SC 12 – WP 10

SALAS Y GOMEZ AND NAZCA TASK TEAM

Terms of Reference and Workplan

SUMMARY

At its 2024 annual meeting, the Commission adopted Decision 17-2024 that tasked the Scientific Committee (SC) to include Salas y Gómez and Nazca Ridges as an agenda item for its meeting in 2024 and annually thereafter. Within this agenda item, the SC — taking into consideration its priorities and available resources during its first year — will compile and review all relevant scientific information and data about the area and recommend possible measures to the Commission at its following regular meeting , based on an ecosystem-based approach that aims at preserving its biodiversity and SPRFMO fishing resources as well as a sustainable use of marine resources.

For the consideration of the SC 12 Chile presented the SC12 Doc 36: Salas y Gómez and Nazca ridges: the need for protection, with a minimum impact on fisheries, which "recommends that the area located in ABNJ of the Salas y Gómez and Nazca EBSA should be permanently closed to fishing activities regulated by the SPRFMO as soon as possible", This recommendation was not agreed by the Scientific Committee.

Peru presented the SC12 - Doc 37 Nazca Ridge Report: Geology, Chemistry and Biophysical Coupling components, which states that the Easter-Salas y Gomez Seamount Chain (ESC) and Nazca Ridge are separate units or systems with important differences in their history, geology, oceanography, hydrodynamic features, structure and function; in that sense, the degree of dependence on matter and energy between the surface and the seabed (benthic-pelagic coupling) could be different between both systems. Finally, it recommends greater scientific research effort in order to achieve a better understanding of key processes, such as, the carbon export in relation to the pelagic fishery.

Finally, the creation of a Task Team for SGN was proposed and supported by some CNCPs. In this regard, the Salas y Gomez and Nazca Ridges Task Team will produce a report for presentation to SC13 in 2025 that
1) complements the information presented to the SC12 that reviews and summarizes relevant scientific information relating to the Salas y Gomez and Nazca Ridges (here after called "area").
2) includes the characterisation geological, oceanographic, biogeochemical (including carbon exportation), biodiversity, ecology, cultural, connectivity, bentho-pelagic coupling and conservation information of the area.
3) includes the current status of SPRFMO's benthic and pelagic resources fished within the area, as well as possible threats to those resources;
4) assesses the current level of fishing effort by gear including 2024 fishing activities and its possible impacts within the area;
5) considers the current possible level of impact of the other threats identified previously in the SC12-Doc 36;
6) Present to the SC possibles measures based on the ecosystem approach that aims at preserving the biodiversity in the Salas y Gomez and Nazca Ridges and SPRFMO fishing resources, as well as sustainable marine resources and provide possible actions for the SC to consider; and
7) propose a monitoring and evaluation scheme for future work.

1. Introduction

At its 2024 annual meeting, the Commission adopted Decision 17-2024 that tasked the Scientific Committee (SC) to include Salas y Gomez and Nazca Ridges as an agenda item for its meeting in 2024 and annually thereafter. [1] Within this agenda item, the SC — taking into consideration its priorities and available resources during its first year — will compile and review all relevant scientific information and data about the area and recommend possible measures to the Commission at its following regular meeting, based on an ecosystem-based approach that aims at preserving its biodiversity and SPRFMO fishing resources as well as a sustainable use of marine resources.

In addition, the 2025 multiannual work plan of the SC considers the Salas y Gomez and Nazca Ridges as a cross-cutting task, defining the following subtasks; 1) research cruises aimed to know the biooceanographic and meteorologic characteristics of Salas y Gomez ridge; as well as biodiversity, current circulation, morphology and geology of sea bottom for 2023 – 2024; 2) Climate change impacts of fisheries in Salas y Gomez and Nazca Ridges for 2024 and, 3) expedition to Salas y Gomez and Nazca aboard oceanographic research vessel for 2024-2025.

In line with that tasking and to support the effective and efficient preparation of scientific advice for the Commission, the SC agrees to create a Salas y Gómez and Nazca Ridges Task Team with these terms of reference.

2. Terms of Reference

a. Objective

The objective of the Task Team, in line with Decision 17-2024, shall be to review relevant scientific information and data about the area (including the papers in References), as well as other relevant information provided by members and observers, and to provide advice to the SC possible measures based on the ecosystem approach that aims at preserving the biodiversity in the Salas y Gomez and Nazca Ridges and SPRFMO fishing resources, as well as sustainable marine resources

All activities carried out by the Task Team will refer to the Area of Application of the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean, as specified in its Article 5.

b. Structure

The Task Team is open to all interested Members, CNCPs and observers who may nominate one or more suitably qualified representatives to the Secretariat before 15 November 2024.

Ideally, all meetings should allow the virtual participation so as not to unfairly discriminate against small delegations with limited ability to travel. In addition, the meeting calendar of this Task team shall consider the overlap with other RFMOs meeting dates to avoid clashes with SIOFA and WCPFC meetings , or any other relevant RFMOs.

c. Responsibilities

- 1) complements the information presented to the SC12 that reviews and summarizes relevant scientific information relating to the Salas y Gomez and Nazca Ridges (here after called “area”).

- 2) includes the characterisation geological, oceanographic, biogeochemical (including carbon exportation), biodiversity, ecology, cultural, connectivity, bentho-pelagic coupling and conservation information of the area.
- 3) includes the current status of SPRFMO's benthic and pelagic resources fished within the area, as well as possible threats to those resources;
- 4) assesses the current level of fishing effort by gear including 2024 fishing activities and its possible impacts within the area;
- 5) considers the current possible level of impact of the other threats identified previously in the SC12- Doc 36;
- 6) Present to the SC possibles measures based on the ecosystem approach that aims at preserving the biodiversity in the Salas y Gomez and Nazca Ridges and SPRFMO fishing resources, as well as sustainable marine resources and provide possible actions for the SC to consider; and
- 7) propose a monitoring and evaluation scheme for future work.
- Produce a report for presentation to SC13 in 2025.
- Propose a monitoring and evaluation scheme for any actions listed.
- Submits a report to the Secretariat and the SC Chair to be discussed in the 2025 SC meeting.
- Creates an open repository of the documentation reviewed for the SC members.

Workplan

The activities of the Task Team will require several meetings, but endeavours to virtually meet at least twice a year and if cost effective, also include an in-person workshop before the following 2025 SC meeting.

Activity	Date	Objective
Virtual meeting	November 2024 (last week)	Agreed the procedural aspect of the work of the Task Team and agreed the matters and topics for the workshop.
In person workshop*	TBC at the first task team meeting	Address the relevant scientific information relating to the Salas y Gomez and Nazca Ridges.
Virtual meeting	August 2025	Work on the results and recommendations.
In person meeting	Sept/Oct. 2025 (in the margins of SC-13)	Agreed the final document including the recommendations.

* Chile and the Center for Ecology and Sustainable Management of Oceanic Islands (ESMOI) are available to organize the in-person workshop and finance all arrangements including the participation of one representative from each Member. To maximise participation and reduce travel and SPRFMOs carbon footprint it is preferable for this meeting be held just prior to, or after to SPRFMO COMM13.

The dates will be confirmed at the first task team meeting.

1. References (to be made a WP)

Boteler, Ben, Daniel Wagner, Carole Durussel, Emily Stokes, Carlos F Gaymer, Alan M Friedlander, Daniel C Dunn, Felipe Paredes Vargas, David Véliz, and Carolina Hazin. "Borderless Conservation:

Integrating Connectivity into High Seas Conservation Efforts for the Salas Y Gómez and Nazca Ridges." Frontiers in Marine Science 9 (October 11, 2022). https://doi.org/10.3389/fmars.2022.915983.

Chavez-Molina, Vasco, Daniel Wagner, Emily S. Nocito, Michelle Benedum, Carlos F. Gaymer, Duncan Currie, Emily Golden Beam, and Cassandra M. Brooks. "Protecting the Salas Y Gomez and Nazca Ridges: A Review of Policy Pathways for Creating Conservation Measures in the International Waters of the Southeast Pacific." Marine Policy 152, no. 105594 (n.d.). https://doi.org/10.1016/j.marpol.2023.105594.

Horacek III, H. Joseph, Eulogio H. Soto, Eduardo Quiroga, and Jeroen Ingels. "Meiofaunal Nematode Abundance, Composition, and Diversity at Bathyal to Hadal Depths in the Southeast Pacific Ocean." Deep Sea Research Part I: Oceanographic Research Papers 188, no. 103837 (October 2022): 103837. https://doi.org/10.1016/j.dsr.2022.103837.

Friedlander, Alan M., Enric Ballesteros, Jim Beets, Eric Berkenpas, Carlos F. Gaymer, Matthias Gorny, and Enric Sala. 2013. "Effects of Isolation and Fishing on the Marine Ecosystems of Easter Island and Salas Y Gómez, Chile." Aquatic Conservation: Marine and Freshwater Ecosystems 23 (4): 515–31. https://doi.org/10.1002/aqc.2333.

Friedlander, A. M., Ballesteros, E., Caselle, J. E., Gaymer, C. F., Palma, A. T., Petit, I., Varas, E., Muñoz Wilson, A., & Sala, E. (2016). Marine biodiversity in Juan Fernández and Desventuradas Islands, Chile: Global endemism hotspots. PloS One, 11(1), e0145059. https://doi.org/10.1371/journal.pone.0145059

Friedlander, Alan M., Whitney Goodell, Jonatha Giddens, Erin E. Easton, and Daniel Wagner. "Deep-Sea Biodiversity at the Extremes of the Salas Y Gómez and Nazca Ridges with Implications for Conservation." PLoS ONE 16, no. 6 (June 30, 2021): 1–27. https://doi.org/10.1371/journal.pone.0253213.

Gaymer, Carlos F., Wagner, D., Álvarez-Varas, R., Bravo L., Dewitte B., Easton E., Hormazábal S., Hucke-Gaete R., Friedlander AM., Gorny M., Luna-Jorquera G., Ramos M., Rodrigo C. Sellanes J., Soto E., Thiel M., Véliz D (2022). Paper on the importance of the Salas y Gómez and Nazca ridges. 10th Meeting of the scientific committee SC10-Doc30. SPRFMO

Gaymer, CF, Ramajo, L, Arthur, J, Aburto, J, González, J, Dewitte, B, Edmunds, T, Borquez, G, Bravo, L, Rivadeneira, M, Huke, H, Almendra, I, Isola E, Carrasco-Hotus, E, Huke, T, Barraza, J, Edmunds, L, Figueroa, V, Gundermann, H. (2024b). Diagnóstico del Riesgo Climático de Rapa Nui: Co-diseño de medidas de adaptación al cambio climático para el patrimonio costero, la pesca y el turismo. Informe final proyecto "Impactos, vulnerabilidad y capacidad de adaptación al cambio climático en Rapa Nui: hacia la identificación de fuentes de resiliencia a través de metodologías colaborativas". Iniciativa Sobre Impactos Climáticos en los Océanos - Chile de Fundación David & Lucile Packard.

McDonald, Gavin, Jennifer Bone, Christopher Costello, Gabriel Englander, and Jennifer Raynor. "Global Expansion of Marine Protected Areas and the Redistribution of Fishing Effort." Proceedings of the National Academy of Sciences 121, no. 29 (July 9, 2024). https://doi.org/10.1073/pnas.2400592121

Mecho, A., Dewitte, B., Sellanes, J., van Gennip, S., Easton, E. E., & Gusmao, J. B. (2021). Environmental drivers of mesophotic echinoderm assemblages of the southeastern Pacific Ocean. Frontiers in marine science, 8. https://doi.org/10.3389/fmars.2021.574780

Mecho, Ariadna, Javier Sellanes, and Jacopo Aguzzi. 2021. "Seafloor Litter at Oceanic Islands and Seamounts of the Southeastern Pacific." Marine Pollution Bulletin 170 (September): 112641. https://doi.org/10.1016/j.marpolbul.2021.112641.

Tapia-Guerra, J. M., Mecho, A., Easton, E. E., Gallardo, M. de L. Á., Gorny, M., & Sellanes, J. (2021). First description of deep benthic habitats and communities of oceanic islands and seamounts of the Nazca Desventuradas Marine Park, Chile. Scientific Reports, 11(1), 6209. https://doi.org/10.1038/s41598-021-85516-8

Wagner, Daniel, Liesbeth Van der Meer, Matthias Gorny, Javier Sellanes, Carlos F. Gaymer, Eulogio H. Soto, Erin E. Easton, et al. "The Salas Y Gómez and Nazca Ridges: A Review of the Importance, Opportunities and Challenges for Protecting a Global Diversity Hotspot on the High Seas." Marine Policy 126, no. 104377 (April 2021). https://doi.org/10.1016/j.marpol.2020.104377.

Wagner, Daniel, Liesbeth Van der Meer, Javier Sellanes, Carlos Gaymer, Eulogio Soto, Erin Easton, Alan Friedlander, et al. 2020. "The Salas Y Gómez and Nazca Ridges: A Global Diversity Hotspot in Need of Protection." https://www.coralreefshighseas.org/s/2020-8-SPRFMO-proposal-on-Salas-y-Gomez-Nazca-Ridges.pdf.

Wright, Glen, Jeff Ardron, Kristina Gjerde, Duncan Currie, and Julien Rochette. 2015. "Advancing Marine Biodiversity Protection through Regional Fisheries Management: A Review of Bottom Fisheries Closures in Areas beyond National Jurisdiction." Marine Policy 61 (November): 134–48. https://doi.org/10.1016/j.marpol.2015.06.030.

SC12-Doc37 NAZCA RIDGE REPORT GEOLOGY, CHEMISTRY AND BIOPHYSICAL COUPLING COMPONENTS

Geology

Calvès G, Mix A, Giosan L, Clift PD, Brusset S, Baby P, and Vega M (2022) The Nazca Drift System – palaeoceanographic significance of a giant sleeping on the SE Pacific Ocean floor. Geological Magazine 159: 322–336. https://doi.org/10.1017/S0016756821000960

Clift PD, Pecher I, Kukowski N and Hampel A (2003) Tectonic erosion of the Peruvian forearc, Lima Basin, by subduction and Nazca Ridge collision. Tectonics 22, 1023. doi: 10.1029/2002TC001386.

Espurt N, Baby P, Brusset S, Roddaz M, Hermoza W, Regard V, Antoine PO, Salas-Gismondi R and Bolanos R ˜ (2007) How does the Nazca Ridge subduction influence the modern Amazonian foreland basin? Geology 35, 515–18. doi: 10.1130/G23237A.1.

Fletcher, M., and Wyman, D., 2024, The missing ridge Enigma: A new model for the Tuamotu Plateau conjugate and Peruvian flat slab: Geosphere, v. 19, no. X, p. 1–10, https://doi.org/10.1130/GES02679.1

Hampel A (2002) The migration history of the Nazca Ridge along the Peruvian active margin: a re-evaluation. Earth and Planetary Science Letters 203, 665–79. doi: 10.1016/S0012-821X(02)00859-2.

Hampel A, Kukowski N, Bialas J, Huebscher C and Heinbockel R (2004) Ridge subduction at an erosive margin: the collision zone of the Nazca Ridge in southern Peru. Journal of Geophysical Research: Solid Earth 109, B02101. doi: 10.1029/2003JB002593.

Harris PT, Macmillan-Lawler M, Rupp J and Baker EK (2014). Geomorphology of the oceans. Marine Geology 352, 4–24. doi: 10.1016/j.margeo.2014.01.011.

IHO (2007). The twentieth meeting of the GEBCO Sub-Committee on Undersea Feature Names (SCUFN). Intergovernmental Oceanographic Commission (of UNESCO). International Hydrographic Bureau. Monaco. 9-12 July 2007. Final Report.

Kukowski N, Hampel A, Hoth S and Bialas J (2008) Morphotectonic and morphometric analysis of the Nazca plate and the adjacent offshore Peruvian continental slope – implications for submarine landscape evolution.

Lonsdale P (1976) Abyssal circulation of the southeastern Pacific and some geological implications. Journal of Geophysical Research (1896–1977) 81, 1163–76. doi: 10.1029/JC081i006p01163

Müller RD, Sdrolias M, Gaina C and Roest WR (2008) Age, spreading rates and spreading symmetry of the world's ocean crust. Geochemistry, Geophysics, Geosystems 9, Q04006. doi: 10.1029/2007GC001743.

Pilger, R.H., Jr., 1981, Plate reconstructions, aseismic ridges, and low-angle subduction beneath the Andes: Geological Society of America Bulletin, v. 92, no. 7, p. 448–456, https://doi.org/10.1130/0016-7606(1981)92<448:PRARAL>2.0.CO;2.

Ray, J.S., Mahoney, J.J., Duncan, R.A., Ray, J., Wessel, P., and Naar, D.F., 2012, Chronology and geochemistry of lavas from the Nazca Ridge and Easter Seamount Chain: An ~30 Myr hotspot record: Journal of Petrology, v. 53, no. 7, p. 1417–1448, https://doi.org/10.1093/petrology/egs021.

Sandwell, D.T., Müller, R.D., Smith, W.H.F., Garcia, E., and Francis, R., 2014, New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure: Science, v. 346, p. 65–67, https://doi.org/10.1126/science.1258213.

Shipboard Scientific Party (2003a) Leg 202 summary. In Proceedings of the Ocean Drilling Program, Initial Reports, vol. 202 (eds AC Mix, R Tiedemann, P Blum, FF Abrantes, H Benway, I Cacho-Lascorz, M-T Chen, ML Delaney, J-A Flores, L Giosan, AE Holbourn, T Irino, M Iwai, LH Joseph, HF Kleiven, F Lamy, SP Lund, P Martinez, JF McManus, US, Ninnemann, NG Pisias,

RS Robinson, JS Stoner, A Sturm, MW Wara and W Wei), pp. 1–145. College Station, Texas. doi: 10.2973/odp.proc.ir.202.101.2003.
Tassara, A.; Götze, H.-J.; Schmidt, S. & Hackney, R. (2006). Three-dimensional density model of the Nazca plate and the Andean continental margin, en prensa Journal of Geophysical Research.
Tiedemann R and Mix A (2007) Leg 202 synthesis: southeast Pacific paleoceanography. In Proceedings of the Ocean Drilling Program, Scientific Results, vol. 202 (eds R Tiedemann, AC Mix, C Richter and WF Ruddiman), pp. 1–56. College Station, Texas. doi: 10.2973/odp.proc.sr.202.201.2007.
von Huene R, Pecher IA and Gutscher M-A (1996) Development of the accretionary prism along Peru and material flux after subduction of Nazca Ridge. Tectonics 15, 19–33. doi: 10.1029/95TC02618.
Woods MT, Okal EA. (1994) The structure of the Nazca Ridge and Sala y Gomez seamount chain from the dispersion of the Rayleigh waves. Geophys. J. Int. 117, 205-222.

Oceanography

Altabet MA, Ryabenko E, Stramma L, Wallace DWR, Frank M, Grasse P, et al. An eddy-stimulated hotspot for fixed nitrogen-loss from the Peru oxygen minimum zone. Biogeosciences. 2012; 9(12):4897– 908
Andrade, I., Hormazábal, S. & Correa-Ramírez, M. (2014). Time-space variability of satellite chlorophyll-a in the Easter Island Province, southeastern Pacific Ocean. Lat. Am. J. Aquat. Res., 42(4): 871-887.
Andrade, I., Sangrà, P., Hormazabal, S., and Correa-Ramirez, M. (2014). Island mass effect in the Juan Fernández Archipelago (33◦ S), Southeastern Pacific. Deep Sea Res. Part I Oceanogr. Res. Pap. 84, 86–99. doi: 10.1016/j.dsr.2013.10.009
Arévalo-Martínez DL, Kock A, Loöscher CR, Schmitz RA, Stramma L, Bange HW. Influence of mesoscale eddies on the distribution of nitrous oxide in the eastern tropical South Pacific. Biogeosciences Discuss. 2016; 13:1105–1118.
Behrenfeld, M.J., R.T. O'Malley, D. Siegel, C.R. McClain, J.L. Sarmiento, G.C. Feldman, A.J. Milligan, P.G. Falkowski, R.M. Letelier & E.S. Boss. (2006). Climate-driven trends in contemporary ocean productivity. Nature, 444: 752-755.
Bourbonnais A, Altabet MA, Charoenpong CN, Larkum J, Hu H, Bange HW, et al. N-loss isotope effects in the Peru oxygen minimum zone studied using a mesoscale eddy as a natural tracer experiment. Global Biogeochemical Cycles. 2015; 29(6):793–811.
Brannigan L. Intense submesoscale upwelling in anticyclonic eddies. Geophysical Research Letters. 2016; 43(7): 3360–3369.
Callbeck, C.M., Lavik G., Stramma, L., Kuypers, M.M. & Bristow, L. (2017). Enhanced Nitrogen Loss by Eddy-Induced Vertical Transport in the Offshore Peruvian Oxygen Minimum Zone. PLoS ONE 12(1): e0170059. doi:10.1371/journal. pone.0170059
Carhuapoma, W., Graco, M., Vásquez, L., Anculle, T., Mendoza, U., Fernández & Velazco, F. (2023). Oceanographic and chemical conditions in the water column overlying to the Nazca Ridge. Bol Inst Mar Perú / Vol 38 / No 1 / Enero-Junio. pp. 21-34. https://doi.org/10.53554/boletin.v38i1.380
Chaigneau, A. & O. Pizarro. (2005). Surface circulation and fronts of the South Pacific Ocean, east of 120ºW. Geophys. Res. Lett., 32, L08605, doi:10.1029/2004 GL022070
Chaigneau, A., Gizolme, A., & Grados, C. (2008). Mesoscale eddies off Peru in altimeter records: Identification algorithms and eddy spatio-temporal patterns. Progress in Oceanography, 79(2-4), 106-119.
Chaigneau, A., Le Texier, M., Eldin, G., Grados, C., & Pizarro, O. (2011). Vertical structure of mesoscale eddies in the eastern South Pacific Ocean: A composite analysis from altimetry and Argo profiling floats. Journal of Geophysical Research: Oceans, 116(C11).
Chelton, D.B., M.G. Schlax, R.M. Samelson & R.A. de Szoeke. (2007). Global observations of large oceanic eddies. Geophys. Res. Lett., 34(15): 1-5, doi:10.1029/ 2007GL030812
Claustre, H., Morel, A., Babin, M., Cailliau, C., Marie, D., Marty, J. C., Tailliez, D., and Vaulot, D. (1999). Variability in particle attenuation and chlorophyll fluorescence in the Tropical Pacific: Scales, patterns, and biogeochemical implications, J. Geophys. Res., 104, 3401–3422.
Clauster, H. & Maritorena, S. (2003). The many shades of ocean blue. Science, 302: 1514-1515.
Claustre, H., Huot, Y., Obernosterer, I., Gentili, B., Tailliez, D., and M. Lewis (2007). Gross community production and metabolic balance in the South Pacific Gyre, using a non-intrusive bio-optical method. Biogeosciences Discuss., 4, 3089–3121.
Cochran, K., Bokuniewics, H. & Yager, P. (2019). Encyclopedia of Ocean Sciences. Reference Work: Third Edition. 3: 115-127. https://doi.org/10.1016/B978-0-12-409548-9.11642-2
Del Giorgio, P. A., Cole, J. J., and Cimbleris, A. (1997). Respiration rates in bacteria exceed phytoplankton production in unproductive aquatic systems, Nature, 385, 148–151.
Del Giorgio, P.A. & C.M. Duarte. (2002). Respiration in the open ocean. Nature, 420: 379-384.
Dietze, H. and Oschlies, A. (2005). Modeling abiotic production of apparent oxygen utilization in the oligotrophic subtropical North Atlantic, Ocean Dyn., 55, 28–33.
Domínguez, N., Asto, C. y Gutiérrez, D. (2023). Climatología termohalina frente a las costas del Perú. Período: 1991 – 2020. Inf Inst Mar Perú, 50(1), 19-35.
Doty, M.S. & M. Ogury. (1956). The island mass effect. J. Cons. Int. Explor. Mer, 22: 33-37.
Duarte, C.M. & A. Regaudie-de-Gioux. (2009). Thresholds of gross primary production for the metabolic balance of marine planktonic communities. Limnol. Oceanogr., 54: 1015-1022.
Falkowski, P.G., D. Ziemann, Z. Kolber & P.K. Bienfang. (1991). Role of eddy pumping in enhancing primary production in the Ocean. Nature, 352(6330): 55-58.

Falkowski, P.G., E.A. Laws, R.T. Barber & J.W. Murray. (2003). Phytoplankton and their role in primary, new, and export production In: M.J.R. Fasham (ed.). Ocean biogeochemistry: the role of the ocean carbon cycle in global change. Springer-Verlag, Berlin, pp. 99-121.

Fielding S, Crisp N, Allen JT, Hartman MC, Rabe B, Roe HSJ. Mesoscale subduction at the Almeria— Oran front: Part 2. Biophysical interactions. Journal of Marine Systems. 2001; 30(3–4):287–304.

Gardner, W. D., Walsh, I. D., and Richardson, M. J. (1993). Biophysical forcing of particle production and distribution during a spring bloom in the North Atlantic. Deep Sea Research Part II: Topical Studies in Oceanography, 40, 171–195.

Graco, M., Ledesma, J., Flores, G. & Girón, M. (2007). Nutrientes, oxígeno y procesos biogeoquímicos en el sistema de surgencias de la corriente de Humboldt frente a Perú. Rev. Peru. Biol., 14(1), 117- 128. https://doi.org/10.15381/rpb.v141.2165

Gruber, N., Keeling, C. D., Bacastow, R. B., Guenther, P. R., Lueker, T. J., Wahlen, M., et al. (1999). Spatiotemporal patterns of carbon-13 in the global surface oceans and the oceanic Suess effect. Glob. Biogeochem. Cycles 13, 307–335. doi: 10.1029/1999GB900019

Gruber, N. (2005). A bigger nitrogen fix, Nature, 436, 786.

Gruber, N., Lachkar, Z., Frenzel, H., Marchesiello, P., Münnich, M., McWilliams, J. C., ... & Plattner, G. K. (2011). Eddy-induced reduction of biological production in eastern boundary upwelling systems. Nature geoscience, 4(11), 787-792.

Hardy, J., A. Hanneman, M. Behrenfeldt & R. Horner. (1996). Environmental biogeography of near-surface phytoplankton in the southeast Pacific Ocean. DeepSea Res. I, 43: 1647-1659.

Hasegawa, D., M.R. Lewis & A. Gangopadhyay. (2009). How islands cause phytoplankton to bloom in their wakes. Geophys. Res. Lett., 36, L20605, doi:10.1029/ 2009GL039743.

Heywood, K.J., D.P. Stevens & G.R. Bigg. (1996). Eddy formation behind the tropical island of Aldabra. DeepSea Res. I, 43: 555-578.

Hormazábal, S., G. Shaffer & O. Leth. (2004). Coastal transition zone off Chile. J. Geophys. Res-Oce., 109, C1, doi:10.1029/2003JC001956.

Jenkins, W. J. (1982). Oxygen utilization rates in North Atlantic subtropical gyre and primary production in oligotrophic systems, Nature, 300, 246–248.

Jenkins, W. J. (1988). Nitrate flux into the euphotic zone near Bermuda, Nature, 331, 521–523.

Karl, D., Laws, E. A., Morris, P., Williams, P. J. l., and Emerson, S. (2003). Metabolic balance of the open sea, Nature, 426, 32.

Landaeta, M.F. & L.R. Castro. (2004). Zonas de concentración de ictioplancton en el archipiélago de Juan Fernández, Chile. Cienc. Tecnol. Mar, 27(2): 43-53.

Leth, O. & G. Shaffer. (2001). A numerical study of the seasonal variability in the circulation off central Chile. J. Geophys. Res., 106(C10): 22229-22248

Lewis, M. R., Harrison, W. G., Oakey, N. S., Hebert, D., and Platt, T. (1986). Vertical nitrate fluxes in the oligotrophic ocean, Science, 224, 870–873.

Loisel, H. and Morel, A. (1998). Light scattering and chlorophyll concentration in case 1 waters: A reexamination, Limnol. Oceanogr., 43, 847–858.

Löscher CR, Bourbonnais A, Dekaezemacker J, Charoenpong CN, Altabet MA, Bange HW, et al. N2 fixation in eddies of the eastern tropical South Pacific Ocean. Biogeosciences Discuss. 2015; 13:2889– 2899.

Mahadevan A. The impact of submesoscale physics on primary productivity of plankton. Annual Review of Marine Science. 2016; 8(1):161–84.

Mahadevan A, Thomas LN, Tandon A. Comment on "Eddy/wind interactions stimulate extraordinary mid-ocean plankton blooms". Science. 2008; 320(5875):448.

McGillicuddy DJ. Mechanisms of physical-biological-biogeochemical interaction at the oceanic mesoscale. Annual Review of Marine Science. 2016; 8(1):125–59.

McGillicuddy, D.J., L.A. Anderson, N.R. Bates, T. Bibby, K.O. Buesseler, C.A. Carlson & C.S. Davis. (2007). Eddy/Wind interactions stimulate extraordinary midocean plankton blooms. Science, 316(5827): 1026.

Montes, I. & Manay, R. (2023). Reserva Nacional Dorsal de Nazca: Experimento numérico bajo condiciones climatológicas. Boletín Científico EL Niño. v. 10, n. 4. pp. 11-15.

Morel, A., Gentili, B., Claustre, H., Babin, M., Bricaud, A., Ras, J., and Tieche, F. (2007) Optical 30 properties of the “clearest” natural waters, Limnol. Oceanogr., 52, 217–229.

Morel, A., Huot, Y., Gentili, B., Werdell, P. J., Hooker, S. B., and Franz, B. A. (2007) Examining the consistency of products derived from various ocean color sensors in open ocean (Case 1) waters in the perspective of a multi-sensor approach. Remote Sensing of Environment, in press.

Morel, A., H. Claustre & B. Gentili. (2010). The most oligotrophic subtropical zones of the global ocean: similarities and differences in terms of chlorophyll and yellow substance. Biogeosciences, 7: 3139-3151.

Nauw, J.J., H.M. van Aken, J.R.E. Lutjeharms & W.P.M. de Ruijter. 2006. Intrathermocline eddies in the southern Indian Ocean. J. Geophys. Res., 111, C03006. doi:10.1029/2005JC002917.

Omand MM, D’Asaro EA, Lee CM, Perry MJ, Briggs N, Cetinić I, et al. Eddy-driven subduction exports particulate organic carbon from the spring bloom. Science. 2015; 348(6231):222–5. doi: 10.1126/ science.1260062 PMID: 25814062

Oschlies, A. (2002). Can eddies make ocean deserts bloom?, Global Biogeochem. Cycles, 16, 1106, doi:10.1029/2001GB001830.

Porovic, J., C. Parada, B. Ernst, S. Hormazábal & V. Combes. (2012). Modelación de la conectividad de las subpoblaciones de la langosta de Juan Fernández (*Jasus frontalis*), a través de un modelo biofísico. Lat. Am. J. Aquat. Res., 40(3): 613-632.

Raimbault, P., Garcia, N., and Cerrutti, F. (2007). Distribution of inorganic and organic nutrients in 3109 BGD 4, 3089–3121. Gross community production in the South Pacific Gyre-Evidence for long-term accumulation of organic matter in nitrogen depleted waters, Biogeosciences. 4, 3041–3087, 2007.
Riser, S.C. & K.S. Johnson. (2008). Net production of oxygen in the subtropical ocean. Nature, 451: 323-325.
Sangrà, P., M. Auladell, A. Marrero-Díaz, J.L. Pelegrí, E. Fraile-Nuez, A. Rodríguez-Santana, J.M. Martín, E. Mason & A. Hernández-Guerra. (2007). On the nature of oceanic eddies shed by the Island of Gran Canaria. Deep-Sea Res. I, 54: 687-709.
Serratosa, J.; Hyrenbach, K.D.; Diego Miranda-Urbina, M.; Portflitt-Toro, M.; Luna, N. & G. Luna-Jorquera. (2020). Environmental Drivers of Seabird At-Sea Distribution in the Eastern South Pacific Ocean: Assemblage Composition Across a Longitudinal Productivity Gradient. Frontiers in Marine Science. 6. https://doi.org/10.3389/fmars.2019.00838
Siegel, D. A., Dickey, T. D., Washburn, L., Hamilton, M. K., and Mitchell, B. G. (1989). Optical determination of particulate abundance and production variations in the oligotrophic ocean, Deep-Sea Res., 36, 211–222.
Signorini, S.R., C.R. McClain & Y. Dandonneau. (1999). Mixing and phytoplankton bloom in the wake of the Marquesas Islands. Geophys. Res. Lett., 26: 3121- 3124.
Stramma, L., Bange, H. W., Czeschel, R., Lorenzo, A., & Frank, M. (2013). On the role of mesoscale eddies for the biological productivity and biogeochemistry in the eastern tropical Pacific Ocean off Peru. Biogeosciences, 10(11), 7293-7306.
Thomsen S, Kanzow T, Colas F, Echevin V, Krahmann G, Engel A. Do submesoscale frontal processes ventilate the oxygen minimum zone off Peru? Geophysical Research Letters. 2016; 43(15):8133–42.
Von Dassow, P. & Collado-Fabbri, S. (2014). Biological oceanography, biogeochemical cycles, and pelagic ecosystem functioning of the east-central South Pacific Gyre: focus on Easter Island and Salas y Gómez Island. Lat. Am. J. Aquat. Res., 42(4): 703-742. https://doi.org/10.3856/vol42-issue4-fulltext-4
Williams, P. J. l. B. (1998). The balance of plankton respiration and photosynthesis in the open oceans, Nature, 394, 55–57.Williams, P. J. L., Morris, P. J., and Karl, D. M. (2004). Net community production and metabolic balance at the oligotrophic ocean site, station ALOHA, Deep-Sea Res., 51, 1563–1578.
Wollast, R. (1998). Evaluation and comparison of the global carbon cycle in the coastal zone and in the open ocean. Sea 10, 213–252.

Biophysical Coupling

Brink, K.H. 1989. The effect of stratification on seamount-trapped waves. Deep-Sea Research 36:825–844.
Brink, K.H. 1990. On the generation of seamount-trapped waves. Deep-Sea Research 37:1,569–1,582.
Brink, K.H. 1995. Tidal and lower frequency currents above Fieberling Guyot. Journal of Geophysical Research 100:10,817–10,822.
Carney RS. 2005. Zonation of deep biota on continental margins. Oceanogr. Mar. Biol. Annu. Rev. 43:211–78
Chapman, D.C. 1989. Enhanced subinertial diurnal tides over isolated topographic features. Deep-Sea Research 36:815–824.
Chapman, D.C., and D.B. Haidvogel. 1992. Formation of Taylor caps over a tall and isolated seamount in a stratified ocean. Geophysical and Astrophysical Fluid Dynamics 64:31–65
Clark, M. R., Rowden, A. A., Schlacher, T., Williams, A., Consalvey, M., Stocks, K. I., Rogers, A. D., O'Hara, T. D., White, M., Shank, T. M., & Hall-Spencer, J. M. (2010). The ecology of seamounts: structure, function, and human impacts. Ann Rev Mar Sci, 2(0), 253-278. https://doi.org/10.1146/annurev-marine-120308-081109
Cobb Seamount. Journal of Geophysical Research 102:22,993–23,007.
Codiga, D., and C.C. Eriksen. 1997. Observations of low-frequency circulation and amplified subinertial tidal currents at
Comeau, L.A., A.F. Vezina, M. Bourgeois, and S.K. Juniper. 1995. Relationship between phytoplankton production and the physical structure of the water column near Cobb Seamount, Northeast Pacific. Deep-Sea Research Part I 42:993–1,005.
de Steur, L., D.M. Holland, R.D. Muench, and M.G. McPhee. 2007. The warm-water “Halo” around Maud Rise: Properties, dynamics and impact. Deep-Sea Research Part I 54:871–896.
Dower, J.F., and D.L. Mackas. 1996. Seamount effects in the zooplankton community near Cobb seamount. Deep-Sea Research Part I 43:837–858.
Eriksen, C.C. 1998. Internal wave reflection and mixing at Fieberling Guyot. Journal of Geophysical Research 103(C2):2,977–2,994
Fernandez de la Mora, J. 2007. The fluid dynamics of Taylor cones. Annual Review of Fluid Mechanics 39:217–243
Freeland, H. 1994. Ocean circulation at and near Cobb Seamount. Deep-Sea Research 41:1,715–1,732.
Garrett, C. 2003. Internal tides and ocean mixing. Science 301:1,858–1,859.
Garrett, C., and E. Kunze. 2007. Internal tide generation in the deep ocean. Annual Review of Fluid Mechanics 39:57–87.
Genin A, Boehlert GW. 1985. Dynamics of temperature and chlorophyll structures above a seamount: An oceanic experiment. J. Mar. Res. 43:907–24
Genin A, Dayton PK, Lonsdale PF, Spiess FN. 1986. Corals on seamount peaks provide evidence of current acceleration over deep-sea topography. Nature 322:59–61
Genin A, Dower JF. 2007. Seamount plankton dynamics. See Pitcher, Morato, Hart, Clark, Haggen, Santos 2007, pp. 86–100
Genin, A., and G.W. Boehlert. 1985. Dynamics of temperature and chlorophyll structures above a seamount: An oceanic experiment. Journal of Marine Research 43:907–924.

Genin, A., and J.F. Dower. 2007. Seamount plankton dynamics. Pp. 85–100 in Seamounts: Ecology, Fisheries, and Conservation. T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan, and R.S. Santos, eds, Blackwell, Oxford, UK.

Genin, A., P.K. Dayton, P.F. Lonsdale, and F.N. Spiess. 1986. Corals on seamounts provide evidence of current acceleration over deep sea topography. Nature 322:59– 61

Goldner, D.R., and D.C. Chapman. 1997. Flow and particle motion induced above a tall seamount by steady and tidal background currents. Deep-Sea Research Part I 44:719–744.

Holloway, P.E., and M.A. Merrifield. 1999. Internal tide generation by seamounts, ridges, and islands. Journal of Geophysical Research 104:25,937–25,951.

Huppert, H.E., and K. Bryan. 1976. Topographically generated eddies. Deep-Sea Research 23:655–679.

Kunze E, Stanford TB. 1997. Tidally driven vorticity, diurnal shear and turbulence atop Fieberling Seamount. J. Phys. Oceanogr. 27:2663–93

Lavelle, J. & Mohn, Christian. (2010). Motion, Commotion, and Biophysical Connections at Deep Ocean Seamounts. Oceanography. 23. 10.5670/oceanog.2010.64.

Lavelle, J.W. 2006. Flow, hydrography, turbulent mixing, and dissipation at Fieberling Guyot examined with a primitive equation model. Journal of Geophysical Research 111, C07014, doi:10.1029/2005JC003224

Levin LA, Huggett CL, Wishner KF. 1991a. Control of deep-sea benthic community structure by oxygen and organic-matter gradients in the eastern Pacific Ocean. J. Mar. Res. 49:763–800

Mienis F, de Stigter HC, White M, Duineveld G, de Haas H, van Weering TCE. 2007. Hydrodynamic controls on cold-water coral growth and carbonate-mound development at the SW and SE Rockall Trough margin, NE Atlantic Ocean. Deep Sea Res. Part I 54:1655–74

Mourino B, Fernadez E, Serret P, Harbor D, Sinha B, Pingree R. 2001. Variability and seasonality of physical ˜ and biological fields at the Great Meteor Tablemount (subtropical NE Atlantic). Oceanol. Acta 24:1–20

Mouriño, B., E. Fernández, P. Serret, D. Harbour, B. Sinha, and R. Pingree. 2001. Variability and seasonality of physical and biological fields at the Great Meteor Tablemount (subtropical NE Atlantic). Oceanologica Acta 24:167–185.

Mullineaux, L.S., and S.W. Mills. 1997. A test of the larval retention hypothesis in seamount-generated flows. Deep-Sea Research Part I 44:745–770.

Noble, M., and L.S. Mullineaux. 1989. Internal tidal currents over the summit of Cross Seamount. Deep Sea Research 36:1,791–1,802.

O'Hara TD. 2007. Seamounts: Centres of endemism or species richness for ophiuroids? Glob. Ecol. Biogeogr. 16:720–32

Owens, W.B., and N.G. Hogg. 1980. Oceanic observations of stratified Taylor columns near a bump. Deep-Sea Research 27:1,029–1,045.

Pitcher, T.J., M.R. Clark, T. Morato, and R. Watson. 2010. Seamount fisheries: Do they have a future? Oceanography 23(1):134–144.

Proudman, J. 1916. On the motion of solids in a liquid possessing vorticity. Proceedings of the Royal Society of London A 92:408–424.

Roden, G.I. 1987. Effects of seamounts and seamount chains on ocean circulation and thermohaline structure. Pp. 335–354 in Seamounts, Islands and Atolls. B. Keating, P. Fryer, R. Batiza, and G. Boehlert, eds, Geophysical Monograph 43, American Geophysical Union, Washington DC.

Rogers AD, Baco A, Griffiths H, Hart T, Hall-Spencer JM. 2007. Corals on seamounts. See Pitcher, Morato, Hart, Clark, Haggen, Santos 2007, pp. 141–69

Taylor, G.I. 1917. Motions of solids in fluids when the flow is not irrotational. Proceedings of the Royal Society of London A 93:99–113.

Taylor, G.I. 1923. Experiments on the motion of solid bodies in rotating fluids. Proceedings of the Royal Society of London A 104:213–218.

Thistle D. 2003. The deep-sea floor: An overview. In Ecosystems of the World, ed. PA Tyler, pp. 1–37. New York: Elsevier

Toole JM, Schmitt RW, Polzin KL. 1997. Near-boundary mixing above the flanks of a mid latitude seamount. J. Geophys. Res. C102:947–59

Verron, J., and C. Le Provost. 1985. A numerical study of quasi-geostrophic flow over isolated topography. Journal of Fluid Mechanics 154:231–252.

White M, Bashmachnikov I, Arístegui J, Martins A. 2007a. Physical processes and seamount productivity. See Pitcher, Morato, Hart, Clark, Haggen, Santos 2007, pp. 65–84

White, M., I. Bashmachnikov, J. Aristegui, and A. Martins. 2007. Physical processes and seamount productivity. Pp. 65–84 in Seamounts: Ecology, Fisheries, and Conservation. T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan, and R.S. Santos, eds., Blackwell, Oxford, UK.

Wilson, C.D., and G.W. Boehlert. 2004. Interaction of ocean currents and resident micronekton at a seamount in the central North Pacific. Journal of Marine Systems 50:39–60.

Wishner K, Levin L, Gowing M, Mullineaux L. 1990. Involvement of the oxygen minimum in benthic zonation on a deep seamount. Nature 346:57–59