° of Student from the Center</i>	<i>N° of Attendees</i>	<i>Duration in days</i>	<i>Participating Researchers</i>	<i>Responsible for the activity</i>
<i>Puppets Show "Tony Tonina: Aletas en Acción" en Coliumo</i>	<i>Puppet Show</i>	<i>National</i>	<i>Primary Students General Community</i>	<i>6-01-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>35</i>	<i>1</i>	<i>Oswaldo Iván Ulloa Quijada.</i>	<i>Bárbara Léniz Genta</i>
<i>MACI Ranquil</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>5-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>3</i>	<i>49</i>	<i>1</i>		<i>Pamela Fierro</i>
<i>Inclusion Approach workshop</i>	<i>Seminar</i>	<i>National</i>	<i>University Students</i>	<i>1-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>2</i>	<i>16</i>	<i>1</i>	<i>Diana Johana Medellín Mora. Paulina Andrea Aguayo Venegas.</i>	<i>Bárbara Léniz Genta</i>
<i>IMO at the School "Deep Ocean" Concepción</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>2-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>25</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>"The water we live in" workshop for kids</i>	<i>Workshop</i>	<i>National</i>	<i>Primary Students</i>	<i>2-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>1</i>	<i>49</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>MACI Contulmo</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>6-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>5</i>	<i>95</i>	<i>1</i>		<i>Pamela Fierro</i>
<i>MACI Ñiquen</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>7-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>5</i>	<i>130</i>	<i>1</i>		<i>Pamela Fierro</i>
<i>MACI San Fabian</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>8-03-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>5</i>	<i>127</i>	<i>1</i>		<i>Pamela Fierro</i>
<i>IMO at the School "Deep Ocean"</i>	<i>Exhibition</i>	<i>National</i>	<i>Primary Students</i>	<i>9-04-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>12</i>	<i>1</i>		<i>Bárbara Léniz</i>

"ExploSub: Science and Technology for Submarine Exploration" Project	Submarine Robotic Workshops	National	Secondary Students	0-04-18	Chile	Bío Bío	2	150	150	Víctor Enrique Villagrán Orellana.	Bárbara Léniz Genta
Atacama Trench: a journey to our unknown Sea	Conference	National	General Community	4-04-18	Chile	Antofagasta	0	74	1	Oswaldo Iván Ulloa Quijada.	Oswaldo Ulloa
Talk "Mysteries of the Deep Ocean"	Conference	National	Secondary Students	6-04-18	Chile	Antofagasta	0	150	1	Oswaldo Iván Ulloa Quijada.	Oswaldo Ulloa
Puppets Show "Tony Tonina: Aletas en Acción" en Santiago	Puppet Show	National	General Community	1-04-18	Chile	Metropolitan of Santiago	1	25	1		Pamela Fierro
IMO laboratories visit	Exhibition	National	Primary Students	6-04-18	Chile	Bío Bío	1	12	1		Bárbara Léniz
Month of the Sea Launching in Dichato	Field trip	National	Primary Students	7-05-18	Chile	Bío Bío	1	205	1	Ramiro Antonio Riquelme Bugeño.	Bárbara Léniz Genta
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	8-05-18	Chile	Bío Bío	1	44	1		Pamela Fierro
Visit to EBM Dichato	Salida a terreno	National	Primary Students	8-05-18	Chile	Bío Bío	1	40	1		Pamela Fierro
Marine Scientific Fair in Arauco	Exhibition	National	General Community	0-05-18	Chile	Bío Bío	2	100	1		Pamela Fierro
IMO at the School "Deep Ocean" Arauco	Exhibition	National	Secondary Students Primary Students General Community	0-05-18	Chile	Bío Bío	0	185	1		Pamela Fierro
Puppets Show "Tony Tonina: Aletas en Acción" en Hualqui	Puppet Show	National	Primary Students	1-05-18	Chile	Bío Bío	0	160	1		Bárbara Léniz Genta
IMO at the School "Biogeography"	Exhibition	National	Primary Students	4-05-18	Chile	Bío Bío	0	28	1		Bárbara Léniz

Marine illustration Workshop	Workshop	National	General Community	9-05-18	Chile	Bío Bío	0	55	1		Aida Granell
MACI in "Artistas del Acero"	Exhibition	National	Primary Students	2-05-18	Chile	Bío Bío	5	87	1		Pamela Fierro
MACI Concepción	Exhibition	National	Primary Students	1-05-18	Chile	Bío Bío	5	112	1		Pamela Fierro
MACI El Carmen	Exhibition	National	Secondary Students	5-06-18	Chile	Bío Bío	4	80	1		Pamela Fierro
Deep Ocean Workshop	Exhibition	National	General Community	6-06-18	Chile	Bío Bío	1	12	1		Bárbara Léniz Genta
Science and Tecnology Exhibition in Mejillones	Exhibition	National	Teachers General Community	7-06-18	Chile	Antofagasta	1	120	1		Pamela Fierro
Marine illustration Workshop	Workshop	National	Primary Students Secondary Students	7-06-18	Chile	Bío Bío	1	28	1		Felipe Gamonal
World Ocean Day Fair	Exhibition	National	General Community	8-06-18	Chile	Bío Bío	7	450	1		Bárbara Léniz Genta
Poetry Workshop for teachers	Workshop	National	Teachers	8-06-18	Chile	Bío Bío	0	13	1		Bárbara Léniz Genta
IMO at the School "Biogeography"	Exhibition	National	Primary Students	2-06-18	Chile	Bío Bío	3	25	1		Pamela Fierro
Illustration Workshop for teachers	Workshop	National	Teachers	5-06-18	Chile	Bío Bío	0	13	1		Bárbara Léniz Genta
MACI Tome	Exhibition	National	Secondary Students	5-06-18	Chile	Bío Bío	4	149	1		Pamela Fierro
MACI Concepción	Exhibition	National	Primary Students	3-07-18	Chile	Bío Bío	2	107	1		Pamela Fierro
Puppets Show "Tony Tonina: Aletas en Acción" en Coihueco	Puppet Show	National	Primary Students	2-08-18	Chile	Bío Bío	0	120	1		Bárbara Léniz Genta

IMO at the School "How communicate Science"	Exhibition	National	Primary Students	4-08-18	Chile	Bío Bío	1	12	1		Bárbara Léniz Genta
Web platform "Immerse" (Sumérgete) in Comkids Interactive	Competencia	International	General Community	7-08-18	Brasil		0	70	2		Bárbara Léniz Genta
Puppets Show "Tony Tonina: Aletas en Acción" en Coronel	Puppet Show	National	Primary Students	7-08-18	Chile	Bío Bío	1	145	1		Bárbara Léniz Genta
MACI Hualqui	Exhibition	National	Primary Students	9-08-18	Chile	Bío Bío	4	180	1		Pamela Fierro
MACI Concepción	Exhibition	National	Primary Students	1-08-18	Chile	Bío Bío	4	226	1		Pamela Fierro
MACI Coronel	Exhibition	National	Secondary Students	3-09-18	Chile	Bío Bío	1	80	1		Pamela Fierro
MACI Hualqui	Exhibition	National	Primary Students	4-09-18	Chile	Bío Bío	4	200	1		Pamela Fierro
MACI Hualqui	Exhibition	National	Secondary Students	0-09-18	Chile	Bío Bío	2	150	1		Pamela Fierro
IMO at the School "Deep Ocean" Penco	Exhibition	National	Primary Students	5-09-18	Chile	Bío Bío	2	280	3		Bárbara Léniz Genta
Exploring our deepest sea: Atacama Trench	Conference	National	General Community	6-09-18	Chile	Metropolitan of Santiago	0	50	1	Oswaldo Iván Ulloa Quijada.	Oswaldo Ulloa
Exhibition and awards of "Immerse to Explore" contest	Exhibition	National	Primary Students Secondary Students Teachers	2-10-18	Chile	Bío Bío	1	30	1		Bárbara Léniz Genta
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	8-10-18	Chile	Bío Bío	0	20	1		Bárbara Léniz

IMO stand in Provincial Explora Congress San Carlos	Exhibition	National	Secondary Students Primary Student	8-10-18	Chile	Bío Bío	0	120	1		Bárbara Léniz Genta
Talk of Deep Ocean in "Ciencia sin ficción" event	Conference	National	General Community	9-10-18	Chile	Bío Bío	0	450	1	Ramiro Antonio Riquelme Bugeño.	Ramiro Riquelme
Puppets Show "Tony Tonina: Aletas en Acción" in "Artistas del Acero"	Puppet Show	National	Primary Students	0-10-18	Chile	Bío Bío	0	124	1		Bárbara Léniz
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	1-10-18	Chile	Bío Bío	0	25	1		Bárbara Léniz
XII Fiesta de la Ciencia y la Tecnología	Exhibition	National	General Community	3-10-18	Chile	Metropolitan of Santiago	1	450	2		Bárbara Léniz
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	2-10-18	Chile	Bío Bío	0	25	1		Bárbara Léniz
MACI Tumbes	Exhibition	National	Primary Students	2-10-18	Chile	Bío Bío	3	3	1		Pamela Fierro
Visit to EBM Dichato	Taller	National	Primary Students	5-10-18	Chile	Bío Bío	0	18	1		Bárbara Léniz
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	9-10-18	Chile	Bío Bío	0	4	1		Bárbara Léniz
Science Fair in Llico	Exhibition	National	General Community	1-10-18	Chile	Bío Bío	1	120	1		Bárbara Léniz
IMO at the School "Deep Ocean"	Exhibition	National	Primary Students	1-10-18	Chile	Bío Bío	0	24	1		Bárbara Léniz
Science and Innovation Fair "Crea e Innova"	Exhibition	National	General Community	8-11-18	Chile	Bío Bío	0	85	1		Bárbara Léniz
Science and Technology Fair - Coihueco	Exhibition	National	General Community	8-11-18	Chile	Bío Bío	0	140	1		Bárbara Léniz

<i>Puppets Show "Tony Tonina: Aletas en Acción" Tumbes</i>	<i>Puppet Show</i>	<i>National</i>	<i>Primary Students</i>	<i>2-11-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>144</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>Talk in Scholar National Explora Congress</i>	<i>Conference</i>	<i>National</i>	<i>Secondary Students Primary Student</i>	<i>6-11-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>188</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>Puppets Show "Tony Tonina: Aletas en Acción" San Pedro</i>	<i>Puppet Show</i>	<i>National</i>	<i>Primary Students</i>	<i>6-11-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>0</i>	<i>86</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>Knowledge Party</i>	<i>Exhibition</i>	<i>National</i>	<i>General Community</i>	<i>9-12-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>3</i>	<i>200</i>	<i>1</i>		<i>Bárbara Léniz</i>
<i>Ocean culture workshop for Teachers</i>	<i>Workshop</i>	<i>National</i>	<i>Teachers</i>	<i>0-12-18</i>	<i>Chile</i>	<i>Bío Bío</i>	<i>3</i>	<i>13</i>	<i>1</i>		<i>Bárbara Léniz</i>

## **7.2. - Products of outreach**

<i>Type of product</i>	<i>Number</i>	<i>Target public</i>	<i>Scope</i>
<i>Web Design</i>	<i>1</i>	<i>Secondary students. Primary students. General Community School teachers</i>	<i>National</i>
<i>Audiovisual Show (Itinerant Scientific Audiovisual Show)</i>	<i>1</i>	<i>Secondary students. Primary students. School teachers</i>	<i>National</i>
<i>Animated children's series</i>	<i>1</i>	<i>General Community Primary students. School teachers</i>	<i>International</i>
<i>Videogame</i>	<i>1</i>	<i>Primary students. School teachers</i>	<i>National</i>
<i>Theater show with Puppets</i>	<i>1</i>	<i>Primary students. General Community School teachers</i>	<i>National</i>



<i>Type of product</i>	<i>Number</i>	<i>Target public</i>	<i>Scope</i>
<i>Workshop for teachers</i>	<i>1</i>	<i>School teachers</i>	<i>National</i>
<i>Annual Television Series</i>	<i>1</i>	<i>Scientific Community. Community in General.</i>	<i>National</i>
<i>Workshop</i>	<i>1</i>	<i>School teachers Secondary students</i>	<i>National</i>
<i>TV Series</i>	<i>1</i>	<i>Primary students</i>	<i>National</i>

### **7.3.- 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	26	4	18	0	3	<b>53</b>
Internet	1	12	1	12	0	13	<b>39</b>
Audiovisual	3	11	2	1	0	0	<b>17</b>
<b>TOTAL</b>	<b>6</b>	<b>49</b>	<b>7</b>	<b>31</b>	<b>0</b>	<b>16</b>	<b>109</b>

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

Activity and Objective	Expected Impact	Obtained Results	Type of Connection [Number]	Type of Activity [Number]	Institution Name	Institution City, Region & Country	Agent Type [Number]	Economic Sector
Agreement NKE France	Transfer services to scientific and industrial sector	Signed Agreement with NKE Instrumentation	1	7	NKE Instrumentation	France	1	Oceanographic Probes
					Casco Antiguo	Chile	1	Industrial Observation Systems
POMEQ Network	Cooperate with scientists and public sector	GRASP-GOOS and the CPPS evaluating using the same system	2	2	GRASP-GOOS and the CPPS	Perú government		
						Chile government		
						Colombia government		
						Ecuador government		

**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 type of activity)

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

**Annex 9.- Total incomes:**

<b>Funds</b>	<b>Accumulated incomes to last year [\$]</b>	<b>2018 Incomes Amount (\$)</b>	<b>Percentage of resources used by the Center (%)</b>	<b>Total income to 2018 [\$]</b>
MSI IC 120019	3.431.029.122	840.000.000	86%	4.153.429.122
MSI - PME (Outreach)	57.067.381	10.228.796	95%	66.784.737
MSI - RFC (Networking)	2.935.000	0		2.935.000
FONDECYT	806.786.585	249.734.000	100%	1.056.520.585
Conicyt-Explora	29.909.840	24.374.096	98%	53.796.454
CONICYT Capital Humano	30.157.060	63.168.000	100%	93.325.060
CONICYT Otro	450.120.000	604.688.616	100%	1.054.808.616
CORFO-Innova Chile	42.965.772	0		42.965.772
Becas Otros	-	13.440.000	100%	13.440.000
Otros Fondos Internacionales	291.451.781	556.600.000	100%	848.051.781
Otros fondos sector Público	493.492.220	57.446.000	100%	550.938.220
Otros fondos sector Privado	51.700.000	1.700.000	100%	53.400.000
Otro	32.501.284	6.279.726	100%	38.781.010
<b>Total</b>	<b>5.687.614.761</b>	<b>2.421.379.508</b>	<b>95%</b>	<b>7.990.395.348</b>

**Annex 10.- Exchange:****Investigadores del centro que van al Extranjero**

Tipo Investigado	Nombre	Tipo de actividad realizada	Duración de la estadía	País al que viajó	Entidad que financia (Milenio/Externo/Mixto)
Postdoctorante	Carlos Henríquez	Análisis de Genomas de Célula Única (Georgia Institute of Technology)	15-08-2018 al 10-12-2018	USA, Atlanta	Externo
Postdoctorante	Natalia Osma	Comprender el funcionamiento de un sistema de mesocosmo para manipular simultáneamente los niveles de pCO2 y oxígeno, en Universidad de Santa Cruz,	22-09-2018 al 02-10-2018	USA, California,	Externo
Postdoctorante	Vera Oerder	Reuniones con investigadores del laboratorio LOCEAN en Paris, Francia: Revisión del artículo: "Disentangling the Mesoscale Ocean-Atmosphere Interactions", ahora aceptado por Journal of Geophysical Research con los Drs. François Colas y Sebastien Masson.  – Trabajo de escritura de un artículo "Current feedback to the energy input to the ocean: a global picture" para enviar a Nature Geosciences, con los Drs François Colas y Sebastien Masson.	02-09-2018 al 15-09-2018	Francia, Paris,	Externo
Investigador Asociado	Rubén Escribano	Coloquio Internacional " El Océano frente a los cambios globales"	02-10-2018 al 04-10-2018	Perú, Lima	Externo
Investigador Asociado	Cristian Vargas	Coloquio Internacional " El Océano frente a los cambios globales"	04-10-2018 al	Perú, Lima	Mixto
Investigador Asociado	Rubén Escribano	Invitado como miembro del Equipo de Desarrollo de la Red de Acción en el Conocimiento del océano (KAN), para asistir a dos reuniones en París, "High Level Scientific Conference of the Intergovernmental Oceanographic Commission of UNESCO", y en "Second Meeting of the Ocean KAN Development Team of Future Earth Program", las que tendrán lugar en la Universidad Pierre et Marie Curie.	10-09-2018 al 13-09-2018	Francia, Paris	Mixto
Investigador	Cristian	Pasantía en Estación Científica Charles Darwin, en Puerto Ayora, visita realizada por	19-08-2018 al	Ecuador, Isla	Mixto

Asociado	Vargas	beca entregada por Scientific Committe for Oceanic Research, capacitación y expedición a una fuente Volcánica natural de CO2 en Islas Galápagos.	28-08-2018	Galápagos,	
Investigador Asociado	Peter Von Dassow	Pasantía en el Alfred Wegener Institute for Polar and Marine Research (Germany), colaborando con Dr. Uwe John en el análisis filo-genómica para determinar la historia evolutiva del género Emiliana/Gephyrocapsa de coccolitoforidos (fitoplancton).	12-06-2018 al 29-06-2018	Alemania, Bremenhaven	Externo
Investigador Asociado	Cristian Vargas	“Taller sobre Plasticidad Fenotípica en Zooplancton”	07-06-2018 al 08-06-2018	Argentina, Buenos Aires	Mixto
Postdoctorante	Natalia Osma	“Taller sobre Plasticidad Fenotípica en Zooplancton”	07-06-2018 al 08-06-2018	Argentina, Buenos Aires	Mixto
Investigador Joven	Victor Aguilera	“Taller sobre Plasticidad Fenotípica en Zooplancton”	07-06-2018 al 08-06-2018	Argentina, Buenos Aires	Mixto
Investigador Joven	Pierre Amaël-Auger	Ultra-limpieza de insumos de laboratorio para experimentos de enriquecimiento en hierro, y medición del hierro disuelto y particulado en aguas costeras frente a Valparaiso (colaboracion H. Planquette, LEMAR-CNRS, Brest, Francia; Proyecto internacional GEOTRACES)	01-06-2018 al 20-06-2018	Plauzané Francia	Mixto

**Investigadores que desde el extranjero viajan al centro**

Nombre Investigador	Nacionalidad	Tipo de actividad realizada	Duración de la estadía	País desde el que viajó	Entidad que financia (Milenio/Externo /Mixto)
Philippe Tortell	Canadian	A new generation of ocean observing tools linking plankton dynamics to fisheries science and management	4 días	Canadá	Externo
Emilio Alemany Rodriguez	Cubano	Investigación y Entrenamiento en facultad de ciencias naturales y oceanográficas de la Universidad de Concepción	30 días	Cuba	Mixto
Kurt Hanselmann	Swiss, Zürich	Curso internacional de postgrado Ecology and Diversity of Marine Microorganisms (ECODIM) que se realizará en la Estación de Biología Marina del Departamento de Oceanografía de Dichato	22 días	Zürich	Mixto
Ger Van de Engh	Nederlandse	Curso internacional de postgrado Ecology and Diversity of Marine Microorganisms (ECODIM) que se realizará en la Estación de Biología Marina del Departamento de Oceanografía de Dichato	22 días	Alemania	Mixto
Kevin Hardy	Estadounidense	Participantes en el crucero Atacamex, a cargo de especificar funciones y manejar Lander	9 días	Estados Unidos	Milenio
Erich Horgan	Estadounidense	Participantes en el crucero Atacamex, designado por el MOCNESS es el acrónimo de Multiple Opening / Closing Net y Environmental Sensing System y es un sistema de red para el plancton en el océano.	9 días	Estados Unidos	Mixto
Ger Van de Engh	Estadounidense	Participantes en el crucero Atacamex, a cargo de citómetro	9 días	Alemania	Mixto
Ana Carolina Peralta	Venezolana	Curso de entrenamiento de sistema OBIS	7 días	Venezuela	Mixto