



# Connecting the world around ocean forecasting



## **MOSA: an operational forecast system for Chilean Patagonia**

Pablo Reche, IFOP Chile



# 1. WHAT IS MOSA?

**MOSA**  
“Modelo Operacional Sur Austral”





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“Modelo Operacional Sur Austral”



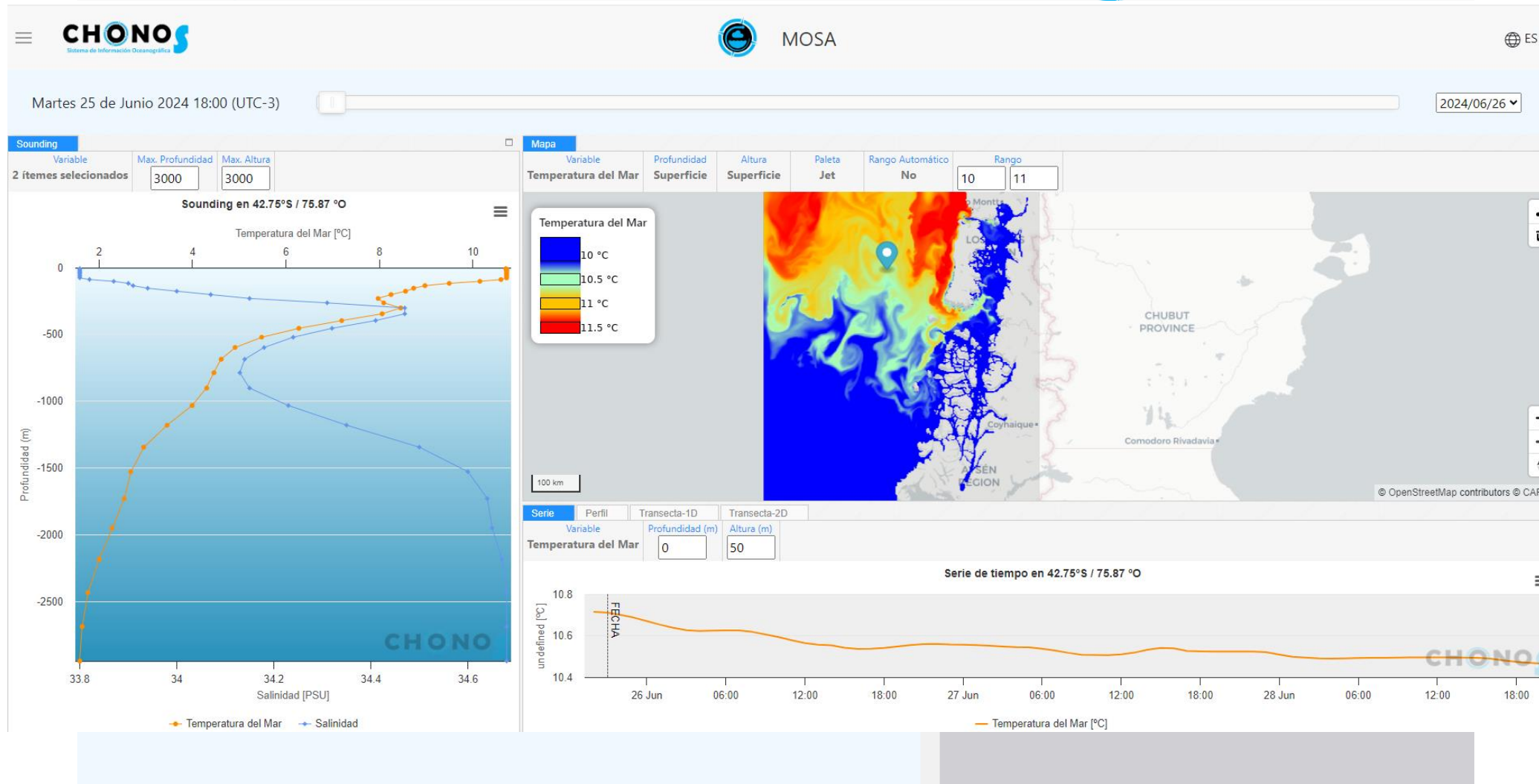
**CHONOS**

OCEANOGRAPHY AND CLIMATE GROUP

**CHONOS**



# 1. WHAT IS MOSA?





# 1. WHAT IS MOSA?


Ministerio de Economía, Fomento y Turismo | Subsecretaría de Pesca y Acuicultura

**CHONOS**  
Sistema de Información Oceanográfica

60 años IFOP

WHAT IS CHONOS? | APPS | TEAM WORK | CONTACT | ES

Towards a sustainable development of the coastal systems of Patagonia

CENTRO DE DATOS	MOSA	PARTI-MOSA	ATLAS	CLIC	FLOW	REDMET	CRUCEROS	WIKI
 Buoys Project - Data visualization tool, Version 1	 Oceanographic and Atmospheric Operational Forecast Model.	 Particle Dispersion Forecast Model.	 Historical oceanographic information based on numerical	 Statistics and connectivity matrices of biophysical models	 High-resolution hydrological flows model	 Weather monitoring network in real time	 Virtual catalog of oceanographic measurements campaigns	 CHONOS Supplemental Information Library

<https://chonos.ifop.cl/>

**FREE!**



## 2. WHERE DOES MOSA BELONG TO?

**MOSA**

“Modelo Operacional Sur Austral”



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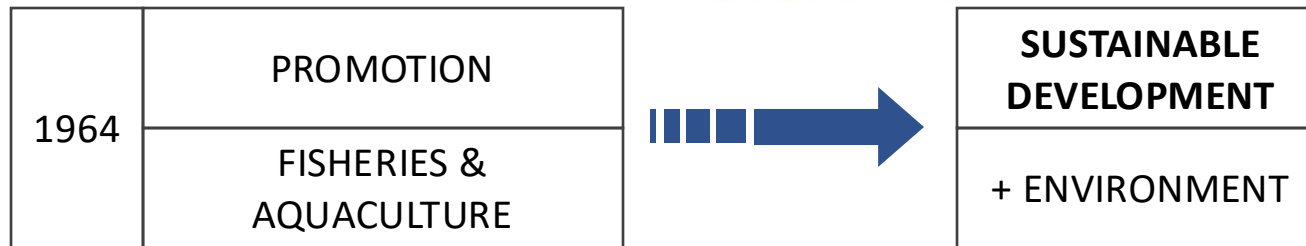
ENVIRONMENT DEPARTMENT

AQUACULTURE RESEARCH DIVISION

INSTITUTO DE FOMENTO PESQUERO



## 2. WHERE DOES MOSA BELONG TO?



**TECHNICAL REPORTS → DECISION MAKERS**  
**PERMANENT RESEARCH PROGRAMME**  
**Fisheries and Aquaculture General Law 18.892**





### 3. WHY MOSA?

## AQUACULTURE



- *Salmo salar*
- *Oncorhynchus mykiss*

- 2nd national industry
- 1st industry in southern regions
- 70000 jobs
- 2nd producer worldwide (≈ 1 million tn/year)
- 5000 million USD



- *Mytilus chilensis*
- *Aulacomya atra*

- 2nd industry in southern regions
- 17000 jobs
- 2nd producer worldwide (≈ 450k tn/year)
- 200 million USD





### 3. WHY MOSA?



## AQUACULTURE

## THREADS & CHALLENGES



- High carbon/nutrient inputs into environment
- Degradation seabed
- Eutrophication
- Harmful Algae Blooms (A. Catenella, H. akashiwo, Pseudochatonella sp.)
- Low-oxygen water column conditions
- Outbreak and Spread of Salmon Diseases (ISAv, sealice, SRS)
- Extreme wind and wave events (escapes)

- High carbon/nutrient inputs into environment
- Harmful algae blooms (A. Catenella, H. akashiwo, Pseudochatonella sp.)
- Variability and uncertainty in seed catches and growth.



### 3. WHY MOSA?

## NEED OF VALUABLE INFORMATION

Scarce Environmental Information

No previous operational forecast ocean experiences

High Climatic Variability (North-South)

Extense Coastline & Complex Bathimetry

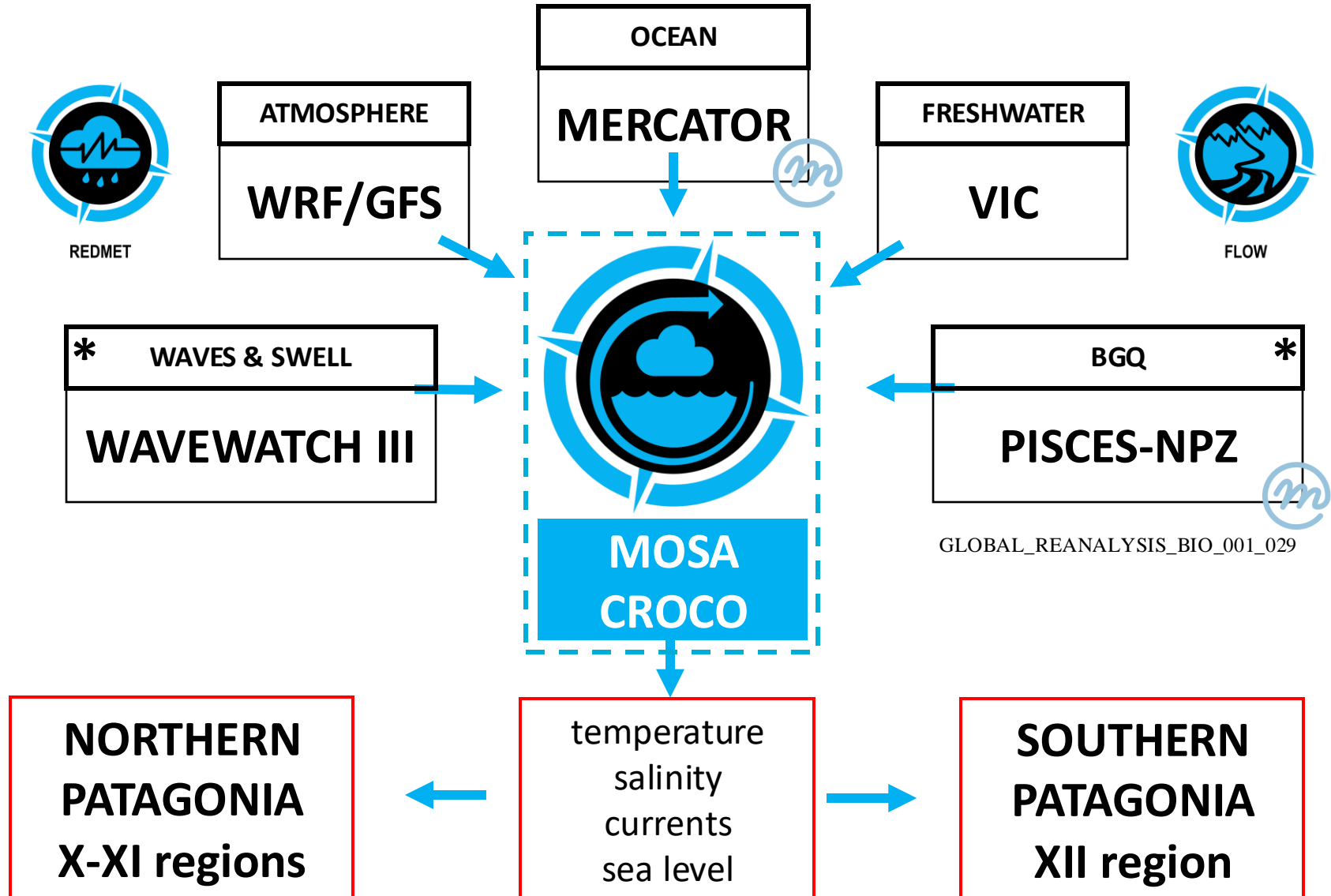
High precipitation rates & 3rd largest Ice Mass

Complex Circulation Patterns → Estuarine circulation





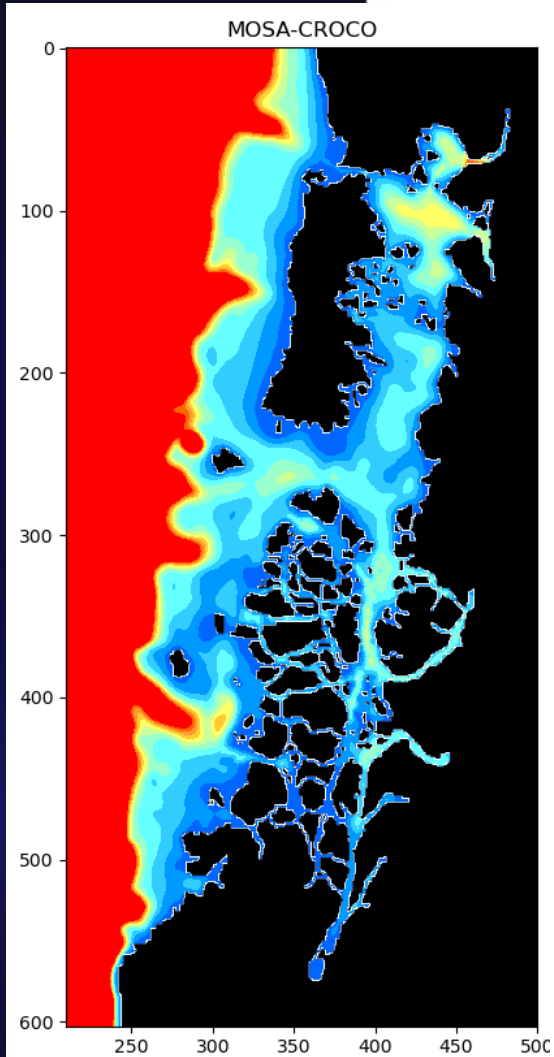
# 4. HOW DOES MOSA WORK?



\* Under testing

# 4. HOW DOES MOSA WORK?

**NORTHERN  
PATAGONIA  
X-XI regions  
Chiloé-Aysén**



Daily since 2017  
3 day forecast (1 hour output )

Horizontal resolution = 1 km  
Vertical resolution = 42 sigma layers

Bathymetry = GEBCO + SHOA charts

Spin-Up: downscaling **MERCATOR**  
Daily Initial Conditions: use restart condition after 24 hours day before

Atmosphere → MOSA-WRF (3km)  
Freshwater → FLOW-VIC (monthly mean last 40 years)

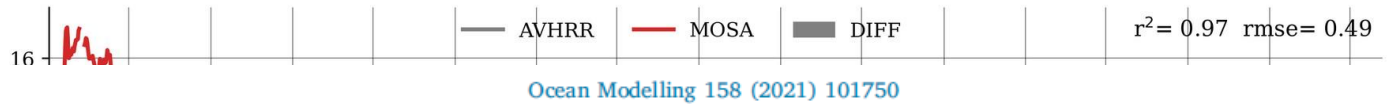
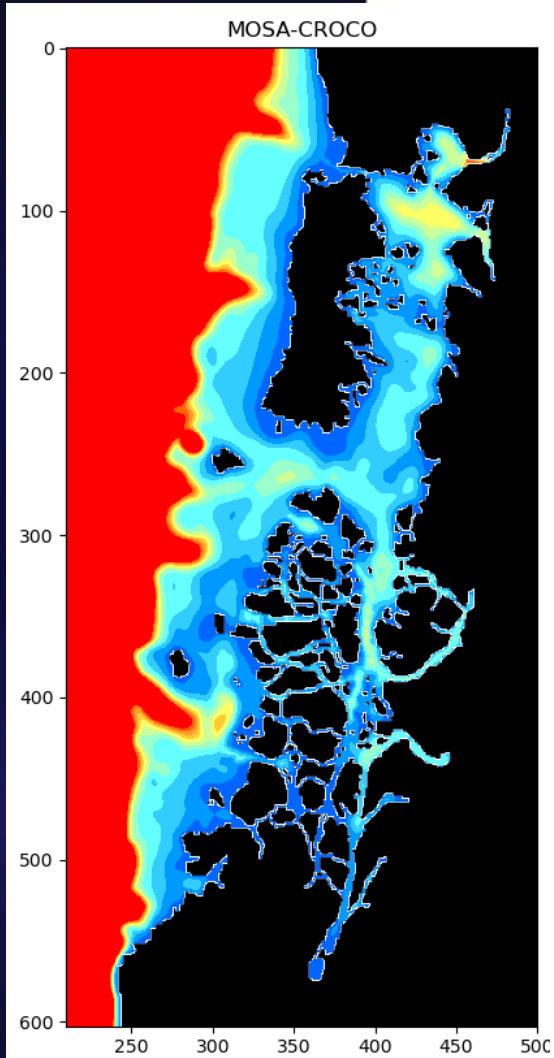
Temp/Sal/U/V/sea level → **MERCATOR**  
GLOBAL\_ANALYSIS\_FORECAST\_PHY\_001\_024



# 4. HOW DOES MOSA WORK?

## 3.1 HOW WELL DOES MOSA WORK?

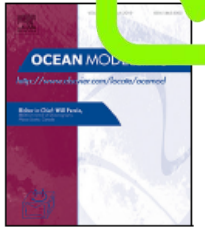
**NORTHERN  
PATAGONIA  
X-XI regions  
Chiloé-Aysén**



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

**Ocean Modelling**

journal homepage: [www.elsevier.com/locate/ocemod](http://www.elsevier.com/locate/ocemod)

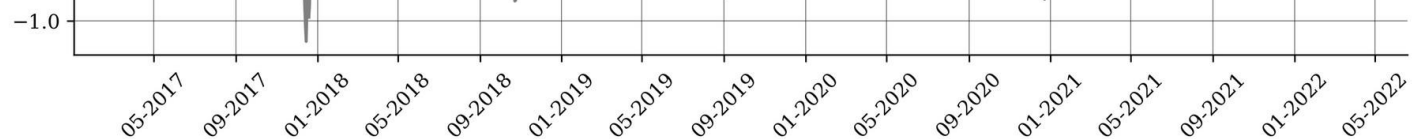


### Stratification and mixing in the Chilean Inland Sea using an operational model

Cristian Ruiz <sup>a</sup>, Osvaldo Artal <sup>a,\*</sup>, Elías Pinilla <sup>a</sup>, Héctor H. Sepúlveda <sup>b</sup>

<sup>a</sup> Environmental Department, Aquaculture Research Division, Fisheries Development Institute (IFOP), Castro, Chile

<sup>b</sup> Department of Geophysics, University of Concepción, Concepción, Chile





## 4. HOW DOES MOSA WORK?

Daily since 2021  
3 day forecast (1 hour output )

Horizontal resolution = 1.6 km  
Vertical resolution = 42 sigma layers

Bathymetry = GEBCO + SHOA charts

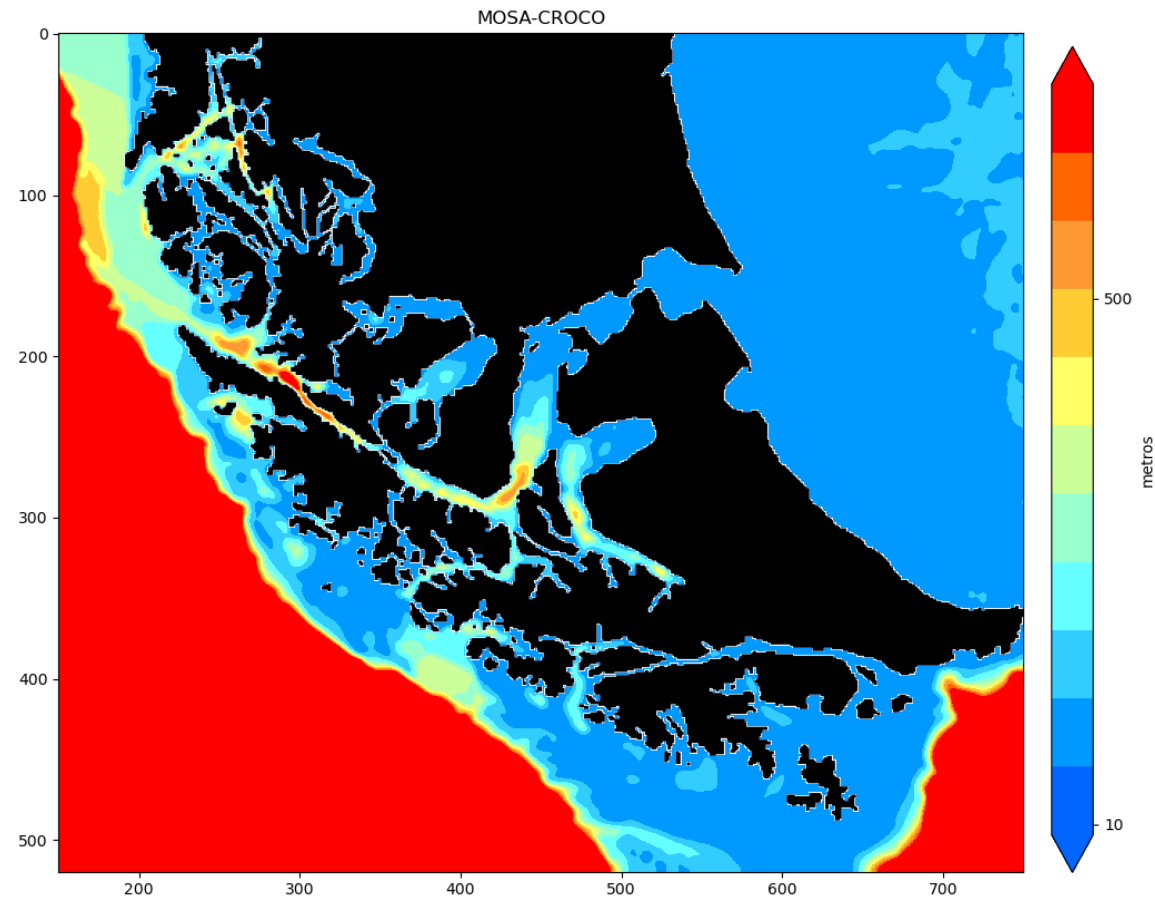
Spin-Up: downscaling **MERCATOR**  
Daily Initial Conditions: restart 24 hours day before

Atmosphere → GFS (30km)  
Freshwater → FLOW-VIC (monthly mean last 40 years)

Temp/Sal/U/V/sea level → **MERCATOR**  
GLOBAL\_ANALYSIS\_FORECAST\_PHY\_001\_024



**SOUTHERN  
PATAGONIA  
XII region  
Magallanes**

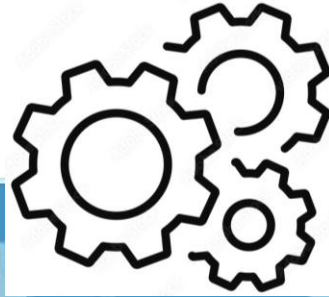




# 4. HOW DOES MOSA WORK?

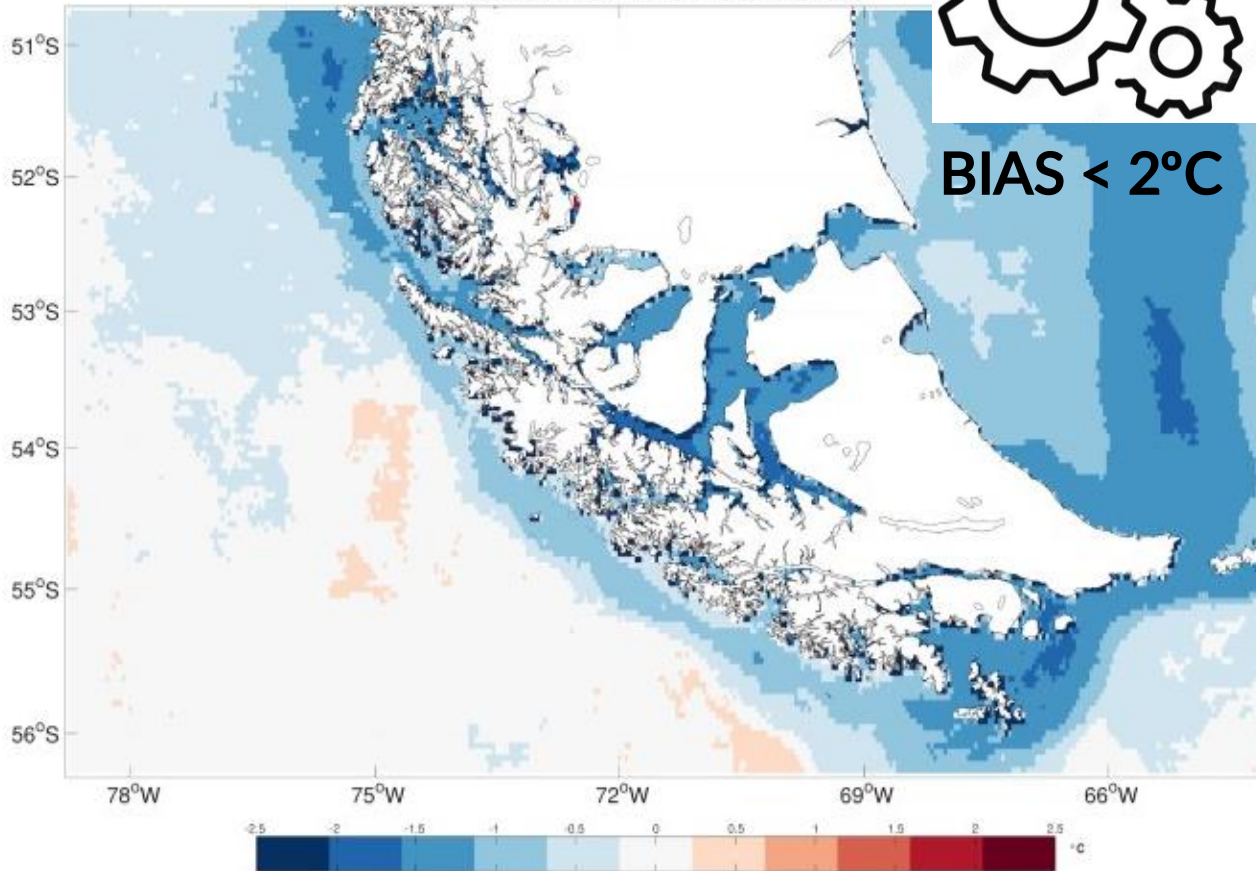
## 3.1 HOW WELL DOES MOSA WORK?

**SOUTHERN  
PATAGONIA  
XII region  
Magallanes**

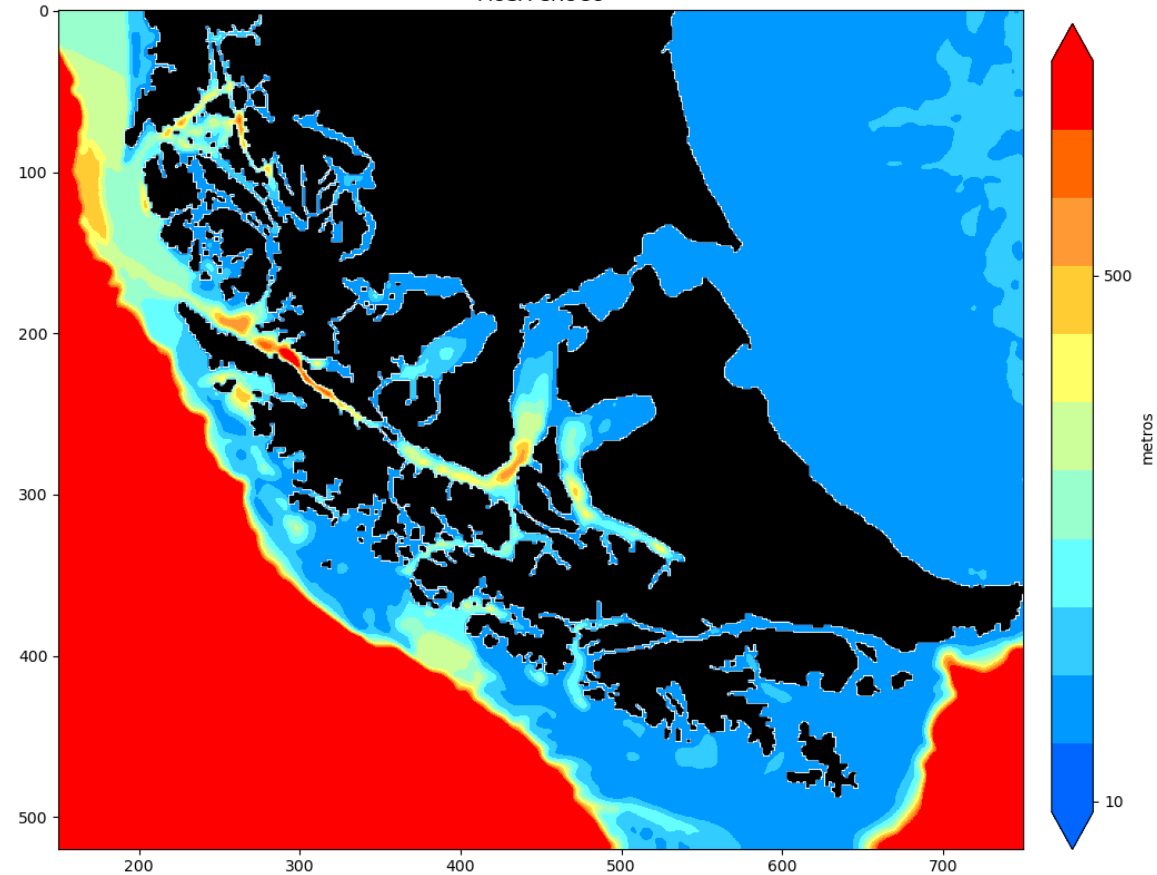


**BIAS < 2°C**

Diferencias promedio de TSM, MOSA-VIIRS



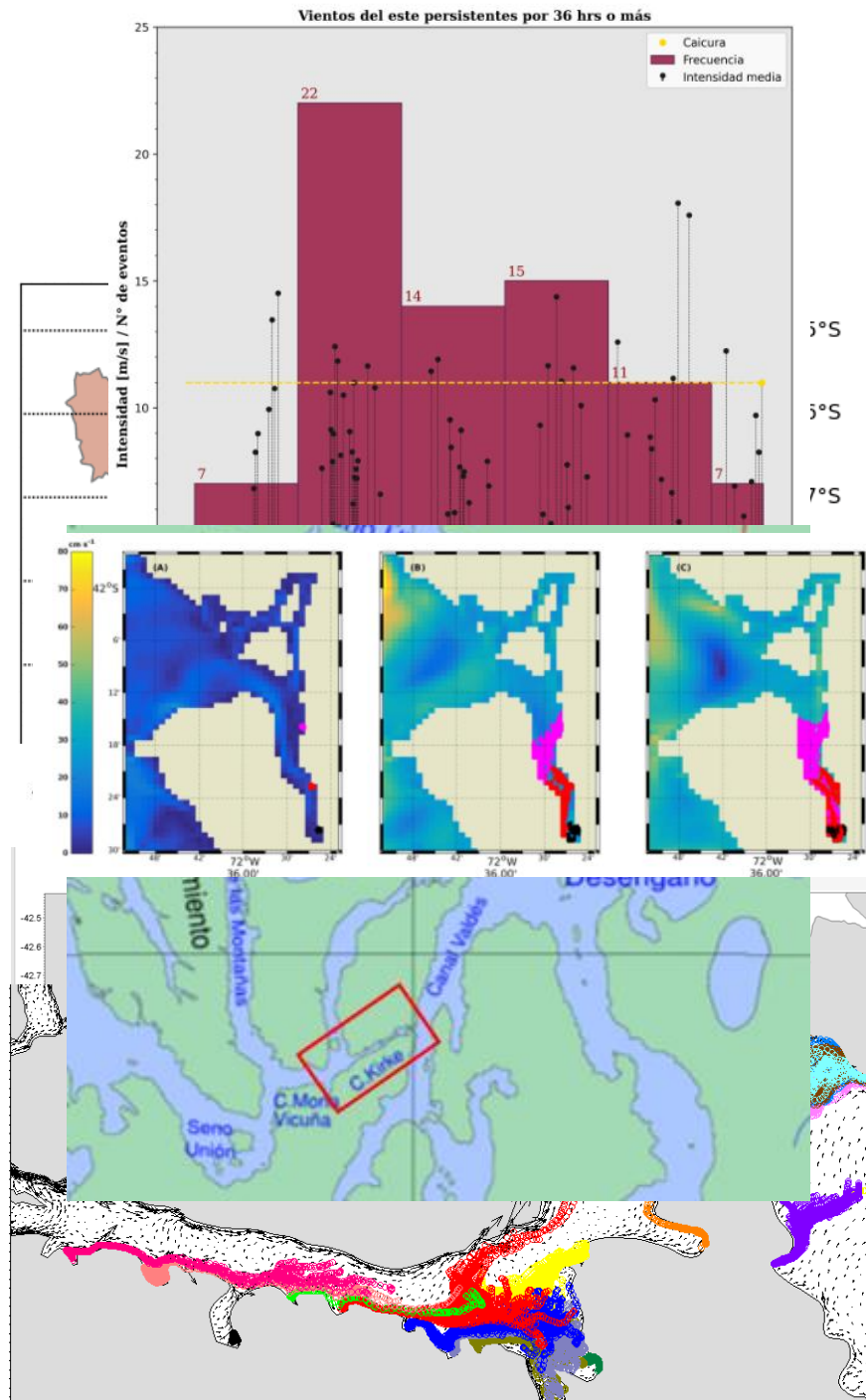
MOSA-CROCO





# 5. CASES OF STUDY

Salmon Disease Outbreaks	ISAv (Rowlett - august 2018)
Extreme Current & Wind Conditions	Salmon Escapes (Reloncaví julio 2018 - julio 2020)
	Salmon Farms (ACS X-XI)
HAB ( <i>H. akashiwo</i> , <i>A. catenella</i> )	Comau (autumn 2021)
Salmon Management Areas (ACS)	ACS 28B (Aysén fjord)
Environmental Impact	Widening Kirke canal (Puerto Natales)
Oil Spills	Seikongen event (Chonchi - october 2017)
Aquaculture Buoy Monitoring Network	Salmon Management Areas (ACS X-XI-XII)
Environment Conditions	HAB (Arauco gulf - january 2022)
Colonisation of Invasive Alien Species	Beaver Mainland Expansion (Magellan strait)



Environmental Science  
Contents lists available at ScienceDirect  
Environmental Science journal homepage

ELSEVIER

Review

The holobiome of marine harmful algal ecosystem-based approach for implementing managing decisions

Gonzalo Gajardo<sup>a,\*</sup>, Jesús Morón-López<sup>a,b</sup>, Karen Oscar Espinoza-González<sup>c</sup>, Alondra Sandoval<sup>c</sup>, Carlos Riquelme<sup>d</sup>, Henry Camerón<sup>d</sup>, Satoshi Nagaoka<sup>e</sup>, Kyoko Yarimizu<sup>f</sup>, Mariela A. González<sup>g</sup>, Benjamin Duran<sup>h</sup>

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<sup>b</sup> Institute of Plant Sciences  
<sup>c</sup> Centro de Estudios de  
<sup>d</sup> Centro de Biotecnología  
<sup>e</sup> Coastal and Inland Fisheries  
<sup>f</sup> The IDEC Institute, Hironaka  
<sup>g</sup> Center for Holobiome  
<sup>h</sup> Graduate School of Human and Environmental Studies  
<sup>i</sup> Scientific and Biotechnology  
<sup>j</sup> Laboratorio de Ecología  
<sup>k</sup> Doctorado en Ciencias

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Continental Shelf Research 254 (2023) 104905

Contents lists available at ScienceDirect

# SUMMARY

Continental Shelf Research

journal homepage: [www.elsevier.com/locate/csr](http://www.elsevier.com/locate/csr)

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CONTINENTAL SHELF RESEARCH

Check for updates

## Wind influence on residual circulation in Patagonian channels and fjords

Camila Soto-Riquelme<sup>a,\*</sup>, Elias Pinilla<sup>a,b</sup>, Lauren Ross<sup>b</sup>

<sup>a</sup> Instituto de Fomento Pesquero, Castro-Chiloé, Chile  
<sup>b</sup> Department of Civil and Environmental Engineering, University of Maine, 5711 Boardman Hall, Orono, ME, USA

Journal of Marine Systems

journal homepage: [www.elsevier.com/locate/jmarsys](http://www.elsevier.com/locate/jmarsys)

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JOURNAL OF MARINE SYSTEMS

Biogeosciences, 21, 1433–1459, 2024  
Biogeosciences Open Access EGU  
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## Abiotic processes driving low-oxygen conditions in Patagonian fjords

Iván Pérez-Santos<sup>2,3,4</sup>, Paulina Montero<sup>3,4</sup>, Patricio A. Díaz<sup>2,5</sup>, Claudia Aracena<sup>6,7</sup>, Fernando Barrera<sup>9,10</sup>, Manuel Castillo<sup>11</sup>, Aida Alvera-Azcárate<sup>12</sup>, Mónica Alvarado<sup>13</sup>, Gabriel Soto<sup>8</sup>, María la Schwertner<sup>2</sup>, Sara Arenas-Uribe<sup>2</sup>, Pilar Navarro<sup>2</sup>, Guido Mancilla-Gutiérrez<sup>2</sup>, María José Soto<sup>2</sup>, Javiera San Martín<sup>8</sup>, and Camila Soto-Riquelme<sup>8</sup>

<sup>1</sup> Instituto de Ciencias, Mención Conservación y Manejo de Recursos Naturales, Universidad de Los Lagos, Casilla 557, Puerto Montt, Chile  
<sup>2</sup> Centro de Investigación Científica y Tecnológica, Universidad Bernardo O'Higgins, Casilla 1497, Santiago, Chile  
<sup>3</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>4</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>5</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>6</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>7</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>8</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>9</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>10</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>11</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>12</sup> Centro de Estudios Científicos, Valdivia, Chile  
<sup>13</sup> Centro de Estudios Científicos, Valdivia, Chile

## Water age variability in a Patagonian fjord

Elías Pinilla<sup>a,b</sup>, Manuel I. Castillo<sup>c</sup>, and Arnoldo Valle-Levinson<sup>f</sup>

<sup>a</sup> Instituto de Fomento Pesquero, CTPA-Putemún, Castro, Chile  
<sup>b</sup> Programa de Magister en Oceanografía, Universidad de Valdivia, Chile  
<sup>c</sup> Centro de Observación Marino para Estudios de Riesgos del Medio Ambiente, Universidad de Valdivia, Chile  
<sup>d</sup> Centro de Investigación Oceanográfica COPAS Sur-Austral, Universidad de Valdivia, Chile  
<sup>e</sup> Centro i-mar, Universidad de Los Lagos, Puerto Montt, Chile  
<sup>f</sup> Civil and Coastal Engineering Department, University of Florida, Gainesville, FL, USA

Patricio A. Díaz<sup>1</sup>, Iván Pérez-Santos<sup>2</sup>, Gonzalo Álvarez<sup>3</sup>, René Alondra Sandoval<sup>4</sup>, Michael Araya<sup>5</sup>, Francisco Álvarez<sup>6</sup>, José Rengifo Loreto López<sup>7</sup>, Luis Iriarte<sup>8</sup>, Gabriela Igor<sup>9</sup>, Beatriz Reguera<sup>10</sup>

<sup>1</sup> Centro i-mar, Universidad de Los Lagos, Casilla 557, Puerto Montt, Chile  
<sup>2</sup> CeBiB, Universidad de Los Lagos, Casilla 557, Puerto Montt, Chile  
<sup>3</sup> Centro de Investigación Oceanográfica COPAS Sur-Austral, Universidad de Concepción, Concepción, Chile  
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<sup>5</sup> Centro de Investigación y Desarrollo Tecnológico en Algas (CIDTA), Facultad de Ciencias del Mar, Larrondo 1281, Universidad Católica del Norte, Coquimbo, Chile  
<sup>6</sup> Departamento de Geofísica, Universidad de Chile, Santiago 8370449, Región Metropolitana, Chile  
<sup>7</sup> Center for Climate and Resilience Research, CR2, Santiago 8370449, Región Metropolitana, Chile  
<sup>8</sup> Instituto de Fomento Pesquero (IFOP), Putemún, Castro, Chile  
<sup>9</sup> Instituto de Acuicultura y Programa de Investigación Pesquera, Universidad Austral de Chile, Los Pinos s/n, Puerto Montt, Chile  
<sup>10</sup> Centro de Investigaciones en Ecosistemas de la Patagonia (CIEP), Coyhaique, Chile  
<sup>11</sup> Centro de Estudios de Algas Nocivas (CREAN), Instituto de Fomento Pesquero (IFOP), Enrique Abello 0552, Punta Arenas, Chile  
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Ocean and Coastal Management 208 (2021) 105634

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## Ocean and Coastal Management

journal homepage: <http://www.elsevier.com/locate/ocecoaman>

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Ocean and Coastal Management

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## CHONOS: Oceanographic information website for Chilean Patagonia

Pablo Reche<sup>a,\*</sup>, Osvaldo Artal<sup>a</sup>, Elías Pinilla<sup>a</sup>, Cristian Ruiz<sup>a</sup>, Oliver Venegas<sup>a</sup>, Andrés Arriagada<sup>b</sup>, Mark Falvey<sup>b</sup>

<sup>a</sup> Instituto de Fomento Pesquero, Almirante Manuel Blanco Encalada 839, Valparaíso, Chile  
<sup>b</sup> Meteodata Ltd, Domeyko, 1864, Santiago de Chile, Chile

## Ocean Modelling

journal homepage: [www.elsevier.com/locate/ocemod](http://www.elsevier.com/locate/ocemod)

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OCEAN MODELLING

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## Modeling the Chilean Inland Sea using an operational oceanography system

Cristian Ruiz<sup>a</sup>, Osvaldo Artal<sup>a</sup>, Elías Pinilla<sup>a</sup>, Héctor H. Sepúlveda<sup>b</sup>

<sup>a</sup> Environmental Department, Aquaculture Research Division, Fisheries Development Institute (IFOP), Castro, Chile  
<sup>b</sup> Department of Geophysics, University of Concepción, Concepción, Chile

<sup>1</sup> Departamento de Geofísica, Universidad de Chile, Santiago, Chile  
<sup>2</sup> Centro de Ciencia del Clima y la Resiliencia (CR2), Universidad de Chile, Santiago, Chile  
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<sup>4</sup> Department of Civil and Environmental Engineering, University of Maine, Orono, ME, USA  
<sup>5</sup> Salmoles Camanchaca S.A., Puerto Montt, Chile  
<sup>6</sup> Instituto de Acuicultura y Programa de Investigación Pesquera, Universidad Austral de Chile, Los Pinos s/n, Puerto Montt, Chile  
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<sup>9</sup> Centro Oceanográfico de Vigo, Instituto Español de Oceanografía (IEO-CSIC), Vigo, Spain



THANK YOU

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de Pesca y  
Acuicultura

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**Oceanography & Climate**  
**Patagonian Coastal Systems Research Centre**  
Aquaculture Division  
Environment Department

Marcela Arriagada - Osvaldo Artal - Luis Avello - Valentina Besoain - Elías Pinilla – Pablo Reche -  
Cristian Ruiz - Milton Salas - Patricio Salas - Javiera San Martin - Camila Soto-Riquelme –  
Sebastián Sepúlveda - Pedro Valdebenito - Jurleys Vellojin - Oliver Venegas - Miguel Vergara



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