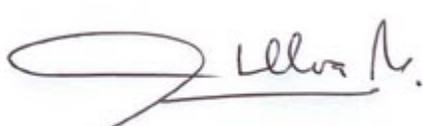




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1. 1.1 Executive Summary

Chile is on the southeastern border of the Pacific Ocean, the largest biome on the planet which accounts for most of the biological production in the oceans. The Pacific is also the largest ocean basin, and its circulation is a major controlling element of global climate. Ocean-atmosphere dynamics in the Pacific, such as the warm El Niño and cold La Niña alternation, particularly 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.

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.

IMO scientists include ecologists, microbiologists, physical oceanographers, chemical oceanographers, biological oceanographers, ecosystem modelers, science-outreach specialists, and special equipment-developers. IMO research is also supported by a global network of scientific collaborators. During 2017, IMO included 33 researchers in different categories, 26 research technicians, and 5 administrative staff. Funding sources for IMO came from ICM (55%) and increasing share has come from externally funded projects secured by IMO researchers, including national (ea g. FONDECYT, FIPA, CONICYT) and international funding agencies (Agouron, Gordon and Betty Moore Foundation Marine Microbiology Initiative) (45%), not including individual grants or external fellowships to postdocs and students. IMO has continued its activities in education and training as developed in previous years, and involves 10 postdocs, 50 undergraduate and graduate students.

Activities during 2017:

- A major effort in all research lines was towards the processing of data and analysis of results from the successful field campaigns conducted in prior years (2014-2016). This work resulted in 22 published manuscripts, completion of 3 undergraduate, 2 Masters, and 2 Doctoral theses, and is central to ongoing 14 Masters and 14 ongoing Doctoral projects.
- Focused field campaigns did continue in 2017. These included:
 - Field observations and microcosm experiments testing whether production in the coastal upwelling at 30° S is limited by low iron.
 - Glider ocean climatology observations from the central Chile coast to 75° W (≈185 km).
 - Participation in an international cruise (Mirai MR16-09) studying hydrographic variations related to global climate change in the southern Chile coastal zone.

- Preparation of the ATACAMEX/LowpHOx 2 cruise, to explore the deepest depths of the Atacama trench and to conduct follow-up, more advanced observations of the upper 2000 m of the water column sampled by the LowpHOx 1 cruise in 2015. This cruise was originally scheduled for December 2017, but was moved to February of 2018 as the research vessel was offered for helping Argentina in the emergency search for a lost submarine.
- In preparation for ATACAMEX, we achieved a major technological advance with the completion of the design and construction of the ocean lander “Audacia”, which includes the capability of sampling the water column (for chemistry and microbiology studies) as well as both camera observations and trap captures of benthic animals in the hadal zone (>6000 m).

IMO outreach activities in 2017 focused on continuing and expanding successful programs implemented in previous years, such as the “Itinerant Scientific Audiovisual Exhibition” (MACI, for its spanish initials), the TV series for children “The Scientific Recipe of Tony Tonina” (along with new associated puppet shows and other activities). Some new activities in 2017 to highlight:

- The “Wednesday at the Academy” series of lectures on ocean science organized by the IMO with the Chilean National Academy of Sciences
- ExploSub – a new IMO project financed by the EXPLORA program of CONICYT which seeks to inspire students and teachers in marine technology development by training them to build a small-scale prototype of a robotic submarine for ocean exploration.

2017 also revealed IMO as a consolidated center for excellence that the governments and the larger society can consult for broader scientific expertise in policy. Three IMO researchers played a leading role in the articulation aspects related to ocean science in the new National Ocean Policy of Chile, signed by the Chilean President on 9 March 2018. IMO researchers were also involved in the Chilean Atomic Energy Commission (CChEN) and the International Atomic Energy Agency (IAEA).

In 2017, IMO’s capacity as a center to lead the scientific community in policy issues was demonstrated when a Canadian company Oceaneos proposed to repeat – in Chilean waters – the controversial (and unauthorized) commercial iron fertilization first realized in the North Pacific in 2012, claiming it would “heal” the ocean and greatly improve fisheries yields. The IMO organized the Chilean marine scientific community to communicate to the public that there was no scientific evidence to support the company’s claims of certain benefits from ocean iron fertilization, that the current scientific consensus was that such activities at commercial scales had serious and currently unmanageable risks (e.g., toxic harmful algal blooms are induced by iron addition), and that, for these reasons, the London Protocol on Ocean Dumping – an international treaty signed by Chile – currently prohibits these activities. As well as appearing in national and international media, IMO organized a public forum, unified most of Chile’s marine science centers for excellence in a public declaration, and IMO researchers led written and oral reports solicited by branches of the Chilean Navy in charge of coastal protection and enforcing compliance with the London Protocol obligations.

1.2 Resumen Ejecutivo

Chile se encuentra situado en la región sur oriental del Océano Pacífico, el cual constituye el mayor bioma del planeta sustentando la mayor parte de la producción biológica de los océanos mundiales. El Pacífico también es la cuenca oceánica más extensa, cuya circulación es un componente clave controlador del clima global. La dinámica océano-atmósfera en el Pacífico, tal como los eventos alternados El Niño/La Niña, causan en particular cambios sustanciales en la estructura y funcionamiento en el Pacífico sur oriental (PSE), con impactos ecológicos y económicos globales. En el mismo contexto, el cambio climático actual impacta sostenidamente los sistemas socio-económicos, la disponibilidad de alimento, la salud humana, e incluso la gobernanza. Chile, como país ribereño, es particularmente susceptible a estos cambios, a pesar de eso el PSE sigue siendo menos explorado y comprendido que el resto del Pacífico.

El Instituto Milenio de Oceanografía (IMO) apunta a posicionar la ciencia Chilena en la frontera del desarrollo de conocimiento científico integrado del PSE y de los cambios de corto y largo término que afectan la estructura y funcionamiento de los ecosistemas del PSE. 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 PSE 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 PSE;
- 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.

Los científicos del IMO incluyen ecólogos, microbiólogos, oceanógrafos físicos, oceanógrafos químicos, oceanógrafos biológicos, modeladores ecosistémicos, expertos en comunicación científica, y un equipo de desarrollo tecnológico. Durante el 2017, IMO incluyó 33 científicos en diferentes categorías, 26 técnicos y 5 de personal administrativo. Las fuentes de financiamiento para IMO vinieron desde ICM (55%) y un incremento compartido provino desde financiamiento externo a través de proyectos obtenidos por investigadores IMO, incluyendo fondos de agencias nacionales (Ej. FONDECYT, FIP, CIMAR) e internacionales (Agouron, Fundación Gordon & Betty Moore, Marine Microbiology Initiative) (45%), excluyendo fondos individuales o becas externas a postdocs y estudiantes. IMO continuó el desarrollo de sus actividades en educación y entrenamiento como en años previos, e involucró 10 postdocs y 50 estudiantes de pregrado y postgrado.

Actividades durante 2017:

- Un gran esfuerzo en todas las líneas de investigación se invirtió en el procesamiento y análisis de datos derivados de exitosas campañas de terreno conducidas entre los años 2014-2016. Este trabajo resultó en 22 manuscritos publicados, la finalización de 3 tesis de pregrado, 2 de magíster, y 2 tesis doctorales, y constituyendo foco central de 15 tesis de magíster en desarrollo y 15 tesis doctorales en desarrollo.
- Campañas de terreno enfocadas continuaron el 2017. Estas incluyeron:
 - Observaciones de campo y experimentos en microcosmos para probar si la producción en la zona de surgencia costera de los 30° se encuentra limitada por hierro.

- Observaciones océano-climáticas por medio de planeadores desde la costa de Chile central hasta los 75° W (\approx 185 km).
- Participación en crucero internacional (Mirai MR16-09) estudiando las variaciones hidrográficas asociadas al cambio climático global en la zona sur de Chile.
- Preparación del crucero ATACAMEX/LowpHOx 2 para explorar las mayores profundidades de la Fosa de Atacama y para conducir observaciones complementarias y más avanzadas en los 2000 m superiores de la columna de agua muestreada durante el crucero LowpHOx 1 el 2015. Este crucero originalmente fue programado para diciembre 2017, pero debió posponerse a febrero 2018 dado que el barco científico fue ofrecido para asistir a Argentina en la emergencia de búsqueda de submarino perdido.
- En preparación para ATACAMEX, pudimos alcanzar un avance tecnológico mayor con la finalización del diseño y construcción del aterrizador oceánico “Audacia”, el cual incluyó capacidades para muestrear la columna de agua (para estudios químicos y microbiológicos), así como observaciones de cámaras y trampa para capturar organismos del bentos en la zona hadal (>6000 m).

Las actividades de divulgación de IMO en el 2017 se enfocaron en la continuación y expansión de programas exitosos implementados en años previos, tales como la “Muestra Audiovisual científica Itinerante” (MACI), la serie de TV para niños “La Receta Científica de Tony Tonina” (junto a su función de títeres y otras actividades asociadas). Otras actividades nuevas del 2017 para resaltar:

- Los “Miércoles en la Academia” una serie de charlas sobre ciencia del océano organizada por IMO y la Academia Nacional de Ciencias de Chile.
- ExploSub – un Nuevo proyecto IMO financiado por el programa EXPLORA de CONICYT, el cual busca inspirar estudiantes y profesores en el desarrollo de tecnología marina a través de su entrenamiento en la construcción de un pequeño prototipo de un submarino robótico para exploración del océano.

2017 destacó a IMO como un centro de excelencia consolidado que el gobierno y la sociedad en conjunto pueden consultar para una amplia experiencia en política científica. Tres investigadores IMO jugaron un papel de liderazgo en la articulación de aspectos relacionados a la ciencia del océano en la nueva Política Oceánica Nacional de Chile, firmada por la Presidenta de Chile el 9 de marzo de 2018. Investigadores de IMO estuvieron también involucrados en la Comisión Chilena de Energía Nuclear (CChEN) y la Agencia Internacional de Energía Atómica (IAEA).

El 2017, la capacidad de IMO como centro para liderar la comunidad científica en temas políticos fue demostrada cuando la compañía canadiense OCEANEOS propuso repetir – en aguas chilenas – la fertilización comercial controversial (y no autorizada) primeramente realizada en el Pacífico Norte en el 2012, declarando que podría “sanar” el océano y mejorar grandemente los rendimientos pesqueros. IMO organizó la comunidad científica Chilena para comunicar al público de que no existía evidencia científica para apoyar la declaración de esta compañía que argumentaba beneficios para el océano mediante la fertilización con hierro, y que el consenso científico era que tales actividades a escala comercial poseían serios e inmanejables riesgos (Ej., florecimientos de algas tóxicas pueden ser inducidos por adición de hierro), y que, por tales razones, el protocolo de Londres sobre Desperdicios en el Océano – un tratado internacional firmado por Chile – actualmente prohíbe tales actividades. Así como la aparición en los medios nacionales e internacionales, IMO organizó un foro público, uniendo la mayoría de los centros de excelencia para ciencias del mar a través de una declaración pública, e investigadores de IMO lideraron los informes orales y escritos solicitados por ramas de la Armada de Chile a cargo de la protección y cumplimiento y obligaciones del Protocolo de Londres.

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 fourth 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 and Change: 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 Eastern South Pacific and the Humboldt Current system, which includes coastal upwelling. 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 pCO₂/pH, O₂ 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 2017, 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 2017, its fourth year, IMO consisted of 33 researchers: the 8 original associate researchers, 2 senior researchers, 9 adjunct researchers, 4 young researchers and 10 postdocs. The associate researchers: 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 26 professionals/technicians, 5 administrative staff, as well as 50 students (16 undergraduate, 17 M.Sc., and 17 Ph.D.).

The institute is 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); this team is 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. Carmen Morales and Samuel Hormazabal lead Research Line 1; Wolfgang Schneider and Oscar Pizarro lead Research Line 2; Peter von Dassow, Cristian Vargas and Osvaldo Ulloa lead Research Line 3; and Rubén Escribano and Osvaldo Ulloa lead Research Line 4.

The associate researchers meet at the beginning of every year 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 3 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, 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. Research line 1: Mesoscale

Research in Line 1 focuses on two sub-lines. First is understanding the physical processes at mesoscale (10-1000 km) and sub-mesoscales (1-10 km), looking at both fronts and eddies. This work interacts significantly with Line 2, for example for understanding the variability of the Oxygen Minimum Zone, or for understanding how large scale climate variability impacts patterns of mesoscale activities. Second, the resolution of ocean physics at these scales is applied to understanding how these processes impact plankton communities.

1.1. Coastal fronts

Sub-mesoscale (and mesoscale) frontal characteristics and their spatio-temporal variability have been rarely documented for the Humboldt Current System (HCS). A new method for the detection of main upwelling fronts was developed, using daily, high-resolution, satellite SST maps. The algorithm was applied to an area north of Point Lavapié (36.5-37°S), where high probability of front formation has been recently reported, and the variability in front characteristics during the upwelling season in the 2003-2016 period was assessed. These studies reveal the dynamics and mechanisms of fronts formation in the upwelling zone off central/southern Chile, their frequency and seasonal variability, as well as their interaction with other mesoscale features under the effect of seasonal upwelling (e.g. mesoscale eddies) (**Morales et al., 2017; Oerder et al., 2018**).

1.2. Mesoscale eddies

The analyses of large datasets of in situ CTD-O profiles carried out by graduate and undergraduate students, and postdoc, reveal that intra-thermocline eddies (ITEs) drive the coastal upper oxycline variability off Chile and southern Peru, and appear to be the most dominant mechanism of vertical variability in the Oxygen Minimum Zone (OMZ) everywhere offshore outside of the equatorial band. There is some evidence that ITEs constitute the borders of the OMZ where their variability may then drive the shape of the large-scale OMZ (**Auger et al., submitted**).

A study on mesoscale processes in seamounts of the Juan Fernandez Archipelago (JFA) and one close to the coast (O'Higgins seamount) found a significant influence from the coastal upwelling zone through surface and subsurface mesoscale eddies, in particular, ITEs (V. Salas, M.Sc. Thesis Oceanography, PUCV; C. Parada, unpublished data). Altogether, the JFA is characterized by intense submesoscale and mesoscale activity, including fronts, meanders, eddies and Von-Karman vortices, as derived from modelling and satellite analyses (S. Cornejo-Guzmán, undergraduate Thesis Geophysics, UdeC). Eddy-eddy interactions and the barrier effect associated with the Robinson Crusoe Island are also relevant (**Medel et al., 2018**). Processes of double diffusion, with evidence of double convective diffusion in the upper limit of the OMZ and of salt fingers in its lower limit were analyzed (L. Valencia, undergraduate Thesis Oceanography, PUCV).

Results from the Valparaiso Oceanographic Time Series (STOV), together with sea level data, show a significant variability in the water column associated with the passage of intra-seasonal coastal trapped waves and coastal upwelling events; ITEs and fronts are also characteristic (D. Pecarevic, M.Sc. Thesis Oceanography, PUCV). Biogeochemical variability indicates lower C/N ratio and higher ^{15}N in the organic matter in the upwelling front and mesoscale eddies during the upwelling season (G. Polanco, M.Sc. Thesis Oceanography, PUCV). In the zone of mesoscale eddies formation, low-oxygen cores, high nutrients and greenhouse gases content in the water column are found (V. Villegas, M.Sc. Thesis Oceanography, PUCV).

2. Influence of submesoscale-mesoscale activity on planktonic communities in the eastern South Pacific

SST fronts are usually associated with increases in phytoplankton biomass in the oceans. Chl-a frontal detection and processes off central Chile were analyzed using satellite high-resolution (1 km) SST and Chl-a data. Results indicated that Chl-a values in SST frontal regions in the coastal upwelling region were higher in comparison with those in the surrounding areas, especially during spring and summer months (S. Cornejo-Guzman, undergraduate Thesis, Geophysics, UdeC). In situ data obtained during the PHYTO-FRONT cruise, combined with satellite time series data, were further processed during 2017 and highlights of the results include (V. Anabalón, Ph.D Thesis, ULPGC; **Morales et al., 2017**):

- Intense submesoscale variability in nutrients and phytoplankton across the coastal upwelling and coastal transition zones, with dramatic changes on each side of the frontal zone, including a biomass maximum at the front (surface), as well as increases in the ITE area (subsurface).

- A mixture of coastal and oceanic diatom species in the area of front-eddy interaction suggested both offshore and onshore advection in the system. This finding (strong exchange in both directions) is in contrast with current views on the role of mesoscale eddies on phytoplankton distribution (offshore advection and loss to the coastal system).

In situ data obtained during the MOPEX cruise in the coastal and coastal transition zone off Valparaíso (Nov. 2016) indicate that the distribution of total Chl-a values was concentrated in the surface layer of the coastal stations and the subsurface layer of the coastal transition zone (20-40 m depth), with the frontal zone in between. The micro-planktonic Chl-a was dominant all along the transect and the front appears to strongly contribute to a subduction process of this biomass (from to 20 to 60-80 m depth) (C. Morales, unpublished data).

Satellite approximations were also used to improve the remote detection of phytoplankton community structure at the submesoscale and mesoscale levels in the area off central Chile. A new approach that improves the spectral-based PHYSAT method for identifying phytoplankton functional types (PFT) was developed and applied/calibrated with in situ data obtained during the PHYTO-FRONT cruise (**Correa-Ramirez et al., 2018**). PHYSTWO increases the accuracy of PFT identification, extends the application of this tool to waters with high chlorophyll-a (Chl-a) concentration, and it significantly decreases (~50%) the undetermined retrievals when compared with PHYSAT.

A satellite-based application of a phytoplankton size-class model, fitted with in situ size fractionated Chl-a data, was tested and the variability in phytoplankton size classes (PSC) in surface waters associated with mesoscale and submesoscale variability was assessed (**Corredor-Acosta et al., submitted**). Results show that the modeled and in situ size-fractionated Chl-a data were highly correlated and that the largest changes in size structure took place during the early life of eddies (~2 months). A larger contribution by the microplankton fraction was only observed in young eddies (surface cyclonic and ITEs) located closer to the coast. In contrast, the nanoplankton fraction was dominant and the picoplankton almost constant (<20%) throughout the lifetime of eddies in offshore waters.

In situ field observations and microcosms experiments on the response of phytoplankton to submesoscale and mesoscale dynamics (remote detection) were carried out in the area off Coquimbo (~30°S; October 2017), with an emphasis on the iron-control of coastal phytoplankton productivity in upwelled waters. Intense coastal upwelling does not correlate with higher primary productivity in the region and previous results have shown evidence of iron-limitation. Results indicate that coastal phytoplankton community biomass and photo-physiology can be limited by lack of iron despite proximity to the continent, but whether communities are iron-limited or replete varied at the submesoscale (P. von Dassow, unpublished data).

Biophysical modelling studies in the JFA indicate that mesoscale but especially submesoscale activity coupled to biological behavior (i.e. diel vertical migration), likely promote the aggregation of spiny lobster larvae around the islands, which could be key for their survival and retention in those waters (Medel et al., 2018). In situ data from the Robinson Crusoe Island (2016) show a predominance of salps and copepods, and a clear coastal-oceanic gradient in zooplankton composition, with a high consistency between the acoustic survey and the net sampling. Local and remote oceanographic processes affecting the circulation dynamics around R. Crusoe Island were identified, which have a profound impact on the spatial and temporal distribution of plankton (C. Parada, unpublished data). Similar metazooplankton communities in the O'Higgins and JFA seamounts suggests transport of plankton from coastal to open ocean waters through mesoscale eddies (Postdoc S. Zamora-Terol, unpublished data).

The organization of the mesoscale eddy field as preferred eddy tracks (PET) was found to structure primary productivity and the OMZ at the mesoscale level in the region off central-Chile, with potential implications for marine ecosystems. The expression of PET in satellite records of ocean color and in a set of numerically simulated biogeochemical tracers (chlorophyll, oxygen, etc.) has been evidenced as zonal bands of positive-negative average mesoscale anomalies, based on an eddy-resolving physical-biogeochemical multi-decadal simulation (1984-2013, ROMS-PISCES). Eddy trapping generally dominates the footprint of PET, except for the surface phytoplankton biomass and the subsurface OMZ in the CTZ which are mainly impacted by the eddy advection caused by eddy-eddy interactions (V. Villegas, M.Sc. Thesis Oceanography, PUCV).

Research line 2. Ocean Variability and Change

During 2017, integrated IMO research on this theme was dedicated to:

- a) Intensification of the South Pacific gyre circulation due to climate change
- b) Eastern South Pacific Intermediate Water Mass under climate variability
- c) ENSO dynamics and its impact on the Humboldt Current system
- d) Variability of the Oxygen Minimum Zone of the eastern South Pacific
- e) Collaboration with Theme 1

The most relevant and integrated IMO activities in 2017 were:

- Ocean climatology observations by glider. As part of the glider monitoring program off Central Chile, 2 transects were carried out along 36°30'S (from the coast to 75°W) during summer (Jan.-Feb.) and winter (Jul.-Aug.) of 2017 bringing to 10 the number of transects carried out since 2010 on this line.
- Participation in the international RV Mirai cruise MR16-09 Leg 2 (17 Jan - 8 Feb 2017) to study of variability in hydrographic properties in the coastal zone of southern Chile in relation to global climate change present and past. W. Schneider led the physical oceanography group.

The most relevant scientific achievements in Theme 2 during 2017 were:

- Understanding sea level changes in the South Pacific in the 20th Century. A spatially non-uniform sea level rise was observed in the South Pacific Ocean during 1993-2015, with up to 8 mm/yr in the southwest subtropical Pacific, much lower values in the eastern ocean, and negative trends observed further south. In recent decades, observed sea level trends have been interpreted as a spin-up of South Pacific subtropical gyre circulation. The analysis of data from Phase 5 of the Coupled Model Intercomparison Project (CMIP5) shows that both anthropogenic climate change

and natural climate variability influence sea level changes. To quantify the impacts of natural variability, a multiple linear regression was performed between sea level and dominant climate indices in the region, the latter representing interannual to interdecadal climate variability. Our results indicate that natural variability is the main contributor to observed sea level trends during the last two decades. Preliminary results were presented in the International WCRP/IOC conference on “Regional Sea Level Changes and Coastal Impacts” carried out during 10-14 July 2017, Columbia University, New-York. This work has been led by the post-doc Frauke Albrecht in collaboration with the IMO researchers Oscar Pizarro and Aldo Montecinos.

- Interannual energy flux in the subthermocline of the Southeastern Pacific. During 2017 we continued studying the vertical propagation of low-frequency, long-wavelength extra-tropical Rossby waves in the eastern South Pacific in collaboration with researchers from Center for Advanced Studies in Arid Zones (CEAZA), the Catholic University of the North and the “Laboratoire d’Etudes en Géophysique et Océanographie Spatiales” (LEGOS) and IRD in France. This work led to a publication (**Vergara et al. 2017**).

- Variability of the Oxygen Minimum Zone of the eastern South Pacific. A high-resolution coupled physical/biogeochemical model simulation was used to investigate the seasonal variability of the OMZ off central Chile. Main results indicate that the seasonal variations of the OMZ can be interpreted as resulting from the seasonal modulation of the Peru-Chile Undercurrent and mesoscale activity. This work is part of a PhD thesis of the graduate IMO student Matias Pizarro-Koch in collaboration with researchers from LEGOS in Toulouse, France. One manuscript was submitted to Journal of Geophysical Research (Ocean) during 2017 and a revised version will be re-submitted during the first semester of 2018 (**Pizarro-Koch et al., submitted**).

- Changes in Eastern South Pacific Intermediate Water (ESPIW) distribution and volume. Update of the ESPIW mass distribution with new Argo information. Change in volume of ESPIW was +50% compared to the 1990ies. Changes in ESPIW could be linked to an Intensification of Ekman Pumping velocity from 2000 on (**Hernández-Vaca et al., 2017**).

- La Niña 2010 originated in the Amundsen and Bellingshausen Seas. La Niña or the cold phase of the El Niño Southern Oscillation is referred to an anomalous cooling of SST in the central Equatorial Pacific which occurs on inter-annual timescales. In such an event the easterly trade winds accelerate, strengthening the Equatorial Upwelling where deeper and colder water comes to the surface, thus further cooling the Equatorial Cold Tongue. Trade wind velocity is determined by the meridional pressure gradient at sea surface between the South Pacific High and the Equatorial Low, meaning that an extraordinary intense South Pacific High is needed to initiate a strong La Niña event. This century’s strongest La Niña scenario with SST anomalies $< -1.4^{\circ}\text{C}$, according to the Oceanic Niño Index (NOAA, listed since 1950, based on mean SST in the region $120\text{-}170^{\circ}\text{W}$ and 5°S to 5°N) started in September 2010 and lasted till January 2011. Monthly mean sea level atmospheric pressure from the ERA INTERIM 1979-2016 reanalysis project on a $0.75 \times 0.75^{\circ}$ resolution were employed in this study to scrutinize sea level air pressure in the Eastern South Pacific with emphasis on how the South Pacific High gained momentum in 2010. We have shown 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 the year was supplied by the Subpolar 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 international V Congreso de Oceanografía Física, Meteorología y Clima, in November 2017 by W. Schneider. Research on this topic will continue and a manuscript will be submitted during 2018.

- The impact ENOS has on the Humboldt Current System. For El Niño and La Niña periods starting 1993, Sea Surface Temperature, surface winds, sea level and sea air pressure were analyzed in order to determine the impact ENSO has on them. During El Niño events SST was 0.6°C warmer

than during La Niña events, sea level was higher and winds were weaker. Research on this topic will continue and a manuscript will be submitted during 2018.

- In collaboration with Theme 1, we have studied submesoscale fronts and mesoscale eddies (**Oerder et al., 2018; Medel et al., 2018; Corredor-Acosta et al., submitted**). In addition, the graduate student Marcela Contreras (M.Sc. Oceanography, UdeC) used a very-high resolution ocean model to analyze the formation mechanisms of subsurface eddies (ITEs) and their relationship with the Peru-Chile Undercurrent.

Research line 3. Adaptations to a Changing Ocean

The objective of this research line is to gain new understanding about the adaptations (at different levels) of key marine groups to chemical/physical changes in the ocean, such as ocean acidification (OA), deoxygenation (DO), and ocean warming (OW), as well as the impact of such changes on biogeochemical cycling. During 2017, IMO researchers analyzed experiments both at sea and in controlled laboratory conditions, from levels of individual animal or eukaryotic phytoplankton species to whole microbial/zooplankton communities. We also continued analysis of *in situ* conditions (research cruises and time series observations) to understand biogeochemical cycles and plankton dynamics in natural low O₂/low pH zones and variable upwelling conditions to contextualize experimental manipulations in present-day and predicted future variability. Finally, we worked to improve technological and analytical capacities related to OA and OD.

1. Major experimental/observational achievements in 2017:

- The reproductive output of the neritic copepod *Acartia tonsa* from northern Chile responds significantly to the variability of pH/pCO₂ in the coastal zone, highlighting the relevance of habitat variability and natural history as key drivers of plankton responses to climate perturbations expected to occur in productive coastal areas (**Aguilera et al. submitted**).
- Low-O₂ conditions exert a strong effect on survival and growth of early stages of dominant zooplankton with important consequences for population dynamics of key species in the upwelling zone off Chile (**Ruz et al. 2018**).
- High pCO₂/low pH conditions affect the structure of microbial communities in a zone of naturally high CO₂/low pH, with OA-conditions favoring some biogeochemically-relevant microbial groups (e.g. Anammox) (**Aguayo et al. unpublished results**).
- While high pCO₂/low pH conditions do not affect growth or primary production of diatom species (e.g. *Skeletonema costatum*), such conditions do affect biochemical composition (**Jacob et al. 2017**), indicating previously unrecognized phytoplankton OA responses.
- Both neritic holoplanktonic and meroplanktonic invertebrates show responses to OA affected by local adaptation and plasticity in response to naturally high CO₂/low pH conditions (**Vargas et al. 2017**). In contrast, the cosmopolitan coccolithophore *Emiliana huxleyi* did not show local adaptation to OA conditions (**von Dassow et al. 2018**): Chilean populations may already be at the limit of this functional group to adapt to OA. These results highlight that future ocean ecology and biogeochemistry will be affected by differences in adaptability among distinct functional groups.
- Experiments continued investigating how local versus generalist adaptation has permitted exceptional cosmopolitanism in *E. huxleyi*. Strains from oceanic versus coastal origins showed differences in response to excess copper (**Echeveste et al. 2018**), and preliminary experiments suggest also in response to iron-limitation. Meanwhile, in 2018 we completed measurements for comparing thermal performance curves (TMCs) to genetic distance among 41 strains of *E.*

huxleyi, and 14 strains of four of its closest relatives (*Gephyrocapsa muelleriae*, *G. oceanica*, *G. parvula*, and *G. ericsonii*) to understand thermal adaptation in phytoplankton.

- Transgenerational carry-over in marine invertebrates under $p\text{CO}_2$ -driven OA conditions modulates the physiological response to multiple drivers (temperature, pH, and metals) in offspring planktonic larvae (**Díaz et al. submitted**), highlighting the importance of conducting experiments of several generations in marine animals.
- Protist grazing rates appear to be reduced in anoxic waters: Protist grazing in the O_2 -depleted waters was conducted using the new in-situ incubation technology (the Microbial Sampler-Submersible Incubation Device, MS-SID) provided by WHOI and deployed on a free-floating mooring. Shipboard grazing rate measures were lower than rates measured from the same water using the MS-SID, showing that in situ incubations minimize artifacts introduced by collection of samples from O_2 -depleted waters (**Medina et al., 2017**). However, analysis of MS-SID data completed in 2017 shows that up to 28% of bacterial biomass may be consumed by protists in waters where O_2 concentrations above $\sim 4.8 \mu\text{M}$, but only up to 13% at a station where O_2 was undetectable.
- We discovered the cryptic oxygen cycle in anoxic marine zones, previously hypothesized based on the presence of photosynthetically active picocyanobacteria *Prochlorococcus* spp. in the sunlit layer of the anoxic marine zones (AMZs). It was demonstrated that photosynthesis by the AMZ *Prochlorococcus* releases significant amounts of O_2 to the otherwise anoxic environment. Free O_2 levels in this layer remain undetectable, reflecting tightly coupled consumption by aerobic processes under apparent anoxic conditions. The rates of gross O_2 production and carbon fixation were found to be similar to those reported for nitrite oxidation, anaerobic dissimilatory nitrate reduction, and sulfate reduction, suggesting this cryptic local O_2 cycle is an important part of total AMZ biogeochemical cycling (**Garcia-Robledo et al., 2017**).

2. Major achievements of *in situ* studies in 2017 include:

- A time series of pH/ $p\text{CO}_2$ variability in coastal waters off Concepcion has revealed the high variability in these parameters in coastal upwelling regions, as well as the importance of multiple-stressors in these coastal areas (low O_2 /low pH). These observations improve the basis for design of future experiments.
- Carbon biogeochemistry seems to be different in anoxic marine zones (AMZs). The pH and $p\text{CO}_2$ levels expected in these anoxic areas appear to be higher/lower than expected, which might be explained partly through dark carbon fixation processes of microbial communities.
- We revealed a relationship between O_2 concentration and ammonia-oxidizing archaeal and bacterial community composition in continental-shelf waters with recurrent hypoxia and anoxia. Analyses of the ammonia monooxygenase subunit A revealed that different clades of the archaeal ammonia-oxidizing group *Nitrosopumilis* sp. were present in oxygenated vs O_2 -depleted months (**Bertagnolli & Ulloa, 2017**). Meanwhile, analysis of the total bacterial community over 4 years of monthly samples using three parallel metagenomic methods revealed that heterotrophic aerobically respiring bacteria dominated when dissolved O_2 exceeded 70 μM . In contrast, groups associated with either oxidative or reductive cycling of inorganic sulfur dominated in waters with dissolved O_2 below $\sim 70 \mu\text{M}$. The presence of sulphate reducer 16S rRNA sequences provides evidence for pelagic dissimilatory sulfate reduction within O_2 -depleted coastal environments, processes previously considered to occur mainly in anoxic sediments (**Aldunate et al., in press**). Low O_2 and high CO_2 may affect dark carbon fixation. Ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) is the key enzyme in the Calvin-Benson cycle, the main C-fixation pathway used by extant autotrophs. The diversity, abundance, and transcriptional levels of the gene for the large subunit form II of the RuBisCO

enzyme (cbbM) was followed in the pelagic continental shelf waters with seasonal hypoxia and anoxia, revealing a potentially novel group of chemolithoautotrophs whose activity increased as O₂ disappeared, suggesting that dark CO₂ fixation becomes more important as O₂ vanishes and CO₂ increases (**Leniz et al., 2017**).

- We showed that variable upwelling conditions exert a strong effect on size structure of both phytoplankton and zooplankton, with impacts on zooplankton feeding, Excretion of nitrogen N compounds (which in turn can influence microbial communities that depend on these compounds), and C flux (**Valdés et al. 2017a, Valdés et al. 2017b**).

3. Improvements in technological and analytical capacity in 2017 include:

- Implementation of standardized analytical high precision measurements of Dissolved Inorganic Carbon (DIC), meeting international carbon research program standards (e.g. IOCCP).
- Continued improvement of laboratory facilities, adding a new incubation system for experiments of multiple-stressors with phytoplankton cells to begin experiments with stable carbon isotopes to test how primary producers use different DIC sources present in the coastal ocean.

We note that a major push in 2017 was to prepare the LowpHox 2 cruise, originally scheduled for December 2017. However, the *R/V Cabo de Hornos* was re-programmed to help in the international search for the lost Argentinian submarine in Nov-Dec, so the cruise was re-scheduled to Jan-Feb. 2018, and will be reported in the next Annual Report.

Research Line 4: The Deep Ocean

During 2017 we invested time and efforts analyzing and processing data and samples from previous cruises, such as the Juan Fernández seamount cruise carried out in September 2015, CIMAR-21 to Easter Island in October 2015, and CIMAR-22 to oceanic islands and seamounts in October 2016. In this period, we also planned and prepared the first expedition to the Atacama Trench (ATACAMEX), which finally took place during February 2018. We also maintained activities in collaboration with fishermen to collect deep-sea fishes for parasites composition analyses and tackling questions on phylogeographic patterns. Highlights on progress and findings are summarized as:

- Open ocean waters in front of central Chile (33°S) appear strongly influenced by upwelling dynamics. Upwelled waters being advected offshore can affect zooplankton community structure and their metabolism in the seamount region of Juan Fernández with implications for C export in oligotrophic waters (**Frederick et al. 2018**).
- Nitrogen cycling mediated by zooplankton plays a key role in fueling regenerated primary production in open ocean blue water of the western south Pacific where diazotrophic processes are main sources for N (**Valdés et al. submitted**).
- From the coastal eutrophic zone to the ultra-oligotrophic water in the South Central Pacific Gyre biogeochemical regions can be distinguished as based on zooplankton community structure and their C and N isotopes signals, revealing the different biogeochemical processes controlling C and N cycles across the zonal gradient (PhD Thesis in Progress of Carolina Gonzalez).
- Deep-water zooplankton (>200 m) is more abundant than expected and spatial (vertical and horizontal) distribution is closely linked to topographic features in the open ocean region, such as ridges, seamounts and islands. Various dominant groups exhibit high diversity below the euphotic zone. Copepods are the most diverse taxa and pelagic amphipods appear as the most

abundant predators (PhD. Thesis in progress of Liliana Espinosa). Species identification allows to continue our contribution to global data bases of marine species and the analysis of global biogeographic patterns (**Dornelas et al. in press**).

- Zooplankton populations have colonized distinct water masses across the coastal-offshore gradient, although genetic structure of key populations reveals that physical and chemical gradients over the zonal gradient can impose ecological barriers preventing panmixia and promoting higher genetic diversity (PhD Thesis in Progress of Carolina Gonzalez).
- Using both morphological and molecular tools, new species and clarification of taxonomic status of parasite are being uncovered for the Eastern South Pacific region with emphasis in deep pelagic fishes (**Ñacari et al. 2017a, Ñacari et al. 2017b, Oliva et al. 2017**).
- Zooplankton structure was analyzed in Juan Fernández seamount. Both copepods and gelatinous communities showed high diversity and differences in their distribution and abundance over the ocean- coast gradient, as well as in their distribution in the vertical plane of the water column associated with the physical dynamics of the seamounts. For both communities, new species records were determined (Undergraduate Thesis of Braulio Fernández and Master Thesis in progress of Pamela Fierro).
- We participated in an international cruise to the Kermadec Trench in the western South Pacific (Nov – Dec 2017). Samples for the carbonate system, carbon isotopes, and microbial DNA were collected and are being analyzed.

Improvements in technological and analytical capacity:

Accessing the hadal (>6000 m) depths of the Atacama Trench first required finding a way other than the massive winch and long wire normally used to plumb the hadal depths. Instead, we relied on the design and construction of a custom hadal-class free vehicle, an ocean lander. Made from modern materials, the high-tech, and compact autonomous deep-ocean vehicle was designed and built by Global Ocean Design (San Diego, CA). The ocean lander “Audacia” is 244 cm tall x 64 cm wide (125 mm wide with the side variable flotation pods) x 253 cm deep, with an weight of approximately 182 kg. In water, the lander was trimmed to float like a spar buoy with 20 kg of positive buoyancy. An expendable anchor weighing 40 kg takes the lander to the bottom at about 1 m/s rate. A SeaBird hadal CTD, two 30-L Niskin bottles, a video camera with LED lights, and a drop arm with a baited trap were chosen for our lander. It was successfully deployed during the ATACAMEX and Sonne SO261 cruises in early 2018 (results will be reported in the 2018 annual report).

Publications cited that are submitted, in revision, accepted, in press, or published in 2018 (so not include in Annex 3):

Aguilera, V.M.; Escribano, R.; González, M.T.; Vargas, C.A. 2018. Upwelling pH-changes and morphological–physiological traits of dominant planktonic grazer upon expected climate change-driven shifts in upwelling intensity. Submitted to Scientific Reports.

Auger, O.A., S. Hormazabal, C. E. Morales, A. Bustamante, and J. P. Berto, “Vertical variability of the oxygen minimum zone in the eastern South Pacific (Peru-Chile): spatial characterization of the influence of intra-thermocline eddies”. Journal of Geophysical Research (revision submitted)

Corredor-Acosta, J.C., C.E. Morales, R.J.W. Brewin, P.A. Auger, O. Pizarro, S. Hormazabal, V. Anabalón. Phytoplankton size structure in association with mesoscale eddies off central-southern Chile: Satellite application of a phytoplankton size-class model (submitted to Remote Sensing, April 2018).

Correa-Ramirez, MA., CE. Morales, R. Letelier, V. Anabalón, S. Hormazabal, “Improving the remote sensing retrieval of Phytoplankton Functional Types (PFT) through the use of empirical orthogonal functions: a case study in a coastal upwelling region”, Remote Sensing (March 2018).

Díaz, R.; Lardies, M.A.; Vargas, C.A. 2018. Transgenerational carry over of the edible mussel *Mytilus chilensis* in pCO₂-driven ocean acidification conditions modulate the physiological response to multiple drivers in offspring plankton larvae. Submitted to Frontiers in Physiology.

Dornelas, M. et al. (in press). BioTIME: a database of biodiversity time series for the Anthropocene. Global Ecology and Biogeography. doi.org/10.1111/geb.12729

Echeveste, P., Croot, P., von Dassow, P. 2018. Differences in the sensitivity to Cu and ligand production of coastal vs offshore strains of *Emiliana huxleyi*. *Science of the Total Environment*. 625: 1673-1680. <https://doi.org/10.1016/j.scitotenv.2017.10.050>

Frederick, L., Escribano, R., Morales, C.E., Hormazabal, S., Medellín-Mora, J. (2018). Mesozooplankton respiration and community structure in a seamount region of the eastern South Pacific. Deep Sea Research I Oceanographic papers. doi.org/10.1016/j.dsr.2018.03.008

Medel, C., C. Parada, CE Morales, O. Pizarro, B. Ernst, C. Conejero. How biophysical interactions associated with sub- and mesoscale structures and migration behavior affect planktonic larvae of the spiny lobster in the Juan Fernández Ridge: A modeling approach. Progress in Oceanography, 162, 98-119. <https://doi.org/10.1016/j.pocean.2018.02.017>.

Ñacari, L.A., Sepulveda, F.A., Escribano, R., Bray, R.A., Oliva, M.E. 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

b) Publications:

A total of 22 journal articles were published in year 4, of which 17 were authored or coauthored by IMO associate researchers (2.1 publications per associate researcher). From these, 55% were in Q1 journals and 24% in the top 10% of the Impact Factor (IF) distribution for the disciplines (Annex 3), being worth noting the publication of two manuscripts in top-level international journals, such as Proceedings of the National Academy of Sciences of the United States of America (PNAS) and Nature Ecology & Evolution. Furthermore, 27% of the 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.

Our strategy of promoting collaborative publications among IMO researchers proved to be successful in year 4. From the 22 total ISI-type articles, 46% included more than one researcher, which constitutes a remarkable increase in joint publications as they only amounted to 3% in year 1, 13% in year 2 and 35% in year 3. Moreover, the number of journal articles co-authored by 3 or more researchers increased from 3% in year 3 to 19% in year 4, revealing a steady positive trend in collaborative work among IMO researchers. The relative number of publications co-authored by students was likewise higher (36%) than in previous years. Hence, the publication record in year 4 evidenced the collaborative effort of IMO associate researchers to publish high-quality and multidisciplinary research in top-level journals.

Complete detail of publications is shown in table in Annex 3.

Summary table

<u>Category of Publication</u>	<u>MSI Center Members</u>	<u>Number of Publications co-authored by students</u>	<u>Total Number of Publications</u>
ISI Publications or Similar to ISI Standard	Associate Researchers	7	17
	Other Researchers	1	5
SCIELO Publications or Similar to SCIELO Standard	Associate Researchers	0	0
	Other Researchers	0	0
Scientific Books and chapters	Associate Researchers	0	0
	Other Researchers	0	0
Other Scientific Publications	Associate Researchers	0	0
	Other Researchers	0	0
<u>Total of Publications</u>		8	22

Other achievements:

Our institute has been identifying technological requirements and working to improve technologies needed in our scientific investigation, analyzing the potential to transfer and protect intellectual property. At the end of 2017, we are ready to present our first dossier to the Chilean National Institute of Industrial Property, for a new device called Aulox to automatize the gold standard of oxygen analysis, and we have applied for regional funds to support application for a patent. Further, through a submarine robotics engineering group, we promote innovation in undergrad students to develop new submarine technology, including deep ocean carcasses, energy optimization, mechanics design, electronics and prototypes. During 2017 we applied to different funding calls, such as Brain Chile, with an ROV prototype “ExploRov”, reaching the second stage of selection. We applied to the First Call to Researchers for Aquatic Fishing System facing Harmful Algae Blooms (HABs), proposing a development of improvement of flow cytometry, with the company MarCy Inc., as base for “early alert” system for HAB phenomena.

- **Patents:** Until now we have no Patents.
- **Intellectual property:** Until now we have no Intellectual Properties.
- **Congress Presentations:**

Summary Table

Type of presentation	National Events [Number]	International Events [Number]
A. Associate Researchers		
Conferences, oral communications, poster communications, others (specify)	56	8
Invited presentations (not included in above row)	3	5

B. Other researchers (Adjunct Researchers, Senior Researchers, Young Researchers, Postdoctoral Researchers and Students)		
Conferences, oral communications, poster communications, others (specify)	31	4
Invited presentations (not included in above row)	2	1

- **Organization of Scientific Events:**

1st Latin American Symposium of Ocean Acidification (LAOCA), October 24th and 26th, 2017, Buenos Aires, ARGENTINA. This event was one of the most scientifically relevant in 2017, given that IMO acted both as a promoter of this network in Latin America (LAOCA), but also as an organizer of this first LAOCA Network symposium. Most of our graduate fellows, postdoc, and researchers associated working in Ocean Acidification showed major results of IMO's research.

Our associated researcher, *Dr. C.A. Vargas* was invited as plenary speaker to different national and international events, such as, the *V Congress of Physical Oceanography, Meteorology and Climate of the South Eastern Pacific, November 7th, 2017, Concepción, Chile*, and the *1st Latin American Symposium of Ocean Acidification (LAOCA), October 24th and 26th, 2017, Buenos Aires, ARGENTINA.*

As discussed later, several IMO researchers (Ulloa, Hormazabal, Morales, von Dassow) organized the emergency special session “**Geo-Engineering – Ocean Iron fertilization: scientific - technological, social-commercial and legal - ethical aspects**” in the context of **XXXVII Congreso Chileno de Ciencias del Mar**, in Valparaiso, to raise awareness in the marine science community and other sectors of the scientific issues relevant to considering a foreign private company's push to conduct large scale commercial iron fertilization on the Chilean coast.

A detailed table including the scientific events is presented in Annex 4.

- **Scientific Editorial Boards:**

- Journal of Plankton Research – Peter von Dassow (Editorial Board)
- Frontiers in Marine Science - Osvaldo Ulloa (Review Editor)
- Frontiers in Microbiology - Osvaldo Ulloa (Associated Editor)
- Frontiers in Marine Science - Ruben Escribano (Guest Editor Special Issue)
- Oceanides - Ruben Escribano (Editorial Board)

- **Awards:**

- **Associate researcher, Dr. C.A. Vargas** was nominated for second period as member of the Executive Council for the *Global Ocean Acidification Observing Network (GOA-ON)*.
- **Associate researcher, Dr. C.A. Vargas** was nominated as Member for second period of the Executive Council of the *International Ocean Carbon Coordination Project (IOCCP)*.
- **Associate researcher, Dr. R. Escribano** was nominated as Member for second period of the Scientific Steering Committee of **IMBeR (Integrated Marine Biosphere Research)**

4. Education and Capacity Building

a) Education and Capacity Building:

The main IMO's educational activities, achievements and results during 2017 were the following:

- **IMO incorporation of postdoctoral researchers**

During 2017, IMO hosted 10 postdocs, 4 of which started during 2017 and received full IMO grants, the rest were recipients of external grants, mostly CONICYT/FONDECYT. Two of the new postdoc, Vera Oerder and Ígor Fernández, incorporated during 2017 originally received a full IMO grant, but she obtained a FONDECYT grant for 2018-2020. The IMO selection processes of postdocs with IMO grants for 2017 finished in May of 2017 and, as in previous IMO calls, all associate researchers participated in this process and selection candidates were agreed by majority. The selection criteria considered the needs in each IMO research theme, the potential for increased interaction between IMO researchers through the selected candidates, and the scientific quality and potential of the individual candidates. Among the 10 postdocs working full time with IMO researchers during 2017, 7 of them came from foreign countries (UK, U.S.A., France, Spain, and Germany). During 2017, 6 postdocs, Drs Bertagnolli, Steele, Murillo, Andrade, Jacob, Zamora, finished their contact and association with IMO. By other hand Drs. Auger and Riquelme, were promoted to Junior researcher, continuing their association with IMO.

- **IMO involvement in graduate and undergraduate Programs**

During 2017, IMO continued to be linked to different undergraduate (5) and postgraduate 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
- Postgraduate 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.

During 2017, 49 students were directly linked to IMO: 16 in undergraduate, 17 in M. Sc., and 17 in Ph.D. Programs. Associate IMO researchers are or were co-tutoring 50% or more students in each of these categories.

IMO makes a call for undergraduate scholarships twice a year and the decision 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 older students developing their thesis. 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 2017, IMO awarded scholarships to a total of 20 students, 6 of undergraduate level and to 14 of graduate level (10 M.Sc. and 4 Ph.D.). In addition, 6 of the 32 graduate students from IMO received a CONICYT scholarship during 2017 whereas the rest had full or partial support from other funding sources (eg. institutional scholarships or through projects from IMO researchers).

- **IMO organization of training**

Advanced courses:

Remote sensing and autonomous underwater vehicle in operational oceanography. This international course was held in the Catholic University of Valparaiso organized by Dr Samuel Hormazabal (IMO) between 11 and 15 of December, 2017 with the participation of undergraduate and graduate students from different South American countries. The invited lecturers were Dr. Antonio Glez Ramos and Ángel Rodríguez Santana, both from Universidad de las Palmas de Gran Canaria, Spain.

Basic Courses:

During 2017 IMO organized short courses in the University of Concepcion to train graduate students and technicians in programming languages and statistical analysis applied to IMO themes. 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:

Valentina Valdés. PhD Thesis in co-tutelle Universidad de Concepcion with University Pierre et Marie Curie, France. “Biological role of zooplankton in nitrogen and phosphorus recycling in the ocean”. Co-tutors: Dr. Escribano with Dr. Camila Fernández and Dr. Fabien Joux (Concepción, Oct. 2017).

Sarah Pinon. Université Pierre et Marie Curie Paris 6. Masters M2 Thesis, Mention Sciences de l’Univers, Environnement, Ecologie, Spécialité Océanographie et Environnements Marins. “Comment l’environnement détermine la structure génétique et la différenciation des populations phytoplanctoniques. Une étude du coccolithophore *Emiliana huxleyi*.” Co-tutors: Dr. von Dassow with Dr. Myriam Valero (CNRS, France). Sept. 2017.

Paula Ruz. PhD Thesis “Respuestas fisiológicas ontogenéticas de copépodos pelágicos bajo condiciones de hipoxia” Co-tutors Dr. R. Escribano with Dr. Pamela Hidalgo (Concepción, May 2017).

Leissing Frederick. MSc Thesis “Respuesta eco-fisiológicas del zooplancton frente a condiciones de hipoxia en el sistema de surgencia costera de Chile”. Tutor Dr. R. Escribano (Concepción, March 2017).

Jorge Ibañez. BIO296M Marine Biology Senior undergraduate research project. Faculty of Biological Sciences, Pontificia Universidad Católica de Chile. “Diferencias intra-específicas en un fitoplancton cosmopolita en respuesta a limitación por hierro.” July 2017. Tutor: Dr. von Dassow.

Theses in progress:

Montserrat Aldunate. PhD 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: Ulloa and von Dassow.

Francisco Javier Díaz Rosas. Faculty of Biological Sciences, Pontificia Universidad Católica de Chile. PhD 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: von Dassow.

Valeria Anabalón, Ph.D. thesis, “Spatio-temporal variability in the structure of planktonic communities in eastern boundary systems: influence of coastal upwelling, mesoscale activity and nutrient concentration”; Tutor: J. Arístegui (U. Las Palmas de Gran Canaria (ULPGC), Spain), co-tutor: CE. Morales. Thesis defense (mid-2018).

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”; Tutor: CE. Morales, S. Hormazabal: co-tutor; Thesis defense (mid-2018).

Carolina González, Ph.D. thesis “Variabilidad oceanográfica espacial y su impacto sobre la filogeografía de copépodos pelágicos en el Pacífico Sur Oriental”. Co-tutor R. Escribano with Dr. 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.

V. 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).

V. Salas, MSc. thesis, “Mesoscale eddies and upwelling filaments around Seamount O'Higgins, Juan Fernández Ridge”; Tutor: S. Hormazabal, CE. Morales: co-tutor; Thesis defense (mid-2018).

L. 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.

D. 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).

S. Cornejo-Guzmán, undergraduate thesis (Habilitación Profesional; 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; thesis defense (March 2018).

5. Networking and other collaborative work

a) Networking:

In 2017 international networking involving IMO research and researchers has been strengthened through participation and co-chairing panels and working groups in various international programs dealing with climate variability and biogeochemistry of the ocean. R. Escribano has been appointed for a second period as member of the scientific steering committee of IMBeR (Integrated Marine Biosphere and Ecosystem Research: www.imber.org). Within IMBeR Escribano also became chair of the Working Group on Eastern Boundary Upwelling Ecosystems (EBUS). Until October 2017 R. Escribano also co-chaired the Program CLIVAR EBUS Research Focus. Both IMBeR and CLIVAR (Climate and Ocean - Variability, Predictability, and Change: www.clivar.org) are programs sponsored by IOC, SCOR and WCRP. In April 2017 in collaboration with researchers from the four major EBUS a proposal was submitted to SCOR to establish a SCOR WG on EBUS under a changing climate. The proposal was approved and R. Escribano became co-chair of this SCOR Group 155 on EBUS. All these international panels are now partners of the Future Earth Program which also implemented the KAN's (Knowledge Action Network panels). A specific KAN was implemented for the ocean and R. Escribano was appointed as member of this panel (Ocean Development Team of the Ocean KAN). IMO has also continued committed to collaborate with oceanographic time series in different regions of Latin America by participation in the ANTARES Network. IMO is also part of the Laboratory International Associate MORFUN which is a collaborative network between Universidad de Concepción and the Oceanographic Observatory of Banyuls sur mer (France) with partial funding from CNRS of France.

During 2017, IMO participated in different national and international collaboration networks for studying the impacts of climate change on the ocean and its marine resources.

A sustained collaboration is related to joint activities in the research line of Adaptations to a Changing Ocean supported by the OA-ICC (Ocean Acidification International Coordination Centre). OA-ICC supported one of the most important networking symposiums in Latin American last year, the organization of the 1st Symposium of the Latin-American Ocean Acidification Network (LAOCA). This first symposium convoked researchers, students, government and industry representatives from Latin America interested in acquiring a regional and global updated knowledge about the impacts of ocean acidification on marine resources and ecosystems. This created an important opportunity for sharing expertise, research results, and exploring new opportunities for collaborative research in the region. More than 120 works were presented, with representatives from more than ten countries in Latin-American (Argentina, Peru, Colombia, Brazil, Mexico, Chile, Ecuador, Costa Rica, Venezuela, Cuba) and invited plenary speakers from France, U.K., Mexico, and Chile.

IMO's associated researchers have been involved in executive councils of highly relevant international network programs. For instance, Dr. Vargas has already participating 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 2017, Dr. Vargas was also actively working in the international network program CO₂ 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. Pier2Peer employs an adaptive and self-driven approach to capacity development with guiding principles to focus on user needs at the local, regional, national, and international level and to foster inter-regional and global collaboration. Dr. Vargas recently on early 2018 received a small grant from The Ocean Foundation for sharing expertise and invite to Ms. Celeste Sánchez from the Universidad de Costa Rica (UCC-Costa Rica) for a research stay of 2 months at IMO. Moreover, Dr. Vargas will visit as a guest researcher the UCC for giving an Advanced Course on Stable carbon isotope application in Ocean Acidification Studies.

RL3 at IMO through the work of Dr. Vargas is also carrying out an incredible work in capacity building in other Latin-American regions (e.g. Peru, Ecuador, and Costa Rica), focused in monitoring and understand the rates and effects of OA, as it is a well-established need of the scientific community in our region. To complement the effort of international network programs, through the Dr. Vargas' work, we hope to offer in-person, concentrated training for highly skilled scientists in premier OA laboratory settings in Chile and/or abroad. Recently, during December 2017, Dr. Vargas was awarded a SCOR (Scientific Committee on Oceanic Research) Visiting Scholar Grant to serve in Ecuador in Galapagos Island being the first visiting scholar from Chile in getting this SCOR grant. Through this grant and additional funds from OA-ICC, Dr. Vargas aiming during 2018 to develop a capacity building expedition to a natural CO₂-volcanic seep in Galapagos Island, focused in understand the local adaptation of marine invertebrates and microbial communities to high pCO₂ conditions.

Collaboration with France continued in the framework of the UMI3614 “Evolutionary Biology and Ecology of Algae”, the international research unit of the CNRS partnered with Université Pierre et Marie Curie (Paris VI), Pontificia Universidad Católica de Chile, and the Universidad Austral de Chile, as well as the larger CNRS-financed international research network International Research Front position is highly variable (100 to 200 km from the coast) and it relates to the position of a coastal jet only when the latter is closer to the coast (<100 km offshore). In contrast, front position was less restrained when an offshore jet was present. Network "Diversity, Evolution and Biotechnology of Marine Algae" (GDRI N° 0803), involving French, Chilean, and Brazilian researchers. IMO Associate Researcher P. von Dassow is part of both networks. In 2017, this collaborative work supported the Masters 2 thesis of Ms. Sarah Pinon, a student of Université Pierre et Marie Curie in Paris who was co-supervised by Dr. von Dassow and Dr. Myriam Valero of the CNRS. These formal networks also facilitate the exchange of phytoplankton strains between the collection of the IMO/PUCCh and the Roscoff Culture Collection and other algal resources in Roscoff. The IMO/PUCCh algal culture collection is run by Dr. von Dassow in charge of phytoplankton and Dr. Sylvain Faugeron, the Sub-Director of the Núcleo Milenio Centro de Conservación Marina (CCM), in charge of macroalgae, so has represented a collaboration between an Instituto Milenio and a Núcleo Milenio.

b) Other collaborative activities:

In 2017, IMO researcher Dr. von Dassow and Dr. Christopher Aiken, an adjunct research of the Nucleo Milenio CCM and assistant professor at PUC, responded to the call “First competition for technological investigation in fisheries systems faced with Harmful Algal Blooms” from the FONDEF-IDEA program with the proposal “Sistema masivo y de bajo costo para el monitoreo de algas nocivas en toda la costa Chile”. This proposal, with Dr. Aiken as Director and Dr. Von

Dassow as Sub-Director, also involves co-investigators Dr. Catharina Alves-de-Souza from University of North Carolina Wilmington and Dr. Giancarlo Troni from the PUC as well as collaboration from the Chilean government agency National Service of Fishing and Aquaculture (SERNAPESCA). This proposal was one of two proposals selected for financing and began in January 2018.

Dr. von Dassow also led and IMO young researchers Victor Aguilera and Pierre-Amaël Auger participated in a collaborative study of whether the coastal waters at 30° S could exhibit limitation of primary production by low iron. This study was executed in Oct. 2017 in collaboration with researchers from three other research centers (CEAZA, CIEP, IDEAL) and logistical support from the aquaculture consortium Invertec-Ostimar.

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

a) **Outreach:**

The multi-disciplinary Outreach team of IMO promotes responsible maritime culture, science in general, and marine science in particular, focusing on increasing awareness of the ocean and empowerment through knowledge. During 2017, the team continued implementation and execution of the principal projects and initiatives that proved highly successful in previous years, and also focused on developing new and innovative proposals.

1. **PME Projects:**

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

This Web platform (with Facebook fan page and YouTube channel) began in 2015 to inform, motivate and delight children with the wonders of the different marine environments of Chile. In collaboration with PAR Explora Biobío, the platform was the basis for a competition called "Dive to Explore". Winners were invited to an Award Ceremony at the the Marine Biology Station of the University of Concepción, in Dichato.

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



This activity "brings the ocean to school" for one day. The activity consists in a display of audiovisual material, followed by practical work and playful activities with elementary students from 1st and 2nd grade. In 2017, a total of 16 MACI were displayed in the Biobío Region. MACI also grew in the regions of Valparaíso, and Antofagasta, where 5 more displays were carried out.

iii. **IMO at the School**

IMO developed 5 different workshops for elementary and high school students in 2017: "Our Ocean", "Marine biodiversity", "Marine Biogeography", "Human impact in the ocean", and "Deep Ocean". In total, 32 workshop events were carried out. Additionally, Adjunct Researcher Dr. Pamela Hidalgo supported two science academies, with one winning the Feria Antártica Escolar (FAE) (Antarctic School Fair) (<http://www.elsur.cl/imprensa/2017/07/02/full/cuerpo-principal/16/>)



iv. **Oceanic culture and marine science workshop for teachers**

A 2-day workshop designed for teachers from Penco and Coihueco was carried out in Dec. 2017, at the Marine Biology Station of the University of Concepción, to update and strengthen their knowledge about marine sciences. "Biodiversity" and "How the ocean moves?" were the topics.

2. Puppet show "Tony Tonina: Fins In Action"

With CONICYT sponsorship, a puppet show inspired by the animated TV series "The Scientific Recipe of Tony Tonina" was performed. In the show, the main characters of the series take life as puppets to live an exciting adventure where they discover a terrible problem that afflicts the inhabitants of the ocean: the plastic waste discarded by humans.

3. Explorers: From the Atom to the Cosmos

The second season of this series was developed to raise awareness among Chileans about national scientific centers of excellence and how they contribute to Chile. IMO is supporting the production of the series, and it included a chapter about IMO work. The series, of 16 chapters co-produced with the channel "24 horas", achieved a high audience, and was renewed for a new season in 2018.

(<https://www.youtube.com/channel/UCJx7VStRwfK7Urcmvbhcjxg/videos>).

4. The Scientific Recipe of Tony Tonina



In 2017, our children's series produced thanks to Explora Program of CONICYT, was spread nationally through the channel NOVASUR, reaching more than 7,200 schools. In addition, the series has been transmitted by the signal of the public television of Peru, Ipaev. Tony Tonina is a character already recognized and loved by the Chilean and Peruvian children (www.tonytonina.cl)

5. ExploSub

In 2017 the IMO proposal "ExploSub: Science and technology for underwater exploration" (Ciencia y Tecnología para la Exploración Submarina) was awarded in the XXI Explora Contest for Valuation and Outreach of Science and Technology: It consists of workshops on applied technological development for teachers and students of Penco, San Pedro, Quillón and Coihueco, who will be guided to build a small-scale prototype of an underwater vehicle for ocean exploration.

6. Wednesday at the Academy

During 2017, IMO and the Chilean National Academy of Sciences organized scientific lectures for the general public about marine science within the context of the National Year of the Oceans. In total there were 8 lectures by leading scientists including: Osvaldo Ulloa, Bernabé Santelices, Alejandro Buschmann, Ruben Escribano, Ricardo de Pol, Cristian Vargas, Miriam Fernandez and Juan Carlos Castilla.

7. Our Ocean Camp

IMO participated in the 2nd camp "Our Ocean", organized by the Young Science Foundation, on board the Chilean oceanographic vessel, *Cabo de Hornos* in the framework of the IV Congreso Internacional de Áreas Marinas Protegidas - IMPAC4 (IV International Marine Protected Areas Congress). IMO researchers, technicians, and students demonstrated practical activities on board to students and teachers.

8. Other significant events

During 2017, we participated in several other school or community science events such as science fairs in Biobío, Ñuble and Metropolitan region; we supported the teaching conference of PAR Explora Biobío; we made on site visits of delegations of students in the Marine Biology Station UdeC, in Dichato. We gave a series of ocean talks during September at the Rendibu Cafe in Concepción. We supported open door activities at the Universidad de Concepción, and in the Explora regional congress; we carried out Microscopy workshops for teachers.

We continue to strengthen the alliances established up to now and adding new ones. To mention some of the most notable: PAR Explora Biobío, Centro Interactivo de Ciencias, Artes y Tecnologías (CICAT), PAR Explora Antofagasta, Universidad de Antofagasta, Pontificia Universidad Católica de Valparaíso, PAR Explora RM Norte, PAR Explora RM Sur Oriente, PAR Explora RM Sur Poniente, [Ecology and Sustainable Management of Oceanic Islands](#) (ESMOI), Instituto Antártico Chileno (INACH), Centro de Investigación en Ecosistemas de la Patagonia (CIEP) and RedPOP.

b) Connections with other sectors:

IMO researchers are increasingly articulating ocean science needs to policy-makers. Three IMO researchers (Ulloa, Hormazabal, and Morales) contributed aspects related to ocean science as consultants in the drafting of the new **National Ocean Policy of Chile**, signed by the Chilean President on 9 March 2018. Our associate researcher, Dr. Cristian A. Vargas was elected again in 2017 as focal point of Chile, for international projects involving a government organization, such as the **Chilean Atomic Energy Commission (CChEN)** and the **International Atomic Energy Agency (IAEA)**, specifically for issues related to Ocean Acidification research.

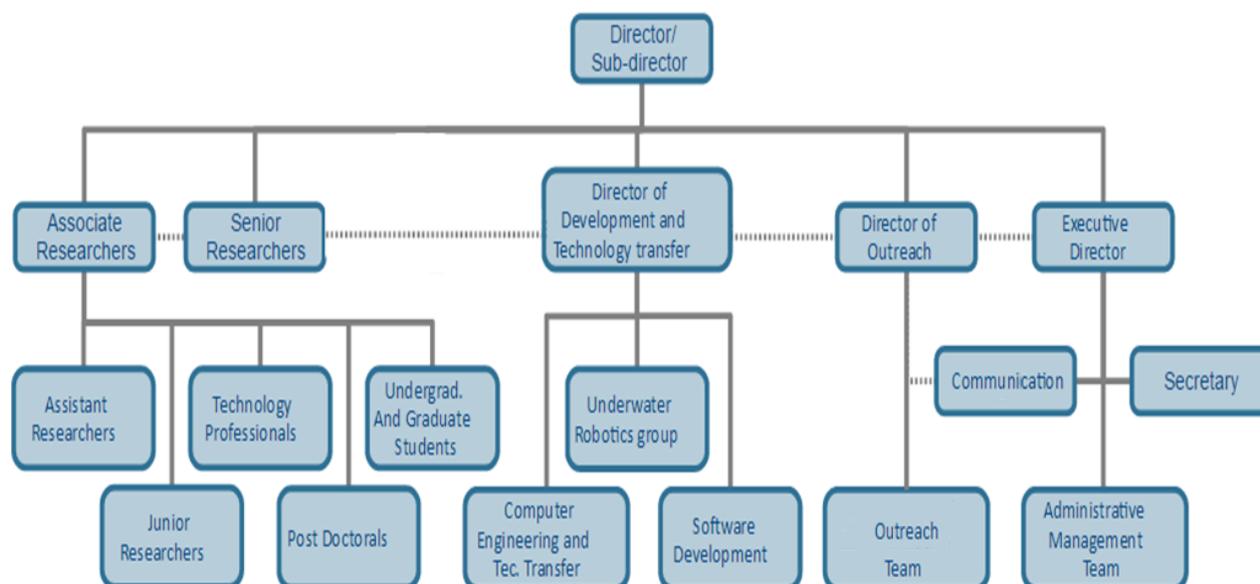
Regarding our Development and Technology Transfer area, our institute is working with Hab APTA where converge more than 15 technology transfer units from Chilean universities and investigation centers linking with different industries, from mining to aquaculture, for example.

In April 2017, a Canadian company “Oceaneos” appeared in the Chilean press, extensive social networks, and even the Lolapalooza music festival in Chile, advocating large-scale commercial ocean iron fertilization as a means to stimulate fisheries and to “heal” the ocean. They proposed to add iron at site offshore in Chilean coastal waters, had raised venture capital funds in Canada and the USA, and had even received financing from the CORFO program of the Chilean Ministry of Economy. The proposed activity is highly controversial, as there is no scientific evidence that large scale artificial ocean iron fertilization (OIF) can have beneficial environmental effects and is considered by the scientific community to be highly risky, for example, being demonstrated to promote toxic phytoplankton. The 2013 amendment to the London Convention/Protocol on Ocean Dumping, an international treaty to which Chile is signatory, specifically prohibits this activity. In response, IMO researchers worked to raise awareness of the issue in the general public, stakeholders, policy makers and decision makers. IMO researchers published letters in the national newspapers and were interviewed for several articles. Also, the IMO organized the special session “Geo-Engineering – Ocean Iron fertilization: scientific - technological, social-commercial and legal - ethical aspects” in the context of XXXVII Congreso Chileno de Ciencias del Mar, in Valparaíso, which was attended by hundreds of marine scientists, students, representatives of government agencies, non-profit organizations, and aquaculture companies. Additionally, IMO researchers led a report on the subject solicited by the Chilean Navy branch DIRECTEMAR, which is in charge of regulating coastal activities and environmental protection, and supervising Chile’s compliance with the London Protocol on Ocean Dumping. IMO researcher Dr. von Dassow was also asked to give an oral presentation of the underlying science at the 38th Plenary Assembly of the National Oceanographic Committee organized by the Chilean Navy’s Hydrographic and Oceanographic Service. In the audience were representatives of major Chilean universities, civil societies, and government agencies involved in fisheries or environmental protection.

7. Administration and Financial Status

a) **Organization and administration:**

The following chart represent the organizational and operational structure during 2017.



The administration team for 2017 was comprised of Mr. Mario Baltazar as Chief Accountant, and Mrs. Olga Pérez as the Assistant Accountant, and IMO’s Executive Secretary, Mrs. Mabel Marcó, 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 33, 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 2017, administrative demand increased greatly compared to the year before, explained by factors such as the addition of new professionals, new Fondecyt projects, obtained by junior and postdoctoral researcher from the Institute, and activities such The Ocean Fertilization Forum, organized by IMO, in the context of XXXVII Congreso Chileno de Ciencias del Mar, in Valparaiso, and new Outreach projects. During this year IMO rented 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	16	17	33
Administrative Staff	3	2	5
TOTAL	19	19	38

b) **Financial Status:** The financial status, in terms of fund sources, income, leverage and expenditure structure is 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	Associate Professor	2
Peter von Dassow	All	American	M	31-03-1974	Oceanographer	D	PUC	Assistant Professor	2
Osvaldo 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 Hormazábal Fritz	1,2	Chilean	M	08-12-1967	Oceanographer	D	PUCV	Associate Professor	2

1.2 Young Researchers

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yyyy	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	Millennium 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
Aldo Manuel Montecinos Gula	2	Chilean	M	24-07-1965	Oceanographer	D	University of Concepción	Associate Professor	2
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
Ricardo Hernán De Pol Holz	2	Chilean	M	17-10-1973	Marine Biologist	D	University of Concepción - University of Magallanes	University Teacher	2
Víctor Enrique Villagrán Orellana	All.	Chilean	M	02-03-1973	Engineer	M	University of Concepción	Chief MIDGEO Laboratory	2
Paulina Aguayo	3	Chilean	F	31-12-1980	Marine Biologist	D	Millennium Institute of Oceanography	postdoctoral fellow	1
Alvaro Alfredo Muñoz Plominsky	4	Chilean	M	24-04-1984	Biologist	D	University of Concepción	postdoctoral fellow	2

Carlos Andrés Henríquez Castillo	3, 4	Chilean	M	06-05-1983	Biochemist	D	University Concepción IMO	of - postdoctoral fellow	2
Pedro Echeveste De Miguel	3, 4	Spanish	M	03-08-1981	Biologist	D	Pontifical Catholic University Chile	of 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	IMO	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	University Concepción IMO	of - Postdoctoral fellow	1
Ígor Fernández	2, 4	Spanish	M	11-11-2015	Biologist	D	IMO	Postdoctoral fellow	1
Diana Medellín Mora		Colombian	M	23-08-1977	Marine Biologist	D	IMO	Postdoctoral fellow	1
Atilio Morgado	All	Chilean	M	23-05-1960	Marine Biologist	M	IMO	Adjunct Researcher	2

NOMENCLATURE:**[Gender]**

[M] Male [F] Female

[Academic Degree][U] Undergraduate [M] Master
[D] Doctoral**[Relation with Center]**

[1] Full time [2] Part time

N°	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
1	Mesoscale processes	What is the role of mesoscale activity in governing energy and matter transfer and ecosystem dynamics in open ocean ecosystems	<p>Mesoscale eddies are characteristic of the southeastern Pacific (SEP) and connect areas with coastal upwelling with oligotrophic oceanic waters, as well as meso- and epipelagic domains. Eddies create unique and relatively isolated environments with distinct biological communities and chemical conditions, depending on the nature of the water trapped, the characteristics and path of eddies and their interactions with winds and topography. Seamounts, submarine mountain ranges and oceanic islands in the southeastern Pacific can also create or strengthen mesoscale activity and consequently increase biological production around them.</p> <p>Our hypothesis is that mesoscale eddies generated in the coastal area create conditions of deficient O₂/low pH in the open sea (or the opposite in areas with minimal oxygen), with corresponding changes in the structure of communities and biochemical cycles, and that differ significantly from those found in adjacent oceanic waters.</p> <p>To address this research theme, we will carry a field experiment to study the characteristics and evolution of mesoscale eddies generated in the sea beyond central Chile (~36 °S) and that are propagated to the northwest, reaching to around the Juan Fernández Archipelago. The field experiment will include time-series observations by satellite teledetection (e.g. ocean altimetry and color), an anchorage in the vicinity of the Juan Fernández Archipelago, and sections with a sailplane, as well as cruises oriented to processes.</p> <p>To study the evolution of the physical-chemical and biological conditions of one of these eddies we will visit it on three occasions as it advances from the coast to the open ocean. On this occasion we assess changes in chemical characteristics (e.g. dissolved organic carbon and organic particulates and dissolved inorganic matter, O₂, pH/pCO₂ and nutrients), community structures, gene expression and biogeochemical activity (e.g. primary production, nitrogen fixation, respiration and others) within and beyond the eddies. Also, we will carry out onboard perturbation experiments; applying individual and multiple stress factor in contrasting waters.</p> <p>Using numeric experiments, we will analyze the structure of these eddies and they ways in which they are generated and transported, in particular in the minimum oxygen zones (ZMO) around oceanic islands and submarine associated with the submarine Nazca and Juan Fernández mountain ranges.</p>	<p>Carmen Eliana Morales Van De Wyngard</p> <p>Samuel Ernesto Hormazábal Fritz</p> <p>Carolina Eugenia Parada Veliz.</p> <p>Marcela Alejandra Cornejo D'Ottone.</p> <p>Juan Carlos Castilla Zenobi.</p> <p>Oscar Roberto Pizarro Arriagada.</p> <p>Peter von Dassow</p> <p>Cristian Antonio Vargas Galvez.</p> <p>Heraclio Rubén Escribano Veloso.</p> <p>Ramiro Antonio Riquelme Bugueño.</p> <p>Pierre Amael Auger</p> <p>Víctor Villagrán Orellana</p> <p>Pablo Rosenblatt</p>	<p>Ecology and environmental sciences.</p> <p>Oceanography</p> <p>Meteorology and climatology.</p> <p>Marine biology.</p> <p>numerical methods and computer science.</p>	26-12-2013	

2	Ocean Variability and Change	How large scale perturbations impact the transport and gradients in physical chemical water properties	<p>The subtropical cell controls the large-scale transport of heat, freshwater, carbon, nutrients and dissolved O₂ through the southeastern Pacific basin. These processes modulate chemistry and biology and the regional component of the climate variability.</p> <p>Models and field observations have shown that in the context of climate warming, the subtropical celda of the South Pacific is reinforced as a response to changes in surface winds on a large scale on the tropical Pacific. As well, it is expected that global warming directly affects the South Pacific by strengthening the degree of productivity.</p> <p>As the temperature of the upper layers increases, the stratification of oceanic water is reinforced, affecting the mixing of water masses and vertical diffusiveness in subtropical regions. In contrast, stronger coastal winds could increase vertical mixing and upwellings of eastern currents. It has been argued that coastal upwelling and transport by the Humboldt Current have intensified in recent decades and has been getting stronger on the scale of decades. This in turn has been modifying the properties of waters that participate in the subtropical cell and in an increase in the physical, biochemical and ecological gradients between the coastal and oceanic environments. The lower O₂ content of the warmer ocean waters and the higher gradients between upwelling and stratified oceanic waters contributes to expanding waters low in O₂/pH and high in pCO₂, which affects biological communities and the biogeochemical cycles in these waters.</p> <p>To address this issue, new and novel observations will be combined with advanced regional numeric models. The observations come from expeditions and regular transects with gliders between the coast and the Juan Fernández Archipelago. The data will include temperature, salinity, O₂ and other biochemical variables (e.g. pH, pCO₂, nutrients, gases, and organic and inorganic carbon, including their isotopes: ¹²C, ¹³C, ¹⁴C, and ¹⁵N). We will also make a high-resolution analysis of the microstructure and the indices of turbulent mixing that allow calculating the vertical flows of salts, heat and relevant biogeochemical properties. These high-resolution data, together with historic data will allow for assessing annual and more frequent changes in meridional transport and in the physical and chemical properties in the thermocline and intermediate waters.</p> <p>This data will be used in refining models and in validating their outcomes. Different simulations will generate outcomes that will be introduced into regional models to assess the mechanisms that affect coastal upwelling, the generation of mesoscale eddies, regional circulation and the modification of water masses.</p>	<p>Oscar Pizarro Arriagada.</p> <p>Wolfgang Schneider</p> <p>Ricardo Hernán De Pol Holz.</p> <p>Carolina Eugenia Parada Veliz.</p> <p>Samuel Ernesto Hormazábal Fritz</p> <p>Carmen Morales Van de Wyngard</p> <p>Peter von Dassow</p> <p>Víctor Miguel Aguilera Ramos.</p> <p>Aldo Manuel Montecinos Gula</p> <p>Heraclio Rubén Escribano Veloso.</p> <p>Víctor Enrique Villagrán Orellana</p> <p>Pierre Amael Auger</p> <p>Frauke Albrecht</p> <p>Pablo Rosenblatt</p>	<p>Biochemistry.</p> <p>Ecology and environmental sciences.</p> <p>Oceanography</p> <p>Meteorology and climatology.</p> <p>Marine biology.</p> <p>numerical methods and computer science.</p>	26-12-2013	
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3	Adap ting to a Chan ging Ocea n	How Key functional plankton groups adapt to changing ocean chemistry and impact biogeochemi cal cycling	<p>The strong and dynamic horizontal chemical gradients in the southeastern Pacific (SEP), from ultra-oligotrophic waters to coastal upwelling, exhibit highly variable combinations of low O₂ and pH/high pCO₂ and include strong vertical changes in O₂ concentrations, from saturation levels at the surface to undetectable levels in the nucleus of minimum oxygen zone (MOZ). These gradients cover a wide range of spatial-temporal scales.</p> <p>The responses of plankton communities and the feedback between community function and biogeochemical dynamics can depend in large measure on adaptations and capacities of acclimatization of key components, which can vary significantly among oceanic habitats. Moreover, the biological responses to multiple stress factors can be additive, synergetic or antagonistic.</p> <p>Our hypothesis is that the genomic variability among marine species is related to the differential functional responses to multiple stress factors and these determine the persistence or the 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 pCO₂, pO₂ and nutrients will be isolated. In association with this activity, a new collection of phytoplankton will be initiated at the PUC in coordination with the Roscoff Culture Collection.</p> <p>Perturbation experiments will be conducted with single stress factors on selected species, focusing on physiological variability in response to variations in pCO₂/pH, and O₂, and allow for improving the design of experiments with multiple stress factors. Based on these results, we conduct genomic analysis of species/genera (e.g. low O₂ – Prochlorococcus; low pH/high pCO₂ – Coccolithophore).</p> <p>For fieldwork, our Institute will conduct observations and experiments during expeditions. In situ estimations will be made of physiological/metabolic rates and communities, gene expression and particle flows (in particular associated with the carbon cycle, which in minimum oxygen zones is relatively unknown).</p> <p>As well, culture-independent genomic analysis of representative species will allow for putting to the test the associations between genomic and physiological variations. The composition and functioning of the communities will be analyzed and compared to the genomic population among the specific representatives of functional plankton groups.</p>	<p>Peter von Dassow.</p> <p>Oswaldo Iván Ulloa Quijada.</p> <p>Cristian Antonio Vargas Galvez.</p> <p>Pamela del Carmen Hidalgo Diaz.</p> <p>Víctor Miguel Aguilera Ramos.</p> <p>Ricardo Hernán De Pol Holz.</p> <p>Alvaro Alfredo Muñoz Plominsky.</p> <p>Heraclio Rubén Escribano Veloso.</p> <p>Gerrit van den Engh.</p> <p>Víctor Enrique Villagrán Orellana</p> <p>Pedro Echeveste De Miguel.</p> <p>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	what are the community structures and the biogeochemical characteristics of the deep and abyssal waters of the ESP	<p>The ecosystems of deep SEP waters are practically unknown. Exploration of mesopelagic (>500 m) and abyssopelagic communities (>3000 m) represent unique opportunities to discover new forms of life, species and genes for science, as well as a major challenge for oceanography in the South Pacific basin.</p> <p>This initiative will allow for identifying the mechanism through which communities are able to distribute themselves widely and colonize unique habitats like the Atacama Trench and the Nazca, Salas & Gómez and Juan Fernández ranges. Our hypothesis is that the ranges contribute significantly to the dispersion of species and the gene flows in the coast-ocean direction, driven by the circulation of water masses and mixing associated with the meso and large scale physical dynamics.</p> <p>To address this theme we will carry out deep water samplings, including a MOCNESS net (maximum depth of 6,500 m) with an underwater video profiler (UVP), conductivity, temperature 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>The expeditions will be conducted jointly with international counterparts. 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>As well, the biogeochemical conditions of the deep ocean will be characterized, including measurements of carbon, and pH/pCO₂ reserves and saturation states of calcite and aragonite (Ω). Inorganic carbon isotopes (12C, 13C, 14C), dissolved organic carbon and age determination (DO14C) will also be included with the aim of learning about biogeochemical rates and the mixing of water masses in deep water ecosystems.</p>	<p>Heraclio Rubén Escribano Veloso.</p> <p>Osvaldo Iván Ulloa Quijada.</p> <p>Marcelo Enrique Oliva Moreno.</p> <p>Pamela del Carmen Hidalgo Diaz.</p> <p>Wolfgang Schneider.</p> <p>Oscar Roberto Pizarro Arriagada.</p> <p>Peter von Dassow</p> <p>Cristian Antonio Vargas Galvez.</p> <p>Pablo Rosenblatt Guelfenbein.</p> <p>Ramiro Antonio Riquelme Bugueño.</p> <p>Víctor Enrique Villagrán Orellana.</p> <p>Pablo Rosenblatt</p> <p>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>	26-12-2013	
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Annex 3.- Publications (Total or partially financed by MSI)

3.1.- ISI Publications or Similar to ISI Standard

1. **Schneider W.**, Donoso D., Garcés-Vargas J., **Escribano R.** (2017) Water-column cooling and sea surface salinity increase in the upwelling region off central-south Chile driven by a poleward displacement of the South Pacific High. Progress in Oceanography 151: 38-48. Q1*, IF: 3.391, Research Line 2.
2. Jacob B., **Von Dassow P.**, Salisbury J., Navarro J., **Vargas C.** (2017) Impact of low pH/high pCO₂ on the physiological response and fatty acid content in diatom *Skeletonema pseudocostatum*. Journal of the Marine Biological Association of the United Kingdom 97: 225-233. Q3, IF: 1.038, Research Line 3.
3. Valdés V., **Escribano R.**, Vergara O. (2017) Scaling copepod grazing in a coastal upwelling system: The importance of community size structure for phytoplankton C flux. Latin American Journal of Aquatic Research 45: 41-54. Q4, IF: 0.613, Research Line 4.
4. **Vargas C.**, Lagos N., Lardies M., Duarte C., Manríquez P., Aguilera V., Broitman B., Widdicombe S., Dupont S. (2017) Species-specific responses to ocean acidification should account for local adaptation and adaptive plasticity. Nature Ecology & Evolution 1: 1-7. Q: NA, IF: NA, Research Line 3.
5. Donoso K., Carlotti F., Pagano M., Hunt B., **Escribano R.**, Berline L. (2017) Zooplankton community response to the winter 2013 deep convection process in the NW Mediterranean Sea. Journal of Geophysical Research: Oceans 122: 2319-2338. Q1, IF: 2.939, Research Line 4.
6. Medina L., Taylor C., Pachiadaki M., Henríquez C., **Ulloa O.**, Edgcomb V. (2017) A review of protist grazing below the photic zone emphasizing studies of oxygen-depleted water columns and recent applications of in situ approaches. Frontiers in Marine Science 4: 1-12. Q: NA, IF: NA, Research Line 3.
7. Alves-de-Souza C., Benevides T., Santos J., **Von Dassow P.**, Guillou L., Menezes M. (2017) Does environmental heterogeneity explain temporal β diversity of small eukaryotic phytoplankton? Example from a tropical eutrophic coastal lagoon. Journal of Plankton Research 39: 698-714. Q2, IF: 1.983, Research Line 3.
8. Léniz B., Murillo A., Ramírez-Flandes S., **Ulloa O.** (2017) Diversity and transcriptional levels of RuBisCO form II of sulfur-oxidizing γ -proteobacteria in coastal-upwelling waters with seasonal anoxia. Frontiers in Marine Science 4: 1-12. Q: NA, IF: NA, Research Line 3.
9. Valdés V., Fernández C., Molina V., **Escribano R.** (2017) Nitrogen excretion by copepods and its effect on ammonia-oxidizing communities in a coastal upwelling zone. Limnology and Oceanography 63: 278-294. Q1*, IF: 3.383, Research Line 4.
10. Vergara O., Dewitte B., Ramos M., **Pizarro O.** (2017) Vertical energy flux at ENSO time scales in the subthermocline of the Southeastern Pacific. Journal of Geophysical Research: Oceans 122: 6011-6038. Q1, IF: 2.939, Research Line 2.
11. Garcia-Robledo E., Padilla C., Aldunate M., Stewart F., **Ulloa O.**, Paulmier A., Gregori G., Revsbech N. (2017) Cryptic oxygen cycling in anoxic marine zones. Proceedings of the

National Academy of Sciences of the United States of America 114: 8319-8324. Q1*, IF: 9.661, Research Line 3.

12. Riquelme-Bugueño R., Gómez-Gutiérrez J., Silva-Aburto J., **Escribano R.**, **Schneider W.** (2017) Embryo and early larval stages of the Humboldt Current krill *Euphausia mucronata* (Crustacea: Euphausiacea). *Invertebrate Biology* 136: 260-270. Q3, IF: 0.949, Research Lines 2 and 4.
13. Lardies M., Benitez S., Osoreo S., **Vargas C.**, Duarte C., Lohrmann K., Lagos N. (2017) Physiological and histopathological impacts of increased carbon dioxide and temperature on the scallops *Argopecten purpuratus* cultured under upwelling influences in northern Chile. *Aquaculture* 479: 455-466. Q1, IF: 2.57, Research Line 3.
14. Castillo N., Saavedra L., **Vargas C.**, Gallardo-Escárate C., Détrée C. (2017) Ocean acidification and pathogen exposure modulate the immune response of the edible mussel *Mytilus chilensis*. *Fish and Shellfish Immunology* 70: 149-155. Q1, IF: 3.148, Research Line 3.
15. Valdés V., Fernandez C., Molina V., **Escribano R.**, Joux F. (2017) Dissolved compounds excreted by copepods reshape the active marine bacterioplankton community composition. *Frontiers in Marine Science* 4: 1-22. Q: NA, IF: NA, Research Line 4.
16. **Morales C.**, Anabalón V., Bento J., **Hormazábal S.**, Cornejo M., Correa-Ramírez M., Silva N. (2017) Front-eddy influence on water column properties, phytoplankton community structure, and cross-shelf exchange of diatom taxa in the shelf-slope area off Concepción (~36–37°S). *Journal of Geophysical Research: Oceans* 122: 8944-8965. Q1, IF: 2.939, Research Line 1.
17. Bertagnolli A., **Ulloa O.** (2017) Hydrography shapes community composition and diversity of amoA containing Thaumarchaeota in the coastal waters off central Chile. *Environmental Microbiology Reports* 9: 717-728. Q2, IF: 3.363, Research Line 3.

3.1.2 Other researchers

1. Luque J., Pereira F., Alves P., **Oliva M.**, Timi J. (2017) Helminth parasites of South American fishes: Current status and characterization as a model for studies of biodiversity. *Journal of Helminthology* 91: 150-164. Q2, IF: 1.63, Research Line 4.
2. Costa G., MacKenzie K., **Oliva M.** (2017) A review of the parasites infecting fishes of the genus *Trachurus* (Pisces: Carangidae). *Reviews in Fisheries Science & Aquaculture* 25: 297-315. Q1, IF: 2.545, Research Line 4.
3. **Belmadani A.**, Concha E., Donoso D., Chaigneau A., Colas F., Maximenko N., Di Lorenzo E. (2017) Striations and preferred eddy tracks triggered by topographic steering of the background flow in the eastern South Pacific. *Journal of Geophysical Research: Oceans* 122: 2847-2870. Q1, IF: 2.939, Research Line 2.
4. **Ruz P.**, **Hidalgo P.**, **Riquelme-Bugueño R.**, Franco-Cisterna B., **Cornejo M.** (2017) Vertical distribution of copepod eggs in the oxygen minimum zone off Mejillones Bay (23°S) in the Humboldt Current System. *Marine Ecology Progress Series* 571: 83-96. Q2, IF: 2.292, Research Line 3.

5. **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: 2.76, Research Line 1.

3.2.- SCIELO Publications or Similar to SCIELO Standard

3.2.1 **Associate Researchers:** No publications

3.2.2 **Other researchers:** No publications

3.3.- Scientific Books and Chapters

3.3.1 **Associate Researchers:** No publications

3.3.2 **Other researchers:** No publications

3.4.- Other Publications

3.4.1 **Associate Researchers:** No other publications

3.4.2 **Other researchers:** No other publications

3.5.- Collaborative publications:

Category of Publication	1 Researcher		2 Researchers		3 Researchers		4 or more Researchers	
	Nº	%	Nº	%	Nº	%	Nº	%
ISI Publications or Similar to ISI Standard	12	54%	6	27%	3	14%	1	5%
SCIELO Publications or Similar to SCIELO Standard	0	0%	0	0%	0	0%	0	0%
Books and Chapters	0	0%	0	0%	0	0%	0	0%
Other Publications	0	0%	0	0%	0	0%	0	0%
<u>Total of Publications</u>	12	54%	6	27%	3	14%	1	5%

Annex 4.- Organization of Scientific Events

Scope	Title	Type of Event	City	Country	Responsible Researcher
International	TARA Meeting Ocean – IMO 2017	Workshop	Concepción	Chile	Oswaldo Iván Ulloa Quijada
International	1st Latin American Symposium of Ocean Acidification (LAOCA)	Symposium	Buenos Aires	Argentina	Cristian Vargas
International	Geo-Engineering – Ocean Iron fertilization: scientific - technological, social-commercial and legal - ethical aspects	Forum	Valparaíso	Chile	Peter Von Dassw
International	V Congress of Physical Oceanography, Meteorology and Climate of the Southeast Pacific	Congress	Concepción	Chile	Oscar Roberto Pizarro Arriagada
National	Remote sensors and autonomous vehicles in operational oceanography	Course	Valparaíso	Chile	Samuel Ernesto Hormazábal Fritz
National	Inaugural Conference TARA "Structuring international scientific cooperation with South America"	Conference	Concepción	Chile	Oswaldo Iván Ulloa Quijada

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

MSI RESEARCHER	Undergraduate students			Graduate students						Postdoctoral researchers			TOTAL NUMBER PER MSI RESEARCHER		
				Magister			Doctorado								
	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
Ruben Escribano				1		1	5		5	1	1	2	7	1	8
Samuel Hormazábal	1		1	2	1	3							3	1	4
Carmen Morales		2	2				1		1	1		1	2	2	4
Oscar Pizarro				1	2	3	1	1	2				2	3	5
Osvaldo Ulloa	1		1	1		1		2	2		2	2	2	4	6
Cristian Vargas				2		2				1		1	3	0	3
Peter Von Dassow	1		1	1		1		1	1		1	1	2	2	4
Wolfgang Schneider								1	1				0	1	1
Carmen Morales, Samuel Hormazabal							1		1				1	0	1
Carmen Morales/Carolina Parada		1	1										0	1	1
Carmen Morales/Samuel Hormazábal							1		1				1	0	1
Oscar Pizarro/Aldo Montecinos		1	1										0	1	1
Oscar Pizarro/Samuel Hormazábal	1		1										1	0	1
Osvaldo Ulloa/Peter Von Dassow							1		1				1	0	1
Ruben Escribano/Marcelo Oliva				1		1		1	1				1	1	2
Ruben Escribano/Pamela Hidalgo	1	1	2	1	1	2	1		1				3	2	5
Samuel Hormazábal/Carmen Morales	1		1	1		1							2	0	2
Samuel Hormazábal/Marcela Cornejo	1	1	2	2		2							3	1	4
Oscar Pizarro/Víctor Villagrán		1	1										0	1	1
Rubén Escribano/Ramiro Riquelme	1	1	2										1	1	2
Carmen Morales/Peter von Dassow											1	1	0	1	1
Samuel Hormazábal/Carmen Morales/Oscar Pizarro										1		1	1	0	1
Wolfgang Schneider/Oscar Pizarro										1		1	1	0	1
Total	8	8	16	13	4	17	12	5	17	5	5	10	36	22	60

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

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
July Andrea Corredor	Plymouth Marine Laboratory	Reino Unido	Dr. Robert Brewin	Aplicación y validación del modelo teórico de tres componentes para la obtención de la estructura de tamaños del fitoplancton a partir de datos satelitales frente a Chile centro-sur	01-12-2016	31-01-2017
July Andrea Corredor	Departamento de Física, Universidad de Las Palmas de Gran Canarias	España	Dr. Angel Rodríguez - Santana	Análisis y procesamiento de datos oceanográficos para caracterizar procesos de mezcla en sistemas frontales y estructuras mesoescalares. Laboratorio de Fluidos Geofísicos y Geofísica Aplicada,	01-09-2017	30-09-2017

Foreign Students

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Yadian Israel La Rosa Izquierdo	Centro Interdisciplinario de Ciencias Marinas - CICIMAR	Mexico	Dr. Rubén Escribano	Processing, analysis and interpretation of research work data for master's thesis. Confront the work with researchers from the Instituto Milenio de Oceanografía, with extensive experience in the study of pelagic communities. Contextualization of the development of the ENSO 2015 event on the western coast of the Baja California peninsula and evaluation of the importance and degree of influence of the environmental descriptors (temperature, salinity, chlorophyll, etc.) on the pelagic copepod community.	16-10-2017	24-11-2017
Sarah Piñon	Université Pierre et Marie Curie - UPMC	Francia	Dr. Peter Von Dassow	Estudio de genética de poblaciones y filogeografía de poblaciones del cocolitoforido <i>Emiliania huxleyi</i> en aguas de surgencia y aguas lejos de la costa, frente a Chile.	27-02-2017	19-05-2017

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		
		Researchers	Postdocs/ Students	Researcher s	Postdocs/ Students	
UMI 3614 "Evolutionary Biology and Ecology of Algae:	I	1	1	6	4	Centre National de la Recherche Scientifique (CNRS) (France),
GDRI 803 "diversity, evolution and biotechnology of marine algae"	I	1		>40		Station Biologique de Roscoff, France (CNRS and UPMC), Observatoire Oceanique de Banyuls, Banyuls, France (CNRS and UPMC), Pontificia Universidad Catolica De Chile, Santiago, Chile, Universidad Austral De Chile, Valdivia, Chile
Ocean Acidification International Coordination Centre	I	1		>40		
Latin- American Ocean Acidification Network (LAOCA)	I	2		35		
Red Pop	LA	1				Museums and centers of Latin American.
HUB APTA (Andes Pacific Technology Access)	N	8		9		Catholic University of the North, University of Antofagasta. University Federico Santa Maria University, University Mayor, University Adolfo Ibáñez, University of Santiago, University of Concepcion, Catholic University of the Holy Concepcion, University of Tarapacá, University of Atacama, University of La Serena. Scientific and Technology Center for Mining Research.

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/St u dents	
Portal Oceanográfico-Meteorológico Operacional (POMEQ)	CORFO InnovaChile	1	3	2	2	
innovación y el desarrollo de los componentes cruciales del sistema de observación de los océanos	Partnership for Observation of the Global Oceans (POGO)					
Cooperación, capacitación y sinergias para mejorar Transferencia Tecnológica	Hub APTA	1	2	15	5	
FONDEF IDEA proposal “Sistema masivo y de bajo costo para el monitoreo de algas nocivas en toda la costa Chile”	PUCCh, Centro de Conservación Marina, SERNAPESCA, UNC-Wilmington.	1		3		
Collaborative experiment to study role of iron limitation in primary productivity at 30° S.	CEAZA, CIEP, IDEAL, Invertec-Ostimar	2	1	3		

Annex 7. - Outreach

7.1. - Outreach activities throughout the period

Event Title	Type of Event	Scope	Target Audience	Date	Country	Region	N° of Student from the Center	N° of Attendees	Duration in days	Participating Researchers	Responsible for the activity
Ocean culture workshop for Teachers Penco	Workshop	National	Public Service	28-12-17	Chile	Bío Bío	3	16	1		Bárbara Léniz
South leader awards	Exhibition	National	General Community	27-12-17	Chile	Bío Bío	0	1	1		Bárbara Léniz
Ocean culture workshop for Teachers Coihueco	Workshop	National	Public Service	12-12-17	Chile	Bío Bío	3	18	1		Bárbara Léniz
Science in the Park	Exhibition	National	General Community	08-12-17	Chile	Metropolitan of Santiago	1	5000	1		Irlin Barrera
Oceanography Day in Marine Biology Station, Dichato	Competition	National	Secondary Students Primary Students	05-12-17	Chile	Bío Bío	2	41	1		Bárbara Léniz
Science and Innovation Fair	Exhibition	National	General Community	22-11-17	Chile	Bío Bío	0	75	1		Bárbara Léniz
"The Senses" Workshop, "Tony Tonina"	Exhibition	National	Primary Students	20-11-17	Chile	Bío Bío	0	20	1		Bárbara Léniz
MACI primary and secondary cycle training	Video-conference	National	Public Service	16-11-17	Chile	Bío Bío	0	1	1		Belén Anais Franco
Puppets Show "Tony Tonina: Aletas en Acción"	Exhibition	National	Primary Students Public Service	15-11-17	Chile	Bío Bío	0	110	1		Bárbara Léniz
Fair of Science, Technology and Environment, in San Pedro	Exhibition	National	Secondary Students Primary Students General Community	09-11-17	Chile	Bío Bío	0	200	1		Bárbara Léniz
IMO Stand in Physical Oc., meteorology and climate Congress	Exhibition	National	University students Public Service	07-11-17	Chile	Bío Bío	2	200	4		Bárbara Léniz
IMO Stand in Seminar of Education	Exhibition	National	Secondary Students Public	03-11-17	Chile	Bío Bío	0	60	1		Belén Anais Franco

			Services							
Visit to Marine Biology Station UdeC, Dichato	Workshop	National	Primary Students Public Service	26-10-17	Chile	Bío Bío	2	100	1	Bárbara Léniz
IMO at the School "Biodiversity"	Conference	National	Primary Students	25-10-17	Chile	Bío Bío	1	90	1	Belén Anais Franco
MACI primary and secondary cycle training	Workshop	National	Public Service	25-10-17	Chile	Bío Bío	0	1	1	Belén Anais Franco
Workshop for infant's teachers	Workshop	National	Primary Students	25-10-17	Chile	Biobío	0	20	1	Bárbara Léniz
Puppets Show "Tony Tonina: Aletas en Acción"	Exhibition	National	Primary Students	24-10-17	Chile	Bío Bío	0	92	1	Bárbara Léniz
MACI Yungay	Exhibition	National	Primary Students	23-10-17	Chile	Bío Bío	4	122	1	Belén Anais Franco
Talking with Scientifics	Exhibition	National	Secondary Students	19-10-17	Chile	Bío Bío	2	12	1	Bárbara Léniz
School Science Fair Coihueco	Exhibition	National	Secondary Students Primary Students General Community	19-10-17	Chile	Bío Bío	1	200	1	Bárbara Léniz
IMO Stand in Open Doors UdeC	Exhibition	National	Secondary Students	17-10-17	Chile	Bío Bío	0	34	2	Bárbara Léniz
Visits to IMO laboratories	Exhibition	National	Primary Students	17-10-17	Chile	Bío Bío	1	66	1	Bárbara Léniz
Pecha Kucha	Conference	National	General Community	11-10-17	Chile	Bío Bío	0	100	1	Cristian Antonio Vargas Galvez Cristian Antonio Vargas Galvez
"Science goes out on the street" Fair Penco	Exhibition	National	General Community	10-10-17	Chile	Bío Bío	2	87	1	Bárbara Léniz
IMO at the School "Deep Ocean"	Conference	National	Primary Students	10-10-17	Chile	Bío Bío	0	78	1	Belén Anais Franco
Family Science Day UdeC	Exhibition	National	General Community	08-10-17	Chile	Bío Bío	0	100	1	Belén Anais Franco Cisterna
Party of Sciences Santiago	Exhibition	National	General Community	07-10-17	Chile	Metropolitan of Santiago	1	500	2	Geraldine Corbinaud
Party of Sciences Los Ángeles	Exhibition	National	Secondary Students Primary Students General	04-10-17	Chile	Bío Bío	0	55	1	Bárbara Léniz

			Community							
IMO at the School "Deep Ocean"	Exhibition	National	Secondary Students Primary Students General Community	04-10-17	Chile	Bío Bío	0	60	1	Bárbara Léniz
MACI Trehuaco	Exhibition	National	Primary Students	04-10-17	Chile	Bío Bío	4	129	1	Belén Anais Franco
Puppets Show "Tony Tonina: Aletas en Acción" - Los Ángeles	Exhibition	National	Primary Students	04-10-17	Chile	Bío Bío	0	78	1	Bárbara Léniz
IMO at the School "Marine Biodiversity"	Exhibition	National	Primary Students	03-10-17	Chile	Bío Bío	0	32	1	Belén Anais Franco
IMO at the School "Our Ocean"	Exhibition	National	Primary Students	03-10-17	Chile	Bío Bío	0	34	1	Bárbara Léniz
Puppets Show "Tony Tonina: Aletas en Acción" Talcahuano	Exhibition	National	Primary Students	03-10-17	Chile	Bío Bío	0	160	1	Bárbara Léniz
Party of Sciences Concepción	Exhibition	National	Secondary Students Primary Students General Community	02-10-17	Chile	Bío Bío	0	450	1	Bárbara Léniz
Conference Rendibú	Conference	National	General Community	28-09-17	Chile	Bío Bío	0	32	1	Carlos Andrés Henríquez Castillo
MACI Coihueco (in Dichato)	Exhibition	National	Secondary Students	28-09-17	Chile	Bío Bío	1	43	1	Belén Anais Franco
Visit to Marine Biology Station UdeC, Dichato	Workshop	National	Secondary Students	28-09-17	Chile	Bío Bío	1	42	1	Bárbara Léniz
Puppets Show "Tony Tonina: Aletas en Acción" Quillón	Exhibition	National	Primary Students	27-09-17	Chile	Bío Bío	0	82	1	Bárbara Léniz
MACI Tony Tonina Quillón	Exhibition	National	Primary Students	27-09-17	Chile	Bío Bío	0	51	1	Belén Anais Franco Cisterna
MACI Portezuelo	Exhibition	National	Primary Students	26-09-17	Chile	Bío Bío	2	69	1	Belén Anais Franco Cisterna
IMO at the School "Climate change and the oceans"	Workshop	National	Primary Students	25-09-17	Chile	Bío Bío	1	96	1	Bárbara Léniz
Conference Rendibú	Conference	National	General Community	21-09-17	Chile	Bío Bío	0	41	1	Bárbara Léniz

Conference Rendibú	Conference	National	General Community	14-09-17	Chile	Bío Bío	0	42	1		Bárbara Léniz
Conference in Cabo Froward Port	Conference	National	Primary Students	07-09-17	Chile	Bío Bío	0	20	1		Bárbara Léniz
Conference Rendibú	Conference	National	General Community	07-09-17	Chile	Bío Bío	0	40	1		Vera Oerder Gautron
Our Ocean Camp	Exhibition	National	Public Service Secondary Students	05-09-17	Chile	Coqui mbo	0	100	1	Víctor Aguilera Ramos – H.Rubén Escribano Veloso.	H. Rubén Escribano Veloso
Puppets Show "Tony Tonina: Aletas en Acción" Launching	Exhibition	National	Primary Students	17-08-17	Chile	Bío Bío	0	85	1		Bárbara Léniz
MACI Tony Tonina Penco	Exhibition	National	Primary Students	17-08-17	Chile	Bío Bío	1	55	1		Belén Anais Franco
Visit to Marine Biology Station UdeC, Dichato	Workshop	National	Primary Students	17-08-17	Chile	Bío Bío	3	22	1		Bárbara Léniz
Explora Update Day	Conference	National	Public Service	03-08-17	Chile	Bío Bío	0	65	1		Bárbara Léniz
IMO at the School "Biodiversity"	Workshop	National	Primary Students	02-08-17	Chile	Bío Bío	1	30	1		Belén Anais Franco
IMO at the School "Biogeography"	Workshop	National	Primary Students	02-08-17	Chile	Bío Bío	1	40	1		Bárbara Léniz
Explora Update Day	Workshop	National	Public Service	01-08-17	Chile	Bío Bío	0	65	1		Belén Anais Franco Cisterna
MACI Quilleco	Exhibition	National	Primary Students	27-07-17	Chile	Bío Bío	1	188	1		Belén Anais Franco Cisterna
"Biblioteca Viva" Fair	Exhibition	National	General Community	12-07-17	Chile	Bío Bío	2	200	1		Belén Anais Franco Cisterna
IMO at the School "Deep Ocean"	Conference	National	Secondary Students	05-07-17	Chile	Bío Bío	0	35	1		Bárbara Léniz
MACI Concepción	Exhibition	National	Primary Students	05-07-17	Chile	Bío Bío	3	61	1		Belén Anais Franco
Wednesday in the Academy	Conference	National	General Community	05-07-17	Chile	Bío Bío	0	35	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
MACI Penco	Exhibition	National	Primary Students	04-07-17	Chile	Bío Bío	2	112	1		Belén Anais Franco Cisterna
IMO at the School "Biodiversity"	Conference	National	Primary Students	03-07-17	Chile	Bío Bío	1	34	1		Belén Anais Franco Cisterna
Teachers training Contest "Dive"	Workshop	National	Public Service	27-06-17	Chile	Bío Bío	0	18	1		Bárbara Léniz

to Explore"											
IMO at the School "Climate change and the oceans"	Conference	National	Secondary Students	26-06-17	Chile	Metropolitan of Santiago	0	25	1		Pedro Echeveste De Miguel
IMO at the School "Biogeography"	Conference	National	Primary Students	20-06-17	Chile	Bío Bío	0	30	1		Bárbara Léniz
IMO at the School "Biogeography"	Conference	National	Estudiantes de Educación Primaria Secondary Students	14-06-17	Chile	Bío Bío	2	35	1		Bárbara Léniz
IMO at the School "Climate change and the oceans"	Conference	National	Secondary Students	14-06-17	Chile	Bío Bío	2	30	1		Bárbara Léniz
Wednesday in the Academy	Conference	National	General Community	14-06-17	Chile	Bío Bío	0	25	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
IMO at the School "Biodiversity"	Conference	National	Primary Students	13-06-17	Chile	Bío Bío	0	30	1		Belén Anais Franco Cisterna
IMO at the School "Deep Ocean"	Conference	National	Secondary Students	13-06-17	Chile	Bío Bío	0	20	1		Bárbara Léniz
MACI Coronel	Exhibition	National	Primary Students	09-06-17	Chile	Bío Bío	2	120	1		Belén Anais Franco Cisterna
Ocean Day Fair	Exhibition	National	General Community	08-06-17	Chile	Bío Bío	1	200	1		Bárbara Léniz
IMO at the School "Climate change and the oceans"	Conference	National	Secondary Students	08-06-17	Chile	Metropolitan of Santiago	0	35	1		Pedro Echeveste De Miguel
IMO at the School "Climate change and the oceans"	Conference	National	Secondary Students	07-06-17	Chile	Metropolitan of Santiago	0	40	1		Pedro Echeveste De Miguel
Wednesday in the Academy	Conference	National	General Community	07-06-17	Chile	Bío Bío	0	25	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
IMO at the School, "Biogeography"	Conference	National	Secondary Students	01-06-17	Chile	Bío Bío	2	175	1		Bárbara Léniz
MACI Coihueco	Exhibition	National	Primary Students	31-05-17	Chile	Bío Bío	2	112	1		Belén Anais Franco
Wednesday in the Academy	Conference	National	General Community	31-05-17	Chile	Bío Bío	0	35	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
Cultural Heritage Day in	Exhibition	National	General Community	28-05-17	Chile	Bío Bío	1	180	1		Bárbara Léniz

UdeC											
MACI Lota	Exhibition	National	Secondary Students	25-05-17	Chile	Bío Bío	3	144	1		Belén Anais Franco
MACI Talcahuano	Exhibition	National	Secondary Students	24-05-17	Chile	Bío Bío	2	123	1		Belén Anais Franco Cisterna
Wednesday in the Academy	Conference	National	General Community	24-05-17	Chile	Metropolitan of Santiago	0	25	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
MACI Valparaíso	Exhibition	National	Primary Students	22-05-17	Chile	Valparaíso	3	60	1		Eliana Velasco V
Month of the Sea in "the Whale"	Exhibition	National	General Community	20-05-17	Chile	Bío Bío	0	120	1		Bárbara Léniz
MACI Talcahuano	Exhibition	National	Primary Students	19-05-17	Chile	Bío Bío	2	200	1		Belén Anais Franco Cisterna
IMO Scientific Coffee	Conference	National	General Community	18-05-17	Chile	Bío Bío	5	180	2	Heraclio Rubén Escribano Veloso. Cristian Antonio Vargas Galvez.	
IMO at the School for infants	Conference	National	Primary Students	17-05-17	Chile	Bío Bío	0	100	1		Bárbara Léniz
Secondary cycle MACI training	Workshop	National	University students Public Service	16-05-17	Chile	Valparaíso	1	1	1		Belén Anais Franco Cisterna
IMO at the School "Biodiversity"	Conference	National	Primary Students	12-05-17	Chile	Bío Bío	1	30	1		Belén Anais Franco Cisterna
Microscopy workshop	Workshop	National	Public Service	12-05-17	Chile	Bío Bío	0	6	1		Bárbara Léniz
IMO at the School "Climate change"	Conference	National	Secondary Students Primary Students	11-05-17	Chile	Bío Bío	0	47	1		Belén Anais Franco Cisterna
Scientific Fair Tirúa	Exhibition	National	Secondary Students Primary Students Public Services	10-05-17	Chile	Bío Bío	0	400	2		Bárbara Léniz
IMO at the School "Biodiversity"	Conference	National	Primary Students	10-05-17	Chile	Bío Bío	0	35	1		Belén Anais Franco Cisterna
IMO at the School "Climate change"	Conference	National	Secondary Students	10-05-17	Chile	Bío Bío	0	16	1		Belén Anais Franco Cisterna
IMO at the School "Deep Ocean"	Conference	National	Secondary Students	10-05-17	Chile	Bío Bío	0	12	1		Bárbara Léniz
Wednesday in the Academy	Conference	National	General Community	10-05-17	Chile	Metropolitan of	0	25	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein

						Santiago					
IMO at the School "Biogeography"	Conference	National	Primary Students	09-05-17	Chile	Bío Bío	0	48	1		Bárbara Léniz
IMO at the School "Climate change"	Conference	National	Primary Students	09-05-17	Chile	Bío Bío	0	25	1		Belén Anais Franco Cisterna
IMO at the School "Our Ocean"	Conference	National	Primary Students	09-05-17	Chile	Bío Bío	0	12	1		Bárbara Léniz
IMO at the School "Climate change" - Puente Alto	Conference	National	Primary Students	05-05-17	Chile	Metropolitan of Santiago	1	80	1		Francisco Díaz Rozas
Wednesday in the Academy	Conference	National	General Community	03-05-17	Chile	Metropolitan of Santiago	0	35	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt Guelfenbein
MACI Antofagasta	Exhibition	National	Primary Students	28-04-17	Chile	Antofagasta	0	159	245		Belén Anais Franco
Secondary cycle MACI training	Workshop	National	Public Service Estudiantes Universitarios	27-04-17	Chile	Antofagasta	0	21	1		Belén Anais Franco Cisterna
IMO at the School "Biodiversity"	Conference	National	Primary Students	27-04-17	Chile	Antofagasta	0	112	1		Belén Anais Franco Cisterna
IMO at the School "Nuestro Océano"	Conference	National	Primary Students	27-04-17	Chile	Bío Bío	0	12	1		Bárbara Léniz
"Un Mar de Maravillas" Launching	Exhibition	National	Primary Students General Community	27-04-17	Chile	Bío Bío	2	50	1		Bárbara Léniz
"Un Mar de Maravillas" Launching	Exhibition	National	Primary Students	25-04-17	Chile	Bío Bío	1	70	1		Bárbara Léniz
MACI Rafael	Exhibition	National	Primary Students	13-04-17	Chile	Bío Bío	4	200	1		Belén Anais Franco Cisterna
2.0 version "Sumérgete", Launching	Exhibition	National	Public Service	27-03-17	Chile	Bío Bío	0	18	1		Bárbara Léniz
MACI San Pedro	Exhibition	National	Primary Students	23-03-17	Chile	Bío Bío	4	210	1		Belén Anais Franco Cisterna

7.2. - Products of outreach

Name of Product	Product Objective	Target Public	Type of Product"	Scope
<p>“Sumérgete” www.sumergete.cl "Sumérgete: Una travesía por el Océano Profundo"</p>	<p>Approach the general community, mainly school, in a playful way, informing, motivating and enchanting with the wonders of the different marine environments associated with our country.</p>	<p>Secondary students Primary students, School teachers, General Community</p>	<p>Web Design</p>	<p>National</p>
<p>Audiovisual Show MACI (Itinerant Scientific Audiovisual Show)</p>	<p>Take the ocean to school for one day, through playful and diverse activities, which apply different learning methodologies, where students are inspired through audiovisual material, and then reinforce and raise new knowledge with the support of scientific monitors. Thus, it seeks to enchant, teach and bring marine sciences to students.</p>	<p>Primary students, School teachers, General Community</p>	<p>Audiovisual Show</p>	<p>National</p>
<p>Tony Tonina's Scientific Recipe</p>	<p>Children's animated TV series, whose objective is to educate and reinforce learning of natural sciences for primary students. This series is an educational tool for school teachers.</p>	<p>Primary students, School teachers, General Community</p>	<p>Animated children's series</p>	<p>International</p>
<p>Interactive application of the Tony Tonina Scientific Recipe</p>	<p>Video game where students must obtain ingredients to prepare the most entertaining recipes of Tony's magic book. For this, they must answer a series of questions from natural science content of primary school. It aims to be a playful tool to reinforce learning in the classroom.</p>	<p>Primary students, School teachers</p>	<p>Videogame</p>	<p>National</p>

Puppets Show "Tony Tonina: Aletas en Acción"	Show inspired by the children's series "The Scientific Recipe of Tony Tonina", which seeks to enchant children with the ocean and its inhabitants, in addition to awakening in children the interest in science and care of the ocean, through a playful motivational activity that triggers emotions and thus opens the doors of curiosity.	Primary students, School teachers, General Community	Theater show with Puppets	National
Ocean Culture Workshop for teachers	Update and reinforce the knowledge in marine science of teachers, in order to give them tools and resources applicable in the classroom with their students. Thus, promote the development of an oceanic culture between teachers and students.	School teachers	Workshop for teachers	National
"Explorers: from the atom to the cosmos"	Raise awareness among Chileans and let them know what are the excellence scientific centers in our country, and what they are doing and leading.	Scientific Community, Community in General	Annual Television Series	National

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	27	3	13	0	3	48
Internet	6	16	1	20	1	1	45
Audiovisual	5	4	1	2	0	0	11
TOTAL	12	47	5	35	1	4	104

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
Geo-ingeniería marina en Chile: Experimentos comerciales de fertilización con hierro en aguas jurisdiccionales de Chile. Informe y antecedentes solicitados por DIRECTEMAR. Entregada a DIRECTEMAR 6 de Julio de 2017.	Impact on Chilean policy and discussed by homologs at the International Maritime Organization referent to Treaty on Ocean Dumping		2	5	Chilean Navy		2	Public
“La propuesta de una empresa extranjera de fertilizar el ambiente marino de Chile con hierro por fines comerciales : Antecedentes científicos, Reacción de comunidad científica”. <u>P. von Dassow</u> . 07-07-2017. Sesión N°138 de la Asamblea Plenaria del Comité Oceanográfico Nacional. Universidad Arturo Prat de Iquique. Iquique, Chile.			5	5	Chilean Navy		2	Public
					Representatives from several universities and the private sector			

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:

Funds	Accumulated incomes to last year [\$]	2017 Incomes Amount (\$)	Percentage of resources used by the Center (%)	Total income to 2017 [\$]
MSI IC 120019	2.332.192.325	1.098.836.797	84	3.431.029.122
MSI - PME (Outreach)	44.003.613	17.084.687	51%	57.067.381
MSI - RFC (Networking)	2.935.000	0		2.935.000
FONDECYT 1151299	103.250.000	0		103.250.000
FONDECYT 1130511	88.794.600	3.320.000	100	92.114.600
FONDECYT 1141106	132.206.400	51.213.000	100	183.419.400
FONDECYT 1130254	126.000.000	0		126.000.000
FONDECYT 3150507	18.960.000	19.500.000	100	38.460.000
FONDECYT 3160611	10.432.000	0		10.432.000
FONDECYT 3160665	26.792.843	0		26.792.843
FONDECYT 11150914	34.800.000	4831000	100	39.631.000
FONDECYT 1161483	0	44.794.000	100	44.794.000
FONDECYT 3170139	0	24.611.371	100	24.611.371
FONDECYT 11160801	0	4.080.000	100	4.080.000
FONDECYT 1170065	0	25.000.000	100	25.000.000
FONDECYT 1171895	0	63.590.000	100	63.590.000
CONICYT Becas Capital Humano	0	30.157.060	100	30.157.060
AUSPICIO CONICYT	0	1.700.000	100	1.700.000
EXPLORA ED 190157	29.909.840	0		29.909.840
CONA – CIMAR	356.400.000	0	100	356.400.000
CONICYT – TIEMPO BUQUE	178.200.000	267.840.000	100	446.040.000
Private funds	50.000.000	1.700.000	100	51.700.000
FIP 2014-042	63.750.000	0		63.750.000
INNOVA CHILE 15BP-45408	0	42.965.772	100	42.965.772
FIPA N° 2016-68	0	44.342.220	100	44.342.220
CRN3070 - IAI	0	8.060.000	100	8.060.000
UMI 3614 - CNRS (France)	0	1.837.500	100	1.837.500
MOORE FOUNDATION	112.855.258	1.945.240	100	114.800.498
AGOURON INSTITUTE	124.534.172	53.371.787	51	151.753.783
Ocean Carbon Int. Coord. Center (OA-ICC)	0	15.000.000	100	15.000.000
Other public Funds	20.000.000	9.000.000	100	29.000.000
TOTAL	3.856.016.051	1.834.780.434	98%	5.660.623.390

Annex 10.- Exchange:

Tipo Investigador	Nombre	Tipo de actividad realizada	Duración de la estadía	País al que viajó	Entidad que financia (Milenio/Externo/Mixto)
Associate	Cristian Vargas	Meeting participant	4 days	Francia	Mixed
Associate	Cristian Vargas	Meeting participant	4 days	Brasil	Mixed
Associate	Cristian Vargas	Meeting participant	5 days	China	Mixed
Associate	Cristian Vargas	Meeting participant COLACMAR	5 days	Brasil	External
Associate	Cristian Vargas	Meeting participant	2 days	Austria	External
Postdoc	Paulina Aguayo	Project participant KOSMOS colaboración con GEOMAR -IMARPE	3 months	Perú	Milenio
Postdoc	Frauke Albrecht	Stay	5 weeks	Australia	External
Postdoc	Pedro Echeveste	Trabajo en meta-análisis (King Abdullah University of Science and Technology)	5 days	Arabia Saudí	Externo

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)