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1.1 Executive Summary

On-going climate change is one of the most debated and challenging environmental subjects at the international level because of the several scales over which its effects are spread, including ecosystems, socio-economic regimes, food availability, human health, and political governance. The Pacific Ocean, the largest biome on Earth, plays a fundamental role in global climate and ocean circulation, and accounts for most of the biological production in the oceans, which, in total, represent almost a half of the total production on the planet. The ocean-atmosphere dynamics in the Pacific Ocean is intense and it directly relates to climatic events across the Pacific in the first place, including the development of intense cold La Niña and warm El Niño events. The effects of these climatic events have been shown to produce significant changes in the structure and functioning of coastal ecosystems in the Eastern Pacific Ocean (ESP), which, in turn, hit the economies of the rim countries, including Chile.

Climate change observations have indicated an intensification of winds over the ESP, associated with an expansion of the Subtropical South Pacific Gyre (SSPG). The effects of these patterns include stronger wind-driven upwelling in the coastal system along the Peru-Chile region, which are among the most productive systems in the oceans due to nutrient fertilization of surface waters through wind-driven upwelling. At the same time, these coastal systems are directly linked to the open ocean through basin-regional scale circulation and mesoscale activity; also, surface waters are directly linked to deep waters (>3000 m depth) through mixing, particle sinking, and biota movement. That is, the ocean that we do not see because of its large horizontal and vertical extension in the Pacific is totally interconnected and we need to understand these links in order to evaluate the effects derived from climate change.

An integrated scientific view of the processes that drive short and long-term changes in the structure and functioning of marine ecosystems in the ESP is at the core of the Millennium Institute of Oceanography (IMO). 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 (e. g. 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. A network of scientific collaborators provides a strong support to IMO research, understanding the global context of our themes. During 2015, IMO included 23 researchers in different categories, 12 postdocs, 40 undergraduate and graduate students, 21 research technicians, and 4 administrative staff. In terms of graduate and postgraduate education and training, IMO researchers were involved in regular teaching and student guidance associated with 6 graduate programs. A total of 12 undergraduate students, 15 M.Sc., 14 Ph.D. students were directly linked to IMO activities. Funding sources for IMO came from ICM (67%) and the rest from projects secured by IMO researchers, including national (e. g. FONDECYT, FIP, CIMAR) and international funding agencies (33%), apart grants to postdocs or students. IMO's 8 associate researchers published 16 ISI articles, one SCIELO article and one book chapter. Other IMO researchers published 4 additional ISI articles.

During 2015, the IMO led two major oceanographic research cruises and played a leading role in a third large-scale expedition, as well as implemented and maintained important time series work:

- IMO researchers executed the Seamounts Cruise to the Juan Fernandez Ridge System in the RV Abate Molina in September 2015. This cruise focused on studying the mesoscale and submesoscale physical and biological structure in the water column around three seamounts (Research Line 1). In addition, an oceanic mooring was installed in the vicinity of the Robinson Crusoe Island in order to register the passage of mesoscale eddies derived from coastal waters and their impact in the local dynamics around the islands.
- IMO lead the **LOWPHOX 1** cruise aboard the RV Cabo de Hornos in Nov-Dec 2015 to study the integrated comparative biogeochemical functioning of anoxic marine zones (AMZs) and oxygen minimum zones (OMZs) off the northern coast of Chile. As this was a year of a strong El Niño, LOWPHOX also provides insight into the effects this event on these AMZ and OMZ systems. This cruise involved international participants and successfully obtained an invaluable set of data and samples currently under analysis that are directly relevant for Research Lines 2-4.
- IMO researchers participated in, and IMO directly provided major equipment for the **CIMAR 21** expedition aboard the RV Cabo de Hornos sampling from the Chilean coast to Easter Island and Salas-y-Gómez Island in Oct. 2015. This cruise, covering over 3800 km, crosses one of the most largest oceanographic gradient, from the productive coastal upwelling waters to the most oligotrophic waters known on Earth, and provides data and samples currently being analyzed that are directly relevant for all IMO research lines.
- IMO also implemented a new oceanographic time series off the coast of Valparaíso and collaborated with other research centers (COPAS Sur-austral, CR2) to maintain the longest ocean observing time series in Chile near Concepción.

In addition to these major milestones, major achievements or advances were made in each research line

Research Line 1: We established that the mesoscale processes dominate in the Eastern South Pacific (ESP) region affect the dynamics of both coastal upwelling systems and also remote open oceanic waters.

Research Line 2: Based on observations we have quantified the seasonal and intraseasonal variability of the upwelling and micro-phytoplankton abundance and biomass. Using coupled biogeochemical-physical model and glider observations we have also assessed the variability of the oxygen depleted waters off Peru and Chile. Oxygen fluxes related to mesoscale eddies play a dominant role at seasonal and intraseasonal time scales.

Research Line 3: We showed that many groups of marine invertebrate show local adaptation to natural acidification related to the high variability of carbonate parameters on the Chile coast. However, we also found – in contrast – that calcifying phytoplankton (coccolithophores) do not appear to show local adaptation to natural acidification. We also demonstrated the first evidence that hybridization may play a role in adaptation of phytoplankton to new environments, and explored mechanisms of genome change in phytoplankton.

Research Line 4: Although according to IMO plans, this theme will be addressed in the next coming years and presently the focus in this line is obtaining and developing equipment for deep-sea sampling, we have made some important scientific progress. We conducted the first deep sea samplings (below 1000 m), and implemented the use of parasites of deep-sea fishes, caught in by-catches of fisheries, as opportunistic biomarkers to explore biological processes such as colonization in the deep sea.

IMO has been highly active in education and training. This has included formation and supporting students at undergrad, masters, doctoral levels, with IMO providing direct financial support (by fellowships) to 18 students. Likewise, IMO coordinated two new advanced training courses (in Advanced Flow Cytometry and in Ocean Mixing Processes) and supported the advanced course Ecology and Diversity of Marine Microorganisms which has been organized every two years by IMO researcher O. Ulloa, and which won first place in the category “Higher Education in Science” in

Program on Innovation in scientific education, organized by the “Fundación Ciencia Joven” (Chile) and with the support of the Regional Office for Education, linked to UNESCO.

Outreach activities of IMO have been extensive and highly successful, including IMO-led activities such as a new educational website “Sumérgete: una travesía por el Océano Pacífico” (Immerse yourself: A journey through the Pacific Ocean), and Itinerant Scientific Audiovisual Show reaching over 2900 students in 15 different schools, and have passed the first stage in the production of an educational TV show “La Receta Científica de Tony Tonina” (“Tony Tonina’s Scientific recipe”), with funds from Explora (CONICYT). The TV Series “La fuerza del Mar” (The strength of the Sea) directed by Pablo Rosenblatt (IMO’s Outreach Director), was awarded **Special JURY Prize**, at the 9th International Science Film Festival of Athens, 31-08-2015. Additionally, IMO also is leading (since 2015) the project “Science in TVN” with other ICM institutes and the Chilean national television TVN to produce science audiovisual material and a new science TV series. Finally, IMO participated heavily in a wide variety of scientific outreach activities.

1.2 Resumen Ejecutivo

El cambio climático en curso es uno de los temas ambientales más debatidos y desafiantes a nivel internacional, por las distintas escalas y amplitud de sus efectos, incluidos los ecosistemas, regímenes socioeconómicos, disponibilidad de alimentos, la salud humana y la gobernabilidad política. El Océano Pacífico, el mayor bioma de la Tierra, juega un rol fundamental en el clima global y la circulación oceánica, y es responsable de la mayor parte de la producción biológica en los océanos, que, en total, representan casi la mitad de la producción total del planeta. La dinámica océano-atmósfera en el Océano Pacífico es intensa y se relaciona directamente, en primer lugar, con los fenómenos climáticos a través del Pacífico, incluyendo el desarrollo de intensos eventos fríos “La Niña” y cálidos “El Niño”. Se ha demostrado que los efectos de estos fenómenos climáticos producen cambios significativos en la estructura y funcionamiento de los ecosistemas costeros del Océano Pacífico Oriental (OPO), los que, a su vez, afectan a las economías de los países de la cuenca, entre ellos a Chile.

Observaciones sobre el cambio climático han indicado una intensificación de los vientos sobre el OPO, asociado a una expansión del Giro Subtropical del Pacífico Sur (GSPS). Los efectos de estos patrones incluyen el aumento de la surgencia impulsada por el viento en el sistema costero a lo largo de la región Perú-Chile, uno de los sistemas oceánicos más productivos, debido a la fertilización de nutrientes de las aguas superficiales por la surgencia impulsada por el viento. Al mismo tiempo, estos sistemas costeros están directamente vinculados con el mar abierto a través de la circulación de escala cuenca-regional y la actividad de mesoescala; También, las aguas superficiales están directamente vinculados a las aguas profundas (> 3000 m de profundidad) a través de la mezcla, hundimiento de partículas, y el movimiento de la biota. Es decir, el océano que no vemos debido a su gran extensión horizontal y vertical en el Pacífico está totalmente interconectado y tenemos que entender estos enlaces con el fin de evaluar los efectos derivados del cambio climático.

Una visión científica integrada de los procesos que impulsan los cambios a corto y largo plazo en la estructura y funcionamiento de los ecosistemas marinos en el OPO está en el centro del Instituto Milenio de Oceanografía (IMO). Así, IMO está organizado en torno a cuatro líneas de investigación interconectados, cada uno con objetivos ambiciosos:

- 1) **Procesos de mesoescala:** Caracterizar la estructura y procesos de mesoescala física (y sub-mesoescala) en el OPO y su impacto sobre los ecosistemas de océano abierto y de transición (costa-océano);
- 2) **Variabilidad del océano:** Determinar cómo las perturbaciones a gran escala impactan el transporte y los gradientes de las propiedades físico-químicas del agua y la dinámica del OPO;

3) **Adaptaciones a un océano cambiante:** Obtener nueva información acerca de las adaptaciones de los grupos planctónicos clave a los cambios químicos que tienen lugar en el océano (por ejemplo, la acidificación, la desoxigenación, la desertificación) y el impacto de estos cambios en los ciclos biogeoquímicos;

4) **El océano profundo:** Explorar el ambiente pelágico del océano profundo y ultra profundo.

Los científicos de IMO incluyen ecólogos, microbiólogos, oceanógrafos físicos, oceanógrafos químicos, oceanógrafos biológicos, modeladores de ecosistemas, especialistas en divulgación de la ciencia, y un equipo de operaciones especiales. Una red de colaboradores científicos proporciona un fuerte apoyo a la investigación de IMO, y una comprensión del contexto global de nuestros temas. Durante 2015, IMO incluyó 23 investigadores en diferentes categorías, 12 postdoctorados, 40 estudiantes de pre y post-grado, 21 técnicos de investigación, y 4 personal administrativo. Las fuentes de financiación de IMO provinieron de ICM (67%) y el resto de proyectos ganados por los investigadores de IMO, incluyendo fondos nacionales (por ejemplo. FONDECYT, FIP, CIMAR) y de organismos internacionales de financiación (33%), aparte de las becas a los postdoctorados o estudiantes. Los 8 investigadores asociados de IMO publicaron 16 artículos ISI, un artículo SciELO y un capítulo del libro. Los otros investigadores IMO publicaron 4 artículos adicionales ISI. En cuanto a educación de postgrado y formación postdoctoral, los investigadores asociados de IMO se involucraron en la enseñanza regular y el guiado de estudiantes vinculados con 6 programas de postgrado. Un total de 12 estudiantes de pregrado, 15 estudiantes de Magister y 14 de Doctorado estuvieron directamente vinculados con las actividades de IMO.

Durante 2015, IMO encabezó dos importantes cruceros de investigación oceanográfica y jugó un papel principal en una tercera expedición a gran escala, así como implementó y mantuvo una importante labor en campañas de series de tiempo:

- Los investigadores de IMO ejecutaron el **Crucero Montes Submarinos** al Sistema de Dorsales de Juan Fernández, en el RV Abate Molina, en septiembre de 2015. Esta fue una de las principales expediciones que IMO comprometió financiamiento, y fue un gran éxito, produciendo datos sin precedentes relevantes para Línea de Investigación 1.
- IMO encabezó luego el Crucero **LOWPHOX 1**, a bordo del RV Cabo de Hornos en noviembre-diciembre de 2015, para estudiar comparativamente el funcionamiento biogeoquímico integrado de zonas anóxicas marinas (ZAMs) y zonas de mínimo oxígeno (ZMO) frente a la costa norte de Chile. Como este fue un año de un fuerte El Niño, LOWPHOX también da una idea de los efectos de este evento en estos sistemas AMZ y ZMO. Este crucero involucró también participantes internacionales y obtuvo con éxito un valioso conjunto de datos y muestras, actualmente bajo análisis, que están directamente relacionadas con las Líneas de Investigación 2 y 4.
- Los investigadores de IMO participaron y aportaron directamente el principal equipamiento para la expedición CIMAR 21, a bordo del RV Cabo de Hornos, desde la costa central chilena a la Isla de Pascua y Salas-y-Gómez en octubre de 2015. Este crucero, que abarcó más de 3.800 Kilómetros, atravesó uno de los más grande del gradientes oceanográfico, desde las productivas aguas de surgencia costera a las aguas más oligotróficas conocidas en la Tierra, proporcionando datos y muestras que actualmente se están analizando y son directamente relevantes para todas las líneas de investigación de IMO.
- IMO también implementó una nueva serie de tiempo oceanográfica en las costas de Valparaíso y manteniendo otra en colaboración con otros centros de investigación (COPAS Sur-Austral, CR2) para mantener la mayor observación de las series temporales de Chile cerca de Concepción.

Además de estos grandes hitos, se hicieron principales logros o avances en cada línea de investigación

Línea de Investigación 1: Hemos establecido que los procesos de mesoescala que dominan en la región oriental del Pacífico Sur (ESP) afectan tanto la dinámica de los sistemas de surgencia costera como también a aguas oceánicas remotas.

Línea de Investigación 2: Sobre la base de las observaciones hemos cuantificado la variabilidad estacional e intraestacional del afloramiento, abundancia y biomasa del micro-fitoplancton. Usando modelos biogeoquímicos-físicos acoplados y observaciones de planeadores, también hemos evaluado la variabilidad de las aguas con agotamiento de oxígeno frente al Perú y Chile. Los flujos de oxígeno relacionados con remolinos de mesoscala juegan un rol dominante en escalas de tiempo estacionales e intraestacionales.

Línea de Investigación 3: Demostramos que muchos grupos de invertebrados marinos muestran adaptaciones locales a la acidificación natural relacionadas con la alta variabilidad de los parámetros de carbonato en la costa de Chile. Sin embargo, también encontramos - en contraste - que la calcificación de fitoplancton (cocolitofóridos) no parece mostrar una adaptación local a la acidificación natural. Se demostró además la primera evidencia de que la hibridación puede jugar un papel en la adaptación del fitoplancton a nuevos entornos, y exploramos mecanismos de cambio del genoma en el fitoplancton.

Investigación Línea 4: Aunque de acuerdo con los planes de IMO, este tema se abordará en los próximos años y en la actualidad su foco es la obtención y el desarrollo de equipo muestreo en el mar profundo, hemos hecho algunos progresos científicos importantes. Hemos llevado a cabo los primeros muestreos de aguas profundas (por debajo de 1000 m), e implementado el uso de parásitos de peces de aguas profundas, atrapados en las capturas de la pesca, como biomarcadores oportunistas para explorar procesos biológicos tales como la colonización en el fondo del mar.

IMO ha sido muy activo en el área de educación y formación. Esto ha incluido la formación y apoyo a estudiantes de licenciatura, magister y doctorado, proporcionando apoyo financiero directo de IMO (mediante becas) a 18 estudiantes. Del mismo modo, IMO ha coordinado dos nuevos cursos de formación avanzada (en Citometría de Flujo y en Procesos Oceánicos de Mezcla) y apoyando el curso avanzado Ecología y diversidad de Microorganismos Marinos, que ha organizado cada dos años el investigador de IMO Osvaldo Ulloa, y que obtuvo el primer lugar en la categoría "Educación Superior en Ciencia" en el Programa de Innovación en la educación científica, organizado por la "Fundación Ciencia Joven" (Chile) y con el apoyo de la Oficina regional de educación, vinculado a la UNESCO.

Las actividades de divulgación de IMO han sido amplias y de gran éxito, incluyendo las actividades dirigidas por la IMO, tales como un nuevo sitio web educativo "Sumérgete: una travesía por el Océano Pacífico"; la Muestra Audiovisual Científica Itinerante, llegando a más de 2.900 estudiantes en 15 escuelas diferentes; y ya ha pasado la primera fase de producción de un show didáctico para TV "La receta Científica de Tony Tonina ", con fondos de Explora (CONICYT). La serie de televisión "La fuerza del mar", dirigida por Pablo Rosenblatt (Director de Extensión de IMO), fue galardonado con el Premio Especial del Jurado, en el 9º Festival de Cine Internacional de Ciencia de Atenas, el 31-08-2015. Además, IMO está llevando a cabo (desde el 2015) el proyecto "Ciencia en TVN", junto con otros Institutos Milenio y TVN, para producir material audiovisual de ciencia y una nueva serie de ciencia para televisión. Por último, IMO ha participado en gran medida en una amplia variedad de actividades de divulgación científica.

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 researching and exploring 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 second year of activities and the first as a legal Non-Profit Private Corporation.

b) Research Lines:

IMO established the following 4 initial research lines:

1: 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 and modeling work.

Field observations are aimed at studying the characteristics and evolution of mesoscale eddies, which are generated off the coast of central Chile and propagate NW, reaching the surroundings of the Juan Fernández Archipelago. They include time-series observations, through satellite remote sensing and a mooring around the Juan Fernandez Archipelago, as well as glider sections and process-oriented cruises. Perturbation experiments using single and multiple stressors in the contrasting waters will also be carried out. Additionally, using numerical experiments, we will analyze mesoscale-eddy structure, generation and transport, particularly in the OMZ and near oceanic islands and seamounts associated to the Nazca and Juan Fernandez ridges.

2: Ocean Variability: The objective of this research line is to determine how large-scale perturbations impact the transport and gradients in physical-chemical water properties and the dynamics of the eastern South Pacific Ocean. The research strategy is based on observational and modeling work. New hydrographic data will come from IMO and other oceanographic expeditions. Vertical high-resolution microstructure and turbulent mixing indices will also be obtained, which will allow the calculation of vertical fluxes of salt, heat and relevant biogeochemical properties. These high-resolution data, along with historical data, will allow an assessment of the interannual and lower frequency changes in the meridional transport and in the physical and chemical properties in the thermocline and intermediate waters. Different model simulations will generate output to be fed into

regional models for evaluating mechanisms impacting coastal upwelling, mesoscale-eddy generation, regional circulation, and water-mass modifications.

3: Adaptations to a Changing Ocean: The objective of this research line is to gain new understanding about the adaptations (at the genomic, physiological, behavioral and community-structure level) of key planktonic groups to chemical changes taking place in the ocean (e.g., acidification, deoxygenation, 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 will be initially done in order to understand their response to variations in pCO₂/pH, O₂ and nutrients. Based on these results, genome analysis of selected species and multi-stressor experiments will be carried out. For fieldwork, observations and experiments will be carried out in IMO-organized and other oceanographic expeditions. In-situ/On-board physiological/metabolic and community rates, gene content and expression, and particle flux measurements will be obtained. Also, culture-independent genetic/genome analysis of representative species will test associations among genomic variation, variability in physiology, and changes in water chemical properties. On-board experiments will expose distinct onshore and offshore plankton communities to single and multiple stressors.

4: 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.

c) Organization of researcher's team:

During 2015, its second year, IMO consisted of 27 researchers: the 8 original associate researchers, 2 senior researcher, 9 adjunct researchers, 3 young researchers and 12 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 14 professionals/technicians, 4 administrative staff, as well as 41 students (12 undergraduate, 15 M.Sc., and 14 Ph.D.).

The institute's functioning and budget allocation are organized around the 4 research lines, an outreach team (led by Pablo Rosenblatt, Director of Outreach), and a central administrative office based at UdeC (led by Atilio Morgado, Executive Director). IMO also has two senior researcher: Prof. Juan Carlos Castilla, (PUC) and Dr. Gerrit van den Engh (MarCy), both as advisors to the institute.

The 4 research lines combine and share scientific and technical personnel, laboratories, and equipment. 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.

All the associate researchers define collectively annual research priorities for each line -as well as for education and outreach- and the budget is allocated according to these priorities. Central to IMO's research activities are the organization of and participation in oceanographic expeditions, having got

participation in 3 Chilean oceanographic cruises this year: Seamount Cruise, CIMAR21 cruise and LOWPHOX 1 cruise.

3. Scientific and technological research

a) Current status of research lines:

The second year was marked by an increased integration of IMO members both within the research lines and also between the research lines. One of the most important milestones of this second year was the realization of our first IMO Scientific Expedition, *LOWPHOX 1*, which integrates lines 2, 3, and 4. Five IMO associated researchers, along with several young and adjunct researchers, postdocs, and students, participated directly, and the other IMO researchers have provided or are providing important support.

Three projects led by or involving IMO associated researchers were selected to participate in the joint cruise CIMAR 21 onboard the Cabo de Hornos Oceanographic Research Vessel. This 30 day cruise in Oct-Nov. 2015 consisted in a cross-shelf transect from the Chilean coast to Easter Island at 27°S, covering the upwelling zone, coastal transition zone, the Pacific basin and the ultra-oligotrophic zone around Easter Island. In the cruise, Chilean researchers from several institutions and Universities participated with many scientific objectives including the physics, biology and biogeochemistry of the open ocean ecosystem. These data will be relevant to all IMO research lines. Finally, the Seamounts Cruise to the Juan Fernandez Ridge System was most directly associated with line 1, but also provided an important set of samples relevant to line 4.

I. Mesoscale Processes

During 2015, IMO researchers worked collaboratively among each other and with international researchers to implement both observational and modeling studies targeting mesoscale activity and processes in the flow of energy and matter between the coast and the open ocean in the Eastern South Pacific (ESP). These new studies initiated in 2015 included:

- Launching (January 2015) of a time series monitoring line off Valparaíso (STOV) to study climatic variability and mesoscale processes. Monthly sampling including CTD (6 stations) and, at one of these stations, biogeochemical (O_2 , nutrients, and greenhouse gases) and biological sampling (Chl-a, DNA, RNA, and stable isotopes of organic matter). Led by IMO researchers S. Hormazábal and M. Cornejo with institutional support from the PUCV, this effort includes participation of IMO postdocs (A. Murillo/P.A. Auger) and graduate/undergraduate students, as well as international collaboration with A. Rodriguez and P. Sangra (U. Las Palmas de Gran Canaria, Spain).
- Oceanographic survey on board the RV Abate Molina (September 2015) conducted to characterize mesoscale and sub-mesoscale activity around 3 seamounts in the Juan Fernández Ridge System (JFRS), including physical, biogeochemical, and biological samplings. Analyses of data and samples have been completed recently. IMO researchers S. Hormazábal, M. Cornejo, C. Morales, and R. Escribano collaborated through this FIP-financed project, together with two IMO postdocs (A. Murillo/P.A. Auger), technicians and graduate/undergraduate students.
- Deployment in the JFRS region of an IMO oceanographic mooring, equipped with several autonomous devices (September 2015), to register mesoscale activity generated in the coast off central Chile. This collaborative effort between IMO researchers S. Hormazábal, O. Pizarro, C. Morales, and J.L. Blanco, involved the participation of several IMO students and technicians during the mooring-assembling and/or deployment.
- Sensitivity experiments with ROMS circulation model of the ESP (22-45°S, 70-105°W) to study the dynamics of oceanic striations and mesoscale eddies. Directed by young researcher A. Belmadani with international collaborators A. Chaigneau (IRD, France), F. Colas (IRD, France), N. Maximenko (U. Hawaii, USA) and E. Di Lorenzo (GATech, USA).

- Implementation of a biophysical and a biogeochemical model for the JFRS in order to resolve spatio-temporal variability in circulation and mesoscale activity, combined with simulation experiments to understand physical-biological (planktonic) coupling in the system. Coordinated by adjunct researcher C. Parada and O. Artal, with the participation of undergraduate students and collaboration from associate researchers O. Pizarro, S. Hormazábal, and C. Morales, from young researcher A. Belmadani, from A. Sepúlveda, and B. Ernst (UdeC) in Chile, and from international collaboration with V. Echevin (IRD, France), V. Combes (OSU, USA) and E. Di Lorenzo (GATech, USA).
- Generation of coupled physical-biogeochemical ROMS-PISCES simulation of the Chile-Peru upwelling region with explicit representation of the mesoescala processes to understand the drivers of primary productivity, plankton size-composition, and C-export. IMO Postdoc P.A. Auger and S. Hormazábal have led this activity, with contributions from international collaborators T. Gorgues and O. Aumont (IRD, France), and E. Di Lorenzo (GATech, USA).

During 2015, one of the main scientific achievements in Theme 1 was that the mesoscale processes that dominate in the Eastern South Pacific (ESP) region affect the dynamics of both coastal upwelling systems and also remote open oceanic waters. Our focus has been to characterize the circulation and mesoscale activity in the region, using a combination of approaches: models, satellite, and field observations:

- Characterizing the eddy field variability in the ESP using a high-resolution model experiment revealed an asymmetry between the surface and subsurface fields. Surface-intensified cyclones were slightly more frequent than anticyclones whereas the subsurface field was dominated by anticyclones (Intra-thermocline eddies: ITEs), triggered by instabilities of the Peru-Chile Undercurrent (PCUC). Interannual variability of ITEs was significantly correlated with ENSO; strong El Niño led to increases in PCUC transport and a decrease in ITEs transport of coastal waters. We proposed that the relaxation of isopycnals along the coast during El Niño events leads to weakened baroclinic instability and, thereby, a decrease in the transport by ITEs. This work has now been published and was part of an international collaboration associated with associate researcher S. Hormazábal (V. Combes et al., 2015)
- A relationship between oceanic striations and preferred eddy paths off central Chile was established: bands of alternated eddy polarity coincide with (are co-located with) striations in the subtropical front and coastal transition zones, suggesting striations are the signature of polarized eddy tracks. This also indicates that new eddies are formed offshore along the striations, and suggesting a possible feedback of striations onto the eddy field. (A. Belmadani, E. Concha, D. Donoso, A. Chaigneau, F. Colas, N. Maximenko, E. Di Lorenzo, in preparation).
- An intercomparison of 4 eddy algorithms showed that the Halo et al. (2014) has a flawed amplitude-class distribution; the Pegliasco et al. (2015) is not freely available; the Chelton et al. (2011) only provide results for old AVISO data; and the Mason et al. (2014) is reasonably good and available now at DGEO/IMO and was used to characterize eddy properties off central Chile in model and altimetry data (O. Artal and A. Belmadani, in preparation).
- Temporal and spatial variability patterns of the ocean circulation and mesoscale activity in the Juan Fernandez Ridge System (JFRS) have been characterized through modeling. Results show that ocean circulation around the islands is dominated by anticyclonic relative vorticity and positive anomalies of temperature and salinity at the subsurface layer. These characteristics are associated with ITEs and submesoscale structures can play an important role in the vertical transport of nutrients to the euphotic zone in this system (C. Conejeros, C. Parada, V. Combes, B. Ernst, in preparation).
- Using in situ profiles (World Ocean Database and Argo buoys), we characterized the influence of ITEs on the vertical variability of the oxygen minimum zone (OMZ) in the Peru-Chile upwelling system. Results indicated that ITEs influenced the vertical variability of the OMZ in the coastal region off Chile (18-40°S) whereas waves and/or surface eddies did so off northern Peru (4-10°S). Offshore, ITE influence was the most relevant. This work has been led by IMO postdoc P.A.

Auger, MSc student A. Bustamante and associate researcher S. Hormazábal and is being prepared for submission in 2016.

- Application and improvement of an algorithm based on high resolution SST data to detect coastal fronts, in combination with satellite altimetry data to detect mesoscale (and sub-mesoscale) eddies during their formation in the region off central Chile, have shown that there is a strong interaction between upwelling/downwelling conditions and front-eddy interaction. Time series to characterize the dynamics of eddies and fronts during the upwelling period were obtained and analyzed by a FONDECYT collaborator J. Bento (doctoral student at U. Christian Albrecht, Kiel, Germany), with the participation of associate researchers S. Hormazábal and C. Morales, IMO postdoc P.A. Auger, and international collaboration with P. Cornillon (URI, USA). A paper led by J. Bento is in preparation.
- The impact of mesoscale eddies on nutrient distribution and the structure of planktonic communities in coastal upwelling systems and the adjacent oceanic ecosystems is still debatable in the literature given the gap on field observations. During 2015, we used field observations, satellite approximations, and modeling to study the impact of eddies generated off central Chile:
- We found a strong eddy-front interaction in the area adjacent to the coastal upwelling zone off central Chile. Such interaction appears to enhance the cross-shelf exchange of phytoplankton (as opposed to what was expected from a front alone) as we found mix-assemblages of coastal and oceanic phytoplankton species in both structures, suggesting active horizontal and vertical mixing of shelf and oceanic waters. This work is led by associate researcher C. Morales and IMO graduate student V. Anabalón, in collaboration with IMO researchers S. Hormazábal and M. Cornejo, and is being prepared for submission in 2016.
- A long-lived anticyclonic eddy (10 months old) in oceanic waters of the ESP (900 km from the coast of Chile) was found to have an impact on the biogeochemical characteristics of the water column. The oxygen concentrations in subsurface waters (150-450 m depth) of this eddy decreased to suboxic and even anoxic levels. This condition implies a strong impact on the nitrogen cycle in the region. This work was led by IMO young researcher M. Cornejo in a collaboration that includes associate researcher O. Pizarro and other IMO adjunct researcher L. Farías (M. Cornejo et al., 2015).
- An unaccounted for N₂O sink in the surface water of the ESP has been described using an experimental approach. Surface waters from the eddy generation zone off central Chile typically exhibit strong N₂O sub-saturation, usually attributed to physical mechanisms. However, we found that this sub-saturation is driven by biological processes via N₂O consumption. This work was led by IMO adjunct researcher M. Cornejo with the collaboration of also adjunct researcher L. Farías and IMO postdoc A. Murillo (M. Cornejo, et al., 2015).
- Model simulations have shown that mesoscale eddies are responsible for nutrient injections to the euphotic zone in the coastal upwelling off central Chile (24-40°S) whereas a loss occurs in southern Peru (12-24°S). Summing over the whole of the Peru-Chile coastal system, mesoscale eddies cause a net decrease in phytoplankton biomass (led by IMO postdoc P.A. Auger, with collaboration of J. Bento, E. Di Lorenzo E., IMO young researcher A. Belmadani and supervised by IMO associate researcher S. Hormazábal; it is in preparation for submission in 2016).
- Satellite data analysis of chlorophyll (SeaWiFS), wind (QuickSCAT) and sea surface height (AVISO, Ssalto-Duacs 2014) revealed that the interannual variability of surface chlorophyll in the Coastal Transition Zone is not explained by mesoscale activity off Chile, although the offshore production is connected to the coastal production, likely through a cross-shore transport by mesoscale eddies in Central-South Chile. A significant role of wind stress, which enhances mixing-induced vertical mixing, is actually highlighted, along with horizontal advection by the large-scale circulation. This work has been led by P.A. Auger with collaboration of IMO young researcher A. Belmadani, IMO adjunct researcher A. Montecinos and IMO associate researcher S. Hormazábal; it is being prepared for submission in 2016.
- Model-simulation experiments have been used to explore the impact of mesoscale eddies on larval distribution, vertical migration and growth. Results show that there is a significant interaction between mesoscale eddies, von Karman vortices, and mesoscale wakes, and differential vertical

migrational patterns which contribute to enhance patchiness and impact pelagic larval growth in the JFRS (C. Medel undergraduate thesis under supervision of IMO adjunct researcher C. Parada supervisor; involves collaboration with A. Sepulveda and IMO assoc. researchers O. Pizarro, and C. Morales and is in preparation for submission in 2016).

- Model-simulation experiments also showed a high level of retention associated to low eddy kinetic energy and anticyclonic eddies, allowing the retention of jack mackerel pelagic larvae for at least 4 months in the seamount region in the ESP off central Chile. We discussed the relevance of seamounts playing a double role as spawning and nursery regions from a conservation and biodiversity viewpoint (this work is led by IMO adj. researcher C. Parada, and is in preparation for submission in 2016).

II. Ocean variability

To address ocean variability at larger spatial (regional and basin-scale) and temporal (seasonal, interannual or longer) scales, we have used both observational and modeling approaches. One major focus has been the temporal variability of the oxygen minimum zone of the ESP. Climate change may cause a decreasing in the amount of dissolved oxygen in the tropical and subtropical eastern Pacific impacting on marine life. However, these regions undergo large natural variability at seasonal, interannual and interdecadal scales, preventing to distinguish anthropogenically forced trends from natural climate variability. During 2015 we focused on the seasonal variability of the OMZ in the Peru-Chile current system analyzing preexisting glider data off Concepcion (~37°S; Pizarro et al. in press). We have also been using a regional, coupled biogeochemical-physical model and found that the seasonal variability of the OMZ off Peru and Chile is largely controlled by changes in the physics: advection and eddy diffusion. Off Peru the mean eddy flux of dissolved oxygen (DO) is the larger term. At the deeper part of the offshore boundary of the OMZ, the mean seasonal DO flux shares similar characteristics to those of the energy flux associated with the annual extra-tropical Rossby waves. Off Central Chile, the Peru Chile Undercurrent is the major component for the presence of OMZ along the coast, but the dominant physical term in the seasonal variability is the cross-shore transport of oxygen by seasonal disturbances in the velocity field, which are correlated to seasonal changes in the oxygen concentration. As off Peru, these disturbances are likely associated to mesoscale eddies. Off Peru and Chile, the coastal ocean may act as a source of DO through eddy-induced offshore transport. Some of this modeling work has now been accepted for publication (Vergara et al. submitted to Biogeosciences) and other parts are in preparation for submission in 2016 (Pizarro-Koch et al. in prep).

Through concurrent projects and IMO initiatives in 2015, several IMO researchers have joined efforts with researchers from other centers (COPAS Sur-austral, CR2) to continue with time series observations and experiments in the upwelling zone off Concepcion (36°S), which began in 2002. IMO associate researcher R. Escribano also led parallel time series work in Northern Chile (23°S). A principal finding in 2015 was the detection of inter-annual variability in the coastal upwelling off central Chile and in the structure of planktonic communities. These efforts, led by IMO associate researchers R. Escribano and C. Morales, have resulted in one publication in 2015, one published in early 2016, and one already submitted:

- Coastal upwelling off central Chile presents strong seasonal variability in micro-phytoplankton abundance and biomass (an increase of ~1 order of magnitude during the upwelling period), with a few dominant diatom genera explaining most of this change. A change in oceanographic conditions between 2002-2006 (warmer-fresher) and 2006-2009 (colder-saltier) was combined with a decrease (~40%) in abundance/biomass during the upwelling season of the second period, suggesting a negative effect of climate-induced increases in upwelling activity in this and other mid-latitude upwelling regions. This work, led by IMO graduate student V. Anabalón, under the direction of associate researcher C. Morales, has included the collaboration of other biological oceanographers (H.E. González and E. Menschel (UACH), IMO associated researchers R.

Escribano, W. Schneider, and S. Hormazábal; it was submitted to the journal *Progress in Oceanography* in 2015.

- Intra-seasonal variation of upwelling is an important factor modulating zooplankton community structure (size and composition). Over an inter-annual scale, we also found that in the last decade increased coastal upwelling (possibly linked to global warming) has significantly impacted the zooplankton community, modifying its composition and size structure. This work, led by IMO associate researcher R. Escribano, the participation of the IMO adjunct researcher P. Hidalgo and two graduate students (C. González and J. Medellín), has led to two publications (González et al., 2015; Medellín-Mora et al., 2016).

We have continued to make progress in characterizing the regional circulation of the ESP, in particular evaluating the interannual and interdecadal variability of the Peru-Chile Current System off Chile:

- As part of the thesis work by Mr. Carlos Conejero, a high resolution, interannual (1958-2008) model simulation was analyzed, showing that interannual variability is dominated by remote forcing: Over a few months prior to El Niño, the Chile Coastal Current (CCC) weakens, while the Peru-Chile Undercurrent (PCUC) strengthens. Conversely, after El Niño peaks (about 6-8 months later) the CCC is strengthened and the PCUC weakened. During El Niño (La Niña) the transport anomalies of the CCC are ~ -0.4 Sv ($\sim +0.2$ Sv), while transport anomalies of the PCUC are of ~ 1 Sv (~ -0.7 Sv). These results are included in a paper in preparation "Circulation and variability in the Peru-Chile Current System: A modeling study" for planned submission in 2016 or early 2017.
- Work led by IMO assoc. researcher W. Schneider determined that water-column cooling and sea surface salinity increase in the upwelling region off central Chile driven by a pole-ward displacement of the South Pacific High: Direct observations of seawater temperature and salinity over the continental shelf off central Chile showed an unprecedented cooling of the entire water column and an increase in upper layer salinity during 2002 to 2013. We provided evidence that this phenomenon is related to the intensification but mostly to a recent southward displacement of the South Pacific High over the same period, from 2007 on. This in turn has accelerated along-shore, equator ward, subtropical coastal upwelling favorable winds, particularly during winter, injecting colder water from below into the upper water column. Consequently, the environmental conditions at the shelf off central Chile shifted from a warmer (fresher) to a cooler (saltier) phase; water column temperature dropped from 11.7°C (2003-2006) to 11.3°C (2007-2012) and upper layer salinity rose by 0.25; water column stratification gradually decreased. The biological impacts of such abrupt cooling are apparently already happening in this coastal ecosystem, as recent evidence shows substantial changes in the plankton community and negative trends in zooplankton biomass over the same period. These results were submitted to *Progress in Oceanography*.

The group led by IMO researcher W. Schneider participated in the research cruise CIMAR 21 from Caldera to Easter Island during Oct.-Nov. 2015, with the project titled "Changes in hydrographic parameters in the water column between Caldera and Easter Island (2015 – 1999)". The objective of this study is to determine changes in the hydrographic variables and in the geometry that occurred along this 4000 km long oceanic section since 1999 (the same track was covered in the same month during that year by the CIMAR 5 cruise). About 30 hydrographic stations were sampled and are currently being processed. Analysis is scheduled to be completed during 2016. In addition to line 2, these results are crucial for line 4 (the deep ocean).

The CIMAR 21 project "Extreme zonal and vertical trophic gradients in the eastern basin of the South Pacific: A study of variations in biomass and diversity of photosynthetic microorganisms and the interchange and content of greenhouse gases" is led by adj. researcher L. Fariás in collaboration between assoc. researchers O. Ulloa and P. von Dassow. On this cruise, samples were collected for flow cytometry to be analyzed in parallel using older and more advanced flow cytometry technology in the labs of Dr. Ulloa and Dr. von Dassow (to be completed in 2016), in order to allow comparisons

with data previously published from similar transects across this gradient by Dr. Ulloa's lab during the Beagle (2003) and BIOSOPE (2004) cruises. Samples were also collected for P. von Dassow's group for analysis of coccolithophore communities, an analysis that will begin in 2016 and be completed in 2017. The biological results will then be related to the chemical results on N_2O and CH_4 gases and nutrient gradients obtained by the group of L. Farías. In addition to indicating the large-scale biogeochemical variability of the ESP on both spatial and temporal scales (line 2), this work is also fundamental for understanding adaptations to oligotrophy in the context of line 3).

Oceanographic Bulletin. During 2015 we started the edition of a monthly report with a diagnostic analysis of the oceanographic and meteorological conditions observed in the tropical Pacific Ocean and along the western coast of South America. The main scope of the "Oceanographic Bulletin" (<http://www.dgeo.udc.cl/extension/boletin-oceanografico/>) is to monitor the evolution of the El Niño - Southern Oscillation based on the main mechanisms driving its evolution. Unlike other bulletins, the dynamical point of view provide physical basis to project the evolution of the coupled system during the next months, comparing different key variables and indices with previous El Niño and La Niña events. The target audience is the government institutions, the academic community, the fisheries and the aquiculture industry in Chile, other applied oceanographic institutes, and the national community in general.

III. Adaptations to a Changing Ocean

The main objective of this research line is to gain new understanding about the adaptations (at the genomic, physiological, behavioral and community-structure level) of key marine groups to the physical-chemical changes taking place in the ocean (e.g., acidification, deoxygenation, desertification, temperature) and the impact of such changes on biogeochemical cycling.

During this second year of the IMO, IMO associated researcher C. Vargas, has led sustained advances in several aspects relating specifically to ocean acidification:

- In the Vargas lab, we have now finished the implementation and calibration for measuring the carbonate system in the ocean, including total alkalinity (A_T), potentiometric pH, and, during late 2015, we started the analytical development for measuring Dissolved Inorganic Carbon (DIC) by using new instrumentation acquired by IMO (DIC Analyzer, Apollo Sci Tech).
- Several experiments were led by Vargas' group using the micro/mesocosm system for carrying out perturbation experiments at different pCO_2/pH levels and data synthesis have been carried out during the past year. We have evaluated the impact of pCO_2 -driven ocean acidification on the production of greenhouses (N_2O) by phytoplankton communities (i.e. the green algae *Micromonas pusilla*) (MSc thesis Mr. Alejandro Range); food-web studies have shown significant effects of changes in pH on zooplankton organisms (i.e. copepods), and the potential for local adaptation in coastal populations of these grazers, a key functional group for the energy transfer through the marine food web (Aguilera et al. 2015).
- During this year, C. Vargas has worked on a synthesis of pCO_2 field information (Pérez et al. 2015, Vargas et al. 2015, Duarte et al. 2015) and experiments conducted through different studies from his research group over the past 3-4 years. The synthesis suggests that local adaptations to high pCO_2 levels may exist in specific geographic regions characterized by quasi-permanent exposure to corrosive waters. It also indicates that natural environmental variability along coastal Chile corresponds to the conditions employed in most OA experiments in the literature regarding coastal systems worldwide, which have used future scenarios for the open ocean (e.g. 1000 μ atm pCO_2). Even more importantly, some of these global scenarios did not include changes in temperature (*global warming*) in their estimations. This striking finding, showing that OA experiments to date appear to have tested only responses to natural variability in the present, will be presented in an article to be submitted to *Nature Climate Change* during the next month, which is being prepared for submission in collaboration with other colleagues from Sweden (Sam Dupont) and UK (Steve Widdicombe).

- Coccolithophores are the principal calcifying phytoplankton, responsible for 50-80% of global marine calcification, and are expected to be the phytoplankton group most negatively affected by acidification. IMO graduate student F. Díaz, under supervision of IMO assoc. invest. P. von Dassow, analyzed the relationship between coccolithophores, calcification state of *Emiliania huxleyi* (the numerically dominant coccolithophore), and environmental parameters including pCO₂ in the ESP, finding that total coccolithophore abundance is negatively associated with pCO₂ while the high pCO₂ upwelling is dominated by an over-calcified morphotype of *E. huxleyi*. This correlation suggested that, like the multicellular organisms tested by Dr. Vargas, coccolithophores might exhibit local adaptation to high pCO₂ conditions. However, a set of parallel experiments with alternative designs conducted in Chile by members of the group of Dr. von Dassow (Dr. Daniella Mella and technician Daniela Thomas in collaboration with Dr. Rodrigo Torres of the CIEP and Dr. Juan Diego Gaitán) and in Germany by collaborators Dr. Sebastian Rokitta, Dr. Uwe John, and their masters student Jennifer Hülskotter. Both parallel experiments revealed no evidence that over-calcified *E. huxleyi* forms from the Chilean high pCO₂ upwelling represent local adaptations to high pCO₂. This set of work, planned to be submitted in 2016, has led Dr. von Dassow and Dr. Vargas to plan a further set of experiments together starting in May 2016, to extend this result to other species endemic to SE Pacific high pCO₂ or low pCO₂ waters.

Upwelling causes hypoxic conditions in the upper layer by ascending the oxygen minimum zone, impacting the physiology and survival of some key zooplankton species. Assoc. invest. R. Escribano and adj. researcher P. Hidalgo have led publications (e.g., Ruz et al., 2015) and supervised several theses from graduate students that have been developed during 2015 on the subject of how this change. The possibility that the OMZ system experiences a vertical expansion as driven by stronger upwelling (climate effects) raises more questions on ecological responses of plankton communities to hypoxia. Biological interactions between microbial and zooplankton components in the water column linked to the OMZ system are studied by PhD student Sonia Yañez and MSc student Belén Franco, while PhD student Paula Ruz and MSc student Leissing Frederick are tackling questions on physiological and metabolic responses of zooplankton to variable hypoxia conditions. Meanwhile, biochemical and physiological responses of zooplankton to changing conditions of temperature, oxygen and food resources have been investigated by Postdoctoral Fellows Sara Zamora and Ramiro Riquelme in collaboration with adjunct researchers P. Hidalgo and M. Cornejo. The LowPhox cruise was an excellent opportunity to carry out onboard experiments with key zooplankton species inhabiting the OMZ or interacting with variable oxygen conditions in the northern upwelling region of Chile. Scientific results from these studies are expected to be published during 2017.

A major part of line 3 is dissecting the evolutionary and adaptive processes at work, at gene and genome levels, in specific groups of phytoplankton targeted for functional and phylogenetic importance:

- A major focus in 2015 continued to be on in the model phytoplankton species *Emiliania huxleyi*. This cosmopolitan coccolithophore (calcifying phytoplankton) has been able to adapt to very wide-ranging ocean conditions, being the most numerically abundant member of its functional group in habitats ranging from subpolar to tropical and from high-nutrient upwelling centers to oligotrophic ocean gyres. In contrast, its close relatives exhibit much more restricted ecological conditions. Thus, *E. huxleyi* and its close relatives can offer insight into how phytoplankton adapt to new environments, and why some may adapt while others will not. In 2015 the group led by assoc. invest. P. von Dassow completed the morphological and phylogenetic analysis of three species of close relatives of *E. huxleyi*, isolated into culture for the first time by his group: The analysis of *Gephyrocapsa muellerae* in the context of *E. huxleyi* and *G. oceanica*, the only other member of the family Noëlaerhabdaceae previously cultured successfully, has now been published (Bendif et al. 2015) and the more complete analysis including two more species, *Reticulofenestra parvula* and *G. ericsonii* is scheduled for publication in 2017 (Bendif et al., accepted, Frontiers in Microbiology). This work strongly suggests that hybridization with local endemic species may have played a role in allowing *E. huxleyi* to expand to the entire surface ocean (accept the most

polar waters) since its origins only 291000 years ago. To confirm this prediction, in 2015 the group of P. von Dassow successfully purified the new species into axenic culture and extracted genomic DNA for genome sequencing by Illumina (in progress in 2016). This took more effort than planned, as the new species are more difficult to grow in culture and to extract high quality genomic DNA from.

- In 2015, a study led by P. von Dassow showed that populations of *E. huxleyi* in subtropical and tropical open oceans, where environmental stability is higher and biotic pressure is lower, lose the capacity for producing an alternative life cycle stage and for sex (von Dassow et al. 2015), which is a clear example showing that phenotypic variability responds to environmental variability.
- In addition, postdoc P. Echeveste, in the lab of von Dassow, conducted work on the how resistance to copper toxicity varies among *E. huxleyi* strains depending on their provenance.
- The IMO hosted an internship (Spanish student E. Velasco) and an undergraduate thesis (P. Muñoz) in the lab of P. von Dassow investigating relations between variability in thermal optima and thermal limits of *E. huxleyi* and phylogeny and origin.
- The process of adaptation is greatly affected by whether or not the organism that must adapt engages in sexual recombination (meiosis). Meiosis is only well understood in a small number of model animal, plant, and yeasts. To provide fundamental information the process in an important phytoplankton group and expand knowledge of how meiosis is conserved throughout eukaryotes, von Dassow participated in a collaborative project with colleagues from Stazione Zoologica Anton Dohrn in Italy lead by Maria Ferrante and from Ghent University in Belgium lead by Wim Vyverman, which used transcriptomic and genomic methods to compare the conserved meiotic-specific toolkit in several diatoms and other eukaryotes (Patil et al. 2015).
- *Prochlorococcus* is the smallest and most abundant free-living phototroph in the world, and most strains have adapted to oligotrophic waters. This adaptation has included extensive genome streamlining that has resulted in the loss of the ability to use nitrate, and thus a complete dependency on the use of recycled nitrogen, in most strains. Dr. Ulloa's group has demonstrated that the *Prochlorococcus* that dominate some shallow AMZ waters diverged early during the evolution of this group and retained genes for nitrate utilization. *Prochlorococcus* that sometimes dominate the upper few meters of anoxic marine zones. The PhD candidate Montserrat Aldunate, jointly tutored by IMO researchers O. Ulloa and P. von Dassow, has used an advanced flow cytometric sorting (in the labs of the two PIs) followed by nitrogen stable isotope analysis in the lab of collaborator Dr. Bess Ward (Princeton University) to provide the first evidence that *Prochlorococcus* indeed uses nitrate, but generally appears to be much more dependent on reduced forms of nitrogen. While this work is of specific importance for understanding AMZ systems, it is of general importance for providing insight into what determines if genome streamlining or selection for conservation of biogeochemical function will dominate.
- Von Dassow and Ulloa are collaborating on a 1-year project (lead by von Dassow and including 4 co-investigators) funded by the Moore Marine Microbiology Initiative "Experimental Model Systems" call, starting in Oct. 2015, to test whether unicellular eukaryotic are able to uptake and express exogenous DNA, which is important for understanding the role of horizontal gene transfer in adaptation.

The *LOWPHOX 1* expedition allows us to characterize for the first time the carbon cycle in an anoxic marine zone (AMZ), to test if biogeochemical cycling in AMZs might function differently to that of well-studied oxic oceans. We have carried out a sampling for complete analysis of different carbon pools including the carbonate system. C. Vargas group is leading the analysis of dissolved inorganic carbon parameters (pH, A_T, DIC, PIC), and the dissolved organic fraction (DOC). The group of O. Ulloa is analyzing the particulate organic pool (POC). P. von Dassow is analyzing the particulate inorganic carbon (PIC) by a bulk approach in collaboration with Dr. Barney Balch from the Bigelow Laboratory (in progress) and will analyze one of the most important biological constituents of the PIC pool by microscopic analysis of epipelagic and sinking coccolithophore communities and detached coccoliths. Finally, a detailed isotopic analysis of three dissolved carbon pools ($\delta^{13}\text{C}_{\text{DIC-DOC}}$ and $\delta^{14}\text{C}_{\text{DIC-DOC}}$, $\delta^{14}\text{C}_{\text{POC}}$) is being conducted by adjunct researcher R. de Pol. Results from this expeditions, to be

analyzed during this year 2016, will give us a valuable insight for understanding of AMZ carbon cycling, a critical issue for modeling global biogeochemical cycling and climate change, as well as hind-casting the ancient ocean. Colleagues from several prestigious institutions abroad have accepted our invitations to collaborate on this study (e.g. *Matthew Sullivan*, Ohio State University; USA; *Virginia Edgcomb*, Woods Hole Oceanographic Institution, USA; *Joe Salisbury*-University of New Hampshire, USA; *Pamela Rosse*-University of Oldenburg, Germany, *Brett Walker*, University of California, Irvine, USA; *Barney Balch*-Bigelow Laboratory for Ocean Sciences), and The Agouron Institute (www.agi.org) is providing additional financial support. This work is relevant for line 3, revealing the biogeochemical parameters affecting organism adaptations and how they can feedback on ecosystem biogeochemical function), but also impacts 2 (ocean variability; to understand the impact of large-scale changes in OMZ/AMZs), and 4 (the deep ocean; by revealing whether fluxes from the surface to the deep ocean in the ESP might differ from those in other ocean regions).

IV. The deep ocean ecosystem

This research line focuses on the biological communities, habitats, and biogeochemical and evolutionary processes that comprise and govern the deep oceanic region in the eastern south Pacific basin. We understand and are aware on the ambitious nature of these scientific objectives providing logistics and technical limitations to access to the deep ocean realm. In such context, the study and exploration of the deep Pacific basin, and in particular the Atacama trench constitute mid- to long-term goals for IMO. Therefore, during this second year we have invested time and efforts in strengthening international collaboration, submitting proposals, preparing and testing equipment and developing new approaches to study the dark and high-pressure system. Also, some preliminary research initiatives have already been undertaken by our researchers through national research programs with focus in the open ocean off Chile.

In terms of equipment, through the national grant competition FONDEQUIP we obtained funding to acquire a deep Multi-sampler net, which will allow us to sample zooplankton (meso- and macrozooplankton) and fishes as deep as 6500 m. The equipment is being constructed in USA and should be available for during mid-2016. Meanwhile, we are in a joint project with the Maclane company (USA) to develop an in situ pumping system to sample large amounts of deep seawater (>7000 m). The use of landers to sample the deep Atacama trench is another possibility we are exploring with partners from Denmark, Germany and USA.

The associated researcher, R. Escribano, in collaboration with adjunct researcher P. Hidalgo and Postdoc R. Riquelme, carried out studies on zooplankton communities (taxonomic and molecular diversity) and their biochemical conditions over the horizontal and vertical gradient from surface to 1000 m depth during the CIMAR21 cruise. It is expected that during 2016-2017 scientific results from this that are highly relevant to line 4 will be available and prepared for publication. Additional research efforts have been made with zooplankton communities from deep water (>500 m). During the Juan Fernandez Seamounts cruise carried out by IMO researchers in September 2015 (lead by Associate Researcher S. Hormazábal) we sampled zooplankton from three seamounts in the area of Juan Fernandez ridge (ca. 33° S) down to 800 m using a Multinet zooplankton sampler. Biochemical conditions, size structure and taxonomic analyses of samples are underway and results should soon be available. We also did a deep sampling (about 1500 m) of zooplankton in offshore water during the LowPhox cruise off Iquique (20° S) by using a large Tucker Trawl net. The value of these samples is unique and taxonomic, molecular, and biochemical analyses are also underway.

To address evolutionary processes controlling the dispersal of deep-water communities over the Pacific basin, we are developing approaches based on symbiotic biological interactions, such as parasitism. Parasites act as biomarkers of colonization, dispersion and geographic isolation of species and communities. To work on this subject we are using samples of fishes obtained as by-

catches by local fishermen. During 2015, many parasitic species infecting deep-water fishes have been identified by taxonomic and molecular analyses. The MSc student Luis Nacari completed and defended his thesis and has recently submitted a manuscript to Deep Sea Research Part I describing parasites associated with deep-water fishes in the Pacific basin. An undergraduate student Carolina Bustos also completed her thesis describing parasites associated with macrurid fishes captured at about 1500-2000 m off Chilean coast.

Student participation is a key component for the research activities of Theme 4. For the CIMAR cruise, a doctoral thesis (student Carolina González) will tackle questions on processes governing the dispersion and colonization of zooplankton communities over the Pacific basin using molecular tools to uncover the phylogeography and genetic diversity of key planktonic species. Meantime, a new doctoral thesis project (student Liliana Espinoza) is focused on the diversity and trophic relationships of deep-water amphipods. This is a poorly studied plankton group in the region, which can have a key ecological and biogeochemical role in the deep-water ecosystem.

b) Publications:

A total of 20 articles in ISI journals were published in year 2, of which 16 were authored or co-authored by IMO associate researchers. 75% were in Q1 journals and 45% included more than one IMO researcher as author/coauthor, reflecting increased collaboration (see Table 3.5."Collaborative publications" in Annex). It is also interesting to note that 37% of the ISI publications were associated with more than one research line (see Annex 3.1).

The 20 IMO-associated publications represents an increase from the 9 IMO associated publications in year 1 but a decrease from the total of 37 publications in ISI journals associated with IMO researchers in year 1. This decrease in publications reflects the major effort of IMO researchers in organizing and executing the first large and ambitious IMO-associated field projects (3 major research expeditions and one new time series were equipped and executed principally by IMO researchers in year 2) and more generally the change in focus from individual to more ambitious collaborative projects within the 4 IMO research lines. Nevertheless, the decrease is a cause for concern. We are implementing mechanisms to increase publication levels in 2016-2017 including a) collaborative workshops with goals of joint publications (e.g., on the 2015-2016 ENSO event in the South East Pacific, the first results from the LOWPHOX 1 and CIMAR21 cruises), b) defining clear publication goals and strategies (and biannual reporting) between IMO-associated postdocs and their host researchers, c) prioritizing plans for higher impact collaborative publications among IMO researchers, d) reviewing the contributions of adjunct and young researchers and adjusting IMO composition accordingly, e) re-defining research line 2 as "ocean variability and change on large space and time scales" as a theme that permeates and underpins the three other research lines.

When possible, we publish in journals that are open access or pay an extra fee to the publisher to make them open access.

A detailed list of papers is in Annex 3

Summary table

Category of Publication	MSI Center Members	Number of Publications coauthored by students	Total Number of Publications
ISI Publications or Similar to ISI Standard	Associate Researchers	6	16
	Other Researchers	0	4
	Associate Researchers	0	0

Category of Publication	MSI Center Members	Number of Publications coauthored by students	Total Number of Publications
SCIELO Publications or Similar to SCIELO Standard	Other Researchers	1	1
Scientific Books and chapters	Associate Researchers	0	1
	Other Researchers	0	0
Other Scientific Publications	Associate Researchers	0	0
	Other Researchers	0	0
Total of Publications		6	<u>22</u>

Other achievements:

- **Patents:** No patents reported during the period
- **Intellectual property:** No intellectual property reported during the period
- **Congress Presentations:**

Summary Table

Type of presentation	National Events [Number]	International Events [Number]
A. Associate Researchers		
Conferences, oral communications, poster communications, others (specify)	14	37
Invited presentations (not included in above row)	6	15
B. Other researchers (Adjunct Researchers, Senior Researchers, Young Researchers, Postdoctoral Researchers and Students)		
Conferences, oral communications, poster communications, others (specify)	19	27
Invited presentations (not included in above row)	4	3

- **Organization of Scientific Events:**
A list of the scientific events during 2015 is detailed in Annex 4.
- **Scientific Editorial Boards:**
Frontiers in Marine Science, ISI, 2015-present: Dr. Osvaldo Ulloa
- **Awards:**
TV Series “La fuerza del Mar” (The strength of the Sea) directed by Pablo Rosenblatt (IMO’s Outreach Director), **Special JURY Prize**, 9th International Science Film Festival of Athens, 31-08-2015.

International course "Ecology and Diversity of Marine Microorganisms" ECODIM, organized by IMO and co-directed by O. Ulloa. **Innovation in Scientific Education 2015 Prize**, Category Higher Education, given by the Ciencia Joven Foundation and UNESCO, 26-11-2015.

4. Education and Capacity Building

IMO students and postdocs play a most important role as young researchers developing and/or actively participating in projects directly linked to IMO's research themes. For them, IMO provides: i) advanced research opportunities in terms of access to all IMO researchers facilities and equipment, ii) participation in IMO oceanographic cruises, advanced courses, workshops and meetings, iii) funds in the form of scholarships and fellowships to allow them to initiate or complete their thesis or projects, as well as to attract new students, iv) partial support to attend national and international congresses or advanced courses, and v) complete support with the purchase of materials and reagents which are needed for their thesis work or project development. IMO promotes the interaction between researchers and students through thesis co-tutoring and, in the case of postdocs, by their participation in thesis committees and supporting their own initiatives of collaboration within IMO research. The main IMO's activities, achievements and results on this subject during the 2015 period were the following:

- **IMO incorporation of postdoctoral researchers to strengthen capacity building**

During 2015, IMO hosted a total of 12 postdocs, 5 of which had started during 2014 and included 2 which received full IMO grants and the rest were recipients of external grants, mostly CONICYT/FONDECYT. The new postdocs incorporated during 2015 included 4 which obtained a full IMO grant and 3 which were recipients of external grants. The IMO selection processes of postdocs with IMO grants finished at the end of 2014 and, as in the first IMO call, all associate researchers participated in this process. The criteria considered the needs in each IMO research theme, the potential for increased interaction between IMO researchers through the selected candidates, as well as the scientific quality and potential of the individual candidates. Among the 12 postdocs working full time with IMO researchers during 2015, 5 of them came from foreign countries; by the end of the year, 2 postdocs with external funding (B. Jacob and I. Andrade) finished their contract and association with IMO.



IMO postdocs sharing their experiences in 2015.

IMO's policy is to leverage the IMO-postdoc fellowships as seed funds for attracting young researchers who will be competitive in applying for external funds. During the 2014 selection process, 2 candidates (S. Zamora and P. Echeveste) won A CONICYT/FONDECYT fellowship to start in 2015. In addition, 2 IMO postdocs starting in 2015 won this fellowship to start in 2016 (D. Steele and A. Bertagnoli). Another IMO postdoc (R. Riquelme) applied during 2015 to the CONICYT Program for the incorporation of new researchers to the academia; he was successfully incorporated to UdeC (D. Zoology) and will continue as an IMO young researcher during 2016.

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

During 2015, IMO was linked to 4 undergraduate and 6 postgraduate programs, including teaching basic and advanced courses, practices, and/or project and thesis guidance:

- Undergraduate Programs in Marine Sciences: Marine Biology at UdeC and PUC, 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 UA, Ph.D. in Oceanography at UdeC, Ph. D. in Environmental Sciences at UdeC, and Ph.D. in Biological Sciences at PUC.

During 2015, 41 students were directly linked to IMO: 12 in undergraduate, 15 in M. Sc., and 14 in Ph.D. Programs. 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.



IMO graduate students presented their thesis advances during an internal meeting (April, 2015).

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 been 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.

In 2015, IMO awarded scholarships to a total of 18 students, 8 of undergraduate level and to 10 of graduate level. In addition, 8 of the 28 graduate students from IMO received a CONICYT scholarship during 2015 whereas the rest had full or partial support from other funding sources (eg. institutional scholarships or though projects from IMO researchers).

- **IMO organization of advanced training**

Advanced course in flow-cytometry: first version of a theoretical/practical course fully organized by IMO (21-30 January 2015), held in Dichato (Marine Station, UdeC), with the purpose of enhancing national capabilities on the use of this sophisticated equipment in a diverse type of disciplines. IMO associate researcher P. von Dassow lead this initiative and the classes were taught by IMO senior researcher G. van den Engh, associate researchers P. von Dassow and O. Ulloa, and K. Doggett, a highly experienced technician on flow-cytometry (University of Hawaii, USA). A lecture was also given by the Chilean immunologist M. R. Bono (U. de Chile). The course was financed by IMO and personal donations from Dr. van den Engh. A total of 14 students were selected, including 6 graduate students, 5 postdoctoral researchers, 3 advanced professionals, and one assistant professor; 6 of the participants were directly linked to IMO. Two of the most advanced cytometers/cell-sorters existing today, the InFlux flow-cytometers, were used in the course; they were invented by Dr. van den Engh

and IMO is probably one of the few oceanographic institutions in the Latin-American region which have them available.



Advanced course on ocean mixing processes: Associate researcher Hormazábal organized an advanced course in ocean mixing processes at the Escuela de Ciencias de Mar in the PUCV in January, 2015. The course was lead by the invited professor Dr. Ángel Rodríguez from the Universidad de Las Palmas de Gran Canaria, Spain. The intensive course involved both theoretical and practical works and attracted IMO and non-IMO undergraduate and graduate students from Chile and from Argentina, Brazil, Colombia, Peru, and Uruguay.

Ecology and Diversity of Marine Microorganisms: In 2015, the advanced international course ECODIM (Ecology and Diversity of Marine Microorganisms), organized by IMO and lead by associate researcher O. Ulloa, won the first place in the category “Higher Education in Science”. This award was given by the Program on Innovation in scientific education, organized by the “Fundación Ciencia Joven” (Chile) and with the support of the Regional Office for Education, linked to UNESCO in Latin-America and the Caribbean.

- **Field Training:**

During 2015, 2 oceanographic cruises organized by researchers allowed an active involvement of students and/or postdocs. During the **Seamounts cruise in the JFRS region**, a total of 8 graduate students and one postdoc participated whereas during the **LOWPHOX cruise** off northern Chile, 3 graduate students and 4 postdocs participated. These cruises allow them to gather samples and data for the preparation of their thesis work and/or research. In addition, several types of samples were obtained for the analyses of other students and postdocs that did not participated in the cruise.



5. Networking and other collaborative work

a) Networking:

During 2015, IMO participated in different national and international collaboration networks.

A cooperation program with research groups abroad (e.g. CEFAS and PML (UK), OAICC-IAEA (Monaco), and public and private institutions, to jointly characterize the impact of Ocean Acidification on marine biota was established in 2015 by IMO researcher Dr. C. Vargas. Also, a sustained collaboration is related to joint activities in our research lines supported by the OA-ICC (Ocean Acidification International Coordination Centre). IMO' researchers, Drs. C.A. Vargas and V. Aguilera participated in this OA-ICC network through the Latin American OCean Acidification network (LAOCA), officially launched in December 2015 in a regional meeting involving 27 scientists from 7 Latin-American countries. The LAOCA launch was promoted by IMO (US\$ 7,350), researchers with the support of OAICC (US\$15,000), IOC/UNESCO (US\$8000), and other national oceanographic programs in Chile (IMO-ICM, US\$ 2,500). Drs. Vargas was nominated as co-chair of the LAOCA executive committee. Dr. Vargas is already participating in the Global Ocean Acidification Observation network (GOA-ON) from its launch in 2012. Currently, scientists from 30 countries and from national and international programs and organization (e.g., NOAA, CSIRO, UKOA, IOCCP, IOC-UNESCO) are collaborating in supporting the GOA-OAN goals, which involve understanding the global OA conditions, the ecosystems responses to OA, and to acquire and exchange knowledge to optimize modeling OA and its impacts. During 2015, our IMO' PI, Dr. Vargas was nominated as member of the Executive Council of the GOA-ON and of the Executive Council of the International Ocean Carbon Coordination Program (IOCCP). The IOCCP promotes the development of a global network of ocean carbon observations for research through technical coordination and communication services, international agreements on standards and methods, and advocacy and links to the global observing systems. The IOCCP is co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and the IOC/UNESCO. Dr. Vargas will support the connection between structure of the Latin American community working on Ocean Acidification (e.g. IMO, MUSELS, LAOCA) and global (GOA-ON and IOCCP) network programs, as well as data management in South America for the production of global syntheses and data products.

In 2015, IMO researcher Dr. R. Escribano was appointed as full member of the SSC of IMBER (Integrated Marine Biogeochemistry and Ecosystem Research). This is an international program sponsored by SCOR and IGBP, and recently became a sponsored program of Future Earth. Presence of R. Escribano at IMBER opens a valuable window for IMO visibility at International level. Within IMBER R. Escribano was also appointed as chair of the upwelling core program. During 2015, R. Escribano was also invited to join the Upwelling Focus group of the CLIVAR (Climate Variability) Program. This group met in Ankara, Turkey (October 2015) and aimed at combining climate modeling experts and biologists to tackle questions on the future of eastern boundary upwelling ecosystems (EBUE). Recently the Upwelling Focus group has developed and submitted an implementation plan to CLIVAR where R. Escribano has been suggested as co-chair.

Time series observations in the upwelling zone continued to be the basis for IMO participation in the ANTARES Network. This international network receives some funding from IAI (Inter American Institute for Climate Change) through grant CRN3094 and allows collaborative work among 9 Latin American and North American countries dealing with oceanographic time series observations. During 2015 ANTARES network developed several activities aiming at integrate oceanographic data from the time series and R. Escribano became leader of the Task Team responsible for in situ

oceanographic measurements. A workshop organized by ANTARES to discuss the use of data bases and potential for joint research took place in Santa Marta, Colombia (October 2015).

In the context of IMO research line 4, we have developed collaboration with the National Oceanographic Centre at University of Southampton to study deep water habitats and communities. In May 2015 we invited S. Thadje, professor of University of Southampton, for an IMO Symposium at the Chilean National Congress of Marine Sciences and, thereafter, as a visiting researcher at IMO. Dr. Thadje is a prominent scientific in the field of evolutionary processes and communities of the deep ocean ecosystems. Through this collaboration we aim at capacity building to develop studies in deep ocean communities and currently we are jointly applying for a formal program on Marine Sciences capacity building between UK and Chile.

IMO researcher Dr. P. von Dassow continues to be one of the Chilean researchers in the French Centre National de la Recherche Scientifique (CNRS) international research unit UMI3614 "Evolutionary Biology and Ecology of Algae". This research unit involves three professors from the Pontifical Catholic University of Chile, one professor from the Universidad Austral de Chile, one professor from Université Pierre et Marie Curie Paris VI/Sorbonne Université in France, and two research leaders from the CNRS/Station Biologique de Roscoff (see <http://www.sb-roscoff.fr/fr/umi-biologie-evolutive-et-ecologie-des-algues>). Ulloa and von Dassow are both within a larger International Research Network "Diversity, Evolution and Biotechnology of Marine Algae" (GDRI N° 0803) financed by the CNRS that includes researchers from the French research centers Station Biologique de Roscoff and Observatoire Oceanique de Banyuls, three Brazilian universities, and six Chilean universities. During the end of 2015 von Dassow and Ulloa initiated a new collaboration with CNRS researcher and GDRI member Laure Guillou for characterizing the unicellular dinoflagellate parasites in the group Syndiniales within oxygen minimum zones. Samples for this work were taken during the LOWPHOX I cruise. Within both the UMI 3614 and GDRI 0803, von Dassow continues to maintain and consolidate a large Chilean collection of micro- and macroalgae, in collaboration with the Roscoff Culture Collection. The Chilean collection provides micro- and macroalgal strains both for IMO and non-IMO researchers to use in experimental work.

b) Other collaborative activities:

A collaboration activity with the Mediterranean Institute of Oceanography (MIO) at University Aix Marseille took place during 2015. R. Escribano and adjunct researcher P. Hidalgo visited MIO and met the researcher and subdirector of MIO Dr. Francois Carlotti, who became member of the thesis committee of PhD student Valentina Valdés. During his visit R. Escribano also initiated a joint work with F. Carlotti to analyze zooplankton data from the previous cruise BIOSOPE carried out over a trans-Pacific transect between Chile and New Caledonia. A joint scientific manuscript is been prepared with these data, focused on community structure of plankton from a highly productive upwelling zone to the ultra-oligotrophic area in the subtropical gyre.

During October 2015, the MSci student, Stephanie Mangan, from Exeter University (UK), conducted a research internship of 1 mo at the Dr. Vargas Lab. performing OA experiments, gave seminars, and processing the information of an MS in progress.

Other collaborative activities are included en Annex 6.2.

6. Outreach and connections with other sectors

a) Outreach:

During 2015, our outreach team focused primarily on maintaining long-term strategies that allow us to bring marine scientific knowledge to the society in general and, particularly, to school communities. We have focused on promoting the concept that our ocean, and knowledge of it, represents part of the shared wealth of the country.

For this, we wrote and applied to projects that use multi-platform tools, incorporating traditional media, digital media and others.

In this context, our outreach team focuses in developing the three projects we won last year: PME 1, "Sumérgete: una travesía por el Océano Pacífico" (Inmerse: A journey through the Pacific Ocean) (www.sumergete.cl). This web site gives information about marine sciences, its organisms, and human impacts on different environments. Using, videos, illustrations, animations and audio files. In the first year, we developed intertidal and coastal ocean galleries. Sumérgete has a Fan Page on Facebook, which is constantly being updated with news, curious facts, pictures and contests. Additionally, it has the YouTube channel where the videos are hosted.

PME 2, Muestra Audiovisual Científica Itinerante (MACI) (Itinerant Scientific Audiovisual Show). It consists in an audiovisual exhibition, accompanied by a practical demonstration and oceanographic instruments show. This is aimed at students from three educational levels: primary, middle and high school students.

In total, we carried out 8 MACI, in six districts from Biobio region, with a total of 15 educational institutions and more than 2,900 students.



MACI for secondary and primary students in Laja, August 2015

The third project awarded is: "La Receta Científica de Tony Tonina" ("Tony Tonina's Scientific recipe"), funded by Explora, Conicyt. It is an educational children's TV show, with scientific content. The 10 chapters scripted are ready and now we are working in the animations and in the communication plan for its broadcasting and upcoming.

During 2015, we focused in being part of all kind of outreach, educational and scientific activities. Thanks to that, we were active players in the Family Science Day, at the University of Concepción; The Party of Science and Technology, ICM, Santiago; Explora Regional Congress of Science and Technology, with promotional stand; in VIII version of international Show room of education, organized by Praxedis and EduGlobal, with promotional stand; trash sampling in Coliumo beach, within the program "Científicos de la Basura" (Trash Scientists); several workshops and conferences in schools, given by IMO's graduated students and postdocs; important presence during The Month of the Sea (May) in several activities with children and general public; lectures by our teams members in the First Symposium of Scientific Outreach in the Marine Sciences Congress 2015, Coquimbo; in the Third Meeting of popularizers of science and technology, organized by Chilean Antarctic Institute (INACH), Punta Arenas, and in the XIX International Congress of RedPOP (Popularization of science and technology in Latin America and the Caribbean), Medellin, Colombia. Each meeting was highly significant for Science Outreach in a national and Latin American level.



Heritage Day in CICAT, May 2015



IMO at schools, Colegio Inmaculada Concepción, Talcahuano, May 2015



Trash sampling in Coliumo beach with primary students, October 2015

IMO had an important participation in the development and organization of Marine Scientific Camp's "Our Ocean", during the international conference "Our Ocean", in Valparaiso. A previous contest, allowed 10 girls and boys from Dichato and Concepcion, together with 2 teachers, to represent Biobio region in the Camp. IMO started with the first activity: "Knowing the smallest organisms from the Ocean", on board of the R/V Cabo de Hornos.



Participating students in Marine Science Camp : "Our Ocean", October 2015.

Within the audiovisual area, the documentary series "La Fuerza del Mar" (Force of the Sea) it was the only Latin American scientific documental to win the IX Scientific Documentary Festival in Athens, Greece. It is important to highlight that this series is developed by our outreach director, Pablo Rosenblatt, and has had the participation of two of our associated researchers, Osvaldo Ulloa and Ruben Escribano, and one of our senior researchers, Juan Carlos Castilla.

Furthermore, as IMO, we aim not only to bond with the community through the dissemination of scientific knowledge, but also investigate and innovate new strategies for science education in Chile and other countries in the Andean region. Thus, we pursue national and international partnerships with similar centers to enhance our products and messages.

Within these alliances, it is our participation in RedPOP, which allows us to organize the First IMO Seminar of Scientific Outreach (4 miradas de la Divulgación Científica; 4 looks of Scientific Outreach), the aim was to share and meditate about different experiences in outreach. We counted with the presence of two international speakers: Marilisa de Melo, from Universidad de Campinas, Brasil, and Margot Mena, academic from Communication Faculty of Universidad de Costa Rica and Juan Carlos Gacitua, local exponent, director of CICAT (Interactive Center of Sciences, Arts and Technologies).

Also, in 2015 we continued and strengthened the collaborative network with CICAT, from University of Concepción, through our participation in the second version of the Science Camp ChileVA!, in January 2015, and with the PAR Explora Biobio, through the Multi-institutional network and the development of 2016 projects.

We worked too in the formation of an informal network with other Millennium Centers (and no Millennium), related with oceanographic and marine research, in order to enhance outreach projects together (CEAZA, ESMOI, MUSELS, ECIM).

In this context, it is essential to involve our researchers in our projects and activities. In this regard, last year, one of IMO's researchers, Pamela Hidalgo, supports a science group of secondary students of Salesiano Concepcion School, with the aim of developing scientific projects and participating in several national and regional escolar congress and workshop. Among them, the Explora Scientific and the Scholar Antarctic Fairs. The young participants obtained the National First Place in the Scholar Antarctic Fair (organized by INACH), what allowed them to travel to Antarctic, in January 2016.



Pamela Hidalgo and her laboratory team, supporting a study and exhibition of secondary students who won the Antarctic Fair, September 2015.

We aim to reach every sector and realities, using for this, different methods and strategies. Not only through web sites and social networks, but TV as well. In this order, IMO is leading the project: "Science in TVN", which includes 3 actions: the first one seeks to raise awareness about science in the people leading TVN channel; the second is the production of science audiovisual material for the TVN shows; and the third one is about the creation of a new Science TV show, during prime time.

Finally, IMO's commitment is also to spread the knowledge of marine science to professionals from the area and/or that use this knowledge in their professions. During the second year we continue executing projects framed within this strategy.

A detailed list of activities is in Annexes 7.1 to 7.3.

b) **Connections with other sectors:**

During 2015, IMO's Development and Technology Transfer area, signed a cooperation agreement with a private Company to prepare a project and apply to governmental funds to start the development of an innovative instrument to be used in oceanographic and limnological research. Detailed information of this action is given in Annex 8.

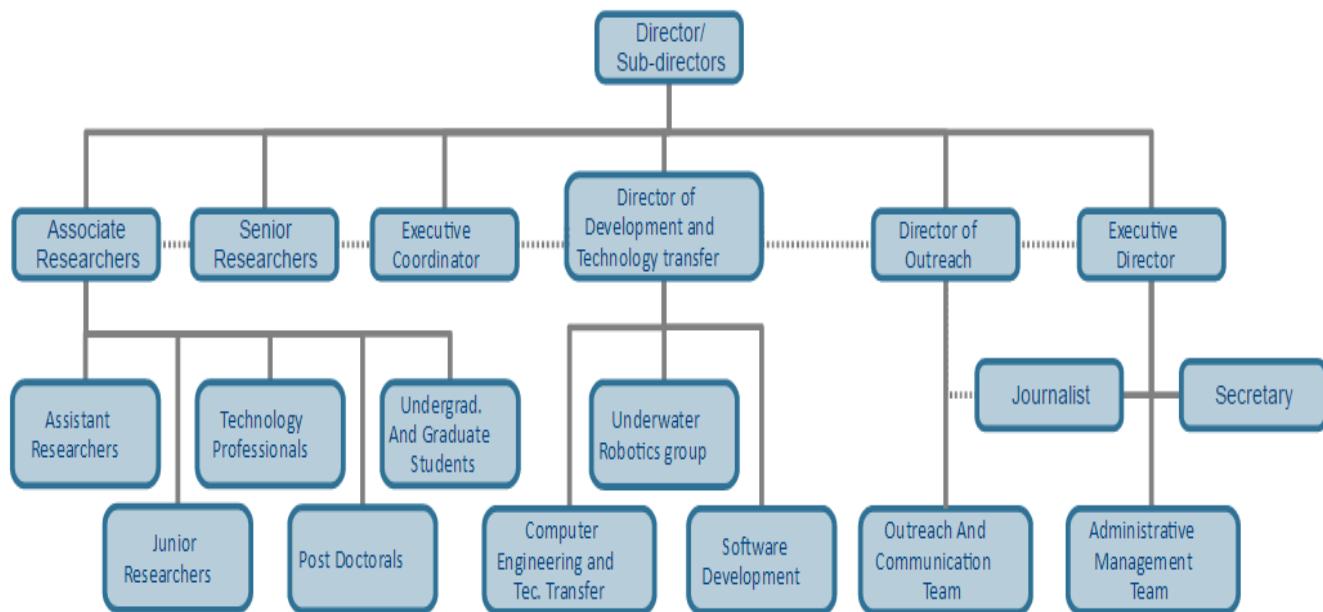
7. Administration and Financial Status

a) Organization and administration:

During July 2015, IMO hired a new Executive Director, Mr. Atilio Morgado, to replace the previous one, Dr. José Luis Blanco. A professional auditor accountant (Mrs. Olga Pérez) was contracted (part-time) to join the administrative team, together with IMO's chief accountant, Mr. Mario Baltazar, the Executive Secretary, Mrs. Mónica Sorondo and the Executive Director.

In July 2015, IMO acquired its official status of Non-profit Private Corporation in the Governmental Taxes Service, allowing us to operate as a legal entity for all sorts of financial and contract matters. IMO's administration was reinforced in 2015 to deal with a larger number of transactions, activities, and projects associated with it.

The organization chart, representing the 2015 operative structure of IMO, is shown below:



During 2015, 21 research assistants and technicians, and 4 administrative staff worked with IMO:

Category	Female	Male	TOTAL
Assistant & Technicians	10	11	21
Administrative Staff	2	2	4
TOTAL	12	13	25

b) Financial Status:

The 2015 financial status for the Center is detailed in the Annexes 9.1 to 9.3

8. Annexes:

8.1 Annex 1.- Institute 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	1,2,3,4	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
Heracio Rubén Escribano Veloso	1,2,3,4	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/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Víctor Miguel Aguilera Ramos	2,3	Chilean	M	01-11-76	Marine Biologist	D	University of Antofagasta	Assistant Professor	2
Marcela Alejandra Cornejo D'Ottone	1	Chilean	F	20-07-77	Oceanographer	D	PUCV	Associate Professor	2
Ali Reda Belmadani	1, 2	Finland	M	04-06-79	Oceanographer	D	UdeC	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: Ocean Variability.	Chilean	M	24-07-1965	Oceanographer	D	University of Concepción	Adjunct Researcher	2
Carolina Eugenia Parada Veliz	1: Mesoscale Processes	Chilean	F	02-10-1970	Oceanographer	D	University of Concepción	Adjunct Researcher	2

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Jose Luis Blanco Garcia	1: Mesoscale Processes. 2: Ocean Variability.	Chilean	M	03-08-1957	Oceanographer	D	Millennium Institute of Oceanography	Adjunct Researcher	2
Laura Farias	3: Adaptations to a Changing Ocean	Argentinian	F	07-07-1963	Oceanographer	D	University of Concepción	Adjunct Researcher	2
Marcelo Enrique Oliva Moreno	4: The Deep Ocean.	Chilean	M	17-03-1952	Biologist	D	University of Antofagasta	Adjunct Researcher	2
Pablo Rosenblatt Guelfenbein	1: Mesoscale Processes. 2: Ocean Variability. 3: Adaptations to a Changing Ocean. 4: The Deep Ocean.	Chilean	M	06-01-1955	Biologist	M	Millennium Institute of Oceanography	Adjunct Researcher	2
Pamela del Carmen Hidalgo Diaz	3: Adaptations to a Changing Ocean	Chilean	F	07-06-1966	Other	D	University of Concepción	Adjunct Researcher	2
Ricardo Hernán De Pol Holz	2: Ocean Variability.	Chilean	M	17-10-1973	Marine Biologist	D	University of Concepción	Adjunct Researcher	2
Rodrigo Alonso De la Iglesia Cabezas	3: Adaptations to a Changing Ocean	Chilean	M	26-12-1978	Biologist	D	Pontifical Catholic University of Chile	Adjunct Researcher	2
Víctor Enrique Villagrán Orellana	1: Mesoscale Processes. 2: Ocean Variability. 3: Adaptations to a Changing Ocean. 4: The Deep Ocean.	Chilean	M	02-03-1973	engineer	M	University of Concepción	Adjunct Researcher	2
Alejandro Andrés Murillo Cordova	1: Mesoscale Processes	Chilean	M	20-01-2015	Biologist	D	University of Concepción	postdoctoral fellow	1
Pierre Amael Auger	1: Mesoscale Processes	Frensh	M	07-09-1984	Engineer	D	Millennium Institute of Oceanography	postdoctoral fellow	1
Deborah J. Steele	1: Mesoscale Processes. 3: Adaptations to a Changing Ocean.	United Kingdom	F	18-11-1986	Biologist	D	IMO	postdoctoral fellow	2
Paulina Aguayo	3: Adaptations to a Changing Ocean	Chilean	F	31-12-1980	Marine Biologist	D	Millennium Institute of Oceanography	postdoctoral fellow	1
Anthony Bertagnolli	2: Ocean Variability. 3: Adaptations to a Changing Ocean.	American	M	15-09-1982	Biochemist	D	Millennium Institute of Oceanography	postdoctoral fellow	2
Ramiro Antonio Riquelme Bugueno	1: Mesoscale Processes	Chilean	M	07-09-1978	Marine Biologist	D	University of Concepción	Postdoctoral fellow	2

Name	Research Line	Nationality	Gender	Date of birth dd/mm/yy	Profession	Academic Degree	Affiliation	Current Position	Relation with Center
Alvaro Alfredo Muñoz Plominsky	3: Adaptations to a Changing Ocean	Chilean	M	24-04-1984	Biologist	D	University of Concepción	postdoctoral fellow	2
Bárbara Jacob Valderrama	3: Adaptations to a Changing Ocean	Chilean	F	02-11-1972	Fishing And Aquaculture Engineer	D	University of Concepción	postdoctoral fellow	2
Carlos Andrés Henríquez Castillo	3: Adaptations to a Changing Ocean. 4: The Deep Ocean.	Chilean	M	06-05-1983	Biochemist	D	Pontifical Catholic University of Chile	postdoctoral fellow	2
Isabel Margarita Andrade Cornejo	1: Mesoscale Processes	Chilean	F	22-10-1979	Marine Biologist	D	Pontifical Catholic University of Valparaíso	postdoctoral fellow	2
Pedro Echeveste De Miguel	2: Ocean Variability.	Spanish	M	03-08-1981	Biologist	D	Pontifical Catholic University of Chile	postdoctoral fellow	1
Sara Zamora Terol	2: Variabilidad Oceánica.	Spanish	F	23-03-1980	Biologist	D	University of Concepción	postdoctoral fellow	2

8.2 Annex 2. Research Lines

Nº	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
1	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. The 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 the eddies and their interactions with winds and topography.</p> <p>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 that are 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.</p> <p>As well, 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 the 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>	Carmen Eliana Morales Van De Wyngard Samuel Ernesto Hormazábal Fritz Ali Reda Belmadani Carolina Eugenia Parada Veliz. Marcela Alejandra Cornejo D'Ottone. Juan Carlos Castilla Zenobi. Isabel Margarita Andrade Cornejo. Oscar Roberto Pizarro Arriagada. Peter von Dassow Cristian Antonio Vargas Galvez. Alejandro Andrés Murillo Cordova. Heracio Rubén Escribano Veloso. Aldo Manuel Montecinos Gula. Ramiro Antonio Riquelme Bugueño. Pierre Amael Auger .	Ecology and environmental sciences. Oceanography Meteorology and climatology. Marine biology. numerical methods and computer science.	26-12-2013	

Nº	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
2	Ocean Variability	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. 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.</p> <p>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. 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>	Oscar Roberto Pizarro Arriagada. Wolfgang Schneider Ricardo Hernán De Pol Holz. Carolina Eugenia Parada Veliz. Samuel Ernesto Hormazábal Fritz Carmen Morales Van de Wyngard Peter von Dassow . Víctor Miguel Aguilera Ramos. José Luis Blanco Garcia. Aldo Manuel Montecinos Gula. Ali Reda Bel Madani . Marco Alejandro Correa Ramirez. Heracio Rubén Escribano Veloso. Víctor Enrique Villagrán Orellana. Sara Zamora Terol. Pierre Amael Auger . Pedro Echeveste De Miguel.	Biochemistry. Ecology and environmental sciences. Oceanography Meteorology and climatology. Marine biology. numerical methods and computer science.	26-12-2013	

3	Adapting to a Changing Ocean	<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. 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. 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/species (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>Osvaldo Iván Ulloa Quijada.</p> <p>Cristian Antonio Vargas Galvez.</p> <p>Laura Farías.</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>Rodrigo Alonso De la Iglesia Cabezas.</p> <p>Heracio Rubén Escribano Veloso.</p> <p>Alejandro Andrés Murillo Cordova.</p> <p>Bárbara Gianella Jacob Valderrama.</p> <p>Víctor Enrique Villagrán Orellana</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

Nº	Research Line	Research Line Objectives	Description of Research Line	Researcher	Research Discipline	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
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>Heracio 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>Laura Farías .</p> <p>Alejandro Andrés Murillo Cordova.</p> <p>Pablo Rosenblatt Guelfenbein.</p> <p>Ramiro Antonio Riquelme Bugeño.</p> <p>Victor Enrique Villagrán Orellana.</p> <p>Sara Zamora Terol.</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	

8.3 Annex 3.- Publications (Total or partially financed by MSI)

3.1.- ISI Publications or Similar to ISI Standard

3.1.1 Associate Researchers:

- 1.- Aguilera, V.M., **Escribano, R.**, Martínez-Oyanedel, J. (2015) Electrophoretic protein profiles of mid-sized copepod Calanoides patagoniensis steadily fed bloom-forming diatoms, *Lat. Am. J. Aquat. Res.* vol.43 no.4. IF: 0.654, Q4. Research line 3.
- 2.- Aguilera, V.M., **Vargas, C.A.**, Lardies, A.M., Poupin, M. (2015) Adaptive variability to lo pH river discharges in *Acartia tonsa* and stress responses to high PCO₂ conditions, *Marine Ecology*, 37: 215–226. doi: 10.1111/maec.12282. IF: 2.042, Q3. Research line 3.
- 3.- Astorga-Eló, M., Ramírez-Flandes, S., DeLong, E.F., & **Ulloa, O.** (2015) Genomic potential for nitrogen assimilation in uncultivated members of *Prochlorococcus* from an anoxic marine zone, *The ISME Journal* 9, 1264–1267; doi:10.1038/ismej.2015.21. IF: 9.438, Q1. Research line 3.
- 4.- Bendif, E.-M., Probert, I., Young, J., **von Dassow, P.** (2015) Morphological and phylogenetic characterization of new *Gephyrocapsa* isolates suggests introgressive hybridization in the *Emiliania/Gephyrocapsa* complex (Haptophyta), *Protist*. 166: 323-366. IF: 3.388, Q1. Research line 3.
- 5.- Castro-González, M., **Ulloa, O.**, Farías, L. (2015) Structure of denitrifying communities reducing N₂O at suboxic waters off northern Chile and Peru. *Revista de Biología Marina y Oceanografía*. 50: 95-110. IF: 0.574, Q4. Research line 3.
- 6.- Combes, V., **S. Hormazábal**, and E. Di Lorenzo. (2015) Interannual variability of the subsurface eddy field in the Southeast Pacific, *J. Geophys. Res. Oceans*, 120, 4907–4924, doi:10.1002/2014JC010265. IF: 3.667, Q1. Research lines 1 and 2.
- 7.- Corredor-Acosta, A., **C. E. Morales**, **S. Hormazábal**, I. Andrade, M. A. Correa-Ramirez. (2015) Phytoplankton phenology in the coastal upwelling region off central-southern Chile (35S–38S): Time-space variability, coupling to environmental factors, and sources of uncertainty in the estimates, *Journal of Geophysical Research: Oceans*, 120. IF: 3.667, Q1. Research line 2.
- 8.- Duarte C.; Navarro, J.M., Acuña, K.; Torres, R.; Manriquez, P.H.; Lardies, M.A.; **Vargas, C.A.**; Lagos, N.A. & Aguilera V. (2015) Intraspecific variability in the response of the edible mussel *Mytilus chilensis* (Hupe) to ocean acidification, *Estuaries & Coasts* 38: 590-598. IF: 2.863, Q1. Research line 3.
- 9.- González, C.E., **Escribano, R.**, Hidalgo, P. (2015) Intra-seasonal variation and its effects on copepod community structure off Central/southern Chile (2002-2009), *Hydrobiologia*, 758:61–74. IF: 2.321, Q1. Research line 1.
- 10.- Patil, S., Moeys, S., **von Dassow, P.**, Huysman, M. J. J., Mapleson, D., De Veylder, L., Sanges, R., Vyverman, W., Montresor, M., Ferrante, M. (2015) Identification of the meiotic toolkit in diatoms and exploration of meiosis-specific SPO11 and RAD51 homologs in the sexual species *Pseudonitzschia multiseries* and *Seminavis robusta*, *BMC Genomics*. 16:930. IF: 4.360, Q1. Research line 3.

11.- Pérez, C.A., DeGrandpre, M.D., Lagos, N.A., Saldías, G.S., Cascales, E.-K. & **Vargas, C.A.** (2015) Influence of climate and land use in carbon biogeochemistry in lower reaches of rivers in central southern Chile: Implications for the carbonate system in river-influenced rocky shore environments, *Journal of Geophysical Research, Biogeosciences* 120 (4): 673-692. IF: 3.667, Q1. Research lines 1, 2, 3.

12.- **Pizarro, O.**, Ramírez, N., Castillo, M., Cifuentes, U., Rojas, W., Pizarro-Koch, M. (2015) Underwater glider observations in the oxygen minimum zone off central Chile, *Bulletin of the American Meteorological Society*. IF: 10.667, Q1. Research line 1.

13.- Riquelme-Bugueño, R., Correa-Ramirez, M., **Escribano, R.**, Nuñez, S., **Hormazábal, S.** (2015) Mesoscale variability in the habitat of the Humboldt Current krill, spring 2007, *Journal of Geophysical Research: Oceans*, 120. IF: 3.667, Q1. Research line 1.

14.- Ruz, P., Hidalgo, P., Yáñez, S., **Escribano, R.**, Keister, J.E. (2015) Egg production and hatching success of Calanus chilensis and Acartia tonsa in the northern Chile upwelling zone (23°S), Humboldt Current System, *Journal of Marine Systems* Volume 148, Pages 200–212. IF: 3.112, Q1. Research lines 1 and 3.

15.- **Vargas, C.A.**; Aguilera, V.M.; San Martín, V.; Manríquez, P.H.; Navarro, J.M.; Duarte, C.; Torres, R.; Lardies, M.A. & Lagos, N.A. (2015) CO₂-Driven ocean acidification disrupts the filter feeding behavior in Chilean gastropod and bivalve species from different geographic localities, *Estuaries and Coasts*, Volume 38, Issue 4, pp 1163-1177. IF: 2.863, Q1. Research line 3.

16.- **Von Dassow, P.**, John, U., Ogata, H., Probert, I., Bendif, E.-M., Kegel, J. U., Audic, S., Wincker, P., Da Silva, C., Claverie, J.M., Doney, S., Glover, D. M., Mella Flores, D., Herrera, Y., Lescot, M., Garet-Delmas, M.-J., de Vargas, C. (2015) Life cycle modification in open oceans accounts for genome variability in a cosmopolitan phytoplankton, *ISME Journal* 9:1365-1377. IF: 9.438, Q1. Research lines 1 and 3.

3.1.2 Other researchers:

1.- Castro-González, M., **Fariás, L.** (2015) The influence of anoxia and substrate availability on N₂O cycling by denitrification in the upper boundary of the oxygen minimum zone off northern Chile, *Journal of Marine Research*, Volume 73, Number 6, pp. 185-205. IF: 1.562, Q2. Research lines 1, 2, 3.

2.- **Cornejo, M.**, **Murillo, A. A.**, **Fariás, L.** (2015) An unaccounted for N₂O sink in the surface water of the eastern subtropical South Pacific: Physical versus biological mechanisms, *Progress in Oceanography* Volume 137, Part A, Pages 12–23 IF: 4.512, Q1. Research lines 1 and 2.

3.- **Fariás, L.**, Besoain, V., García-Loyola, S. (2015) Presence of nitrous oxide hotspots in the coastal upwelling area off central Chile: an analysis of temporal variability based on ten years of a biogeochemical time series. *Environmental Research Letters* IF: 4.419, Q1. Research line 1.

4.- Oerder, V., Colas, F., Echevin, V., Codron, F., Tam, J., **Belmadani A.** (2015) Peru-Chile upwelling dynamics under climate change, *Journal of Geophysical Research: Oceans* IF: 3.667, Q1. Research line 2.

3.2.- SCIELO Publications or Similar to SCIELO Standard

3.2.1 Associate Researchers: No publications

3.2.2 Other researchers

1.- Oliveira, .M., Feliú, G., Palma, S., (2015), *Nemopsis mianzani n. sp. (Hydrozoa, Bougainvilliidae)*, a new hydromedusa from central Chile, *Zootaxa*, 3990 (2): 296–300

3.3.- Scientific Books and Chapters

3.3.1 Associate Researchers:

1.- **Escribano, R.**, Riquelme-Bugueño, R. (2015). Planktonic crustaceans: Lifestyles in the water column, in: Thiel, M., Watling, L., (Eds.) *Lifestyles and feeding biology. Book Series on the Natural History of Crustaceans*, Chapter 10, pp. 162-278, Oxford University Press, New York, USA.

3.3.2 Other researchers: No publications

3.4.- Other Publications:

3.4.1 Associate Researchers: No publications

3.4.2 Other researchers: No publications

3.5.- Collaborative publications:

Category of Publication	1 researcher		2 researchers		3 researchers		4 or more researchers	
	Nº	%	Nº	%	Nº	%	Nº	%
<i>ISI Publications or Similar to ISI Standard</i>	11	50%	7	32%	2	9%	0	0%
<i>SCIELO Publications or Similar to SCIELO Standard</i>	1	5%	0	0%	0	0%	0	0%
<i>Books and chapters</i>	0	0%	1	5%	0	0%	0	0%
<i>Other Publications</i>	0	0%	0	0%	0	0%	0	0%
Total of publications	12	55%	8	36%	2	9%	0	0%

8.4 Annex 4.- Organization of Scientific Events

Scope	Title (poner todo en inglés)	Type of Event	City	Country	Responsible Researcher
Internacional	1st Advance Course In Flow Cytometry	Other	Dichato	Chile	Peter von Dassow
Internacional	Course: Mixing Processes in the Ocean	Other	Valparaiso	Chile	Samuel Ernesto Hormazábal Fritz
Internacional	10 th Sesion of CLIVAR Pacific Panel	Other	Santiago	Chile	Wolfgang Schneider
Internacional	First Regional Latinamerican Ocean Acidification Network Workshop (Regional Red Latinoamericana de Acidificación del Océano, LAOCA Network)	Workshop	Concepción	Chile	Cristian Antonio Vargas Galvez
Internacional	4th Congress to Physical Oceanography, Meteorology and Weather	Other	Valparaiso	Chile	Samuel Ernesto Hormazábal Fritz
Nacional	1 st Workshop Carbonate system in the ocean and CO2SYS Management	Workshop	Concepción	Chile	Cristian Antonio Vargas Galvez
Nacional	Multidisciplinary Workshop about Mesoscale Processes in South Eastern Pacific Ocean	Workshop	Concepción	Chile	Ali Reda Bel Madani
Nacional	Trace metal redox cycling in the ocean under aerobic and anaerobic conditions, reactive oxygen species and why we are interested in kinetic	Conference	Concepción	Chile	Osvaldo Iván Ulloa Quijada
Nacional	2 nd Workshop Carbonate system in the ocean and Parameter Estimation using CO2SYS	Workshop	Santiago	Chile	Cristian Antonio Vargas Galvez
Nacional	Marine Polymer Dynamics	Conference	Concepción	Chile	Osvaldo Iván Ulloa Quijada
Nacional	A modeling approach to understand the links environment / productivity / resource	Conference	Concepción	Chile	Samuel Ernesto Hormazábal Fritz
Nacional	Charting microbial community metabolism along ecothermodynamic gradients in the oxygen-starved ocean	Conference	Concepción	Chile	Osvaldo Iván Ulloa Quijada
Nacional	From Estuary to Upwelling, planktonic life history regarding ocean acidification	Conference	Concepción	Chile	Cristian Antonio Vargas Galvez
Nacional	Advancing our understanding of the deep ocean in the 21st Century: From science to technology	Conferencia	Concepción	Chile	Heraclio Rubén Escribano Veloso

8.5 Annex 5.- Education and capacity building

5.1 Capacity Building inside MSI Centers

MSI RESEARCHER	NUMBER												TOTAL NUMBER PER MSI RESEARCHER		
	Undergraduate students			Graduate students			Postdoctoral researchers								
	F	M	T	F	M	T	F	M	T	F	M	T	F	M	T
S. Hormazábal	0	0	0	1	2	3	0	0	0	1	1	2	2	3	5
R. Escribano	1	0	1	1	0	1	2	0	2	1	1	2	5	1	6
O. Pizarro	1	0	1	0	1	1	0	1	1	0	0	0	1	2	3
O. Ulloa	0	0	0	0	0	0	0	1	1	0	4	4	0	5	5
C. Morales	0	0	0	0	0	0	3	0	3	1	0	1	4	0	4
W. Schneider	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
P. Von Dassow	0	0	0	0	0	0	0	1	1	0	1	1	0	2	2
C.Vargas	0	0	0	1	0	1	0	0	0	2	0	2	3	0	3
M. Cornejo / S. Hormazabal	2	0	2	1	0	1	0	0	0	0	0	0	3	0	3
M. Oliva/ R.Escribano	1	0	1	0	1	1	0	0	0	0	0	0	1	1	2
L. Farías / C. Morales	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
P.Hidalgo/V.Aguilar/R.Escribano	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
R.Escribano/O.Ulloa/P.V.Dassow	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
L. Farías / C.Vargas	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
P.Hidalgo / R.Escribano	1	0	1	2	1	3	2	1	3	0	0	0	5	2	7
P.Hidalgo/O.Pizarro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C.Parada/O.Pizarro	1	2	3	0	0	0	0	0	0	0	0	0	1	2	3
S.Hormazabal/C.Morales	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
O.Ulloa/P.V.Dassow	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1
P.Hidalgo/O.Ulloa	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1
P.Von Dassow/S.Hormazabal	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Total	10	2	12	6	8	14	9	5	14	5	7	12	30	22	52

Annex 5.2. - Short-term Traineeships of MSI students

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Carolina P. Burgos Barra	University of Antofagasta	Chile	Marcelo Oliva	Training on parasites samples preparation for taxonomic and molecular analysis	08-11-2014	16-01-2015
Sonia Yañez	Virginia University	USA	David Elliot	Development of dynamics models of population on estimates of mortality in marine planktonic organisms	15-01-2015	20-02-2015
July A. Corredor Acosta	Universidad Autónoma de Baja California	México	Adriana Gonzalez Silvera	Training on Phytoplankton bio-optical variability, application to the study of coastal systems	16-01-2015	06-02-2015
Valentina P. Valdes Castro	Mediterranean Institute of Oceanography	France	Francoise Carlotti - Mark Pagano	On board a research cruise (OUTPACE): zooplankton and isotope analysis to understand the role of microbes in N and P cycling in the ocean	10-02-2015	18-04-2015
Valentina P. Valdes Castro	Banyuls Oceanographic Observatory	France	Pierre Galand	Training on massive environmental DNA samples sequencing and analysis	19-04-2015	10-06-2015
Alejandro Murillo	Biological station of Roscoff	France	Jonas Collén	Training on marine ecological & evolutionary genomics: population genomics, environmental genomics & comparative genomics	21-05-2015	12-06-2015
Matías B. Pizarro Koch	Instituto Geofísico del Perú (IGP)	Peru	Ivonne Montes	Preparation of scientific paper on the role of the Peru-Chile Undercurrent on seasonal variability of the southern tip of the oxygen minimum zone (30°-38°S): a modeling study	22-06-2015	27-06-2015
Montserrat G. Aldunate Chinchon	Universidad de Princeton	USA	Bess Ward	Study of nitrogen alternative metabolites used by picocyanobacteria inhabitants of anoxic marine zones	30-09-2015	16-10-2015
Paula Mariela Ruz Moreno	Spanish Institute of Oceanography	Spain	Lidia Yebra Mora	Biochemical techniques to study growth rates and metabolism of marine zooplankton	01-10-2015	01-11-2015
Diana Johanna Medellín Mora	Plymouth Marine Laboratory (PML)	England	Angus Atkinson	Marine zooplankton ecology; preparation of scientific paper	11-11-2015	15-12-2015
Belén Anais Franco Cisterna	Banyuls Oceanographic Observatory	Francia	Yves Bouget	Bioinformatics' tools, molecular diversity and evolution	15-11-2015	15-12-2015
Sonia Yañez	Pontifical Catholic University of Chile	Chile	Paul A. Bukaveckas	Marine Microbiology Laboratory: analysis of samples of marine planktonic organisms	15-10-2015	15-11-2015
Anahí Brun ¹	Buenos Aires University	Argentina	O. Pizarro	Studies on the transoceanic flow in southern Patagonia	18-05-2015	18-08-2015
Grazia Quero ¹	Institute of Marine Sciences, National research council	Italy	O.Ulloa	Fundamental steps and bioinformatics tools for the analysis of metagenomics and metatranscriptomic sequence data.	05-10-2015	17-10-2015
Ester Velasco ¹	Cadiz University	Spain	P. Von Dassow	Optimum temperature for different genotypes of coccolithophorids	01-04-2015	01-06-2015

Student name	Institution	Country	Advisor	Project Description	Starting Date [dd/mm/yy]	Ending Date [dd/mm/yy]
Patricia de la Fuente ¹	Cadiz University	Spain	S. Hormazábal	Chromophoric dissolved matter in the seamountns of the Juan Fernandez Ridge	01-06-2015	31-07-2015

¹ : Foreign Students coming to IMO in the context of collaboration/networking; Country of origin is detailed.

8.6 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	Researchers	Postdocs/ Students		
Red Pop	LA	1				Museums and centers of Latin American.	
MBARI – IMO collaboration	I	1				IMO - MBARI (Monterey Bay Aquarium Research Institute)	
ANTARES	I	3	4/8	75		Bedford Institute of Oceanography (Canada) Dalhousie University (Canada) DIMAR (Colombia) La Salle fundation (Venezuela) IMARS (USA) IAFE (Argentina) INIDEP (Argentina) INPE (Peru) INOCAR (Ecuador) IOUSP (Brazil)	

Network Name	Network Scope	Network Participants [Number]				Institutions	
		From the Center		External			
		Researchers	Postdocs/ Students	Researchers	Postdocs/ Students		
						SIO (USA) UABC (Mexico) USB (Venezuela) CONABIO (Mexico) IMARPE (Peru) CIOH (Colombia)	
IAI CRN 3094	I	2	1/4	10		FUNDEP (Brasil) USP (Brasil) UBA (Argentina) INIDEP (Argentina) IAFE (Argentina) UABC (Mexico) CONABIO (Mexico) EDIMAR (Venezuela) IMARPE (Perú) INOCAR (Ecuador)	

Network Name	Network Scope	Network Participants [Number]				Institutions	
		From the Center		External			
		Researchers	Postdocs/ Students	Researchers	Postdocs/ Students		
HUB APTA (Andes Pacific Technology Access)	N	8		9		Catholic University of the North, University of Antofagasta. University Federico Santa María 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/Students		
Teachers Network	National Scholar teachers		8			MACI (Itinerant Scientific Audiovisual Show), conferences and workshops, 14	
Collaboration network with Interactive Center of Sciences, Arts and Technologies (CICAT).	CICAT		6	1		Conferences and workshops, 8	
Multi-institutional network of PAR Explora Biobio	PAR Explora Biobio		5	1		Co-funding projects, 2	
Popularization of science and technology in Latin America and the Caribbean	RedPOP	1	8	3		Seminar: Four looks of Science Outreach, 1	
GIRS (Interest Group in Underwater Robotics)	University of Concepción	4		3	6	Protptype	

8.7 Annex 7. - Outreach

7.1. - Outreach activities throughout the period

Event Title	Type of Event	Scope	Target Audience	Date	Country	Region	Nº of Student from the Center	Nº of Attendees	Duration in days	Participating Researchers	Responsible for the activity
Day of Oceanography	Other	National	Secondary students	07-01-15	Chile	Bío Bío		150	1		Pablo Rosenblatt
IMOVA! Workshop: Knowing the Ocean	Workshop	National	Secondary students	28-01-15	Chile	Bío Bío	0	20	1		Bárbara Léniz
Month of the Sea in CICAT	Workshop	National	Secondary students Primary students General Community	13-05-15	Chile	Bío Bío		100	1		Bárbara Léniz
Microbial World ¿How do we study microorganisms in the ocean?	Conference	National	Secondary students	14-05-15	Chile	Bío Bío		50	1		Bárbara Léniz
Marine Science Day	Other	National	Secondary students	20-05-15	Chile	Bío Bío	2	120	1		Bárbara Léniz
Cultural Heritage Day CICAT	Workshop	National	General Community	31-05-15	Chile	Bío Bío	1	150	1		Bárbara Léniz
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Secondary students Primary students	04-06-15	Chile	Bío Bío	4	240	1		Bárbara Léniz
Month of the Environment	Conference	National	General Community Secondary students Primary students	08-06-15	Chile	Bío Bío		30	1		Bárbara Léniz
I Fair Investiga + Comparte REDOC	Exhibition	National	Undergraduate students	16-06-15	Chile	Bío Bío		500	1		Bárbara Léniz
I Seminar of Environmental Science	Seminar	National	Secondary students	24-06-15	Chile	Bío Bío	1	150	1		Paulina Aguayo
Month of the Sea in CICAT	Exhibition	National	Primary students Secondary students General Community	26-06-15	Chile	Bío Bío	1	60	1		Bárbara Léniz
Month of the environment Conference	Conference	National	Primary students Secondary students General Community	26-06-15	Chile	Bío Bío		50	1		Bárbara Léniz
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Primary students Secondary students	05-08-15	Chile	Bío Bío	3	310	1		Rommy Soto

Event Title	Type of Event	Scope	Target Audience	Date	Country	Region	Nº of Student from the Center	Nº of Attendees	Duration in days	Participating Researchers	Responsible for the activity
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Primary students Secondary students	12-08-15	Chile	Bío Bío	3	225	1		Rommy Soto
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Primary students Secondary students	18-08-15	Chile	Bío Bío	3	280	1		Rommy Soto
Integrated Science Seminar	Seminar	National	General Community	21-08-15	Chile	Metropolitan		550	1		Tamara Luna
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Primary students Secondary students	09-09-15	Chile	Bío Bío	3	114	1		Rommy Soto
Training for Our Ocean	Other	National	Undergraduate students	14-09-15	Chile	Bío Bío		28	1		Gadiel Alarcón
Trash Scientific	Other	National	Primary students	02-10-15	Chile	Bío Bío		35	1		Rommy Soto
Scientific Camp Our Ocean	Other	National	Secondary Students Primary students	04-10-15	Chile	Valparaíso	0	28	1	Osvaldo Iván Ulloa Quijada.	Osvaldo Ulloa
Family Science Day	Exhibition	National	General Community	04-10-15	Chile	Bío Bío		250	1		Rommy Soto
Delegacy of Rapa Nui	Other	National	General Community	09-10-16	Chile	Bío Bío	0	4	1		Rommy Soto
PME Launching	Conference	National	General Community	13-10-15	Chile	Bío Bío	5	50	1	Pablo Rosenblatt Guelfenbein.	Pablo Rosenblatt
PME's dissemination in EXPLORA Congress	Exhibition	National	Secondary students Primary students General Community	19-10-15	Chile	Bío Bío	0	250	2		Rommy Soto
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Secondary students Primary students	21-10-15	Chile	Bío Bío	5	225	1		Rommy Soto
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Secondary students Primary students	27-10-15	Chile	Bío Bío	3	297	1		Rommy Soto
Itinerant Scientific Audiovisual Show (MACI)	Exhibition	National	Secondary students Primary students	18-11-15	Chile	Bío Bío	3	945	1		Rommy Soto

7.2. - Products of outreach

Name of Product	Product Objetive	Target Public	Type of Product"	Scope
www.sumergete.cl	A journey through the Pacific Ocean. This web site aim to give information about marine sciences, its organisms, and human impacts on different environments. Using for this, videos, illustrations, animations and audio files.	High school students. Primary students	Web Design	National
MACI (Itinerant Scientific Audiovisual Show).	Aim to show the ocean and its characteristics, the importance for our country and the global impact, to children with a language close to the school community. It consists of an exhibition of audiovisual products, accompanied by practical and playful work with children, to reinforce the learning.	High school students. Primary students	Audiovisual show	National
"Zooplankton, centinelas del Cambio climático" (Zooplankton, sentinels of climate change) chapter of "The Force of the Sea"	New chapter of the Documental series "The Force of the Sea", which focuses on the study of our research associate, Ruben Escribano, about zooplankton.	General Community	TV Series	National

7.3.- Articles and Interviews

Type of media and scope	Local/Regional		National		International		TOTAL
	Nº Interviews	Nº Articles	Nº Interviews	Nº Articles	Nº Interviews	Nº Articles	
Written			0	11	0	6	17
Internet			2	10	3	23	38
Audiovisual			1	0	1	0	2
TOTAL			3	21	4	29	

8.8 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
To prepare a R&D Project to apply to Government R&D Funds by CORFO	Make an Instrument with new capabilities for Oceanography and Limnology	Project defined. Aplication Form being prepared	2	4	Sea Horse Ltda.	Concepción, Biobio, Chile	1	Oceanographic and Atmosferic Data & Services

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

9. Financial Status

9.1 Total incomes:

Funds	Accumulated incomes to last year [\$]	2015 Incomes		Total incomes to 2015 [\$]
		Amount [\$]	Percentage of resources used by the Center [%]	
MSI	909.821.000	840.000.000	100	840.000.000
PME(MSI)	0	28.999.862	100	28.999.862
Beca Magister PUCV	2.000.000	2.200.000	100	2.200.000
Beca Magister PUCV	2.000.000	2.200.000	100	2.200.000
Beca Magister PUCV	0	2.200.000	100	2.200.000
Beca Magister PUCV	0	2.200.000	100	2.200.000
Beca Magister PUCV	0	1.100.000	100	1.100.000
CIMAR21-Fisica	0	6.450.000	100	6.450.000
CIMAR21-Zooplancton	0	9.540.000	100	9.540.000
CIMAR21-Fitoplancton	0	9.200.000	100	9.200.000
FONDECYT 1130511	37.689.600	55.420.000	75	41.565.000
FONDECYT 1130784	47.154.400	58.922.000	75	44.191.500
FONDECYT 1151299	0	59.000.000	75	44.250.000
FONDECYT 1130254	39.000.000	58.000.000	75	43.500.000
FONDECYT 1141106	47.680.000	59.600.000	75	44.700.000
FIP 2014-042	11.250.000	75.000.000	50	37.500.000
Agouron Inst.	0	177.905.959	50	88.952.980
CONICYT USA 20120014	37.500.000	50.000.000	30	15.000.000
EXPLORA ED 190157	0	29.973.320	12	3.700.000
NÚCLEO MILENIO NC 120086	30.223.600	219.000.000	10	21.900.000
FONDECYT 3160611	0	74.094.000	5	3.700.000
FONDECYT 3160665	0	74.094.000	5	3.700.000
Moore Fund.	0	116.273.720	2	2.325.000
FONDECYT 11150914	0	34.800.000	0	0
TOTAL	1.164.318.600	2.046.172.861		1.299.074.342

9.2 Outcome structure

ITEM	Accumulated expenses to last year [\$]	2015 Expenses [\$]				Total expenses to 2015 [\$]	%
		Operative	Networking	Outreach	Total		
Honoraria Researchers	113.190.002	213.851.170	0	0	213.851.170	327.041.172	21.85
Honoraria students and other personnel	99.634.278	162.478.610	0	10.556.769	173.035.379	272.669.657	18.21
Tickets and travel expenses	57.469.151	79.829.071	0	3.530.229	83.359.300	140.828.451	9.41
Materials/supplies	67.883.593	169.057.476	0	3.315.901	172.373.377	240.256.970	16.05
Goods and equipment	177.098.323	91.823.579	0	3.422.985	95.246.564	272.344.887	18.20
Infrastructure	477.239	5.843.299	0	0	5.843.299	6.320.538	0.42
Administrative expenses	59.387.630	38.666.777	0	0	38.666.777	98.054.407	6.55
Publications and subscriptions	3.232.446	13.403.022	0	0	13.403.022	16.635.468	1.11
Consultancies	13.969.666	15.600.987	0	7.479.659	23.080.646	37.050.312	2.47
Overhead	24.900.000	25.200.000	0	0	25.200.000	50.100.000	3.35
Insurance costs	16.422.625	16.910.925	0	693.556	17.604.481	34.027.106	2.27
Legal personality expenses	1.700.000	0	0	0	0	1.700.000	0.11
Others	0	0	0	0	0	0	0.00
Total Expenses (\$)	635.364.953	832.664.916	0	28.999.099	861.664.015	1.497.028.968	

9.3 Financial accounting

ITEM	2015[\$]				TOTAL TO 2015
	Operative	Networking	Outreach	Total [\$]	
Income	840.000.000	0	28.999.862	868.999.862	1.778.820.862
Outcome	832.664.916	0	28.999.099	861.664.015	1.497.028.968
Annual balance	7.335.084	0	763	7.335.847	Total balance 281.791.894

9.4 Researcher Exchange

Researchers from the center going abroad

Researcher type	Name	Type of activity	Duration	Country he traveled	Funding (Millennium / External / Mixed)
Associated Research	Oscar R. Pizarro	Workshop. Inter American Institute for Global Change Research (IAI)	3 days	Argentina	External
Associated Research	Cristian Vargas	Staying at University of Palermo	7 days	Italy	Mixed
Associated Research	Carmen Morales	Work with Dr. María A. Peña, Institute of Ocean Sciences (IOS), British Columbia	12 days	Canada	Mixed
Associated Research	H. Rubén Escribano	Conferences, Researches and Postgraduates Students meetings in Center of Marine Inv. (CICIMAR) Int. Politécnico from México.	11 days	Mexico	Mixed
Associated Research	H. Rubén Escribano	University of California: Seminars, Conference, Scientific meeting, Labs visit.	6 days	USA	Mixed
Associated Research	H. Rubén Escribano	Middle East Technological University, CLIVAR focus upweling meeting	6 days	Turkey	Mixed
Adjunt Research	Pamela Hidalgo	IMARPE: International meeting COP 20	5 days	Peru	Mixed
Adjunt Research	Pamela Hidalgo	International congress COLACMAR	8 days	Colombia	Mixed
Adjunt Research	Pamela Hidalgo	Conferences, Researches and Postgraduates Students meetings in Center of Marine Inv. (CICIMAR) Int. Politécnico from México.	11 days	Mexico	Mixed
Associated Research	Wolfgang Schneider	Federal do Rio Grande del Sur [FURG] University, Oceanic turbulence Course	10 days	Brasil	Mixed
Associated Research	Wolfgang Schneider	SENALMAR, International congress COLACMAR	8 days	Mexico	Mixed
Associated Research	Osvaldo Ulloa	Binational Meeting of Austral Scientific Marine Inv.	2 days	Argentina	Mixed
Associated Research	Osvaldo Ulloa	Guest Professor at "2nd African Research Discovery Camp"	24 days	Namibia	Millenium
Associated Research	Osvaldo Ulloa	Mt. Holyoke College , Boston: Guest speaker at the Meeting: "Applied & Environmental Microbiology"	4 days	USA	Mixed
Associated Research	Osvaldo Ulloa	Leibniz Institute for Baltic Sea Research Warnermunde (IOW) Guest speaker at SCOR Working Group 144: "Microbial Community Responses to Ocean Deoxygenation"	9 days	Alemania	Mixed
Associated Research	Samuel Hormazábal	Universidad de Buenos Aires: Conference and Member of International Jury to define position in Universidad de Buenos Aires	6 days	Argentina	External
Associated Research	Samuel Hormazábal	IMO-GESAMP Workshop: Guest speaker	2 days	Peru	External

Researchers from abroad coming to the Center

Researcher name	Nationality	Type of activity	Duration	Country from traveling	Funding (Millennium / External / Mixed)
Gerrit Van den Eng	Dutch	Researcher/teacher in Flow Cytometry Advanced Workshop	15 days	USA	Mixed
Angel Rodriguez Santana	Spanish	Teacher in International postgraduate course of ocean mixing processes. Workshop for the use of microstructure's profiler probe of water column (TURBO MAP), designed to study oceanic mixing processes. - Participation in the first measurement campaign of STOV	20 days	Spain	Mixed
Angel Rodriguez Santana	Spanish	- Teacher in ocean mixing processes whorkshop - Training in water column micro-structure data's processing and analysis, obtained in campaigns off Chile. - Participation in the IV Congress of Physical Oceanography Meteorology and Climate in the Southeast Pacific.	11 days	Spain	Mixed