TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

Transboundary Waters: A Global Compendium

Water System Information Sheets: Southern America

Volume 6 - Annex C: Southern America

UNEP

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Volume 6-Annex C

Transboundary Waters: A Global Compendium

Water System Information Sheets: Southern America

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GOOS – Global Ocean Observing System
WCRP – World Climate Research Programme
GACS – Global Alliance of CPR Surveys
PML – Plymouth Marine Laboratory
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Sea Around Us
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Administrative Boundaries: Source of administrative boundaries used throughout the assessment: The Global Administrative Unit Layers (GAUL) dataset, implemented by FAO within the CountrySTAT and Agricultural Market Information System (AMIS) projects.

Contents (Volume 6, Annex C)

Preface

The Global Environment Facility (GEF) approved a Full Size Project (FSP), "A Transboundary Waters Assessment Programme: Aquifers, Lake/Reservoir Basins, River Basins, Large Marine Ecosystems, and Open Ocean to catalyze sound environmental management", in December 2012, following the completion of the Medium Size Project (MSP) "Development of the Methodology and Arrangements for the GEF Transboundary Waters Assessment Programme" in 2011. The TWAP FSP started in 2013, focusing on two major objectives: (1) to carry out the first global-scale assessment of transboundary water systems that will assist the GEF and other international organizations to improve the setting of priorities for funding; and (2) to formalise the partnership with key institutions to ensure that transboundary considerations are incorporated in regular assessment programmes to provide continuing insights on the status and trends of transboundary water systems.

The TWAP FSP was implemented by UNEP as Implementing Agency, UNEP's Division of Early Warning and Assessment (DEWA) as Executing Agency, and the following lead agencies for each of the water system categories: the International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) for transboundary aquifers including groundwater systems in small island developing states (SIDS); the International Lake Environment Committee Foundation (ILEC) for lake and reservoir basins; the UNEP-DHI Partnership – Centre on Water and Environment (UNEP-DHI) for river basins; and the Intergovernmental Oceanographic Commission (IOC) of UNESCO for large marine ecosystems (LMEs) and the open ocean.

The five water-category specific assessments cover 199 transboundary aquifers and groundwater systems in 43 small island developing states, 204 transboundary lakes and reservoirs, 286 transboundary river basins; 66 large marine ecosystems; and the open ocean, a total of 756 international water systems. The assessment results are organized into five technical reports and a sixth volume that provides a cross-category analysis of status and trends:

Volume 1 – ***Transboundary Aquifers and Groundwater Systems of Small Island Developing States: Status and Trends***
Volume 2 – ***Transboundary Lakes and Reservoirs: Status and Trends***
Volume 3 – ***Transboundary River Basins: Status and Trends***
Volume 4 – ***Large Marine Ecosystems: Status and Trends***
Volume 5 – ***The Open Ocean: Status and Trends***
Volume 6 – ***Transboundary Water Systems: Crosscutting Status and Trends***

A ***Summary for Policy Makers*** accompanies each volume.

Volume 6 presents a unique and first global overview of the contemporary risks that threaten international water systems in five transboundary water system categories, building on the detailed quantitative indicator-based assessment conducted for each water category. As a supplement to Volume 6, this global compendium of water system information sheets provides baseline relative risks at regional and system scales. The fact sheets are organized into 14 TWAP regions and presented as 12 annexes. Volume 6 and the compendium are published in collaboration among the five independent water-category based TWAP Assessment Teams under the leadership of the Cross-cutting Analysis Working Group, with support from the TWAP Project Coordinating Unit.

The technical teams of the Transboundary Waters Assessment Programme(TWAP) assessed transboundary aquifers, lakes & reservoirs, river basins, and large marine ecosystems and prepared information (fact) sheets for water systems that were evaluated. Each fact sheet provides basic geomorphological information and presents baseline values of quantitative indicators that were used to establish relative risk levels. The water system fact sheets are organized into 14 TWAP regions that were used in the Crosscutting Analysis described in Volume 6. The regional compilations are presented as 11 annexes (A-K) of a global compendium, combining Southern & Southeastern Asia into one annex (I), and the Pacific Island Countries, Australia & Antarctica into another (Annex K). Each annex highlights contemporary regional risks as well as water system-specific risks. The annexes are:

Annex A. Transboundary waters of Northern America
Annex B. Transboundary waters of Central America & the Caribbean
Annex C. Transboundary waters of Southern America
Annex D. Transboundary waters of Eastern, Northern & Western Europe
Annex E. Transboundary waters of Eastern Europe
Annex F. Transboundary waters of Western & Middle Africa
Annex G. Transboundary waters of Eastern & Southern Africa
Annex H: Transboundary waters of Northern Africa & Western Asia
Annex I: Transboundary waters of Southern & Southeastern Asia
Annex J: Transboundary waters of Eastern & Central Asia
Annex K: Transboundary waters of the Pacific Island Countries, Australia & Antarctica

In the case of the open ocean, which is the largest transboundary water system of planet earth, selected quantitative indicator maps prepared by the Open Ocean Assessment Team, are compiled in Annex L to highlight the contemporaneous state of the global ocean.

Annex L: Selected indicator maps for the open ocean

All information sheets and indicator maps for the open ocean may be downloaded individually from the following websites:

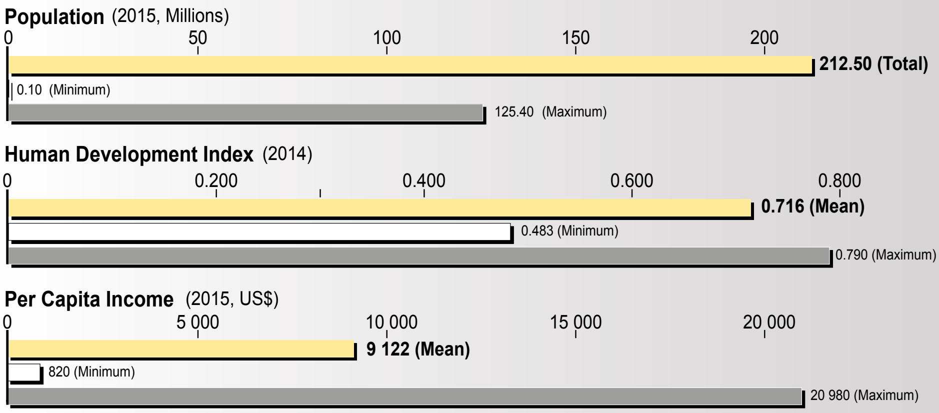
Transboundary Aquifers: http://twapviewer.un-igrac.org
Transboundary Lakes/ Reservoirs: http://ilec.lakes-sys.com/
Transboundary River Basins: http://twap-rivers.org
Large Marine Ecosystems: http://onesharedocean.org
Open Ocean: http://onesharedocean.org

All TWAP publications are available for download at http://www.geftwap.org

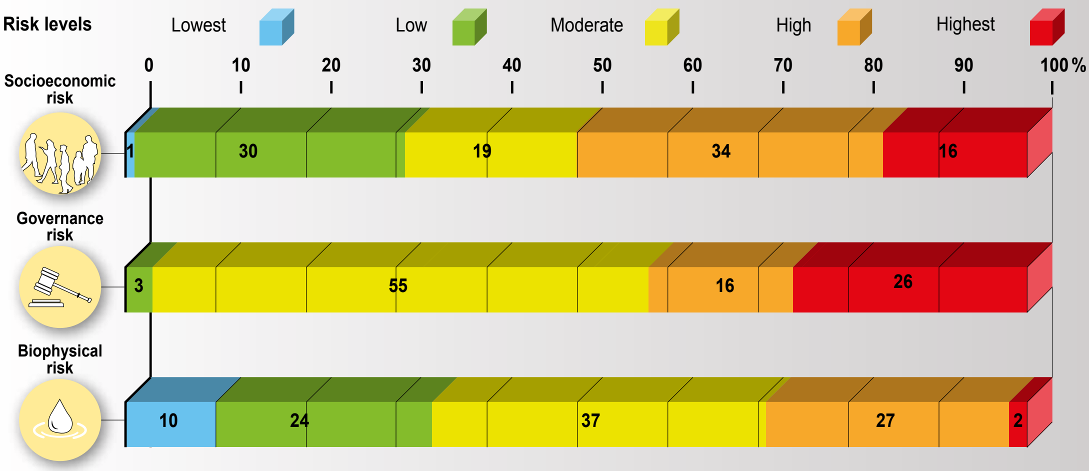
Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

TRANSBOUNDARY WATERS: CENTRAL AMERICA & CARIBBEAN

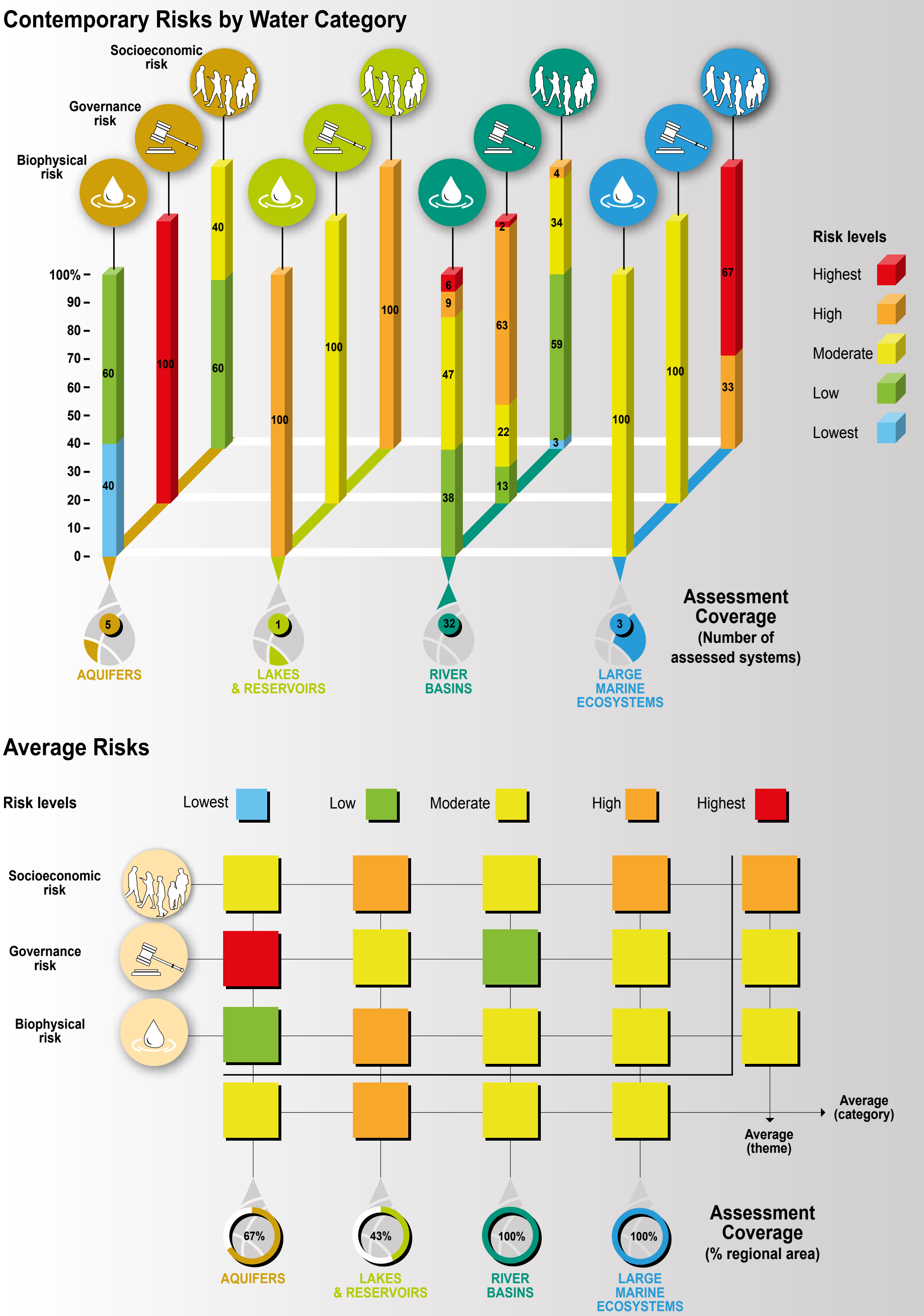
The region belongs to the High HDI group with a regional average HDI of 0.716, and a population reaching 212 million in 2015. Contemporary risks of water systems by water category and theme expressed as percentages are shown at top right. Across 41 transboundary waters in the region (bottom left), 50% experience high to highest socioeconomic risk; 97% are subject to moderate to highest governance risk; and 66% are threatened by moderate to highest biophysical risk. On average (bottom right), the region's transboundary waters are at high socioeconomic risk, and are at moderate governance and biophysical risks. Aquifers, river basins and LMEs are at moderate risk across risk themes, but lakes are at high risk.



Contemporary Risks by Theme



Regional Risks by Water Category

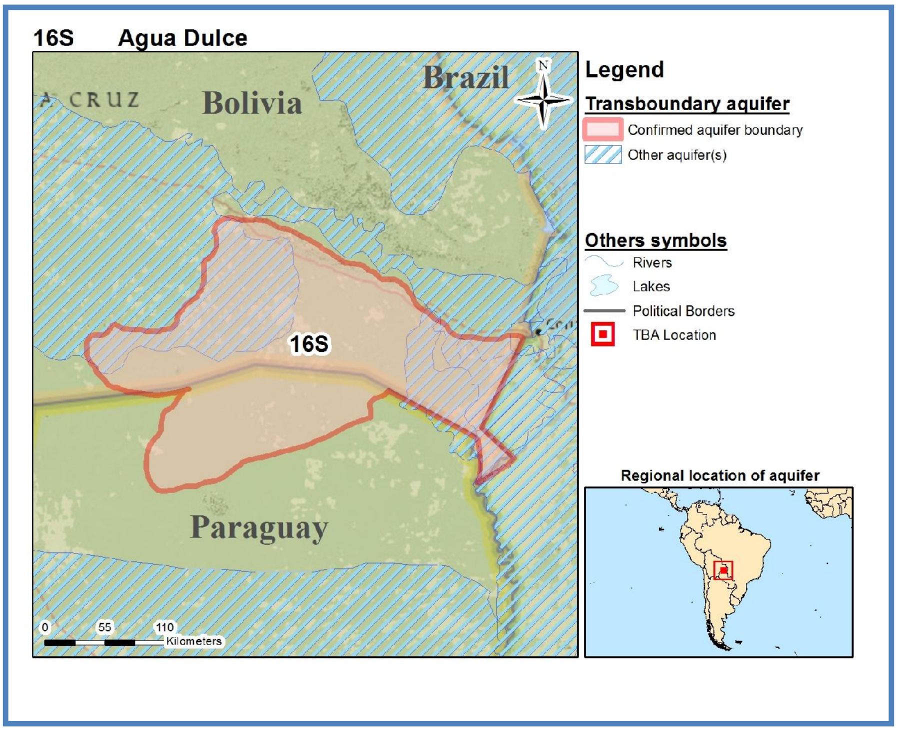


1. Agua Dulce
2. Amazonas
3. Aquidauana-Aquidabán
4. Boa Vista-Serra do Tucano-North Savanna
5. Costeiro
6. Grupo Roraima
7. Litoráneo-Chuy
8. Merged:
   - 8A. Litoral-Cretácico
   - 8B. Serra Geral
   - 8C. Sistema Acuífero Guaraní
   - 8D. Bauru-Caiua-Acaray Aquifer
   - 8E. Salto-Salto Chico
9. Merged:
   - 9A. Coesewijne
   - 9B. A-Sand/ B-Sand
10. Pantanal
11. Permo-Carbonifero
12. Titicaca
13. Yrendá-Toba-Tarijeño
14. Zanderij

16S - Agua Dulce

Geography
Total area TBA (km²): 46 000
No. countries sharing: 3
Countries sharing: Bolivia, Brazil, Paraguay
Population: 54 000
Climate zone: Tropical Dry
Rainfall (mm/yr): 900

Hydrogeology
Aquifer type: Single layer
Degree of confinement: Unconfined
Main Lithology: Massive and semi-consolidated sandstone



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

16S - Agua Dulce

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Bolivia							2			
Brazil							3			
Paraguay			80				<1		D	A
TBA level							**1**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Bolivia	55	35 000	-38	-48	2	50	5	0
Brazil	110	23 000	-22	-29	0	32	5	0
Paraguay	66	240 000	-35	-46	53	53	5	0
TBA level	**59**	**48 000**	**-36**	**-47**	**2**	**50**	**5**	**0**

16S - Agua Dulce

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Bolivia	-1	2	38	74	<1	0	0
Brazil	1	5	19	28	<1	0	0
Paraguay	0	<1	41	81	<1	0	0
TBA level	**-1**	**1**	**38**	**74**	<1	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Bolivia								
Brazil								
Paraguay				Whole aquifer unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits		
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a single-layered, unconfined, aquifer system (information only available from Paraguay).

Hydrogeological aspects

The freshwater aquifers of Cretaceous origin are of granular nature, consisting of red, massive and poorly sorted sandstone. Some aquifer formations consist of Tertiary age semi-consolidated, fine to medium, friable sandstone, confined by a layer of plastic clay. The aquifer material has a high primary porosity and a high horizontal connectivity.

Linkages with other water systems

Groundwater recharge is from precipitation over the aquifer area. No information on the discharge mechanism was provided.

Environmental aspects

The water abstracted from the aquifer is generally of a very good quality. However, Paraguay reports that a significant part of the aquifer has an elevated natural salinity and 30% of the area is not suitable for human consumption. Paraguay also reports that no pollution has been identified and

16S - Agua Dulce

importantly, 100% of the aquifer area within the country is covered with groundwater dependent ecosystems.

Socio-economic aspects
Currently, all of the water abstracted from the aquifer is used to meet the basic needs of the people located on the aquifer area (consumption, sanitation, irrigated orchards).

Legal and Institutional aspects
There is no specific Transboundary legal agreement between the countries about the Agua Dulce Aquifer System. However, Paraguay reports on a Transboundary Institution with a full mandate and full capacity. This needs to be confirmed, seeing it is only reported by one country.

Emerging issues
The shallow, unconfined aquifer system is vulnerable to pollution as well as a high percentage of groundwater dependent ecosystems appear to be the emerging issues of this system. There are also no indications of the readiness for groundwater development and management at National level.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only a very superficial description of the TBA system was possible, because neither of the three aquifer states provided any numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

16S - Agua Dulce

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

13S - Amazonas

Geography

Total area TBA (km^2): 3 600 000

No. countries sharing: 7

Countries sharing: Argentina, Bolivia, Brazil, Colombia, Ecuador, Peru, Venezuela

Population: 18 000 000

Climate zone: Tropical Wet

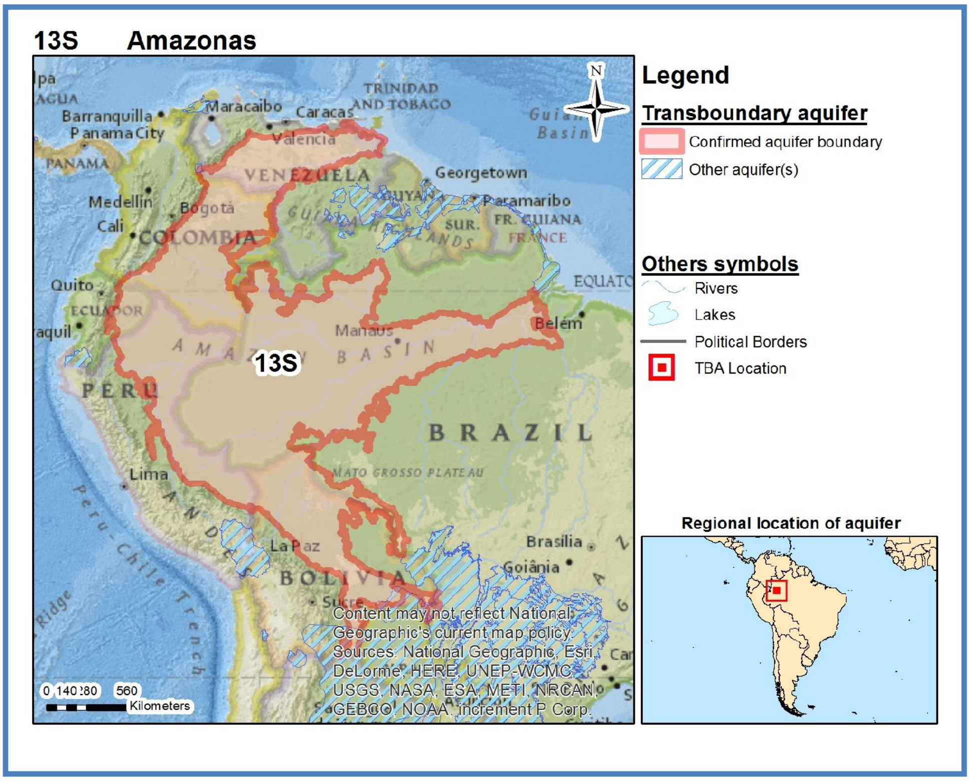
Rainfall (mm/yr): 2300

Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly unconfined, but in some parts confined

Main lithology: Sedimentary rocks - Sandstone



No cross-section available

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13S - Amazonas

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina							11			
Bolivia							6			
Brazil							3		D	C
Colombia							5		D	B
Ecuador							7			
Paraguay							3			
Peru			70				3			D
Venezuela	32	1800	90		0		18	<5	B	D
TBA level							**5**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Argentina	49	4900	-18	-39	21	11	4	38
Bolivia	260	46 000	-35	-52	22	57	4	2
Brazil	540	180 000	-17	-21	11	32	23	3
Colombia	640	120 000	-18	-26	17	22	3	8
Ecuador	510	77 000	-20	-28	6	32	5	0
Paraguay	44	21 000	-28	-48	7	36	4	42
Peru	520	160 000	-22	-31	18	27	18	9
Venezuela	190	9400	-31	-45	8	21	1	1
TBA level	**490**	**92 000**	**-23**	**-33**	**11**	**26**	**1**	**3**

13S - Amazonas

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Argentina	0	10	19	32	1	1	2
Bolivia	-1	6	40	80	<1	0	0
Brazil	-2	3	16	22	<1	0	0
Colombia	0	5	23	36	<1	0	0
Ecuador	-1	7	27	43	<1	0	0
Paraguay	0	2	39	77	<1	0	0
Peru	0	3	26	41	<1	0	0
Venezuela	3	20	32	52	<1	0	0
TBA level	**-1**	**5**	**26**	**44**	<1	0	0

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Primary Porosity	Secondary Porosity	Transmissivity (m^2/d)
Argentina								
Bolivia								
Brazil			400	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Dissolution	
Colombia								
Ecuador								
Paraguay								
Peru	6	20	25	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	Very high primary porosity gravels/ pebbles	Secondary porosity: Fractures	
Venezuela	6	40	34	Aquifer mostly unconfined, but some parts confined	Sediment Sand	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	500
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

13S - Amazonas

Aquifer description

Aquifer geometry

Only 3 of the 6 TBA countries have provided information for this large aquifer system. It is a multiple-layered hydraulically connected system. The average depth to the water table is 6m in both Brazil and Venezuela. The average depth to the top of the aquifer is between 20m and 40m in Brazil and Venezuela respectively. The thickness of the aquifer system varies between 25m and 400m (greatest thickness in Brazil). The aquifer is mostly unconfined, but in some parts confined.

Hydrogeological aspects

The Regional Report sums up the aquifer type as Sedimentary: unconsolidated and consolidated sandstones and clays. In the database Brazil and Peru describe the predominant aquifer lithology as sedimentary rocks – shale and Venezuela as sediment – sand. The shale lithology appears inconsistent with the porosity information that is provided, and should be reviewed. Venezuela reports an average transmissivity of 500m^2/d (variation: 200-1500 m^2/d). The total groundwater volume is 80km^3 within Venezuela. The average annual recharge into the system within Venezuela is 10 000Mm^3/annum.

Linkages with other water systems

Recharge to the system is from precipitation over the aquifer area (see appendix 1) whereas discharge is through river base flow and outflow into lakes (in the case of Venezuela) (see appendix 2).

Environmental aspects

Around 10% of the natural groundwater within Venezuela and 30% within Peru are unsuitable for human consumption but the main cause is not recorded. Venezuela reports that this is only within the superficial layers. Some anthropogenic pollution has been identified within Brazil, Peru, and Venezuela where it is only over the superficial layers. It is due to diverse causes including urban, industrial, agricultural and mining activities. The natural water quality is good but, the aquifer has high vulnerability in several points where the water table is close to the surface. Within Venezuela 40% of the aquifer has shallow groundwater whereas this increases to 70% within Peru. Only Venezuela reports on the aquifer area covered with groundwater dependent ecosystems, very high at 70%.

Socio-economic aspects

The exploitation of the aquifer system varies widely between countries. Indications are that, in general, the level of use of the aquifer system is still moderate and no problems have been detected in this regard. In general the largest use is for public supply and domestic use, except in Venezuela where the highest use is for irrigation (70%). This country reports an average groundwater abstraction of 23 Mm^3/annum.

Legal and Institutional aspects

There is no common reporting under this point. Venezuela reports on a ratified Multi-lateral Agreement with limited scope. The River Basin agreement (Tratado de Cooperación Amazónica - Bolivia, Brasil, Colombia, Ecuador, Guyana, Perú, Suriname and Venezuela) can provide the basis for future agreements for joint management of groundwater.

Emerging issues

The high vulnerability of the shallow aquifer system to pollution appears as an emerging issue. Closer attention also needs to be paid to the conservation of groundwater dependent ecosystems. Reporting has been poor in this important international system and this needs to be addressed in all countries.

13S - Amazonas

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert
Ana Karina Campillo Pérez	Instituto de Hidrología, Meteorología y Estudios Ambientales - IDEAM	Colombia	acampillo@ideam.gov.co	Contributing national expert
Nelson Omar Vargas Martínez	Instituto de Hidrología, Meteorología y Estudios Ambientales - IDEAM	Colombia	nvargas@ideam.gov.co	Lead National Expert
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Carmen Rosa Chamorro Bellido	Autoridad Nacional del Agua	Peru	cchamorro@ana.gob.pe	Contributing national expert
Julio Chunga	Autoridad Nacional del Agua	Peru	jchunga@ana.gob.pe	Contributing national expert
Manuel Celestino Figuera	Instituto Nacional De Meteorología e Hidrología - INAMEH	Venezuela	mfiguera@inameh.gob.ve	Contributing national expert
Sherley Fernández	Instituto Nacional De Meteorología e Hidrología - INAMEH	Venezuela	sfernandez@inameh.gob.ve	Contributing national expert
Fernando Alberto Decarli Rodríguez	Instituto Nacional De Meteorología e Hidrología - INAMEH	Venezuela	fdecarli@inameh.gob.ve, fdecarli@hotmail.com, fdecarlira@gmail.com	Lead National Expert
German Zerpa Calandieli	Instituto Nacional De Meteorología e Hidrología - INAMEH	Venezuela	gzerpa@inameh.gob.ve	Contributing national expert

Considerations and recommendations

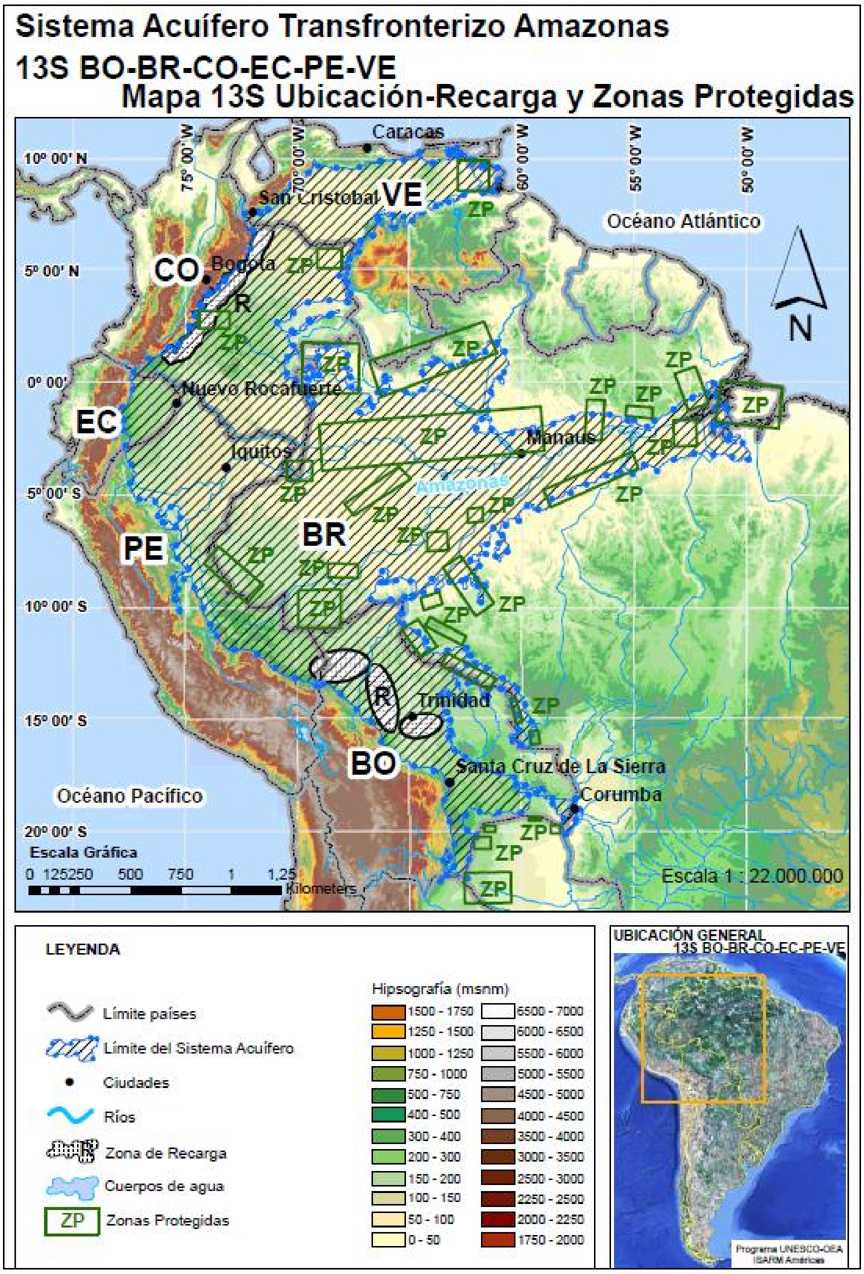
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only 3 of the 6 TBA countries have provided information. This information was also inconsistent and did not allow for an adequate description of this large aquifer system. Only Venezuela provided some quantitative information that allowed calculation of indicators.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

13S - Amazonas

Appendix 1: 13S



Location of recharge and protection zones

13S - Amazonas

Appendix 2: 13S

Showing an area with the main Groundwater Flow directions

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
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13S - Amazonas

References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

19S - Aquidauana-Aquidabán

Geography

Total area TBA (km^2): 27 000

No. countries sharing: 2

Countries sharing: Brazil, Paraguay

Population: 200 000

Climate zone: Humid Subtropical

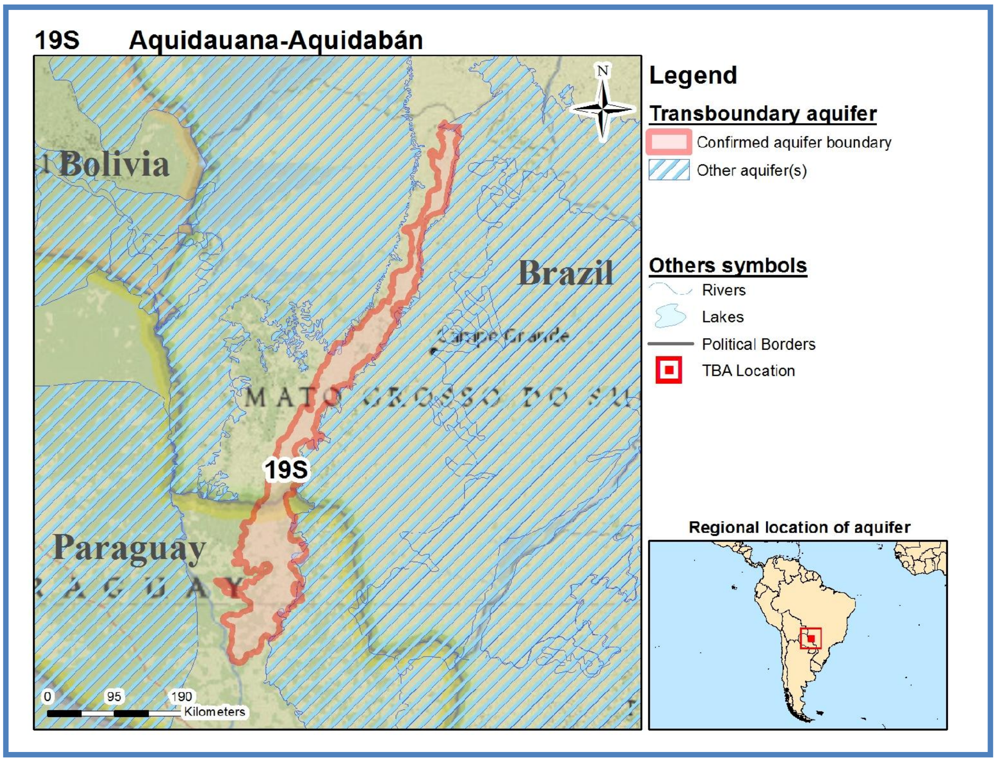
Rainfall (mm/yr): 1 400

Hydrogeology

Aquifer type: Multi-layered

Degree of confinement: Semi-confined

Main Lithology: Cemented and un-cemented sandstone, sedimentary rocks - shales



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

19S - Aquidauana-Aquidabán

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							4		D	C
Paraguay							11			
TBA level							**7**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	160	34 000	-28	-35	28	32	23	23
Paraguay	84	8100	-40	-55	10	11	6	41
TBA level	**120**	**17 000**	**-36**	**-48**	**19**	**21**	**15**	**28**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	-1	5	17	23	<1	0	0
Paraguay	0	10	39	70	<1	0	1
TBA level	**-1**	**7**	**31**	**54**	<1	**0**	**0**

19S - Aquidauana-Aquidabán

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil		150	300	Whole aquifer semi-confined	Sedimentary rocks - Sandstone	Low primary porosity	Secondary porosity: Dissolution	
Paraguay								
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi-layered aquifer system that is entirely semi-confined. The depth to the top of the aquifer is 150 m and average thickness of the aquifer system is 300 m (within Brazil).

Hydrogeological aspects

Although the sedimentary sequence is dominated by a sandstone facies, the aquifer has a low potential for storage and for the supply of water. This characteristic is related to the occurrence of thick packages of cemented sandstones, clayey facies intercalated with sandstone packages and the presence of a clay matrix within the un-cemented sandstones. In the areas of cemented sandstone, the aquifer behaves as a fractured system, where the storage and supply of groundwater is related to fault planes and fractures, with a low hydrogeological potential. The wide diversity in vertical succession of facies interferes with the porosity of the aquifer. Generally the system has a low primary porosity with secondary porosity fractures. This is characterised by a low horizontal and a higher vertical connectivity. No information was recorded on groundwater recharge or discharge mechanisms.

Linkages with other water systems

No information was provided.

Environmental aspects

No information on the natural groundwater quality was recorded. The main sources of anthropogenic groundwater pollution are diffuse sources such as the application of pesticides in agriculture, and point sources, such as disposal of untreated industrial effluents and improper disposal of waste (Brazil).

Socio-economic aspects

The main groundwater use is for household and drinking water supply.

Legal and Institutional aspects

There is no specific legal Transboundary Agreement between the countries in place with regard to this aquifer system. Brazil reports on a National Institute with a full mandate and capacity.

19S - Aquidauana-Aquidabán

Emerging issues
Pollution from a variety of sources appears to be an emerging issue.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only one country has provided very limited numerical information, thus only allowing a very superficial description of the TBA.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

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19S - Aquidauana-Aquidabán

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- All other data: TWAP Groundwater (2015).

Version: October 2015

5S - Boa Vista-Serra do Tucano-North Savanna

Geography

Total area TBA (km^2): 22 000

No. countries sharing: 2

Countries sharing: Brazil, Guyana

Population: 280 000

Climate zone: Tropical Dry

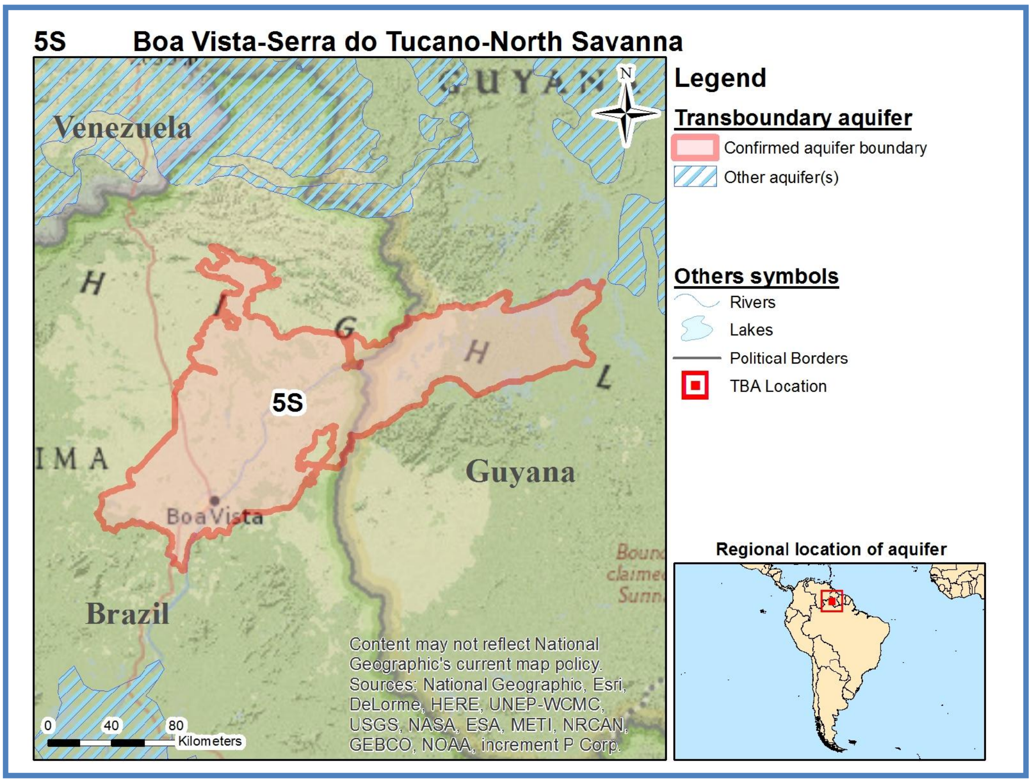
Rainfall (mm/yr): 1500

Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly unconfined

Main Lithology: Arkosic sandstones, conglomerates and siltstones



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

5S - Boa Vista-Serra do Tucano-North Savanna

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							19		D	D
Guyana							<1			
TBA level							**13**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	290	17 000	-17	-22	28	32	11	23
Guyana	170	490 000	-15	-19	18	32	0	0
TBA level	**250**	**21 000**	**-17**	**-22**	**28**	**32**	**11**	**23**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	4	17	16	21	<1	0	0
Guyana	1	<1	13	16	<1	0	0
TBA level	**3**	**12**	**16**	**21**	<1	**0**	**0**

5S - Boa Vista-Serra do Tucano-North Savanna

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Primary Porosity	Secondary Porosity	Transmissivity (m^2/d)
Brazil				Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Dissolution	
Guyana								
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi-layered hydraulically connected system that is mostly unconfined, but some parts are semi-confined.

Hydrogeological aspects

Although consisting of potentially porous sedimentary rocks, the primary porosity is reduced, due to cementation of pores, behaving thus as an aquifer with characteristics of secondary porosity: dissolution. It also has a low horizontal and vertical connectivity.

Linkages with other water systems

Precipitation over the aquifer (see appendix) is mentioned as the main recharge mechanism, but there is no mention of the discharge mechanism.

Environmental aspects

There appear to be some problems with some elevated natural salinity in Brazil but the extent thereof was not recorded. Brazil reports some pollution from households and municipalities. Human consumption in urban areas generally is limited due to the high natural vulnerability (the aquifer has a shallow water table) and the high potential for contamination from poorly constructed wells, and the absence of or the poor protection and lack of basic sanitation, particularly in the urban areas.

Socio-economic aspects

The main use is for human supply, although there is an increasing use for agriculture.

Legal and Institutional aspects

There is no legal agreement between the countries. Brazil reports on a National Institution with a full mandate but limited capacity.

Emerging issues

The high pollution risk of the shallow aquifer system as well as pollution sources of household and municipal origin appears to be the emerging issues.

5S - Boa Vista-Serra do Tucano-North Savanna

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert

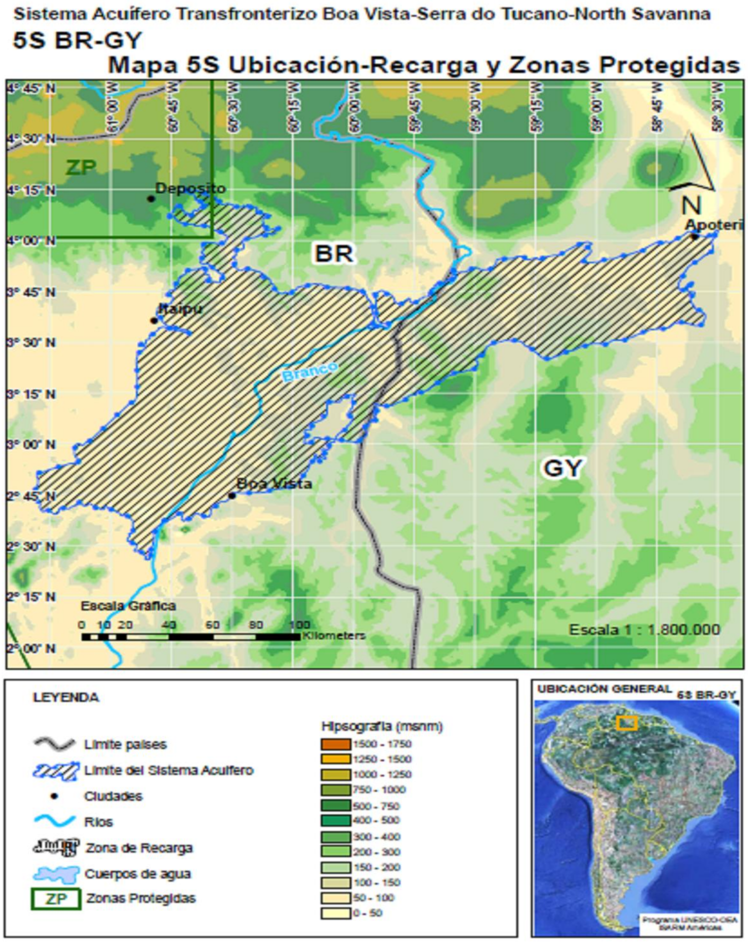
Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only a very superficial description of the TBA system was possible, because neither of the two aquifer states provided any numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix: 5S Boa Vista-Serra do Tucano-North Savanna: Location of recharge and protection zones



5S - Boa Vista-Serra do Tucano-North Savanna

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- All other data: TWAP Groundwater (2015).

Version: October 2015

9S - Costeiro

Geography

Total area TBA (km^2): 34 000

No. countries sharing: 2

Countries sharing: Brazil-French Guiana

Population: 600 000

Climate zone: Tropical Wet

Rainfall (mm/yr): 2900

Hydrogeology

Aquifer type: Single-layered

Degree of confinement: Unconfined

Main Lithology: Alluvial sediments, sandstones

No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

9S - Costeiro

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							19		A	D
French Guiana							15			
TBA level							**18**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	340	20 000	-18	-24	23	32	61	12
French Guiana	220	11 000	-46	-62	0	0	3	0
TBA level	**320**	**18 000**	**-25**	**-35**	**12**	**32**	**18**	**4**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	-1	17	16	21	<1	0	0
French	1	21	65	130	<1	0	0

9S - Costeiro

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Guiana							
TBA level	**-1**	**18**	**25**	**42**	<1	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil				Whole aquifer unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	
French Guiana								
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a single-layered system that is unconfined over the whole aquifer area.

Hydrogeological aspects

The main aquifer lithology is composed of alluvial sediments that are semi-consolidated to unconsolidated.

Linkages with other water systems

No information was provided – (see Recharge zone map in the Appendix below)

Environmental aspects

The natural groundwater quality is good, but the aquifer is highly vulnerable to pollution. Within Brazil problems with natural salinity and the risk of pollution from households and municipalities is experienced.

Socio-economic aspects

This aquifer is used for human water supply. Production wells have yields varying from 20 to 200 m^3/h.

9S - Costeiro

Legal and Institutional aspects
Within Brazil a full-scale signed Agreement exists (Tratado de Cooperación Amazónica, 1978). Brazil also reports on the National Institution that has a full mandate but with limited capacity. Groundwater abstraction, groundwater quality protection, and drilling control are undertaken according to existing legislation but in practice this is with limited application/ implementation/ and enforcement.

Emerging issues
A vulnerable aquifer system and the risk of pollution from households and municipalities appear to be the emerging issues.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert

Considerations and recommendations

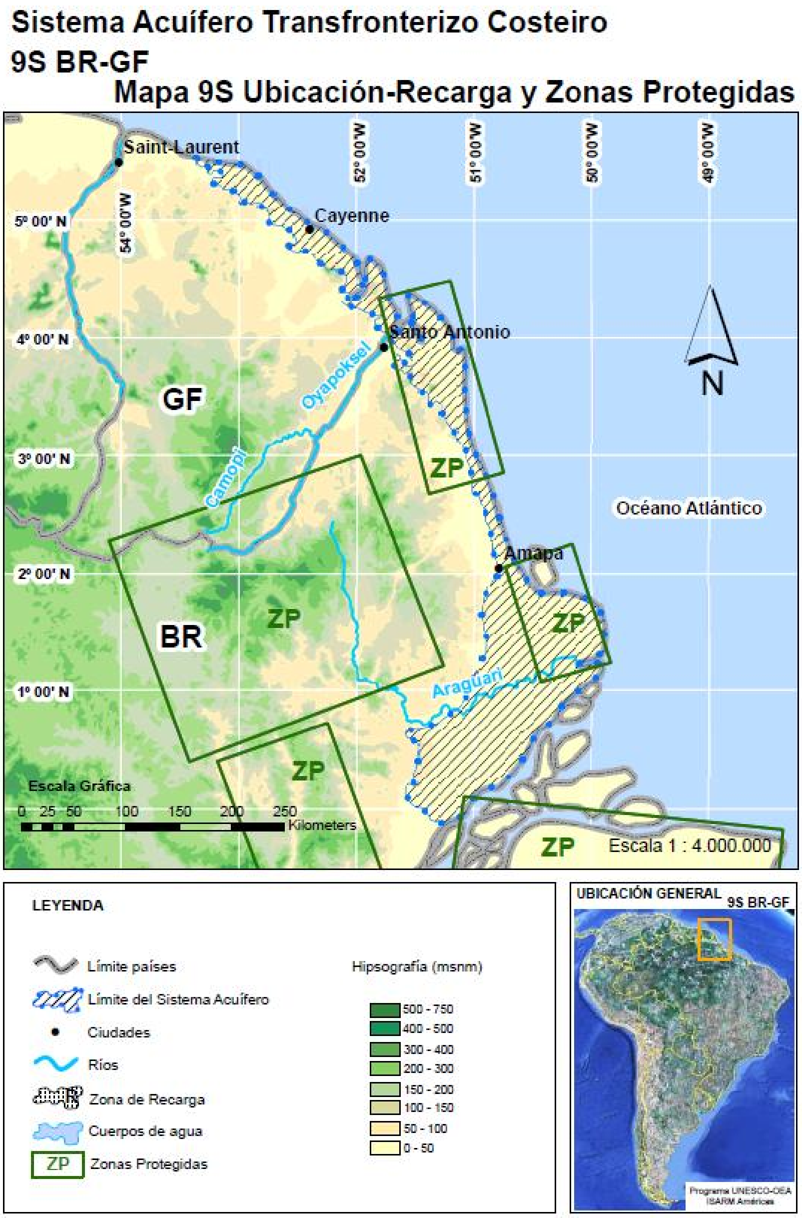
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

The TBA system could only be described very superficially, because both TBA countries did not provide any numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

9S - Costeiro

Appendix: 9S



Map indicating recharge and protection zones

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

9S - Costeiro

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

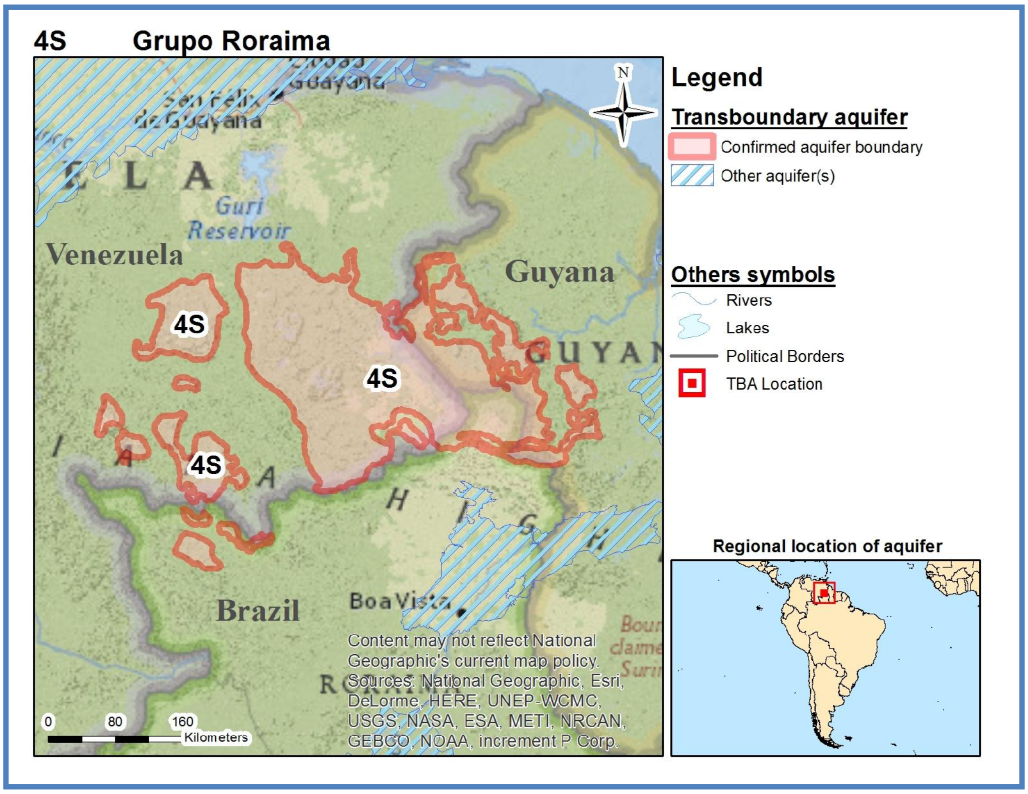
4S - Grupo Roraima

Geography

Total area TBA (km^2): 76 000
No. countries sharing: 3
Countries sharing: Brazil, Guyana, Venezuela
Population: 57 000
Climate zone: Tropical Dry
Rainfall (mm/yr): 2400

Hydrogeology

Aquifer type: Multiple layers hydraulically connected
Degree of confinement: Mostly semi-confined, some parts unconfined
Main Lithology: Sandstones, tuffs and siltstones



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

4S - Grupo Roraima

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							1		A	D
Guyana							<1			
Venezuela							1		B	D
TBA level							**1**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use (%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	420	660 000	-17	-26	16	32	3	0
Guyana	600	1 500 000	-21	-30	23	25	0	0
Venezuela	450	510 000	-27	-41	20	21	3	21
TBA level	**480**	**620 000**	**-26**	**-39**	**19**	**22**	**3**	**21**

4S - Grupo Roraima

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	4	1	17	23	0	0	0
Guyana	2	<1	17	24	0	0	0
Venezuela	5	1	31	52	<1	0	0
TBA level	**4**	**1**	**29**	**47**	**0**	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil				Aquifer mostly semi-confined, but some parts unconfined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Dissolution	
Guyana								
Venezuela			<1	Whole aquifer unconfined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Fractures	
TBA Level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a two layered, hydraulically connected system that is mostly semi-confined, but some parts are unconfined (Venezuela).

Hydrogeological aspects

Although consisting of potentially porous sedimentary rocks (arkosic sandstones, tuffs, paleoproterozoic conglomerates and siltstones), the primary porosity is reduced, due to cementation of pores, behaving thus as an aquifer with intergranular/fractured characteristics. It is characterised by a low to high horizontal and a high vertical connectivity.

Linkages with other water systems

Recharge is from runoff into the aquifer area (see appendix), whereas the discharge mechanism is through groundwater flow into another aquifer.

4S - Grupo Roraima

Environmental aspects

Some of the natural groundwater within Venezuela does not meet drinking water standards within the superficial layers but the exact cause was not recorded. There is some superficial anthropogenic pollution from mining activities and from households and municipal activities but this was not quantified. The main results are excessive amounts of nitrates, pathogens and heavy metals.

Socio-economic aspects

The amount of groundwater abstraction and fresh water use over the aquifer area has not been recorded. However, intakes of groundwater for indigenous communities and for mining are mentioned in the Regional Report, which are not recorded on the data base and need to be addressed, because of their importance.

Legal and institutional aspects

Brazil and Venezuela report on an existing Multi-lateral Agreement. Both countries also make mention about National Institutions that have a limited capacity. Within Venezuela groundwater quality protection and drilling control is done according to law/ regulations and measure are also applied in practice. Within both Brazil and Venezuela groundwater abstraction control is in place but with limited application, implementation, and enforcement.

Emerging issues

The development of groundwater resources for indigenous communities and potential pollution from mining activities appear to be emerging issues.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
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4S - Grupo Roraima

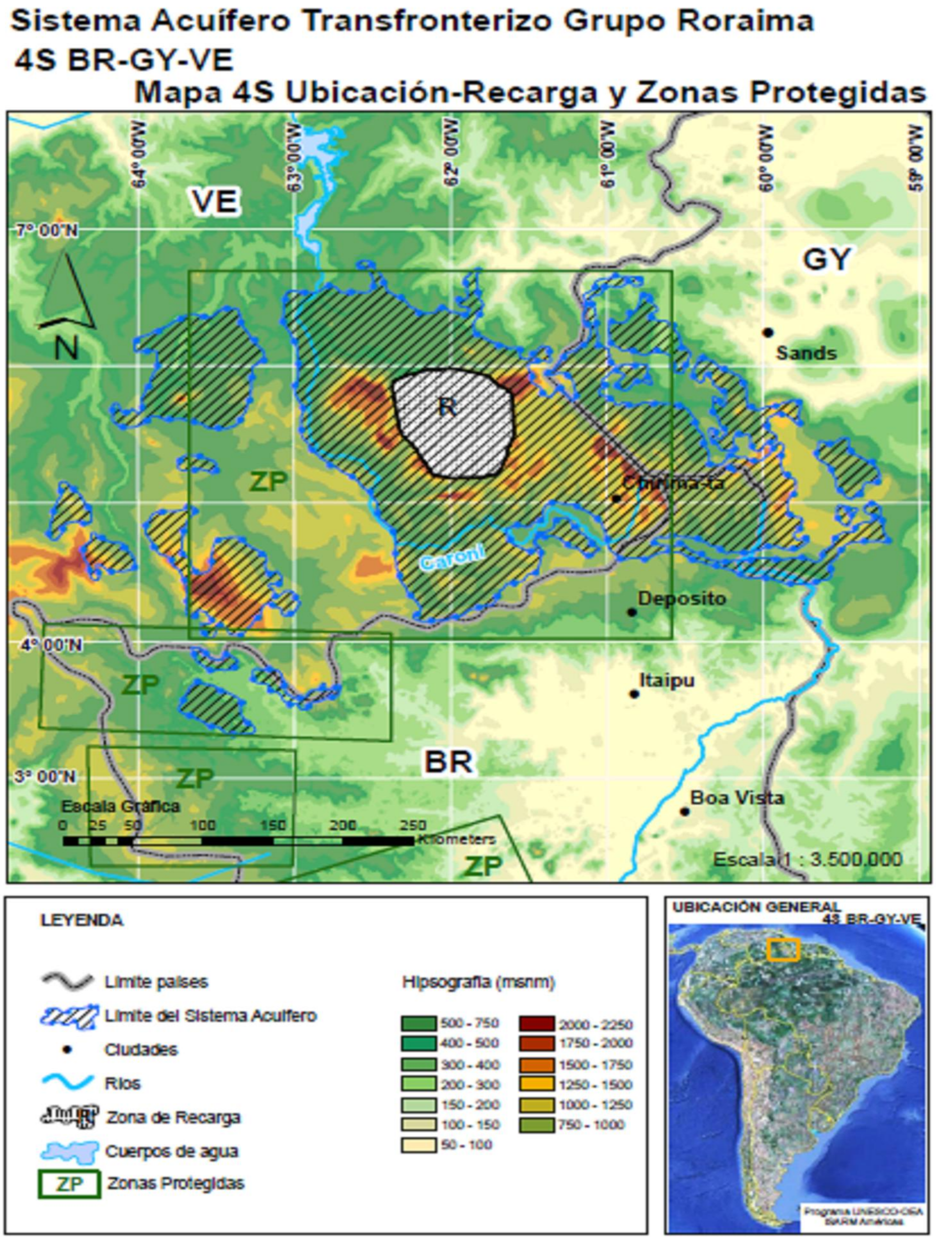
Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only a very superficial description of the TBA system was possible, because neither of the two aquifer states provided any numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix: 4S



Grupo Roraima: Location of recharge and protection zones

4S - Grupo Roraima

Colophon

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

23S - Litoráneo-Chuy

Geography
Total area TBA (km^2): 42 000
No. countries sharing: 2
Countries sharing: Brazil, Uruguay
Population: 2 600 000
Climate zone: Humid Subtropical
Rainfall (mm/yr): 1300

Hydrogeology
Aquifer type: Multiple layers hydraulically connected
Degree of confinement: Mostly semi-confined, some parts unconfined
Main Lithology: Sandstone and shale

No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

23S - Litoráneo-Chuy

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita ($m^3/y/capita$)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							78		D	D
Uruguay			100				8		D	D
TBA level							**60**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state ($m^3/y/capita$)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	190	2300	-14	-19	10	32	1	7
Uruguay	150	22 000	-7	-9	5	18	4	23
TBA level	**180**	**2900**	**-14**	**-19**	**9**	**32**	**1**	**7**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	0	82	16	21	2	2	3
Uruguay	0	7	7	8	<1	0	0
TBA level	**0**	**64**	**16**	**21**	**1**	**1**	**3**

23S - Litoráneo-Chuy

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil				Whole aquifer unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	
Uruguay	5			Aquifer mostly semi-confined, but some parts unconfined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	400
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a two layered, hydraulically connected, aquifer system. The aquifer is mostly semi-confined, but some parts are unconfined (Brazil). The average depth to the groundwater table is 5m within Uruguay.

Hydrogeological aspects

The aquifer system consists of shale and sand, with a grain size of fine to medium, with high primary porosity, with no secondary porosity and a low horizontal and vertical connectivity. The average value for transmissivity is 400 m^2/d within Uruguay that also reports a total groundwater volume of 43 000 km^3 (figure needs to be checked).

Linkages with other water systems

Recharge is from precipitation over the aquifer area, whereas discharge to springs is the main mechanism that is reported in the case of Uruguay.

Environmental aspects

A significant part of the aquifer is unsuitable for human consumption due to elevated natural salinity. Some pollution has been identified in Brazil (households, municipalities and agricultural practices) but areal extent has not been specified. The most vulnerable areas are where the aquifer is unconfined. It is also a coastal aquifer, with the consequent risk of salinization.

Socio-economic aspects

Water quality generally allows most uses, with human supply being the largest user. Private wells also draw water but in amounts that do not compromise the functioning of the aquifer. Uruguay reports a groundwater abstraction of 0.8Mm^3/annum.

23S - Litoráneo-Chuy

Legal and Institutional aspects

There is no specific Transboundary legal agreement between the countries. Both countries have national groundwater institutions with a full mandate, but still with limited capacity.

Emerging issues

Vulnerability of the very shallow unconfined aquifer to pollution appears to be the main issue at present. Sea water intrusion must also be guarded against.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
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23S - Litoráneo-Chuy

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Both countries only provided very limited numerical information, thus only allowing for a superficial description of the TBA.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

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References:

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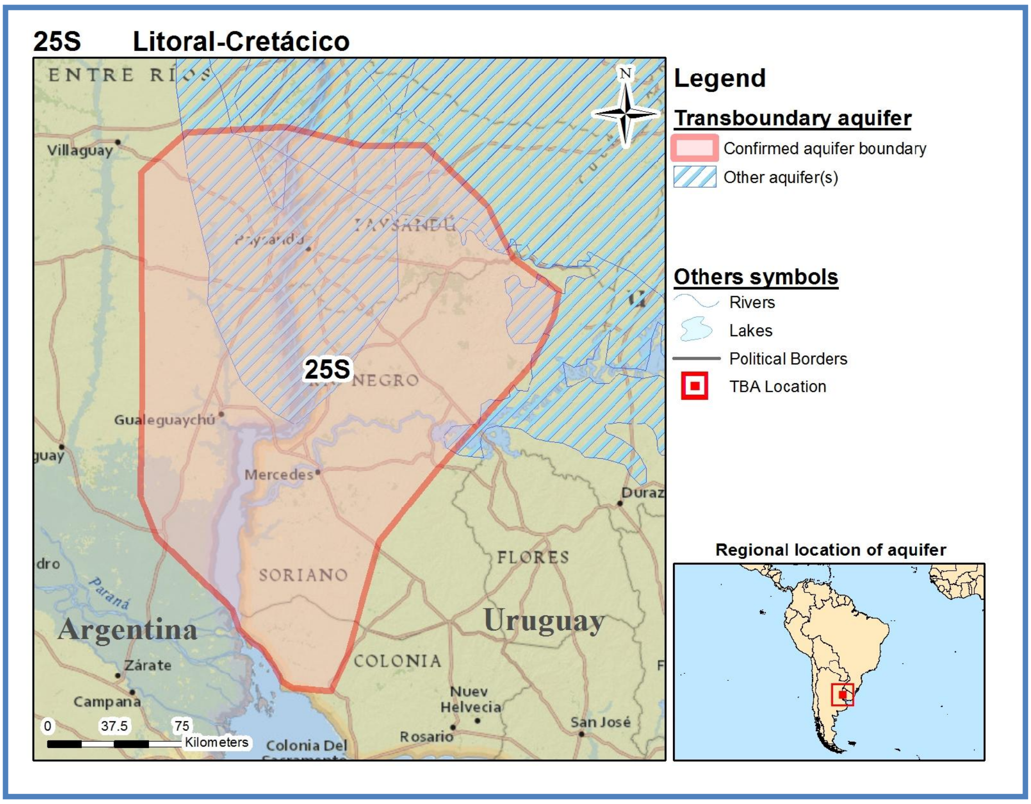
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

25S - Litoral-Cretácico

Geography
Total area TBA (km^2): 33 000
No. countries sharing: 2
Countries sharing: Argentina, Uruguay
Population: 410 000
Climate zone: Humid Subtropical
Rainfall (mm/yr): 1100

Hydrogeology
Aquifer type: Multiple- to single-layered
Degree of confinement: Confined to semi-confined
Main Lithology: Sandstone and silt



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

25S - Litoral-Cretácico

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina			95				18		D	D
Uruguay							9		D	D
TBA level							**12**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Argentina	40	60	70	Whole aquifer confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits		42
Uruguay	13	25	65	Whole aquifer semi-confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	53
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

25S - Litoral-Cretácico

Aquifer description

Aquifer geometry

This aquifer is a multiple-layered hydraulically connected system in Argentina and a single layer system in Uruguay. The average depth to the water table varies between 13m and 40m. The average depth to the top of the aquifer varies between 25m and 60m whereas the average thickness of the aquifer system varies between 65m and 70m. The aquifer is mostly confined to semi-confined.

Hydrogeological aspects

The aquifer lithology consists of conglomeratic sandstones, fine to medium at the base, with interbedded silt, near the top. It has a high primary porosity with secondary-dissolution porosity that seems to occur only in Uruguay. It has a low to high horizontal connectivity and a high vertical connectivity. The groundwater flow direction is from east to west. The average transmissivity varies between 42 – 53m^2/d. The surface outcrop occurs in the territory of Uruguay, where the recharge, that is 100% through natural causes, occurs.

Linkages with other water systems

Recharge is from precipitation over the aquifer area where it outcrops and through infiltration from surface water. Discharge is by means of groundwater flow into another aquifer.

Environmental aspects

In terms of natural water quality, a significant part of the aquifer in Uruguay is unsuitable for human consumption due to elevated levels of fluorides and arsenic. In Argentina around 4% of the aquifer area within the surficial layers are affected by natural salinity. Groundwater pollution has been identified in both countries, in Argentina from municipalities and agricultural practices but only in surficial layers, whereas in Uruguay a significant part of the aquifer has been impacted. No information on shallow groundwater and groundwater dependent ecosystems has been recorded.

Socio-economic aspects

The total groundwater abstraction during 2010 from the aquifer on the Uruguay side was 12Mm^3, with agriculture being the highest user.

Legal and Institutional aspects

There is no specific Transboundary legal agreement between the countries. Both countries make mention of a National Institution with a full mandate, but with limited capacity.

Priority issues

Water quality appears to be a priority issue, both from a natural quality point of view and as a result of pollution. This needs to be addressed by the National Institutions.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Verónicaq del Carmen Musacchio	Facultad de Ingenieria y Ciencias Hídricas. Universidad Nacional del Litoral.	Argentina	musavero@yahoo.com.ar	Contributing national expert
Ofelia Clara Tujchneider	Facultad de Ingenieria y Ciencias Hídricas. Universidad Nacional del Litoral.	Argentina	ofeliatujchneider	Lead National Expert

25S - Litoral-Cretácico

Name	Organisation	Country	E-mail	Role
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Natalia Cabrera Laborde	Dirección Nacional de Aguas-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	ncabrera@mvotma.gub.uy	Contributing national expert
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Andrés Pérez Pablo Decoud	OSE	Uruguay	aperez@ose.com.uy / pdecoud@yahoo.com	Contributing national expert
Luis Reolón	Dirección Nacional de Medio Ambiente-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	luis.reolon@mvotma.gub.uy	Contributing national expert

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

An adequate aquifer description was possible, because three of the four aquifer states reported. The information was not sufficient to calculate the groundwater indicators.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

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25S - Litoral-Cretácico

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- All other data: TWAP Groundwater (2015).

Version: October 2015

22S - Serra Geral

Geography

Total area TBA (km^2): 450 000

No. countries sharing: 4

Countries sharing: Argentina, Brazil, Paraguay, Uruguay

Population: 16 000 000

Climate zone: Humid Subtropical

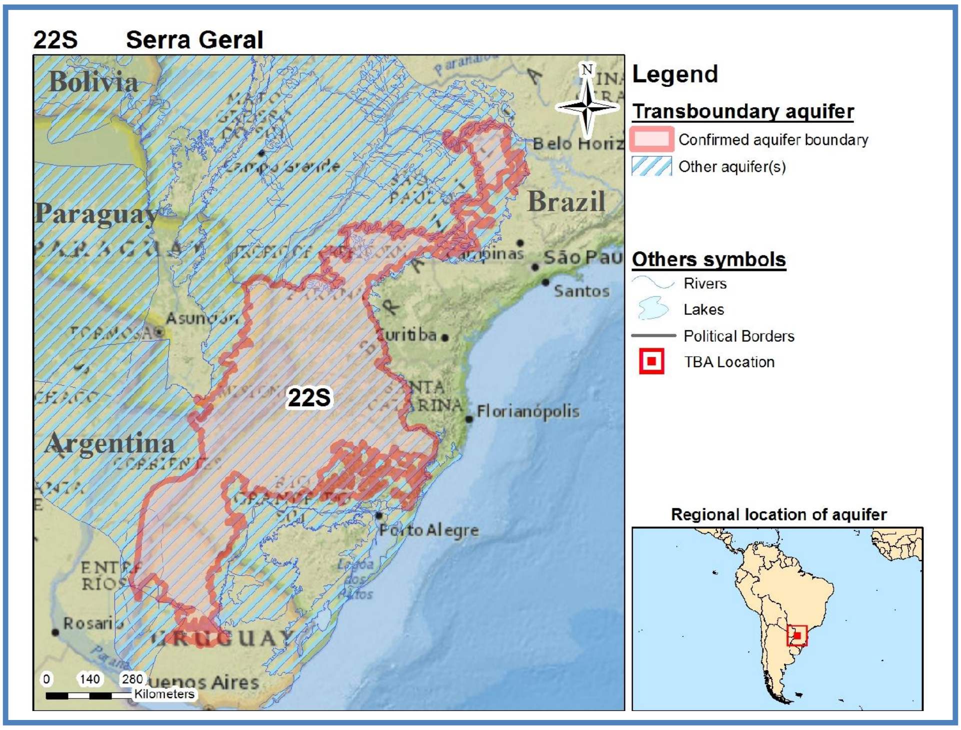
Rainfall (mm/yr): 1600

Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly semi-confined, in some parts unconfined

Main Lithology: Crystalline rocks - Basalt



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

22S - Serra Geral

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina			90				31		D	D
Brazil							39		D	C
Paraguay							48		D	A
Uruguay			100				8		D	D
TBA level							**35**			**F**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Argentina	52		45	Aquifer mostly semi-confined, but some parts unconfined	Crystalline rocks - Basalt	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	95
Brazil				Aquifer mostly confined, but some parts unconfined	Crystalline rocks - Basalt	Low primary porosity intergranular porosity	Secondary porosity: Fractures	340

22S - Serra Geral

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Paraguay	52		45	Aquifer mostly semi-confined, but some parts unconfined	Crystalline rocks - Basalt	Low primary porosity intergranular porosity	Secondary porosity: Fractures	83
Uruguay	13	50		Aquifer mostly semi-confined, but some parts unconfined	Crystalline rocks - Basalt	Low primary porosity intergranular porosity	Secondary porosity: Fractures	
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

The aquifer system is a multiple 2-layered, hydraulically connected system although within Uruguay it is single-layered. It is mostly semi-confined, but in some parts unconfined. The average depth to groundwater level varies between 13m and 52m. The average depth to the top of the aquifer is 50m within Uruguay and the average vertical thickness of the aquifer system is 45m within Paraguay and Argentine.

Hydrogeological aspects

The main lithology is crystalline rocks - basalt of low primary porosity and secondary porosity: fractures. Besides the tectonic fractures that are important for the movement and storage of water, there are fractures of cooling that can be vertical (columnar disjunctions) or sub-horizontal. Connectivity is low horizontally but high vertically. Given the anisotropic characteristics of the aquifer system, the yields exhibit a varied range, with values ranging from 1 m^3/h up to 100 m^3/h. The average transmissivity values vary between 83m^2/d in Paraguay to 340m^2/d within Brazil. Only Argentina reports the total groundwater volume as 30 km^3.

Linkages with other water systems

Recharge to the system is from infiltration from surface water bodies as well as from precipitation on the aquifer (Uruguay). The main discharge mechanism is through river base flow.

Environmental aspects

Argentina and Paraguay report groundwater in parts unsuitably for drinking as a result of natural salinity in the surficial layers. The more alkaline pH values, manganese, iron and fluoride in some samples may exceed the limits of potability. In Argentina this was the case in 10% of the aquifer area. Some pollution has been identified in Argentina (municipalities and agricultural practices - irrigation, pesticides, fertilizers) and Brazil (municipalities, industrial waste disposal, agricultural practices mining activities) and significant pollution in Paraguay (landfills/waste disposal sites, municipalities, agricultural practices). Only Uruguay reported that no pollution has been identified to date. Within

22S - Serra Geral

Argentine 15% of the aquifer area contains shallow groundwater but the extent of groundwater dependent ecosystems was not recorded.

Socio-economic aspects

Water for human consumption makes up the highest percentage of the groundwater use and water quality can in general meet this need. Only Uruguay provides an estimate of groundwater abstraction, namely 4.6 Mm^3/annum.

Legal and Institutional aspects

There are no specific legal agreements between the countries. However, Paraguay reports on a dedicated full scope Transboundary Institution. Three countries report on a National Institution with a groundwater mandate, but in two cases still with limited capacity. The River Basin Agreement (Tratado de la Cuenca del Plata) of which Bolivia is also a part of, can provide the basis for future agreements for joint management of the groundwater.

Emergency issues

Groundwater pollution is becoming a problem in three of the countries. Raising the capacity for groundwater management of the national institutions appears to be a priority.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
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22S - Serra Geral

Name	Organisation	Country	E-mail	Role
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Daniel González Pérez	Dirección Nacional de Aguas-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	dinagua@mvotma.gub.uy	Lead National Expert
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Luis Reolón	Dirección Nacional de Medio Ambiente-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	luis.reolon@mvotma.gub.uy	Contributing national expert

Considerations and recommendations

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References:

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

21S - Sistema Acuífero Guaraní

Geography

Total area TBA (km^2): 1 200 000

No. countries sharing: 4

Countries sharing: Argentina, Brazil, Paraguay, Uruguay

Population: 33 000 000

Climate zone: Humid Subtropical

Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly confined, some parts unconfined.

Main Lithology: Sandstone and shale

No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

21S - Sistema Acuífero Guaraní

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina							18		B	D
Brazil	6	210			1		31	20	A	C
Paraguay							30			
Uruguay	<1	<1	100				9	>1000	A	D
TBA level							**27**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Argentina			250	Whole aquifer confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits		120
Brazil			250	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	340

21S - Sistema Acuífero Guaraní

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Paraguay								
Uruguay	18	480	620	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	110
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi-layered, hydraulically connected system that is mostly confined, but some parts are unconfined. Within Uruguay the average depth to the piezometric groundwater level is 18m; while the average depth to top of aquifer is 480m (minimum 2m and maximum 960m). The average vertical thickness of the aquifer system varies between 250m within Brazil and Argentine to 620m within Uruguay.

Hydrogeological aspects

Guarani Aquifer sandstones (GAS) and shales that are the dominant lithology within the aquifer system. The formation has a high primary porosity with secondary porosity: dissolution in places. It is also characterized by a high horizontal and a low vertical connectivity. Average transmissivity varies between 110 m^2/day (Uruguay and Argentina) and 340m^2/day (Brazil). Groundwater flow of GAS, from recharge areas to discharge areas, has a regional tendency that directs the flow from north to south, accompanying the axis of the Paraná Basin. The average annual recharge within the Brazil portion of the system is 5 200Mm^3/annum. The main recharge area within Uruguay covers an area of 3 000km^2.

Linkages with other water systems

The main source of recharge water is primarily through precipitation over the aquifer area. There is interaction between groundwater and surface water and, generally, base flows in rivers and other water bodies, come from discharges of the aquifer system. In these areas, the aquifer is unconfined (or semi-confined in specific situations).

Environmental aspects

In the case of Argentina, elevated natural salinity and fluorides occur over a significant part of the aquifer. Brazil also reports elevated natural salinity but more within the superficial part of the aquifer. Otherwise the water in the GAS is usually of drinking water standards, with low mineralization (as indicated by the conductivities <1 000 µS/cm). Limited pollution mainly due to nitrates from domestic sources (households, municipalities, landfills and waste disposal) has been reported (Brazil and Uruguay). The extent of shallow groundwater and groundwater dependent ecosystems has not been recorded.

21S - Sistema Acuífero Guaraní

Socio-economic aspects

The main use of abstracted groundwater in the area of GAS is for public supply. In Brazil, despite the prevalence of public use, the distribution of water use is more diversified; in Argentina registered wells are used for recreational purposes only. In Uruguay and Paraguay 90% of resource use is to urban centres. Overall groundwater use of the GAS has been estimated at about 1 040 Mm^3/year, with Brazil responsible for about 90% of the current abstraction and the State of Sao Paulo withdrawing a large portion of this.

Legal and Institutional aspects

There is a full scope (limited in Argentine) Multilateral Agreement signed by the presidents of the four countries, but it has not been ratified by the parliaments of some countries, so it is not being implemented. Three of the countries also report full mandate national groundwater institutions. The Guarani Aquifer System Project presents a milestone in the shared study of transboundary groundwater in America. A successful experience was the creation of National Committees, led by a National Coordinator, which allowed at a country level, the participation of all the institutions involved in this area, resulting in a greater amount of committed people and hence a greater amount of data and knowledge.

Priority issues

Implementation of the Agreement regarding the joint management of this important aquifer system appears to be a priority issue, in particular because one country is by far the largest user at this stage.

Contributors to Global Inventory

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21S - Sistema Acuífero Guaraní

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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

An adequate aquifer description was possible, because three of the four aquifer states reported. The information was not sufficient to calculate the groundwater indicators.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

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References:

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

20S - Bauru-Caiua-Acaray Aquifer

Geography

Total area TBA (km^2): 300 000

No. countries sharing: 2

Countries sharing: Brazil, Paraguay

Population: 7 500 000

Climate zone: Tropical Dry

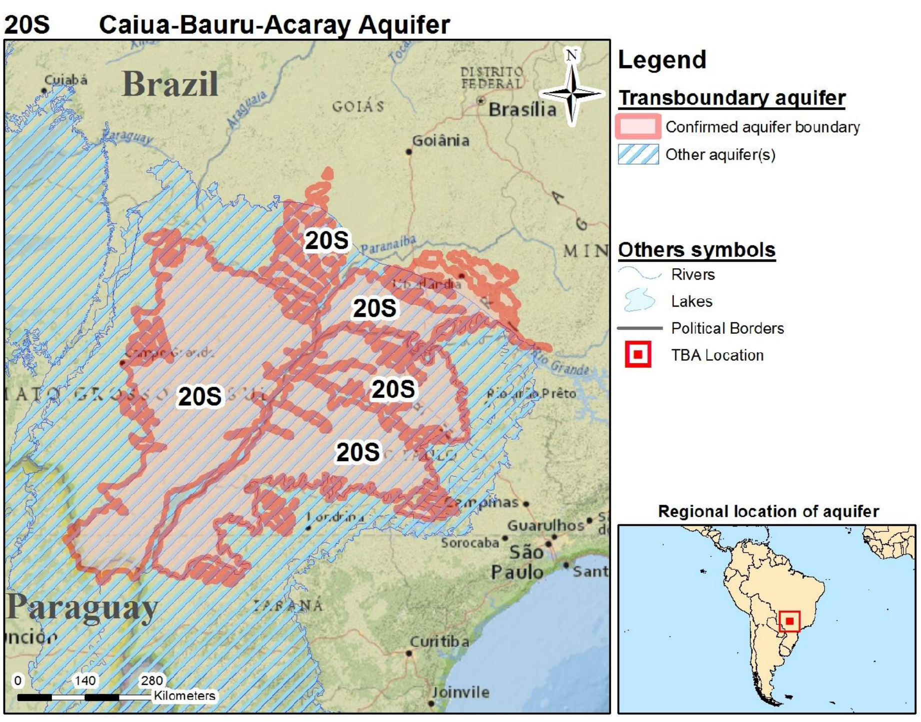
Rainfall (mm/yr): 1400

Hydrogeology

Aquifer type: Single-layered

Degree of confinement: Mostly unconfined, but some parts confined

Main Lithology: Sedimentary rocks - Sandstone



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

20S - Bauru-Caiua-Acaray Aquifer

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							25		A	C
Paraguay							10			
TBA level							**25**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil			150	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	70
Paraguay								
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

20S - Bauru-Caiua-Acaray Aquifer

Aquifer description

As most of the information was provided by Brazil, most of the values within this Brief refer to the portion of the TBA within Brazil.

Aquifer geometry
It is a single layered aquifer that is mostly unconfined, but some parts confined. The average thickness of the Aquifer system is 150m.

Hydrogeological aspects
The Bauru-Caiuá-Acaray aquifer contains fine/medium sedimentary deposits with a high primary porosity. There is also secondary porosity from dissolution. The horizontal connectivity is high, while the vertical connectivity is low. The average transmissivity is 70 m^2/d. The total groundwater volume on the Brazil side was estimated at 970 km^3. The recharge area of 350 000 km^2 is covering the Serra Geral aquifer system. In Brazil, it occupies much of the western part of the state of São Paulo.

Linkages with other water systems
Groundwater recharge is from precipitation over the aquifer area. No information on the discharge mechanism was provided.

Environmental aspects
No information was recorded on the natural groundwater quality. The main sources of anthropogenic groundwater pollution are of diffuse origin, represented by the application of fertilizers and nitrogen inputs, leaks from sewage systems and the influence of polluted rivers in the catchment area of the wells. This leads to localised salinisation and high nitrate levels. No information was recorded on shallow groundwater or on groundwater dependent ecosystems.

Socio-economic aspects
The aquifer is heavily exploited by being easily accessible with low-cost drilling. The main uses are human and industrial supplies.

Legal and Institutional aspects
Brazil makes mention of a full scope signed Transboundary Agreement between the countries. It also mentions a National Institution in Brazil with full mandate and full capacity.

Priority issues
Given its unconfined nature, the heavy exploitation and pollution from a variety of sources, joint management needs to be actively implemented.

Contributors to Global Inventory

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Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert

20S - Bauru-Caiua-Acaray Aquifer

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

The TBA system could not be described fully, because only one of the TBA countries provided adequate numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

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- All other data: TWAP Groundwater (2015).

Version: October 2015

26S - Salto-Salto Chico

Geography

Total area TBA (km^2): 32 000

No. countries sharing: 2

Countries sharing: Argentina, Uruguay, Brazil

Population: 480 000

Climate zone: Humid Subtropical

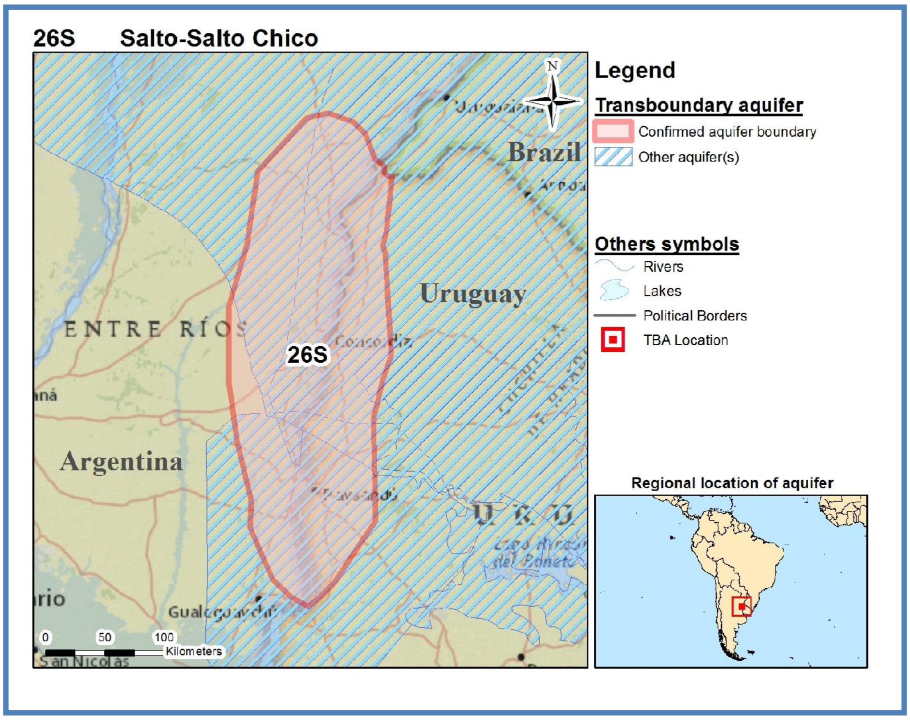
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Single layer

Degree of confinement: Semi-confined to unconfined

Main Lithology: Sandstones and sands



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

26S - Salto-Salto Chico

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina	X	3	100				18	>1000	D	D
Brazil							10			
Uruguay			100				10		D	D
TBA level							**15**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
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(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Argentina	24	25	80	Whole aquifer semi-confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits		X
Brazil								
Uruguay			20	Aquifer mostly unconfined, but some parts confined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	50

26S - Salto-Salto Chico

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Brazil is mentioned as a third aquifer state in the data base, but no data is provided. On the map it appears to be just touching the aquifer.

Aquifer geometry

This is a single-layered aquifer. Within the Argentina segment of the aquifer the average depth to the water table is 24m and the average depth to the top of the aquifer is 25m. The average vertical thickness of the aquifer system varies between 80m in Argentina and 20m in Uruguay. In Argentina the whole aquifer is semi-confined, whereas in Uruguay it is mostly unconfined, but in some parts it is confined.

Hydrogeological aspects

The major aquifer lithologies are Tertiary age medium to coarse grained sandstones of fluvial origin, that exhibit cementation by later silicification, as well as sediments - sand. These have a high primary porosity, with no secondary porosity, and a low to high horizontal connectivity. A transmissivity value of 50 m^2/day is reported for Uruguay. The transmissivity and average annual recharge figures provided by Argentina should be reviewed. They are not consistent with the high primary porosity and high groundwater use reported below.

Linkages with other water systems

Recharge is from precipitation onto outcrops of the aquifer and within tributaries of the Uruguay River and other smaller streams. Discharge is through groundwater flow into another aquifer.

Environmental aspects

There is no information on the natural groundwater quality. Some pollution has been identified in Argentina from agricultural practices (irrigation and herbicide application). The danger of contamination is high in areas where the confining (or semi-confining) layers have small thicknesses or are absent. No information was provided on the extent of shallow water and groundwater dependent ecosystems.

Socio-economic aspects

The aquifer is highly used by both countries, especially for irrigation. In Argentina large volumes of water for rice cultivation are abstracted. The annual amount of groundwater that was abstracted from the system during 2010 was 500Mm^3.

Legal and Institutional aspects

There is no specific legal agreement between the countries. Both countries have National Institutions with a mandate for groundwater resources, but still with a limited capacity.

Priority issues

Given the high groundwater use in both countries, the vulnerable nature of parts of the aquifer system and the potential impacts of widespread agricultural practices, it is important to initiate joint

26S - Salto-Salto Chico

management that includes improved estimation of key aquifer parameters and joint monitoring of the transboundary aquifer system without delay.

Contributors to Global Inventory

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Natalia Cabrera Laborde	Dirección Nacional de Aguas-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	ncabrera@mvotma.gub.uy	Contributing national expert
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Luis Reolón	Dirección Nacional de Medio Ambiente-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	luis.reolon@mvotma.gub.uy	Contributing national expert

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Two of the three aquifer countries reported and provided for a reasonable aquifer description. The different parameters were not always consistent.

26S - Salto-Salto Chico

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

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- All other data: TWAP Groundwater (2015).

Version: October 2015

7S - Coesewijne

Geography

Total area TBA (km^2): 26 000

No. countries sharing: 2

Countries sharing: Guyana, Suriname

Population: 670 000

Climate zone: Tropical Wet

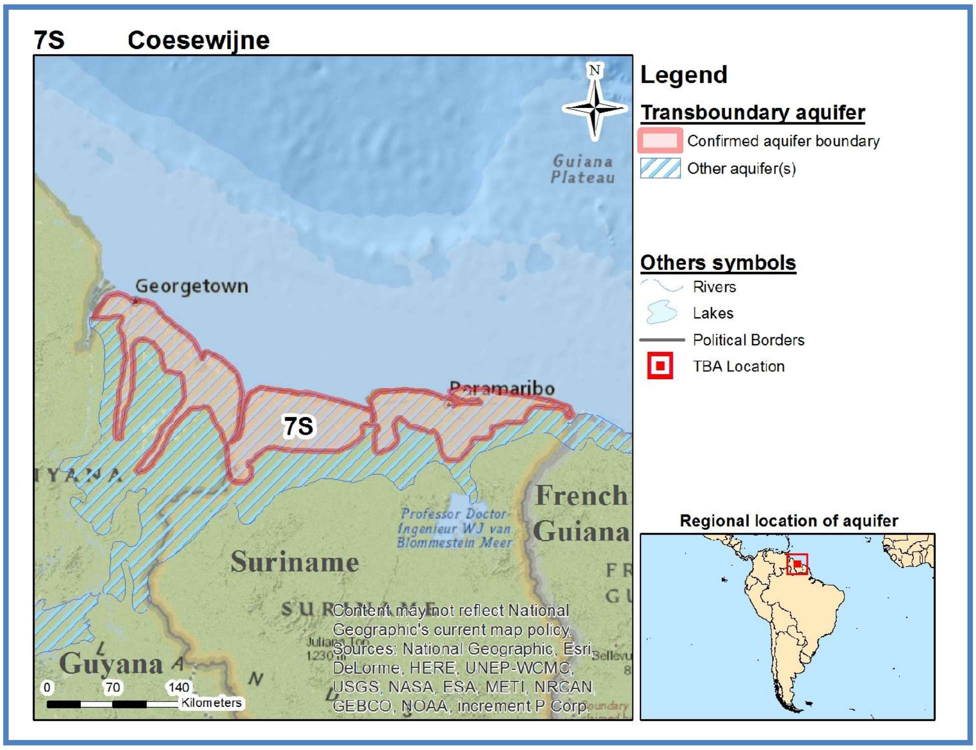
Rainfall (mm/yr): 2 000

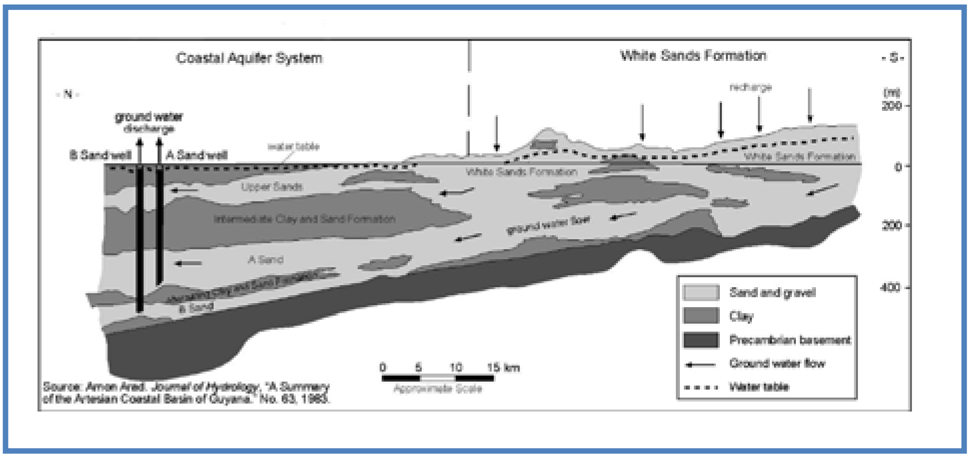
Hydrogeology

Aquifer type: Multi-layered

Degree of confinement: Mostly semi-confined

Main Lithology: Sand and clay





Simplified N–S cross-section

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

7S - Coesewijne

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry
It is a multi-layered aquifer that is mostly semi-confined.

Hydrogeological aspects
The formation consists of alternating sand and clay layers with the thickness of the individual sand layers not exceeding 10 meters. Sand layers constitute 30 to 50 percent of the total formation.

Linkages with other water systems
No information provided.

Environmental aspects
To the north of Paramaribo the aquifer becomes brackish.

Socio-economic aspects
No information provided

Legal and Institutional
There is no legal agreement between the countries.

Emerging issues
At this stage no country information was made available to the data base. Capacity of the country institutions appears to be an issue

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator

Considerations and recommendations

The two TBA states unfortunately did not provide data to the global inventory. The information in the aquifer description was taken from the Regional Report Americas. See colophon for more information, including references to data from other sources.

Request:
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7S - Coesewijne

Colophon

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For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

8S – A-Sand/ B-Sand

Geography

Total area TBA (km²): 26 000

No. countries sharing: 2

Countries sharing: Guyana, Suriname

Population: 670 000

Climate zone: Tropical Wet

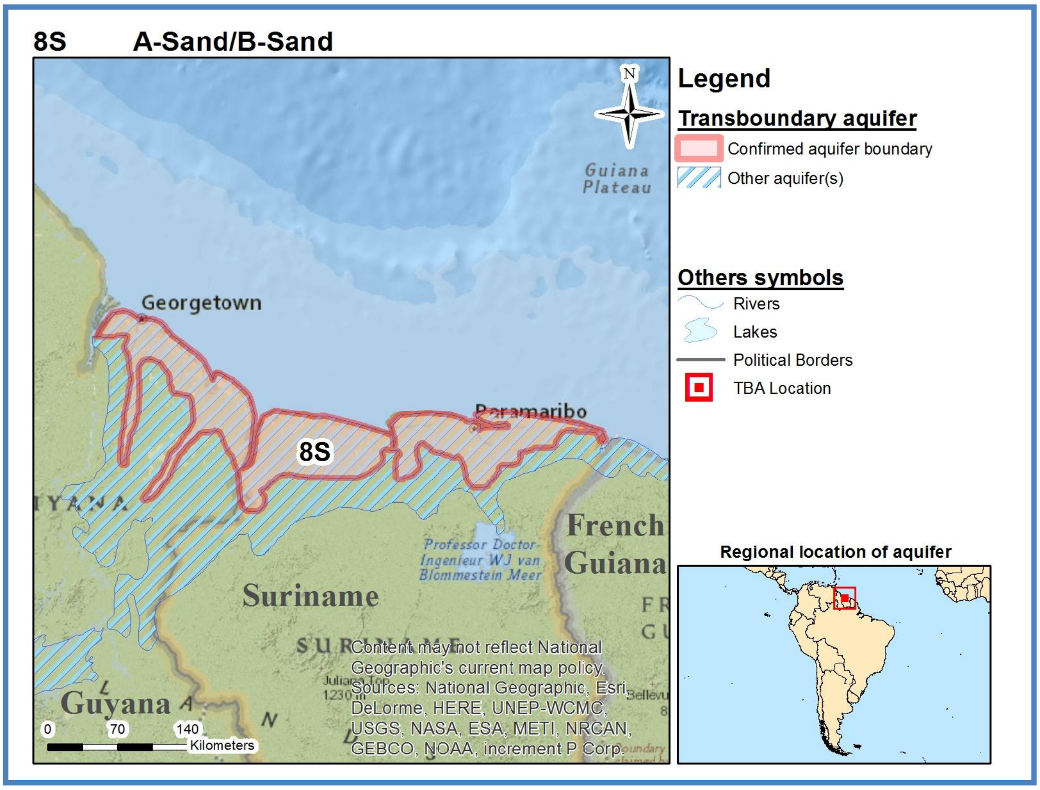
Rainfall (mm/yr): 2000

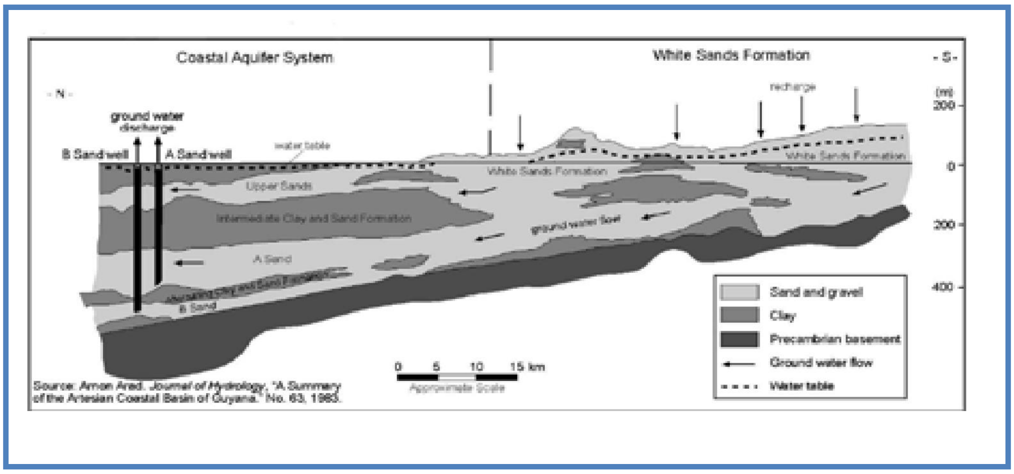
Hydrogeology

Aquifer type: Multi 2-layered

Degree of confinement: Mostly confined

Main Lithology: Sand and gravel





Simplified N-S cross-section

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

8S – A-Sand/ B-Sand

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry
It is a two-layered aquifer (A-Sand and B-Sand), that is mostly confined.

Hydrogeological aspects
The A-Sand aquifer is composed of quartz sand and fine gravel, and ranges from 150 to 215 meters deep and 12 to 27 meters thick. The B-Sand aquifer is composed of angular quartz sand and shale with gravel at depths of 350m to 800m meters and the aquifer system varies in thickness from 15 to 60 meters.

Linkages with other water systems
No information was provided

Environmental aspects
Groundwater is generally not contaminated along the coast in the A-Sand and B-Sand aquifers. The A-Sand aquifer has elevated iron contents, and the B-Sand has elevated temperatures and a hydrogen sulphide odour.

Socio-economic aspects
The A-Sand aquifer is the most exploited one of the coastal system, and even though a decline in piezometric levels has not been too significant in general, averaging about 0.03 to 0.06 meter per year, (Worts, 1958), in some locations, notably the Georgetown area, the decline has been substantial, about 26m since abstraction started in 1926. However, there has been no problem with saline intrusion into any of the wells thus far.

Legal and Institutional aspects
There is no legal agreement between the countries. No information on the National Institutions is available.

Priority issues
The A-Sand aquifer is the most exploited of the coastal system and experiences a limited, but in some areas a notable decline in the piezometric levels was noticed. Saline intrusion could become a problem if the decline in groundwater levels becomes more extended. Groundwater level and quality monitoring is required.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator

8S – A-Sand/ B-Sand

Considerations and recommendations

The two TBA states unfortunately did not provide data to the global inventory. The information in the aquifer description was taken from the Regional Report Americas. See colophon for more information, including references to data from other sources.

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Colophon

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

15S - Pantanal

Geography

Total area TBA (km^2): 200 000

No. countries sharing: 3

Countries sharing: Bolivia, Brazil, Paraguay

Population: 740 000

Climate zone: Tropical Dry

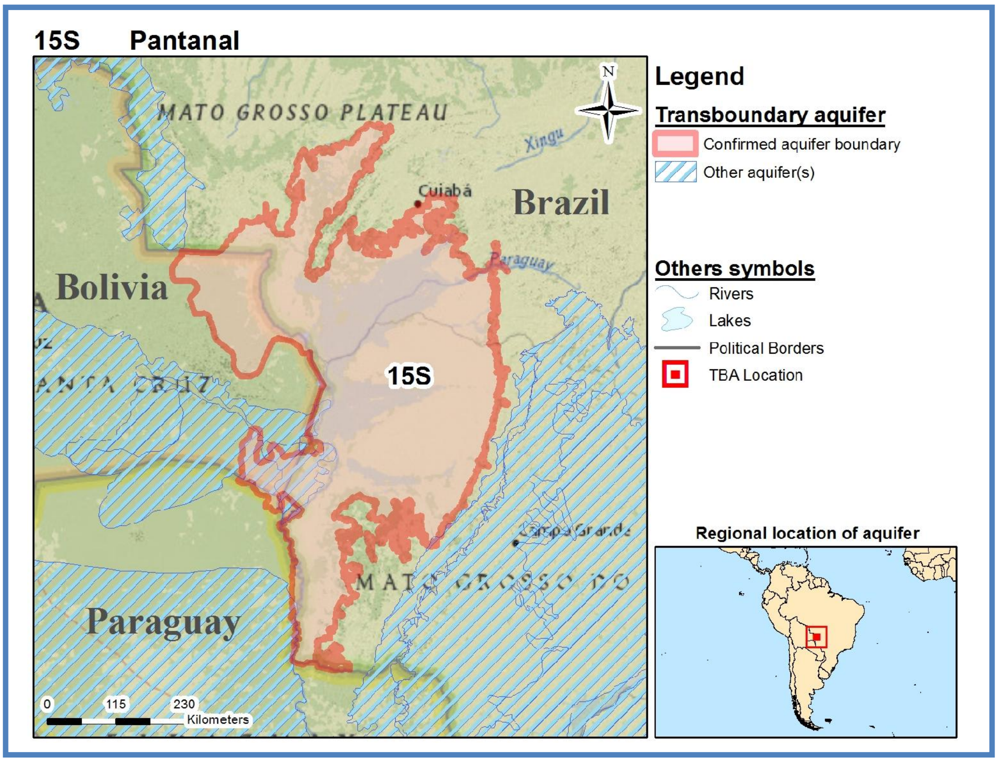
Rainfall (mm/yr): 1 300

Hydrogeology

Aquifer type: Multi-layered

Degree of confinement: Unconfined

Main Lithology: Unconsolidated/semi-consolidated sediments, -sandy, with varying clay content



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

15S - Pantanal

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Bolivia							1			
Brazil							4		D	C
Paraguay							1			
TBA level							**4**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Bolivia	82	70 000	-36	-47	3	41	4	0
Brazil	120	28 000	-23	-29	4	32	4	1
Paraguay	53	56 000	-31	-44	31	34	6	0
TBA level	**110**	**30 000**	**-24**	**-30**	**4**	**33**	**4**	**1**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Bolivia	-1	1	30	56	<1	0	0
Brazil	1	4	16	22	<1	0	0

15S - Pantanal

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Paraguay	0	1	33	61	<1	0	0
TBA level	**0**	**4**	**17**	**24**	<1	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Bolivia								
Brazil				Whole aquifer unconfined	Sedimentary rocks - Sandstone	Low primary porosity: intergranular porosity	Secondary porosity: Dissolution	
Paraguay								
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry
It is a multi-layered, unconfined aquifer system. The thickness of the aquifer system varies between 20 to 200 m.

Hydrogeological aspects
The aquifer system consists of sedimentary rock –sandstone, unconsolidated and semi-consolidated sediments, mostly sandy, with varying clay content. It is characterised by a low primary porosity and intergranular porosity with secondary porosity through dissolution. This results in low horizontal and high vertical connectivity.

Linkages with other water systems
Groundwater recharge is from precipitation over the aquifer area (see Appendix). No information on the discharge mechanism was provided.

Environmental aspects
The natural water quality is good but Brazil has reported that households and municipalities and the use of agrochemicals have partially affected water quality, with elevated concentrations of Nitrogen species and pathogens.

Socio-economic aspects
Most of the water withdrawn from the aquifer system is used to meet basic consumption needs, drinking water for animals, and small home orchards.

Legal and Institutional aspects

15S - Pantanal

There are no specific legal agreements between the countries about the Pantanal Aquifer System. Brazil reports a National Institution with full mandate and full capacity. Groundwater management is still limited in practice.

Emerging issues

Vulnerability of the unconfined aquifer system to pollution appears to be an emerging issue. Increasing attention to groundwater development and management at national level can also be seen as important.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
Julio Thadeu Kettelhut Silva	Ministério do Meio Ambiente	Brazil	julio.kettelhut@mma.gov.br	Lead National Expert

Considerations and recommendations

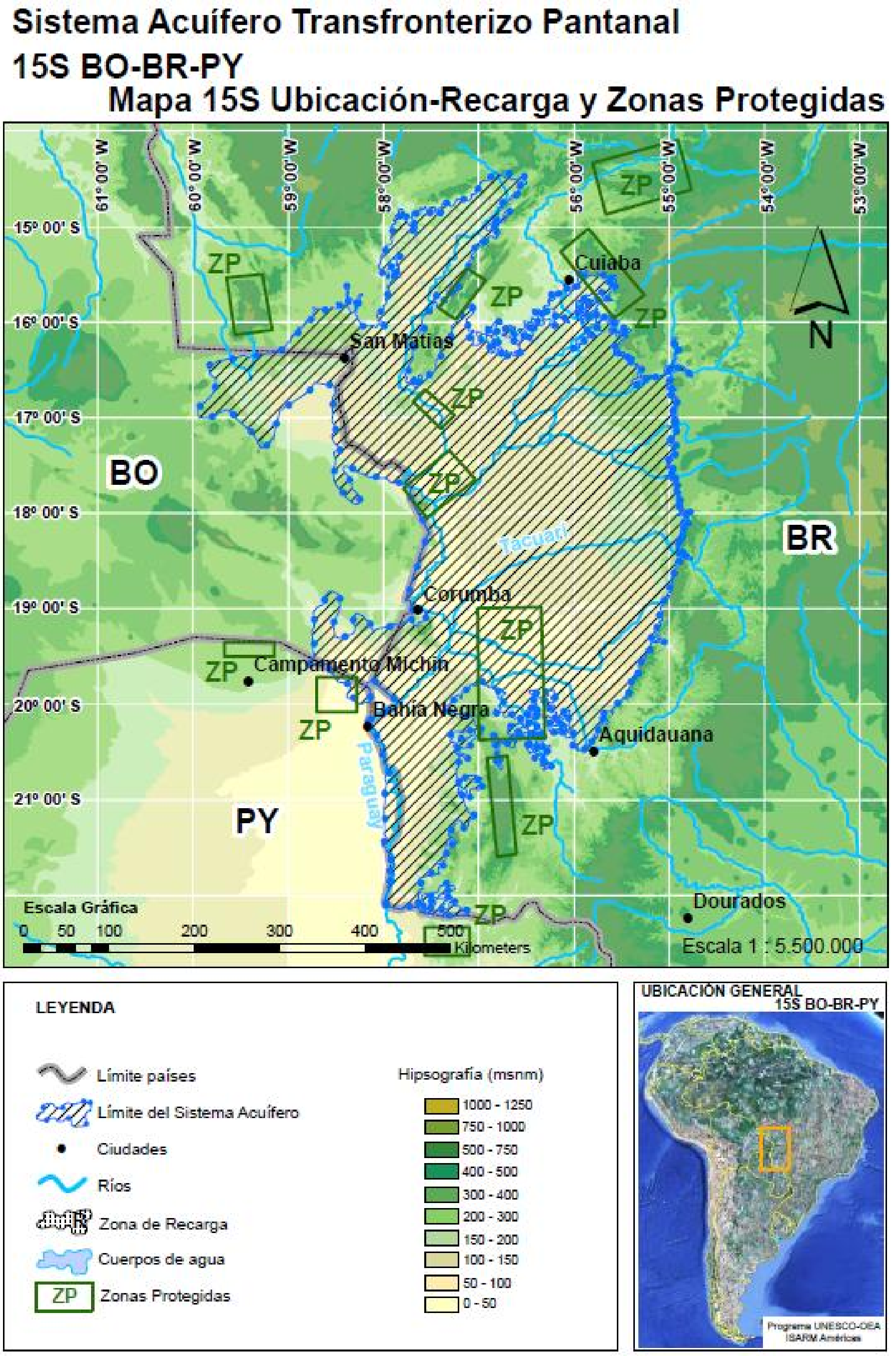
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only a very superficial description of the TBA system was possible, because neither of the three aquifer states provided any numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

15S - Pantanal

Appendix: 15S



Location of recharge and protection zones

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15S - Pantanal

available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

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- All other data: TWAP Groundwater (2015).

Version: October 2015

24S - Permo-Carbonifero

Geography

Total area TBA (km^2): 49 000

No. countries sharing: 2

Countries sharing: Brazil, Uruguay

Population: 570 000

Climate zone: Humid Subtropical

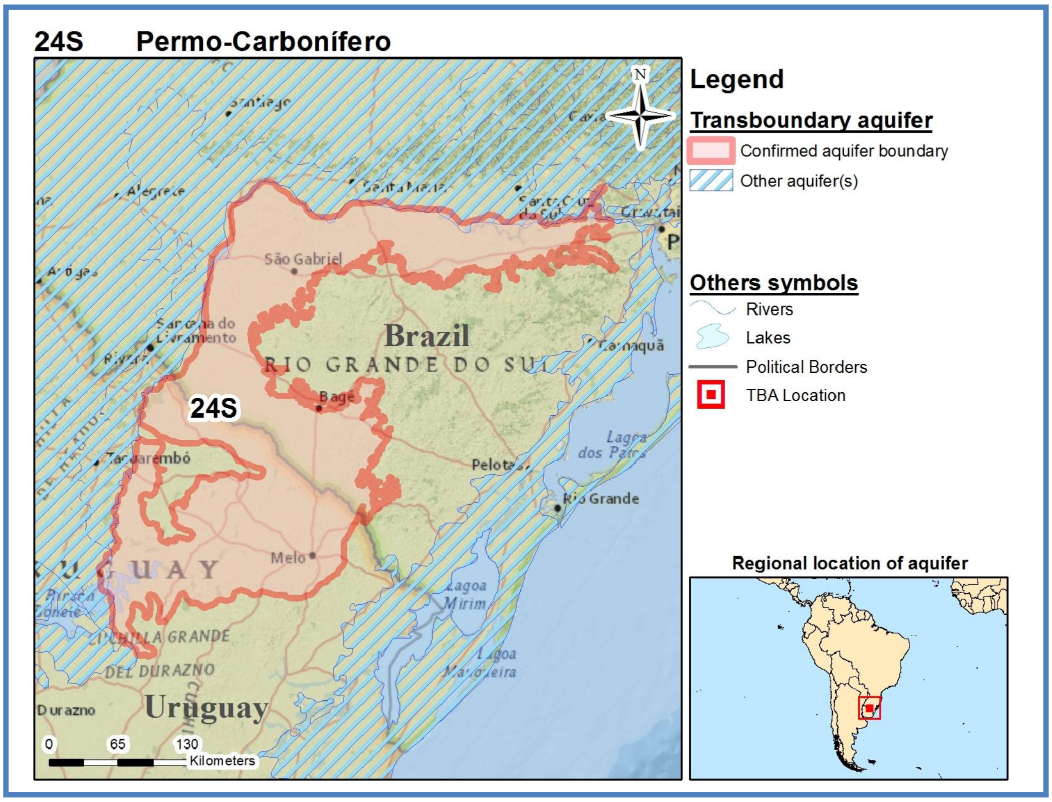
Rainfall (mm/yr): 1300

Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly unconfined, but some parts confined

Main Lithology: Sandstones and shales



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

24S - Permo-Carbonifero

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Brazil							15		A	D
Uruguay	5	700	100				7		D	D
TBA level							**11**		**E**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Brazil	200	12 000	-15	-21	5	32	6	1
Uruguay	140	21 000	-7	-10	5	15	5	8
TBA level	**180**	**14 000**	**-13**	**-19**	**5**	**31**	**6**	**1**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Brazil	0	17	16	21	1	0	1
Uruguay	1	7	7	8	<1	0	0
TBA level	**0**	**13**	**14**	**18**	**1**	**0**	**1**

24S - Permo-Carbonifero

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Brazil				Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Dissolution	
Uruguay		190	40	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	100
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

This aquifer is a multiple-layered hydraulically connected system. The average depth to the top of the aquifer within Uruguay is 190m and the average thickness of the aquifer system varies between 20m and 60m. The aquifer is mostly unconfined, but in some parts confined.

Hydrogeological aspects

The aquifer material consists of fine/medium sedimentary deposits of sandstones and shales with high primary porosity and secondary-dissolution porosity, only in Brazil. It is also characterised by a low to high horizontal connectivity and a low vertical connectivity. The average transmissivity in Uruguay is $100m^2/d$. Uruguay also reports a total groundwater volume of $11km^3$. The average recharge within Uruguay is 100 Mm^3/annum.

Linkages with other water systems

Recharge into the system is through precipitation over the aquifer area. No information on the discharge mechanism was provided.

Environmental aspects

In some parts of Brazil elevated natural salinity occurs, but the extent is not known. Some anthropogenic pollution has been identified within Brazil (households, municipalities, agricultural practices and mining activities).

Socio-economic aspects

Water quality generally allows for most uses, with human consumption being the highest user. Private wells also draw water but in amounts that do not compromise the functioning of the aquifer. The abstraction amounts have not been recorded.

24S - Permo-Carbonifero

Legal and Institutional aspects

Brazil reports on a ratified Bi-lateral Agreement, whereas Uruguay reports that there is no Agreement. It could be that Brazil is referring to the River Basin agreement - Tratado da Bacia do Prata, 1969. Both countries mention their National Institutions with a full mandate, but with limited capacity.

Emerging issues

Pollution of the aquifer may be an emerging issue. This needs to be addressed by the countries' national institutions.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Antonio Calazans Reis Miranda	Ministério do Meio Ambiente	Brazil	antonio.miranda@mma.gov.br	Contributing national expert
Roseli dos Santos Souza	Ministério do Meio Ambiente	Brazil	roseli.souza@mma.gov.br	Contributing national expert
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Andrés Pérez Pablo Decoud	OSE	Uruguay	aperez@ose.com.uy / pdecoud@yahoo.com	Contributing national expert
Luis Reolón	Dirección Nacional de Medio Ambiente-Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente	Uruguay	luis.reolon@mvotma.gub.uy	Contributing national expert

24S - Permo-Carbonifero

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

The TBA system could not be described fully, because only one of the TBA countries provided adequate numerical information.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

14S - Titicaca

Geography

Total area TBA (km^2): 74 000

No. countries sharing: 3

Countries sharing: Bolivia, Chile, Perú

Population: 3 000 000

Climate zone: Highlands

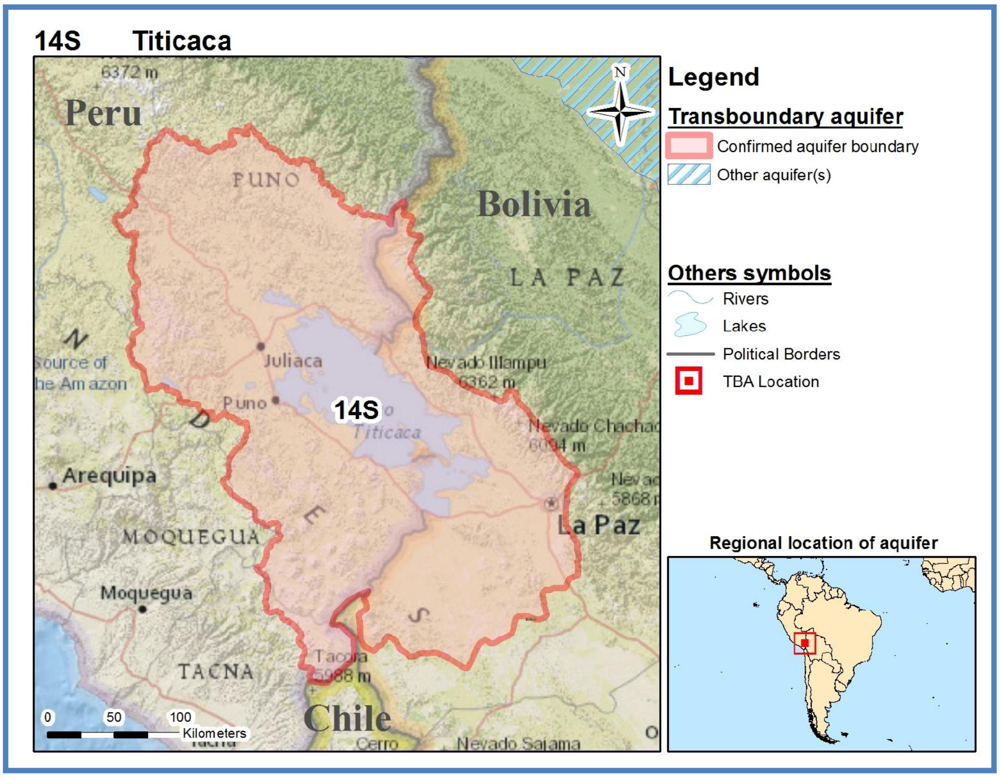
Rainfall (mm/yr): 680

Hydrogeology

Aquifer type: Multi-layered sedimentary system

Degree of confinement: Mostly unconfined or semi-confined

Main Lithology: Conglomerates, sand and clays



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

14S - Titicaca

TWAP Groundwater Indicators from Global Inventory

No data available.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Bolivia	65	1600	-30	-45	21	53	6	10
Chile	5	1700	-11	-25	30	27	31	0
Peru	100	3800	-20	-29	21	27	18	16
TBA level	**88**	**2800**	**-24**	**-37**	**21**	**32**	**11**	**15**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Bolivia	1	42	40	79	2	1	5
Chile	0	3	25	39	9	6	15
Peru	1	26	26	43	2	1	2
TBA level	**1**	**32**	**32**	**59**	**2**	**1**	**3**

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry

It is a multi-layered aquifer system that is mostly unconfined or semi-confined. The range of thickness of the aquifer system varies between 20 to 200 m.

Hydrogeological aspects

The predominant aquifer lithology consists of conglomerates, sand and clays. No further information on the hydrogeological aspects was recorded.

Linkages with other water systems

Not reported on.

Environmental aspects

The natural water quality is good but, locally it can be brackish or polluted with metals and urban waste.

Socio-economic aspects

In general the main use is for agricultural practices (irrigation), and on a smaller scale, for public supply and domestic use.

14S - Titicaca

Legal and Institutional aspects
There are no groundwater-specific Transboundary legal agreements between the countries about the Titicaca Aquifer System. However, the Lake Basin Agreement (Autoridad Binacional Autónoma del Lago Titicaca) can provide the basis for future agreements for joint management of groundwater.

Emerging issues
Countries have not reported and any emerging issues are not clear from the available information.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator

Considerations and recommendations

None of the three TBA states provided data to the global inventory. The only tabular information that could be presented here has been derived from the global WaterGAP model, whereas the limited aquifer description is based on a summary in the Regional Report Americas. See colophon for more information, including references to data from other sources.

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- All other data: TWAP Groundwater (2015).

Version: October 2015

28S - Yrendá-Toba-Tarijeño

Geography

Total area TBA (km^2): 480 000

No. countries sharing: 4

Countries sharing: Argentina, Bolivia, Brazil Paraguay

Population: 2 100 000

Climate zone: Semi-arid

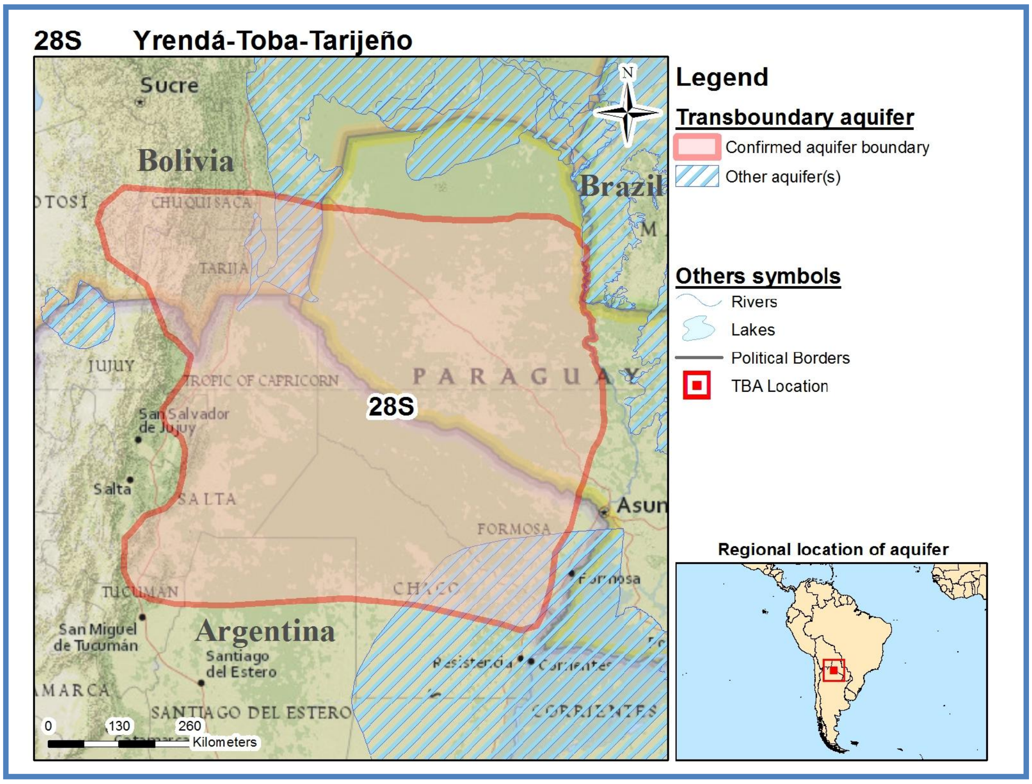
Rainfall (mm/yr): 770

Hydrogeology

Aquifer type: multiple 4-layered hydraulically connected system

Degree of confinement: Unconfined, in some parts confined

Main Lithology: Sediment-sand



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

28S - Yrendá-Toba-Tarijeño

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Argentina			40				5		D	B
Bolivia							9			
Brazil							1			
Paraguay							1		D	B
TBA level							**4**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Argentina	52	9200	-19	-33	6	11	3	28
Bolivia	39	4300	-26	-44	9	54	4	12
Brazil	55	38 000	-39	-48	21	23	7	0
Paraguay	64	62 000	-34	-48	10	11	5	37
TBA level	**54**	**12 000**	**-25**	**-40**	**7**	**16**	**3**	**27**

28S - Yrendá-Toba-Tarijeño

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Argentina	1	6	19	32	1	0	1
Bolivia	0	9	40	81	1	0	2
Brazil	-1	1	30	52	<1	0	0
Paraguay	1	1	38	69	<1	0	0
TBA level	**1**	**5**	**26**	**48**	<1	**0**	**1**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Argentina	100		260	Aquifer mostly unconfined, but some parts confined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits		120
Bolivia								
Brazil								
Paraguay	15	10	200	Aquifer mostly unconfined, but some parts confined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits		190
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

This aquifer is a multiple 4-layered hydraulically connected system. The average depth to the water table varies between 15m in Paraguay and 100m in Argentina. The average thickness of the aquifer system is 200m and 260m in these two countries respectively. The aquifer is mostly unconfined, but some parts are confined. A project on this aquifer is currently underway which will likely produce changes in its delineation.

Hydrogeological aspects

The aquifer material is sediment-sand with a high primary porosity and high horizontal connectivity. The average transmissivity ranges between 120 and 190m^2/d in the two reporting countries. Argentina has estimated its total groundwater volume as 9km^3 but this figure needs to be reviewed.

28S - Yrendá-Toba-Tarijeño

Linkages with other water systems
Recharge into the system is from infiltration from surface water bodies and discharge is through river base flow and through springs in Argentina and Paraguay respectively. The groundwater dynamics in the area is complex and shows influent-effluent relationships with the Pilcomayo River and surrounding creeks. The recharge and discharge areas are not as yet fully identified.

Environmental aspects
A significant part of the aquifer in Argentina (60% - this amount has not been quantified for Paraguay) is unsuitable for human consumption as a result of elevated natural salinity and fluorides. There is a succession of layers of fresh and salt water in the vertical direction, which deserve very detailed studies. Although there is as yet no pollution that has been detected in Paraguay, some pollution has been identified in Argentina resulting from municipalities and agricultural practices. The extent of shallow groundwater within the system has not been recorded although 20% of the aquifer area is covered with groundwater dependent ecosystems within Argentina.

Socio-economic aspects
The resource is used for human consumption, irrigation and livestock, in places where quality is good. The area's population comprise mainly native people, 70% of which are urban. Within Argentina the annual amount of groundwater abstraction during 2010 was $20Mm^3$.

Legal and Institutional aspects
There is no specific legal agreement between the countries. Both Argentina and Paraguay make mention, however, of a Dedicated Transboundary Institution with a limited mandate and limited capacity. The issue of transboundary aquifers of the La Plata Basin and, in particular the Yrenda-Toba-Tarijeño Aquifer System (SAYTT) as a pilot project, is addressed in a Sub-Component Groundwater of a major project, ‘Sustainable Management of the Water Resources of the La Plata Basin with respect to the Effects of Climate Variability and Change’.

Priority issues
Unsuitability of the natural water quality for human consumption of a large part of the aquifer appears to be a priority issue. Linkages with other water systems also demand further attention.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator
Verónicaq del Carmen Musacchio	Facultad de Ingeniería y Ciencias Hídricas. Universidad Nacional del Litoral	Argentina	musavero@yahoo.com.ar	Contributing national expert
Ofelia Clara Tujchneider	Facultad de Ingeniería y Ciencias Hídricas. Universidad Nacional del Litoral	Argentina	pichy@fich.unl.edu.ar; ofeliatujchneider@yahoo.com.ar	Lead National Expert
Daniel Hebert García Segredo	Secretaría del Ambiente - SEAM	Paraguay	daniel.garcia.segredo@gmail.com	Lead National Expert

Considerations and recommendations

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28S - Yrendá-Toba-Tarijeño

Only two of the four TBA states have provided information, thus not yet describing the TBA system fully.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

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- All other data: TWAP Groundwater (2015).

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Geography

Total area TBA (km^2): 41 000

No. countries sharing: 3

Countries sharing: French Guiana, Guyana, Suriname

Population: 250 000

Climate zone: Tropical Wet

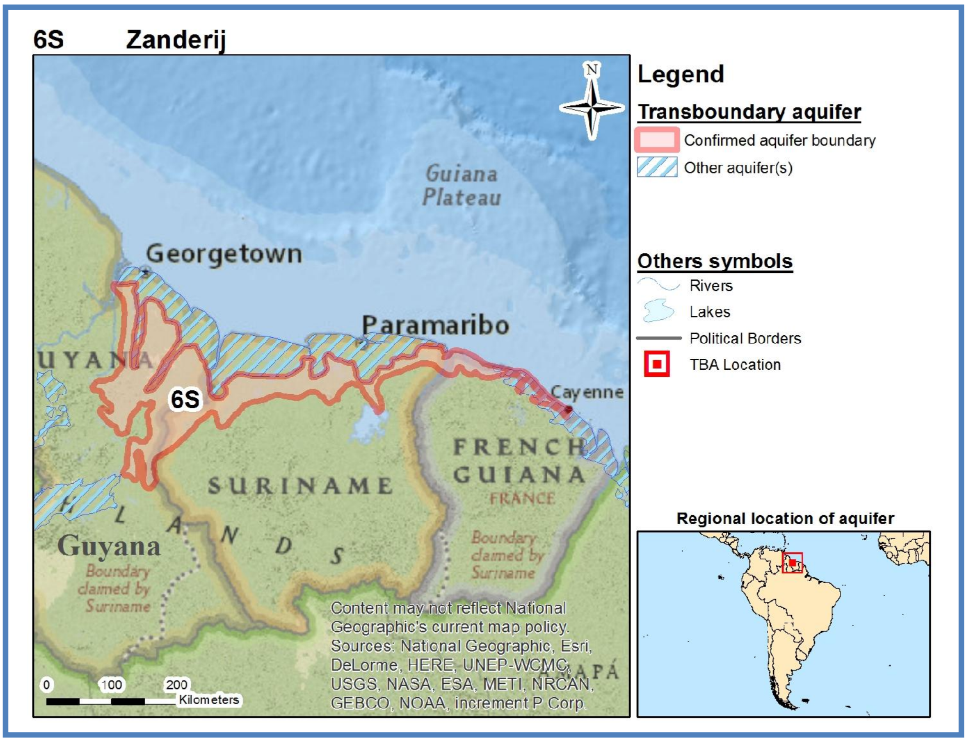
Rainfall (mm/yr): 2300

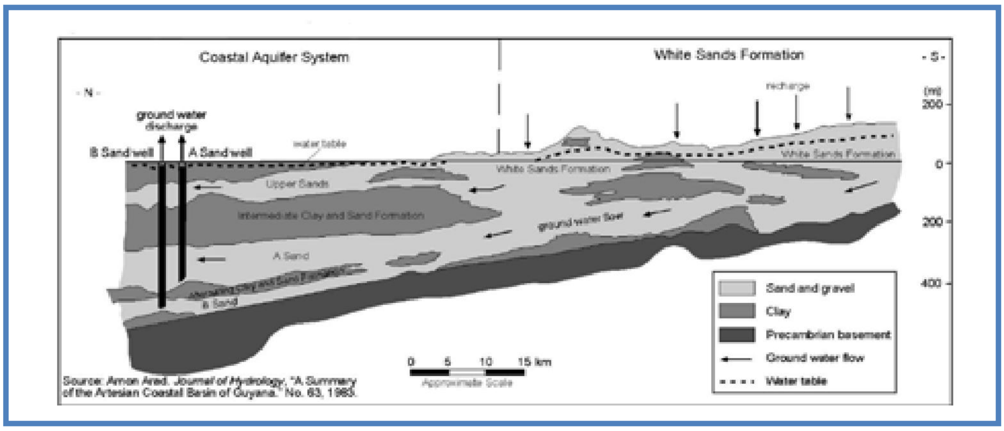
Hydrogeology

Aquifer type: Single layer

Degree of confinement: Mostly unconfined

Main Lithology: Sandstone, siltstone, and gravel





Simplified N–S cross-section

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

6S - Zanderij

TWAP Groundwater Indicators from Global Inventory

No data available.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
French Guiana	230	19000	-49	-64	1	32	3	0
Guyana	470	50000	-26	-32	2	32	0	1
Suriname	300	67000	-27	-33	14	32	0	4
TBA level	**390**	**50000**	**-29**	**-38**	**3**	**32**	**0**	**2**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
French Guiana	1	13	65	130	<1	0	0
Guyana	-1	9	12	14	<1	0	0
Suriname	2	5	17	21	<1	0	0
TBA level	**0**	**8**	**19**	**28**	<1	**0**	**0**

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry

It is a single layered aquifer that is mostly unconfined, but some parts are semi-confined.

Hydrogeological aspects

It consists of unconsolidated to consolidated sediments of sandstone, siltstone, and gravel. The Upper Sands aquifer is 30 to 60 meters deep and ranges in thickness from 15 to 120 meters; it is the shallowest of the three aquifers of the coastal aquifer system.

Linkages with other water systems

This has not been reported on.

Environmental aspects

It has high iron content (> 5 mg/l) and brackish water (TDS > 1 200 mg/l) but the extent was not recorded.

6S - Zanderij

Socio-economic aspects
The aquifer was never fully exploited and withdrawals ceased in 1913 in Guyana, in Suriname it is used for human water supply.

Legal and Institutional aspects
There are no legal agreements between the countries.

Emerging issues
At this stage no country information was made available to the data base. Capacity of country institutions appears to be an issue.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Alberto Manganelli		Uruguay	albertomanganelli@yahoo.com	Regional coordinator

Considerations and recommendations

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Alicia Yo at the English language Wikipedia

Transboundary Lakes / Reservoirs o f Southern America

1. Chungarkkota
2. Itaipu
3. Salto de Grande
4. Titicaca
5. Lago de Yacyreta

ILEC

THE MEADOWS CENTER FOR WATER AND THE ENVIRONMENT
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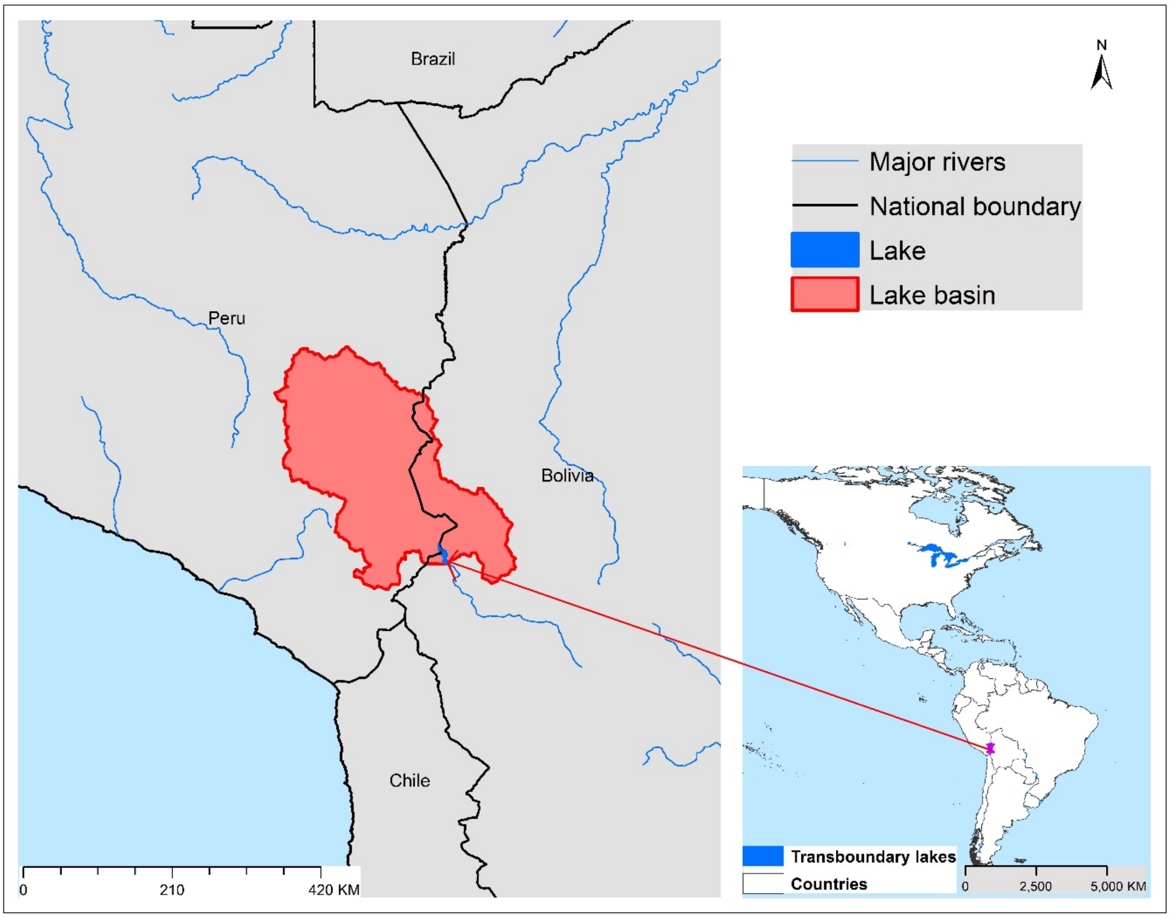
SHIGA UNIVERSITY

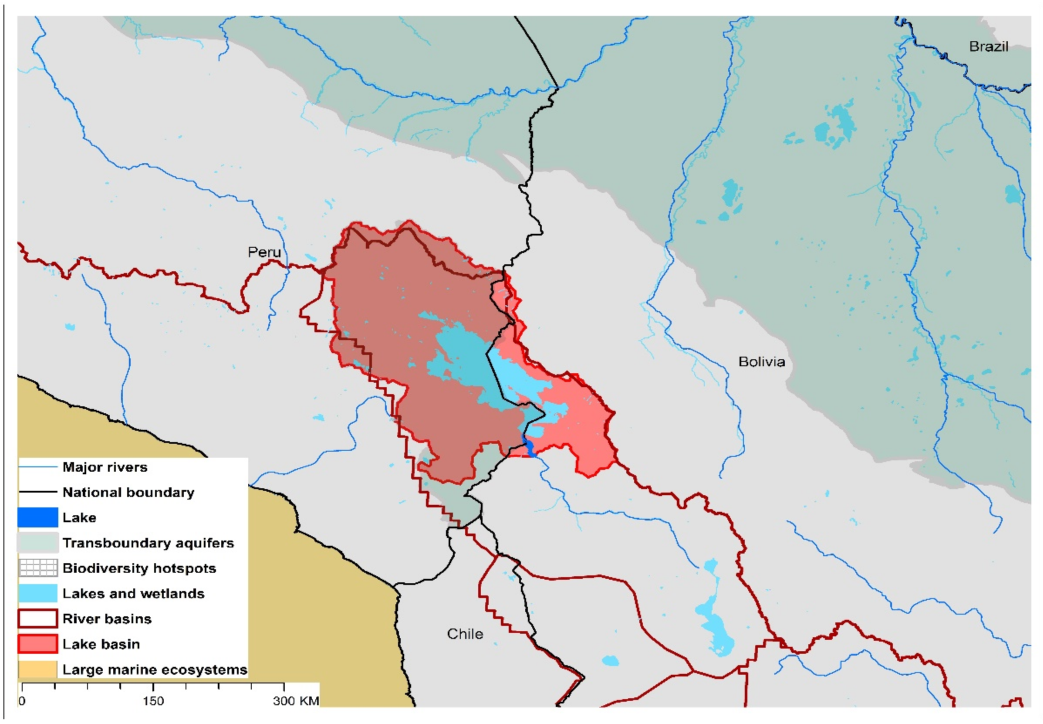
Lake Chungarkkota — Geographic Information

Lake Chungarkkota is an intermittent lake connected to the Lake Titicaca-Poopo complex. There is little information available regarding the status of the lake, although its size and areal extent are related to that of Lake Titicaca, the largest lake in South America by volume. The viability of considering this lake for GEF-catalyzed management interventions, therefore, is related to the same considerations as for Lake Titicaca.

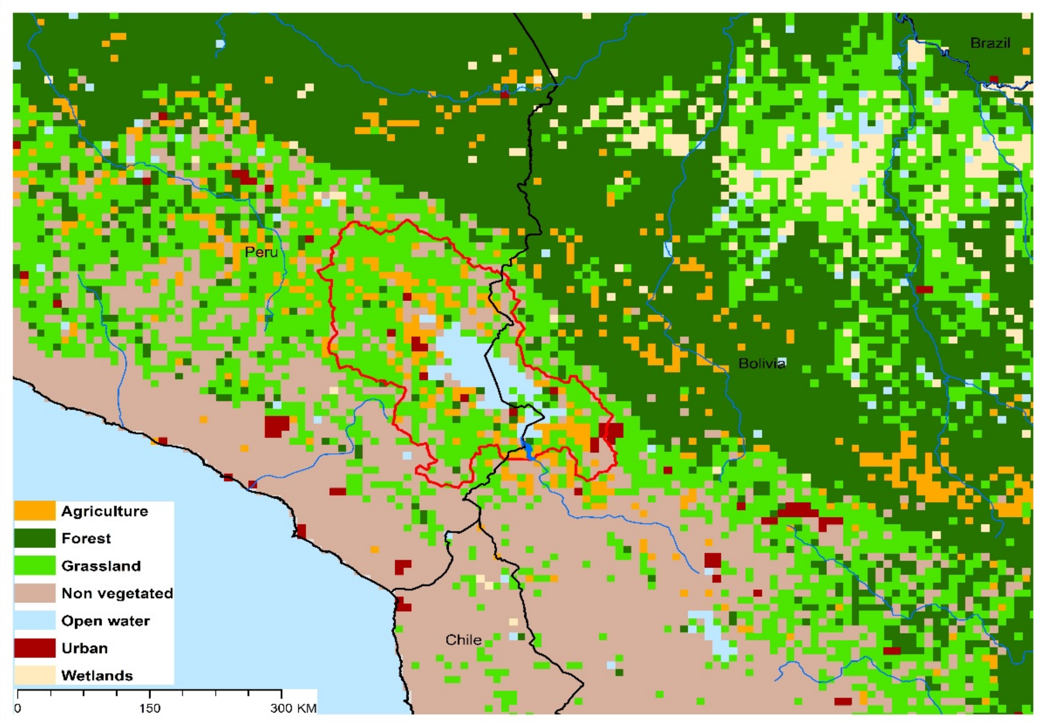


TWAP Regional Designation	Southern America	**Lake Basin Population (2010)**	2,218,424
River Basin	Lake Titicaca-Poopo System	**Lake Basin Population Density (2010; # km^{-2})**	36.0
Riparian Countries	Bolivia, Peru	**Average Basin Precipitation (mm yr^{-1})**	717.3
Basin Area (km^2)	49,597	**Shoreline Length (km)**	104.4
Lake Area (km^2)	52.6	**Human Development Index (HDI)**	0.71
Lake Area:Lake Basin Ratio	0.0009	**International Treaties/Agreements Identifying Lake**	No

Lake Chungarkkota Basin Characteristics



(a) Lake Chungarkkota basin and associated transboundary water systems



(b) Lake Chungarkkota basin land use

Lake Chungarkkota Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Chungarkkota and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Chungarkkota threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Chungarkkota and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lake Chungarkkota Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.82	30		0.69	13		0.71	33

It is emphasized that the Lake Chungarkkota rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Chungarkkota indicates a medium threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Chungarkkota, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a moderately high threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Chungarkkota basin in a medium threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Chungarkkota Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

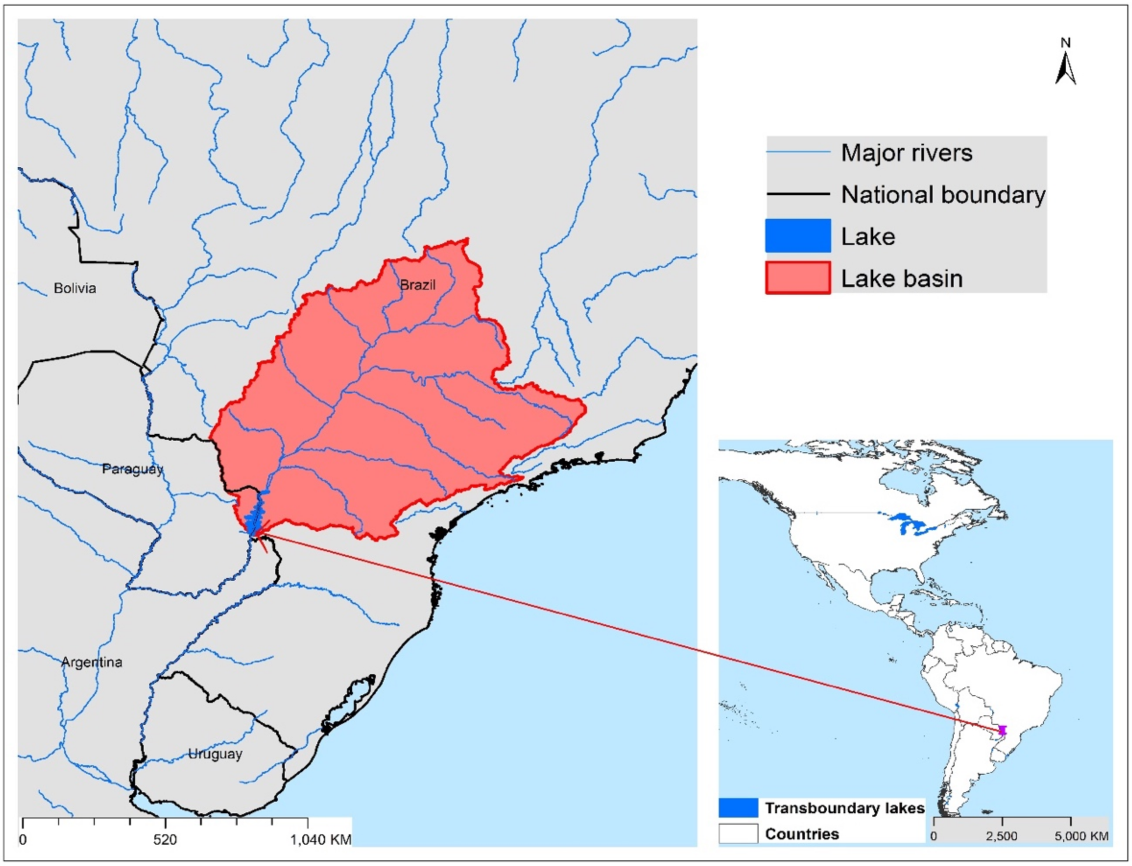
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
31	33	12		43	23		64	34		76	28

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Chungarkkota just within the middle third of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Chungarkkota exhibits a medium threat ranking.

Interactions between the ranking parameters for Lake Chungarkkota indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Chungarkkota must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Chungarkkota basin? Accurate answers to such questions for Lake Chungarkkota, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

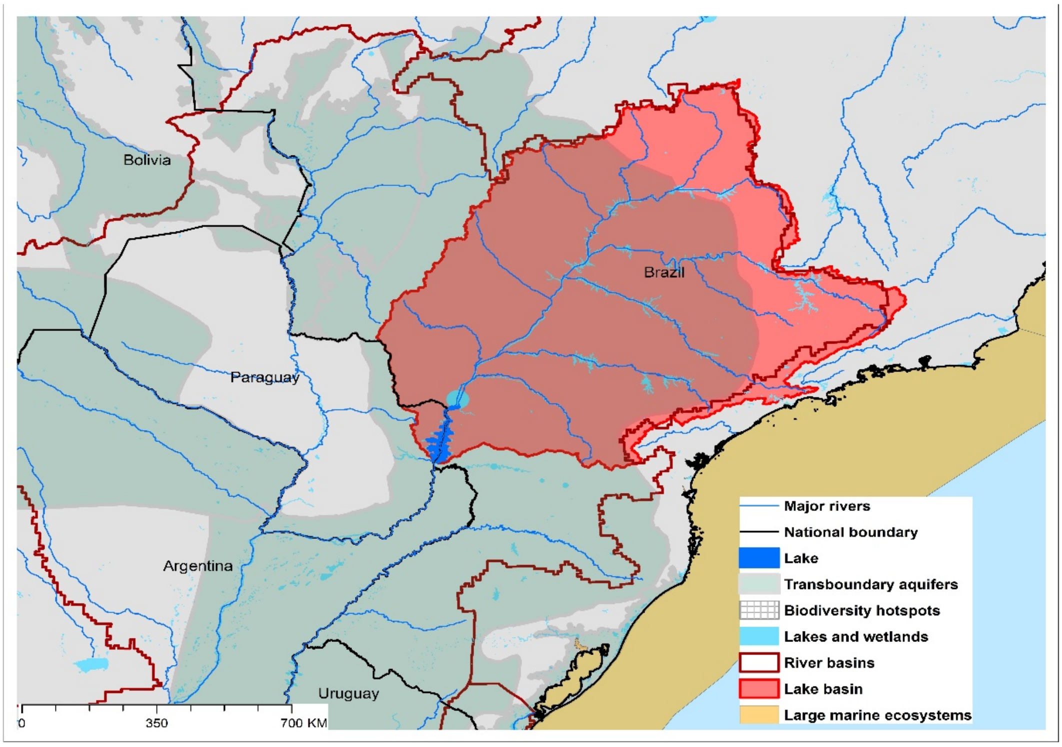
Lake Itaipu — Geographic Information

Lake Itaipu is a large reservoir on the Paraná River, jointly constructed by Brazil and Paraguay to exploit the hydropower resources shared by the two countries. It is one of the world's largest hydropower projects, producing most of the electricity consumed in Paraguay and a sizable portion of that in Brazil. The complex of dams and spillways curves across nearly 8 km, being one of the largest, highest hollow gravity dams in the world. Although selected as one of the seven modern wonders of the world by the American Society of Civil Engineers in 1994, its construction submerged Guaíra Falls, the world's largest waterfall by volume. Although the lake has previously experienced environmental issues, it is not clear from the available information that such issues would be better addressed through GEF-catalyzed management interventions, thereby necessitating an assessment of its current scientific situation prior to such considerations.

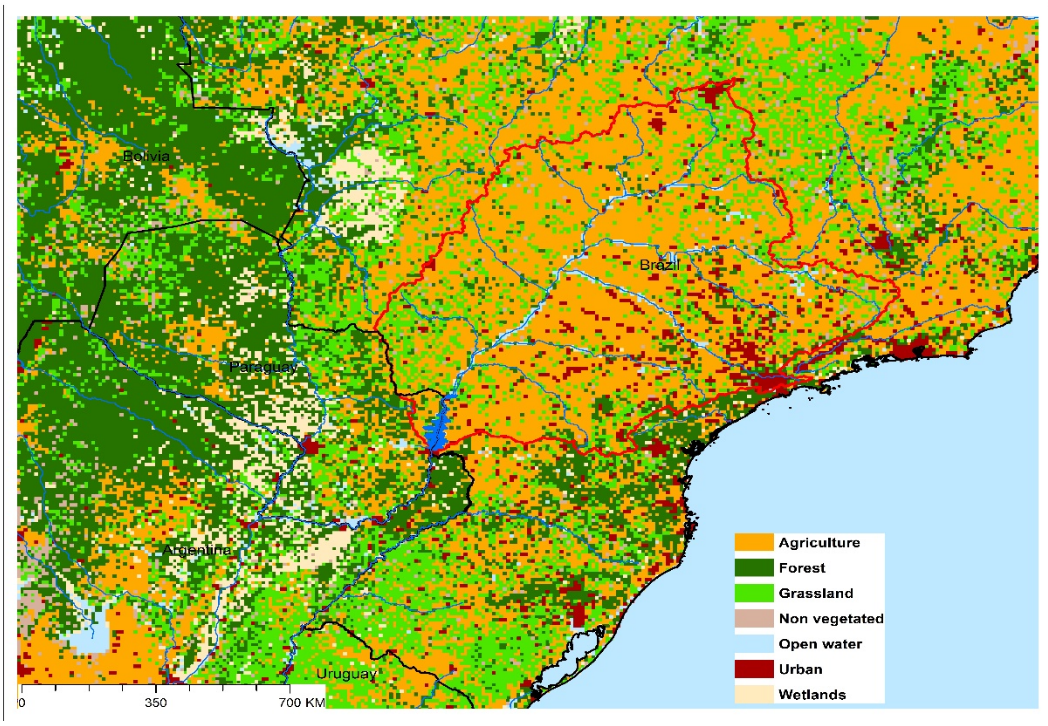


TWAP Regional Designation	Southern America	Lake Basin Population (2010)	57,040,744
River Basin	La Plata	Lake Basin Population Density (2010; # km^{-2})	64.0
Riparian Countries	Brazil, Paraguay	Average Basin Precipitation (mm yr^{-1})	1,421
Basin Area (km^2)	699,118	Shoreline Length (km)	2,817
Lake Area (km^2)	1,154	Human Development Index (HDI)	0.73
Lake Area:Lake Basin Ratio	0.002	International Treaties/Agreements Identifying Lake	Yes

Lake Itaipu Basin Characteristics



(a) Lake Itaipu basin and associated transboundary water systems



(b) Lake Itaipu basin land use

Lake Itaipu Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Itaipu and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Itaipu threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Itaipu and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lake Itaipu Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.75	35		0.58	29		0.73	37

It is emphasized that the Lake Itaipu rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Itaipu indicates a moderately low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Itaipu, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a medium threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Itaipu basin in a moderately low threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Itaipu Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

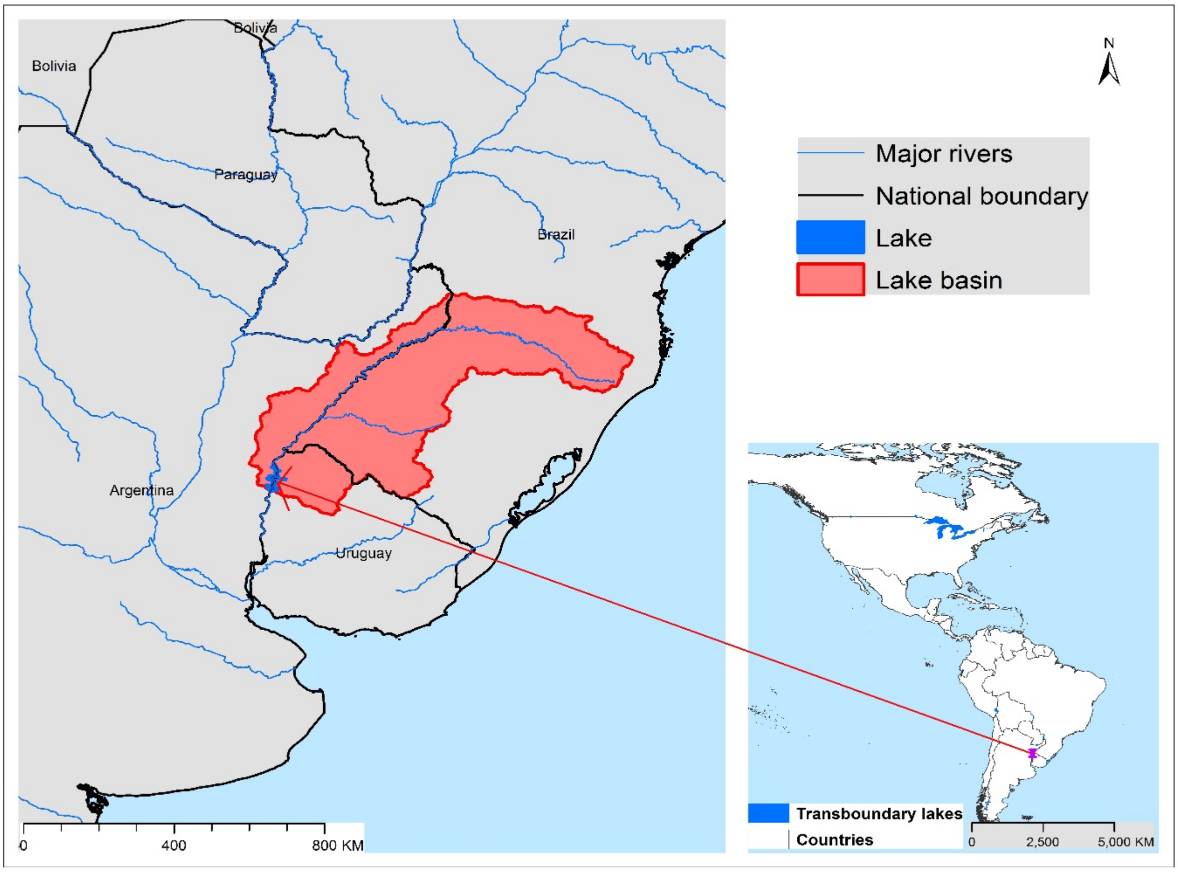
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
37	37	29		66	37		74	37		103	37

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Itaipu in the lower third of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Itaipu exhibits a moderately low threat ranking.

Interactions between the ranking parameters for Lake Itaipu indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Itaipu must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Itaipu basin? Accurate answers to such questions for Lake Itaipu, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

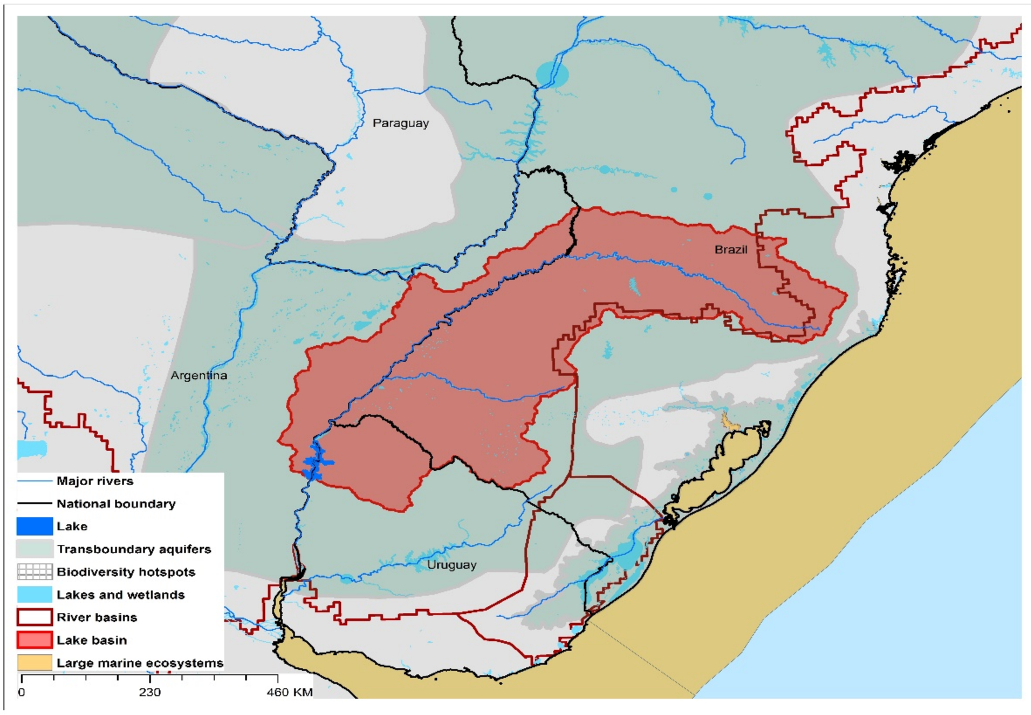
Salto de Grande — Geographic Information

Lake Salto Grande is a reservoir constructed on the Uruguay River between Argentina and Uruguay to produce hydroelectric power for the two countries. Much of the energy is used in Uruguay, which often surpasses the consumption of Montevideo. It also is an important recreational center. Its construction resulted in the relocation of about 22,000 people. The vast flat plains area downstream of the reservoir, experiences results in accelerated soil erosion in the rainy season. Siltation is a resulting problem, in spite of afforestation efforts undertaken around the waterbody. The reservoir is facing a wide range of environmental problems, including eutrophication and trace organic chemical contamination. The suitability of this lake for possible GEF-catalyzed management interventions depends on many factors, including the potential economic and social development gains to be realized for the region. It also requires an assessment of the lake's current scientific status.

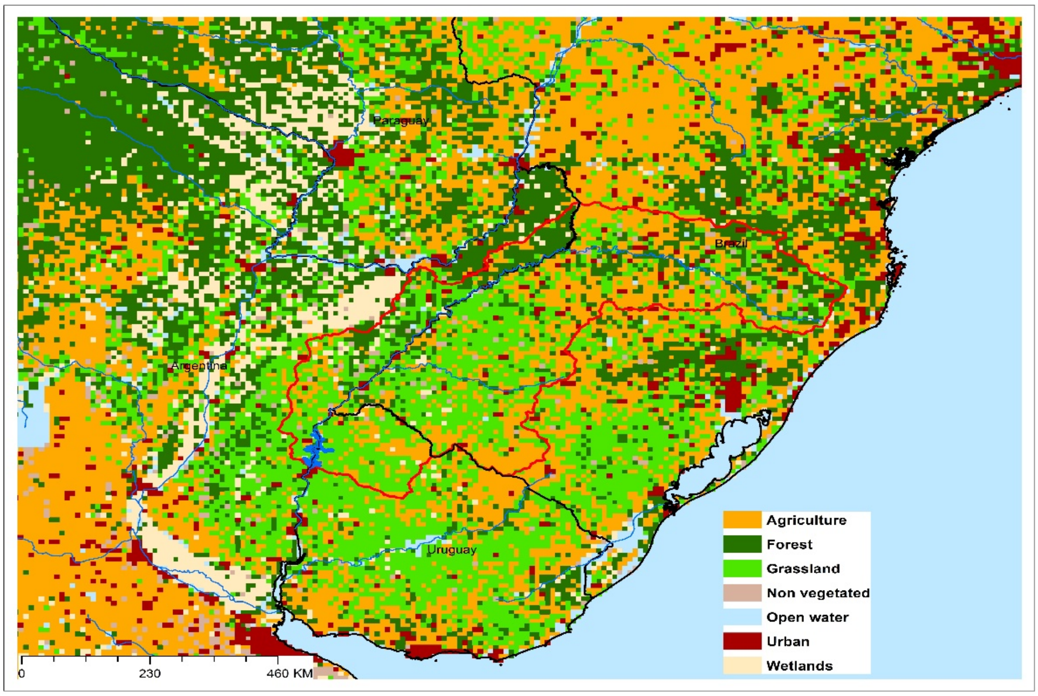


TWAP Regional Designation	Southern America		**Lake Basin Population (2010)**	5,001,392
River Basin	La Plata		**Lake Basin Population Density (2010; # km^{-2})**	15.6
Riparian Countries	Argentina, Uruguay		**Average Basin Precipitation (mm yr^{-1})**	1,613
Basin Area (km^2)	216,544		**Shoreline Length (km)**	683.5
Lake Area (km^2)	533.0		**Human Development Index (HDI)**	0.74
Lake Area:Lake Basin Ratio	0.002		**International Treaties/Agreements Identifying Lake**	

Salto de Grande Basin Characteristics



(a) Salto de Grande basin and associated transboundary water systems



(b) Salto de Grande basin land use

Salto de Grande Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Salto de Grande and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Salto de Grande threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Salto de Grande and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Salto de Grande Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.67	40		0.70	10		0.74	38

It is emphasized that the Salto de Grande rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Salto de Grande indicates a moderately low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Salto de Grande, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a high threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Salto de Grande basin in a moderately low threat rank in regard to its health, educational and economic conditions.

Table 2. Salto de Grande Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
40	38	11		51	28		78	39		89	32

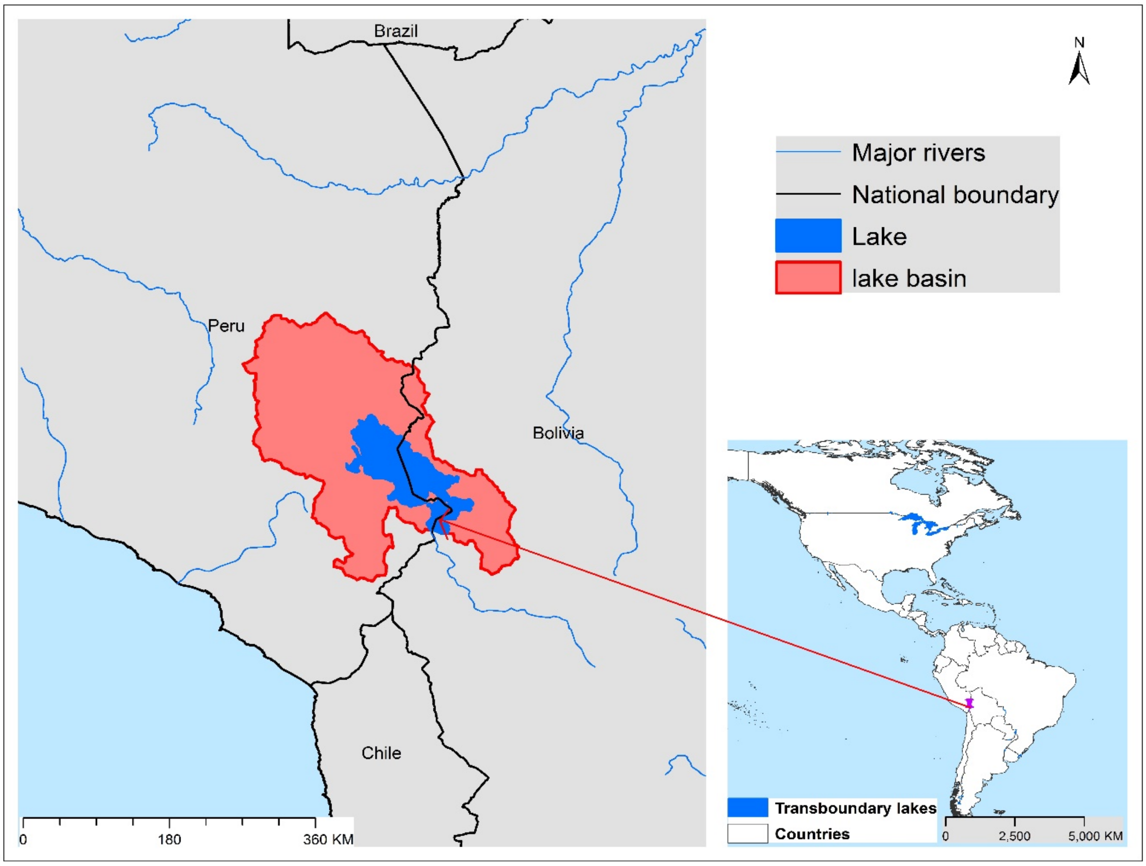
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Salto de Grande in the lower third of the threat ranks. The relative threat is somewhat increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Salto de Grande exhibits a medium threat ranking.

Interactions between the ranking parameters for Salto de Grande indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Salto de Grande must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Salto de Grande basin? Accurate answers to such questions for Salto de Grande, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

Lake Titicaca

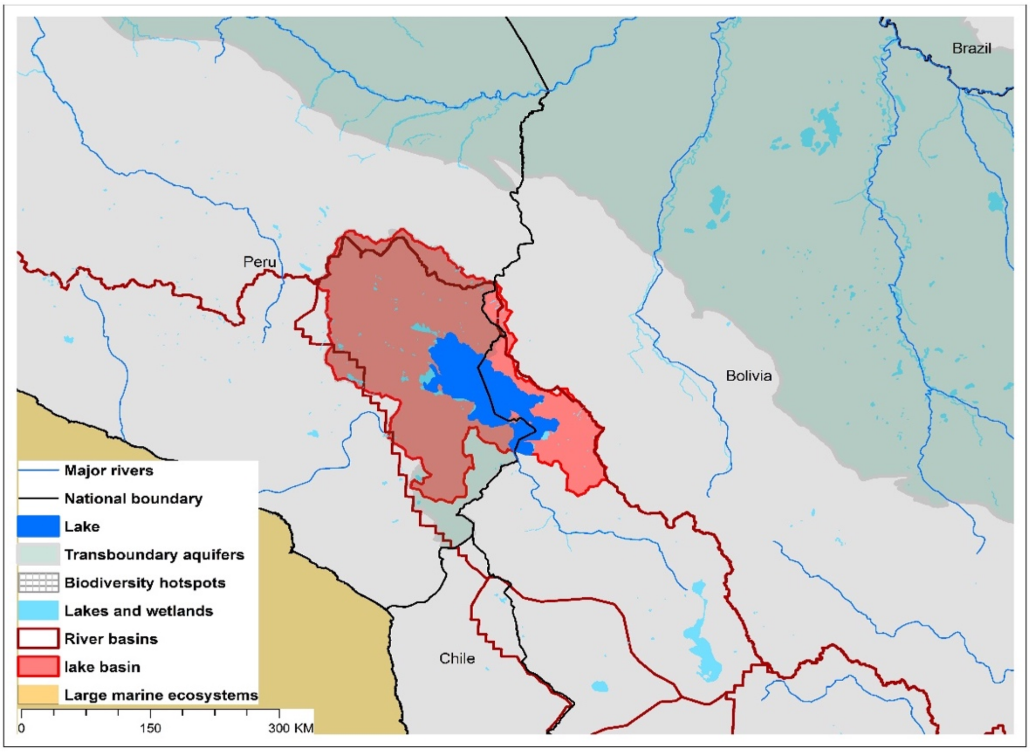
Geographic Information

Lake Titicaca is a large, deep lake in the Andes mountain region, the largest lake in South America by volume. Composed of two nearly separate sub-basins connected by a narrow strait, it also is the world's highest commercially-navigable lake. The lake is a sacred place for the Inca civilization, and the remnants of an ancient people (the Uru), still live on floating mats of a reedlike papyrus that grows in dense stands in the lake's marshy shallows, as well as making traditional crescent-shaped fishing boats from them. The lake holds large water bird populations, having been designated a Ramsar Site. Pollution and invasive species threaten its biodiversity. Although formerly believed to be drying up, more recent studies suggest Lake Titicaca is experiencing a regular risk-and-fall cycle. Although the lake has previously received GEF funding, it is again becoming a possible subject for GEF-catalyzed management interventions, which would require due elaboration of an appropriately-established international consultative process.

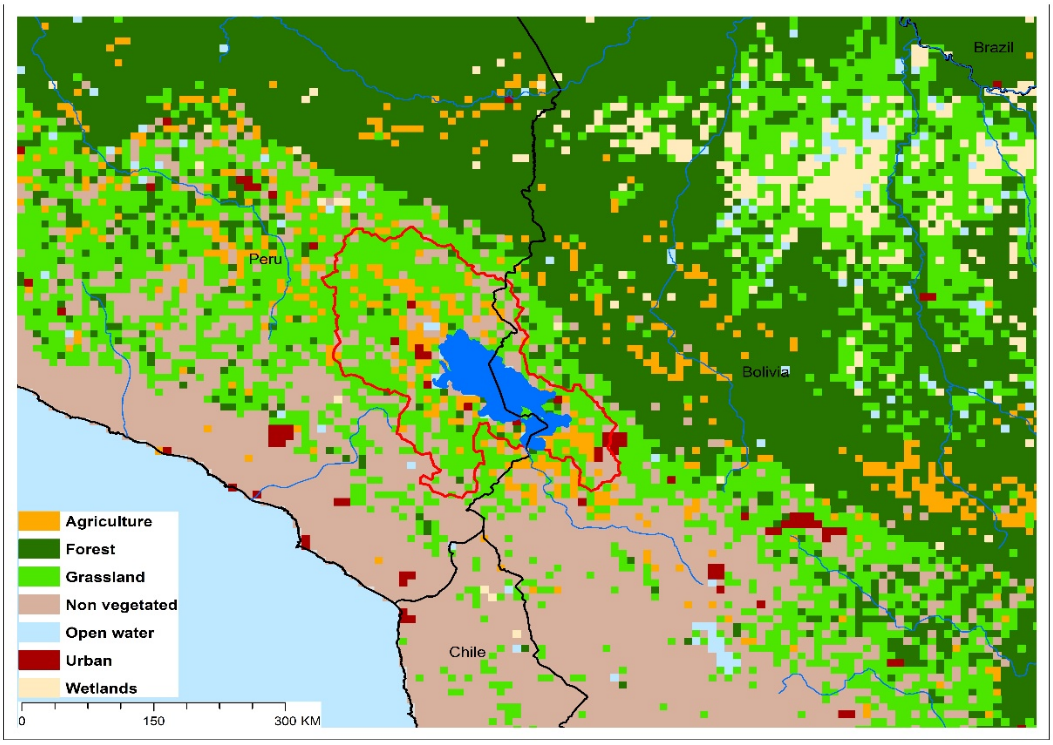


TWAP Regional Designation	Southern America		**Lake Basin Population (2010)**	2,169,134
River Basin	Titicaca-Poopo System		**Lake Basin Population Density (2010; # km^{-2})**	37.0
Riparian Countries	Bolivia, Peru		**Average Basin Precipitation (mm yr^{-1})**	719.0
Basin Area (km^2)	47,648		**Shoreline Length (km)**	1,132
Lake Area (km^2)	7,480		**Human Development Index (HDI)**	0.71
Lake Area:Lake Basin Ratio	0.157		**International Treaties/Agreements Identifying Lake**	Yes

Lake Titicaca Basin Characteristics



(a) Lake Titicaca basin and associated transboundary water systems



(b) Lake Titicaca basin land use

Lake Titicaca Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Titicaca and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Titicaca threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Titicaca and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lake Titicaca Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.82	31		0.71	8		0.71	32

It is emphasized that the Lake Titicaca rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Titicaca indicates a medium threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Titicaca, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a high threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Titicaca basin in a medium threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Titicaca Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

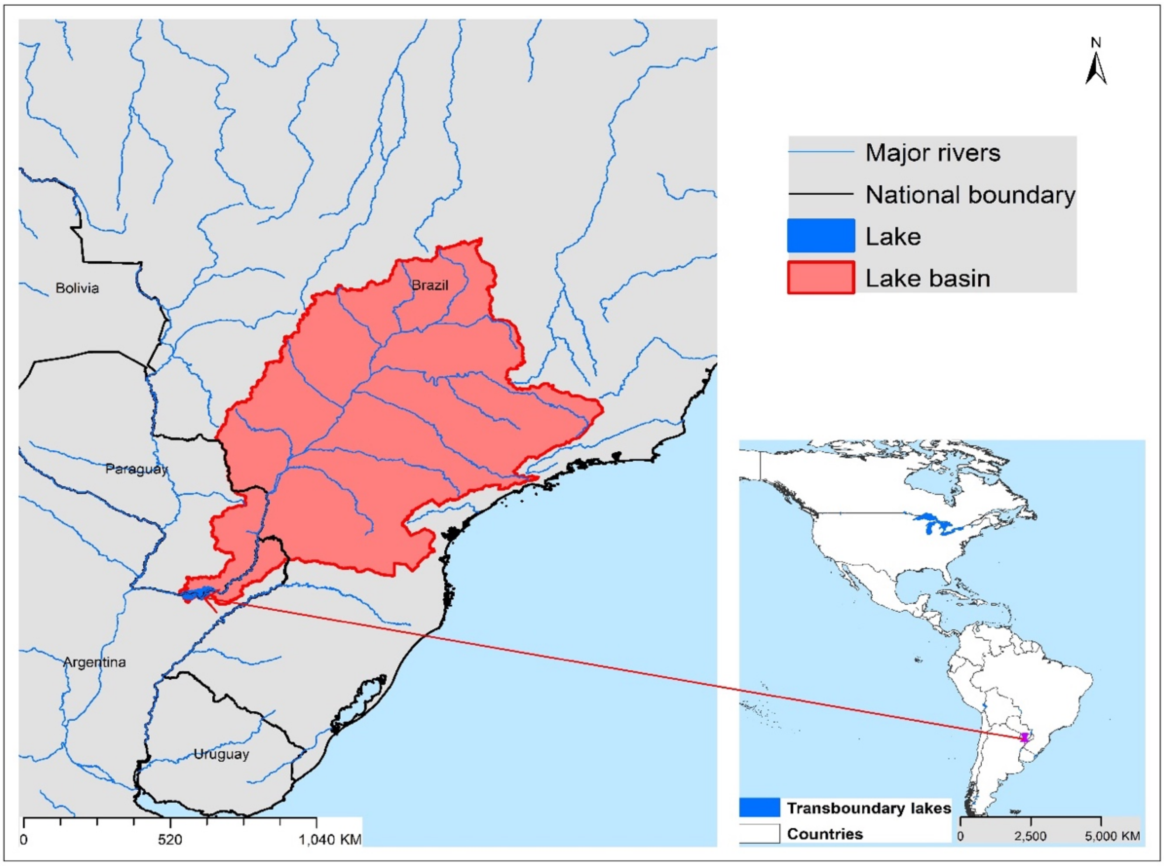
Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Threat Rank	Sum Adj-HWS + HDI	Relative Threat Rank	Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
32	32	8	40	22	25	35	72	26

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Titicaca in the lower third of the threat ranks. The relative threat is somewhat increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Titicaca exhibits a medium threat ranking.

Interactions between the ranking parameters for Lake Titicaca indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Titicaca must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Titicaca basin? Accurate answers to such questions for Lake Titicaca, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

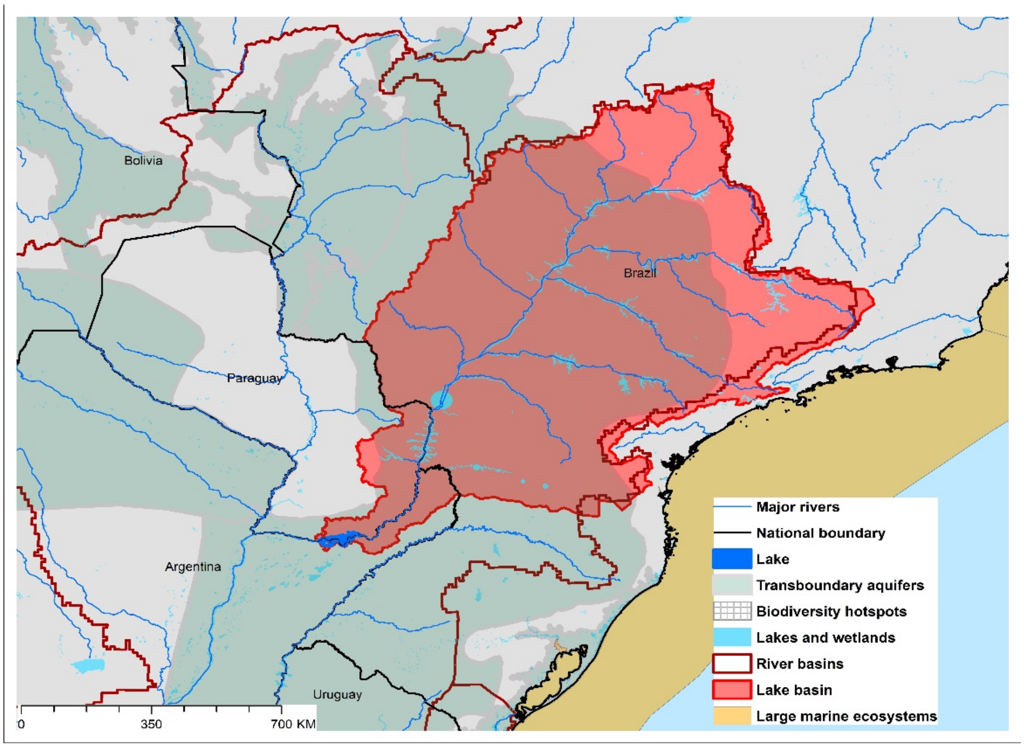
Lago de Yacyreta — Geographic Information

Lago de Yacyreta is a reservoir constructed on the La Plata River for hydropower production for Paraguay and Argentina. Most of the produced energy is utilized in Argentina, with a small portion going to Paraguay. Some criticized the project for an inadequate assessment of needs and environmental damage of the local ecology prior to its construction. Its flooding resulted in the relocation of an estimated 11,000 animals from 110 different species, as well as the relocation of 40,000 people. Nevertheless, the area is reported to have an abundant fauna and fishing areas. A ship lock was built on the Argentine side of the river to ease navigation, as was a fish ladder to aid in fish migration. The lake has long faced some serious environmental challenges, again becoming a subject for potential GEF consideration that would require an appropriately-established international consultative process, including an assessment of the lake's current scientific status.

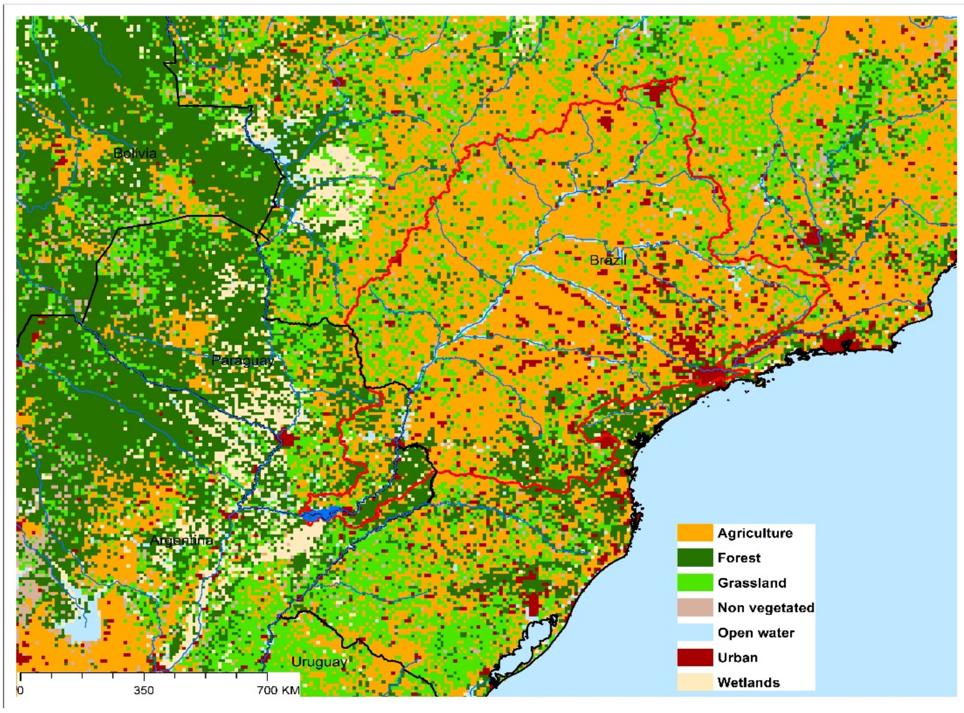


TWAP Regional Designation	Southern America	**Lake Basin Population (2010)**	64,421,204
River Basin	La Plata	**Lake Basin Population Density (2010; # km^{-2})**	55.0
Riparian Countries	Argentina, Paraguay	**Average Basin Precipitation (mm yr^{-1})**	1,454
Basin Area (km^2)	810,470	**Shoreline Length (km)**	1,156
Lake Area (km^2)	1,109	**Human Development Index (HDI)**	0.73
Lake Area:Lake Basin Ratio	0.001	**International Treaties/Agreements Identifying Lake**	Yes

Lago de Yacyreta Basin Characteristics



(a) Lago de Yacyreta basin and associated transboundary water systems



(b) Lago de Yacyreta basin land use

Lago de Yacyreta Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lago de Yacyreta and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lago de Yacyreta threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lago de Yacyreta and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lago de Yacyreta Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.75	37		0.66	19		0.73	35

It is emphasized that the Lago de Yacyreta rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lago de Yacyreta indicates a moderately low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lago de Yacyreta, which is meant to describe its biodiversity sensitivity to basin-derived degradation, increases the lake threat to a moderately high threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lago de Yacyreta basin in a moderately low threat rank in regard to its health, educational and economic conditions.

Table 2. Lago de Yacyreta Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
33	36	20		58	32		74	38		94	34

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lago de Yacyreta in the lower third of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lago de Yacyreta exhibits a moderately low threat ranking.

Interactions between the ranking parameters for Lago de Yacyreta indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lago de Yacyreta must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lago de Yacyreta basin? Accurate answers to such questions for Lago de Yacyreta, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

METHODOLOGY AND CAVEATS REGARDING TRANSBOUNDARY LAKE THREAT RANKS

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential risks be estimated on the basis of the characteristics of their drainage basins, rather than analysis of their in-lake conditions. The lake threat ranks were calculated with a scenario analysis program that allowed incorporation of specific assumptions and preconditions about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services, as defined by the user of the ranking results. Because the transboundary lake threat ranks are based on specific lake and basin assumptions, therefore, the calculated rankings represent only one possible set of lake rankings.

Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics. A global overview of river basin threats based on 23 basin-scale drivers under four thematic areas (catchment disturbance; pollution; water resource development; biotic factors) was modified for the transboundary lakes assessment. The driver weights were initially based on collective opinions of experts exhibiting a range of disciplinary expertise, subsequently being refined with inputs from lake scientists and managers participating in ILEC's 15th World Lake Conference.

A spreadsheet-based, interactive scenario analysis program was used to rank the transboundary lake threats. The lake basin characteristics were determined by superimposing the lake basins over the river basin grids, and scaling the driver data to lake basin scale. Selected basin drivers, weights and preconditions were used in the scenario analysis program to calculate the relative lake threat ranks, expressed in terms of the Incident (HWS) and Adjusted (Adj-HWS) Human Water Security and Incident Biodiversity (BD) threats.

The transboundary lake analyses incorporated several assumptions and preconditions. Small transboundary lakes (area <5 km^2), sparse basin populations (< 5 persons km^{-1}), or that were frozen over for major portions of the year (annual air temperature <5 ^oC), were eliminated from the analyses. The areal extent of the influences of the basin drivers was addressed with a sensitivity analysis that indicated an areal band of 100 km^2 around a lake, appropriately clipped for the surrounding basin, was a realistic upper boundary for the scenario analysis program. The river basin grid size was problematic in that some grids (30' grid [0.5^o]) were often larger than those of some transboundary lake basins, and about 10% of the transboundary lakes lacked driver data for some grids. Based on these considerations, a final list of 53 priority transboundary lakes was selected for the scenario analysis program calculations of relative threat scores.

Insights obtained from lake scientists and managers participating in the 15th World Lake Conference helped address some of these concerns. Region-specific lake questionnaires also were distributed in some cases, obtaining both quantitative and qualitative data regarding the transboundary lakes and their basins.

These various factors and concerns indicate the transboundary lake threat ranks must be considered within the context of the specific basin conditions and assumptions used to derive them, since they represent only one possible set of lake threat rankings. Other factors such as lake and basin area, basin population and density, regional location, per capita Gross National Income (GNI), and Human

Development Index (HDI) could produce markedly different ranking results. Defining the appropriate context and preconditions for interpreting the lake ranking results, a task beyond the scope of this analysis, remains an important responsibility of those using the results, including lake managers and decision-makers.

The calculated ranks of the priority transboundary lakes, based on the specific assumptions and preconditions regarding the lakes and their drainage basins, is expressed below in terms of Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and Human Development Index (HDI) status. The Incident Human Water Security (HWS) score would suggest the current threat ranks of the lakes. However, for identifying needed management interventions, the ability of the basin countries to undertake investments to reduce identified transboundary water threats (i.e., water supply stabilization, improved water services, etc.) is also a relevant factor. This ability is considered within the context of the Adj-HWS threat. Countries less able to make such investments, mainly developing countries, exhibited higher Adj-HWS threats. Thus, the Adj-HWS threat ranks provide a more realistic picture of the transboundary lakes most in need of catalytic funding for management interventions than those with lower Adj-HWS scores.

Our more limited knowledge and experience regarding the ultimate outcomes of ecosystem restoration and conservation activities precluded a BD metric identical to the Adj-HWS threat. The Adj-HWS threat rank is meant to identify the transboundary lakes in most need of management interventions from a water investment perspective. The native biodiversity of most developed countries, however, has already been largely degraded as a result of their economic development activities. Thus, the preservation of those ecosystems still exhibiting the most pristine or undisturbed conditions should be the major BD management intervention goal. To address this goal, a RvBD threat was developed as a BD surrogate to define relative BD threats. It was calculated as 1-BD score, with the resulting RvBD score indicating the relative 'pristineness' of a lake in regard to its biodiversity status. The higher RvBD scores calculated with this normalization procedure identify the transboundary lakes most likely to be sensitive to BD degradation and, therefore, the lakes most in need of management attention.

The Human Development Index (HDI) is a composite statistic used by the United Nations Development Programme (UNDP) to reflect the relative life expectancy, education level, and per capita income of a country. A country whose inhabitants exhibit longer life spans, higher education levels, and higher per capita GDPs typically exhibit higher HDI scores, suggesting a higher overall condition of its citizens. It is meant to indicate that economic growth alone is not the sole criteria to assessment of a country, but that the status of its citizens and their capabilities also are important defining factors, therefore being an indication of potential human development.

Along with the assumptions and preconditions defining specific lake basin characteristics, these three criteria were major indicators considered within the context of the scenario analysis program to calculate the relative threat ranks of the transboundary lakes, as presented in the transboundary lake profile sheets.

Transboundary Lakes Ranked on Basis of (a) Incident Human Water Security [HWS] Threats,
(b) Adjusted Human Water Security [Adj-HWS] Threats, and (c) Incident Biodiversity [BD] Threats

(Cont., continent; Eur, Europe; N.Am, North America; Afr., Africa; S.Am, South America;
Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

(A) Lakes Ranked on Basis of Adjusted Human Water Security (Adj-HWS) Threats

Lake	Cont.	Surface Area (km^2)	Adj-HWS Threat Score	Rank
Sistan	Asia	488.2	0.98	1
Ihema	Afr.	93.2	0.97	2
Azuei	S.Am	117.3	0.96	3
Rweru/Moero	Afr.	125.6	0.96	4
Cohoha	Afr.	64.8	0.96	5
Edward	Afr.	2232.0	0.94	6
Natron/Magadi	Afr.	560.4	0.93	7
Abbe/Abhe	Afr.	310.6	0.93	8
Victoria	Afr.	66841.5	0.91	9
Albert	Afr.	5502.3	0.91	10
Kivu	Afr.	2371.1	0.91	11
Malawi/Nyasa	Afr.	29429.2	0.91	12
Dead Sea	Eur	642.7	0.90	13
Turkana	Afr.	7439.2	0.90	14
Aras Su Qovsaginin Su Anbari	Asia	52.1	0.89	15
Mangla	Asia	85.4	0.87	16
Galilee	Eur	162.0	0.87	17
Darbandikhan	Asia	114.3	0.87	18
Selingue	Afr.	334.4	0.87	19
Shardara/Kara-Kul	Asia	746.1	0.86	20
Nasser/Aswan	Afr.	5362.7	0.86	21
Chilwa	Afr.	1084.2	0.86	22
Josini/Pongola-poort Dam	Afr.	128.6	0.85	23

(B) Lakes Ranked on Basis of Reverse Biodiversity (RvBD) Threats

Lake	Cont.	Surface area (km^2)	RvBD Threat Score	Rank
Lake Congo River	Afr.	306.0	0.80	1
Sarygamysh	Asia	3777.7	0.75	2
Chiuta	Afr.	143.3	0.74	3
Mweru	Afr.	5021.5	0.72	4
Aral Sea	Asia	23919.3	0.72	5
Tanganyika	Afr.	32685.5	0.71	6
Abbe/Abhe	Afr.	310.6	0.71	7
Titicaca	S.Am	7480.0	0.71	8
Chilwa	Afr.	1084.2	0.70	9
Salto Grande	S.Am	532.9	0.70	10
Turkana	Afr.	7439.2	0.70	11
Cahora Bassa	Afr.	4347.4	0.69	12
Chungarkkota	S.Am	52.6	0.69	13
Malawi/Nyasa	Afr.	29429.2	0.68	14
Nasser/Aswan	Afr.	5362.7	0.68	15
Selingue	Afr.	334.4	0.68	16
Kivu	Afr.	2371.1	0.67	17
Natron/Magadi	Afr.	560.4	0.67	18
Lago de Yacyreta	S.Am	1109.4	0.66	19
Kariba	Afr.	5258.6	0.66	20
Edward	Afr.	2232.0	0.65	21
Aby	Afr.	438.8	0.65	22
Chad	Afr.	1294.6	0.64	23

(C) Lakes Ranked on Basis of Human Development Index (HDI) Scores

Lake	Cont.	Surface area (km^2)	HDI Score	Rank
Lake Congo River	**Afr**	**306.0**	**0.34**	**1**
Selingue	**Afr**	**334.4**	**0.36**	**2**
Rweru/Moero	**Afr**	**125.6**	**0.36**	**3**
Cohoha	**Afr**	**64.8**	**0.38**	**4**
Kivu	**Afr**	**2371.1**	**0.38**	**5**
Mweru	**Afr**	**5021.5**	**0.38**	**6**
Abbe/Abhe	**Afr**	**310.6**	**0.40**	**7**
Tanganyika	**Afr**	**32685.5**	**0.40**	**8**
Turkana	**Afr**	**7439.2**	**0.41**	**9**
Chiuta	**Afr**	**143.3**	**0.41**	**10**
Chilwa	**Afr**	**1084.2**	**0.41**	**11**
Malawi/Nyasa	**Afr**	**29429.2**	**0.42**	**12**
Edward	**Afr**	**2232.0**	**0.43**	**13**
Nasser/Aswan	**Afr**	**5362.7**	**0.43**	**14**
Cahora Bassa	**Afr**	**4347.4**	**0.43**	**15**
Chad	**Afr**	**1294.6**	**0.43**	**16**
Kariba	**Afr**	**5358.6**	**0.43**	**17**
Ihema	**Afr**	**93.2**	**0.44**	**18**
Sistan	**Asia**	**488.2**	**0.46**	**19**
Albert	**Afr**	**5502.3**	**0.46**	**20**
Azuei	**S.Am,**	**117.3**	**0.46**	**21**
Victoria	**Afr**	**66841.5**	**0.47**	**22**
Natron/Magadi	**Afr**	**560.4**	**0.51**	**23**

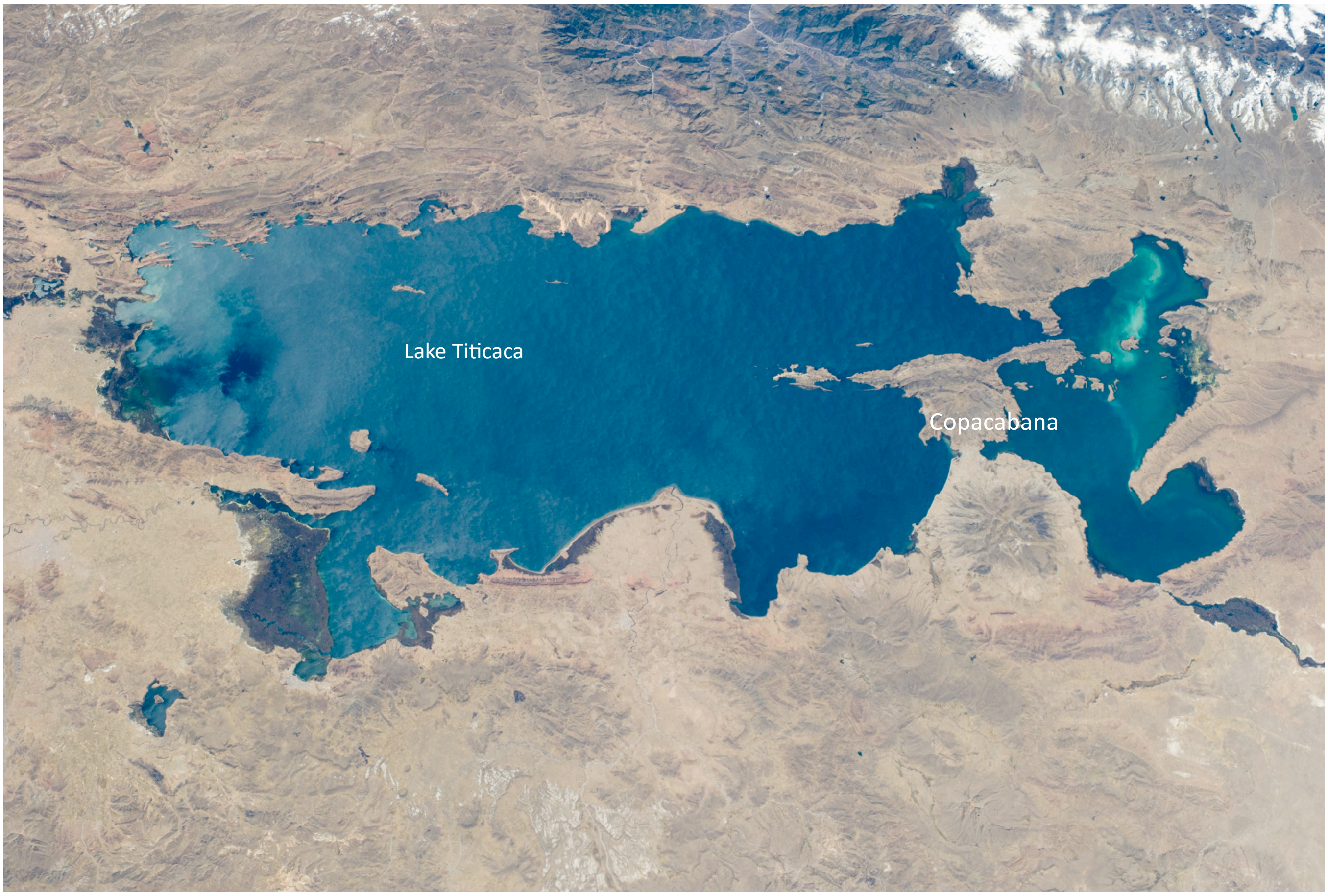
	Afr.	143.3	0.85	24	Albert	Afr.	5502.3	0.63	24	**Aby**	**Afr**	**438.8**	**0.52**	**24**
Chad	Afr.	1294.6	0.84	25	Sistan	Asia	488.2	0.62	25	**Mangla**	**Asia**	**85.4**	**0.54**	**25**
Aral Sea	Asia	23919.3	0.84	26	Amistad	N.Am	131.3	0.61	26	**Aral Sea**		**23919.3**	**0.60**	**26**
Tanganyika	Afr.	32685.5	0.84	27	Caspian Sea	Asia	377543.2	0.60	27	**Josini/Pongola-poort Dam**	**Afr**	**128.6**	**0.61**	**27**
Aby	Afr.	438.8	0.83	28	Cohoha	Afr.	64.8	059	28	**Shardara/Kara-kul**	**Asia**	**746.1**	**0.65**	**28**
Cahul	Eur	89.0	0.82	29	Itaipu	S.Am	1154.1	0.58	29	**Sarygamysh**	**Asia**	**3777.7**	**0.67**	**29**
Chungarkkota	S.Am	52.6	0.82	30	Rweru/Moero	Afr.	125.6	0.58	30	**Darbandikhan**	**Asia**	**114.3**	**0.68**	**30**
Titicaca	S.Am	7480.0	0.82	31	Azuei	S.Am	117.3	0.57	31	**Cahul**	**Eur**	**89.0**	**0.69**	**31**
Sarygamysh	Asia	3777.7	0.82	32	Ihema	Afr.	93.2	0.56	32	**Titicaca**	**S.Am**	**7480.0**	**0.71**	**32**
Mweru	Afr.	5021.5	0.81	33	Victoria	Afr.	66841.5	0.56	33	**Chungarkkota**	**S.Am**	**52.6**	**0.71**	**33**
Cahora Bassa	Afr.	4347.4	0.78	34	Scutari/Skadar	Eur	381.5	0.55	34	**Dead Sea**	**Eur**	**642.7**	**0.72**	**34**
Itaipu	S.Am	1154.1	0.75	35	Shardara/Kara-Kul	Asia	746.1	0.54	35	**Lago de Yacyreta**	**S.Am**	**1109.4**	**0.73**	**35**
Kariba	Afr.	5258.6	0.75	36	Huron	N.Am	60565.2	0.53	36	**Aras Su Qovsaginin Su Anbari**	**Asia**	**52.1**	**0.73**	**36**
Lago de Yacyreta	S.Am	1109.4	0.75	37	Josini/Pongola-poort Dam	Afr.	128.6	0.52	37	**Itaipu**	**S.Am**	**1154.1**	**0.73**	**37**
Lake Congo River	Afr.	306.0	0.75	38	Champlain	N.Am	1098.9	0.51	38	**Salto Grande**	**S.Am**	**532.9**	**0.74**	**38**
Caspian Sea	Asia	377543.2	0.73	39	Ohrid	Eur	354.3	0.51	39	**Ohrid**	**Eur**	**354.3**	**0.74**	**39**
Salto Grande	S.Am	532.9	0.67	40	Macro Prespa	Eur	263.0	0.51	40	**Macro Prespa**	**Eur**	**263.0**	**0.75**	**40**
Scutari/Skadar	Eur	381.5	0.62	41	Dead Sea	Eur	642.7	0.51	41	**Caspian Sea**	**Asia**	**377543.2**	**0.77**	**41**
Neusiedler/Ferto	Eur	141.9	0.58	42	Maggiore	Eur	211.4	0.49	42	**Scutari/Skadar**	**Eur**	**381.5**	**0.78**	**42**
Szczecin Lagoon	Eur	822.4	0.53	43	Szczecin Lagoon	Eur	822.4	0.49	43	**Szczecin Lagoon**	**Eur**	**822.4**	**0.83**	**43**
Erie	N.Am	26560.8	0.51	44	Ontario	N.Am	19062.2	0.47	44	**Falcon**	**N.Am**	**120.6**	**0.85**	**44**
Macro Prespa)	Eur	263.0	0.51	45	Aras Su Qovsaginin Su Anbari	Asia	52.1	0.47	45	**Amistad**	**N.Am**	**131.3**	**0.86**	**45**
Falcon	N.Am	120.6	0.50	46	Darbandikhan	Asia	114.3	0.46	46	**Galilee**	**Eur**	**162.0**	**0.88**	**46**
Amistad	N.Am	131.3	0.49	47	Galilee	Eur	162.0	0.45	47	**Neusiedler/Ferto**	**Eur**	**141.9**	**0.88**	**47**
Ontario	N.Am	19062.2	0.48	48	Michigan	N.Am	58535.5	0.44	48	**Lake Maggiore**	**Eur**	**211.4**	**0.89**	**48**
Ohrid	Eur	354.3	0.47	49	Erie	N.Am	26560.8	0.43	49	**Ontario**	**N.Am**	**19062.2**	**0.92**	**49**
Michigan	N.Am	58535.5	0.44	50	Neusiedler/Ferto	Eur	141.9	0.39	50	**Huron**	**N.Am**	**60565.2**	**0.93**	**50**
Huron	N.Am	60565.2	0.42	51	Cahul	Eur	89.0	0.39	51	**Erie**	**N.Am**	**26560.8**	**0.93**	**51**
Maggiore	Eur	211.4	0.33	52	Mangla	Asia	85.4	0.38	52	**Champlain**	**N.Am**	**1098.9**	**0.94**	**52**
Champlain	N.Am	1098.9	0.29	53	Falcon	N.Am	120.6	0.38	53	**Michigan**	**N.Am**	**58535.5**	**0.94**	**53**

Transboundary Lake Threat Ranks by Multiple Ranking Criteria

(Cont., continent; Eur, Europe; N.Am, North America; Afr, Africa; S.Am, South America;
Adj-HWS, Adjusted Human Water Security threat; HWS, Incident Human Water Security threat; BD, Incident Biodiversity threat;
HDI, Human Development Index, RvBD, surrogate for 'Adjusted' Biodiversity threat;
Estimated risks: Red – highest; Orange – moderately high; Yellow – medium; Green – moderately low; Blue – low)

Cont.	Lake Name	Adj-HWS Threat	RvBD Threat	HDI	Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Rank	Sum Adj-HWS + HDI	Relative Rank	Sum Adj-HWS + RvBD + HDI	Overall Rank
Afr	Abbe/Abhe	0.93	0.71	0.40	7	7	7	14	1	14	3	21	1
Afr	Turkana	0.90	0.70	0.41	13	10	9	22	2	23	10	32	2
Afr	Selingue	0.87	0.68	0.36	16	2	15	31	11	18	5	33	3
Afr	Malawi/Nyasa	0.91	0.68	0.42	9	12	14	23	3	21	9	35	4
Afr	Chiuta	0.85	0.74	0.41	23	9	3	26	5	32	15	35	4
Afr	Cohoha	0.96	0.59	0.38	3	4	28	31	2	7	1	35	4
Afr	Kivu	0.91	0.67	0.38	12	6	18	30	8	18	4	36	7
Afr	Rweru/Moero	0.96	0.58	0.36	4	3	30	34	16	7	2	37	8
Afr	Lake Congo River	0.75	0.78	0.34	35	1	1	36	18	36	19	37	8
Afr	Tanganyika	0.84	0.71	0.40	26	8	6	32	14	34	17	40	10
Afr	Edward	0.94	0.65	0.43	6	13	22	28	7	19	6	41	11
Afr	Chilwa	0.86	0.70	0.41	21	11	10	31	10	32	14	42	12
Afr	Mweru	0.81	0.72	0.38	33	5	4	37	21	38	20	42	12
Asia	Sistan	0.98	0.62	0.46	1	20	25	26	6	21	8	46	14
Afr	Natron/Magadi	0.93	0.67	0.51	8	23	17	25	4	31	13	48	15
Afr	Nasser/Aswan	0.86	0.68	0.43	20	16	16	36	19	36	18	52	16
Afr	Albert	0.91	0.63	0.46	10	19	24	34	15	29	12	53	17
Afr	Ihema	0.97	0.56	0.44	2	18	33	35	17	20	7	53	17
S.Am,	Azuei	0.96	0.57	0.46	5	21	31	36	20	26	11	57	19
Asia	Aral Sea	0.84	0.62	0.60	27	26	5	32	13	53	31	58	20
Asia	Sarygamysh	0.82	0.75	0.67	29	29	2	31	9	58	32	60	21
Afr	Cahora Bassa	0.78	0.69	0.43	34	15	13	47	25	49	25	62	22
Afr	Victoria	0.91	0.56	0.47	11	22	32	43	24	33	16	65	23
Afr	Chad	0.84	0.64	0.43	25	17	23	48	26	42	21	65	23
Afr	Kariba	0.75	0.66	0.43	36	14	19	55	30	50	28	69	25

S.Am	Titicaca	0.82	0.71	0.71	32	32	8	40	22	25	35	72	26
Afr	Aby	0.83	0.65	0.52	28	24	21	49	27	52	30	73	27
S.Am	Chungarkkota	0.82	0.69	0.71	31	33	12	43	23	64	34	76	28
Asia	Shardara/Kara-kul	0.86	0.54	0.65	22	28	35	57	31	50	27	85	29
Eur	Dead Sea	0.90	0.51	0.72	14	34	38	52	29	48	24	86	30
Afr	Josini/Pongola-poort Dam	0.85	0.52	0.61	24	27	37	61	34	51	29	88	31
S.Am	Salto Grande	0.67	0.70	0.74	40	38	11	51	28	78	39	89	32
Asia	Darbandikhan	0.87	0.46	0.68	17	30	46	63	35	47	23	93	33
S.Am	Lago de Yacyreta	0.75	0.66	0.73	38	36	20	58	32	74	38	94	34
Asia	Aras Su Qovsaginin Su Anbari	0.89	0.47	0.73	15	35	44	59	33	50	26	94	34
Asia	Mangla	0.87	0.38	0.54	18	25	53	71	39	43	22	96	36
S.Am	Itaipu	0.75	0.58	0.73	37	37	29	66	37	74	37	103	37
Asia	Caspian Sea	0.73	0.60	0.77	39	41	27	66	36	80	40	107	38
Eur	Galilee	0.87	0.45	0.88	19	46	47	66	38	65	36	112	39
Eur	Cahul	0.82	0.39	0.69	30	31	51	81	42	61	33	112	39
Eur	Scutari/Skadar	0.62	0.55	0.78	41	42	34	75	41	83	41	117	41
N.Am	Amistad	0.49	0.61	0.86	47	45	26	73	40	47	40	118	42
Eur	Macro Prespa (Large Prespa)	0.51	0.51	0.75	44	40	40	84	43	84	42	124	43
Eur	Ohrid	0.47	0.51	0.74	49	39	39	88	46	88	44	127	44
Eur	Szczecin Lagoon	0.53	0.49	0.83	43	43	43	86	44	86	43	129	45
N.Am	Huron	0.42	0.53	0.93	51	50	36	87	45	101	51	137	46
Eur	Neusiedler/Ferto	0.58	0.39	0.88	42	47	50	92	47	89	45	139	47
N.Am	Ontario	0.48	0.47	0.92	48	49	45	93	48	97	49	142	48
Eur	Lake Maggiore	0.33	0.50	0.89	52	48	42	94	50	100	50	142	48
N.Am	Falcon	0.50	0.38	0.85	46	44	52	98	53	90	46	142	48
N.Am	Erie	0.51	0.43	0.93	45	51	49	94	51	96	48	145	51
N.Am	Champlain	0.29	0.51	0.94	53	52	41	94	49	105	53	146	52
N.Am	Michigan	0.44	0.44	0.94	50	53	48	98	52	103	52	151	53



NASA Earth Observatory

Christopher Crouzet, Wikimedia Commons

Transboundary River Basins of Southern America

1. Amacuro
2. Amazon
3. Aviles
4. Aysen
5. Baker
6. Barima
7. Cancoso/ Lauca
8. Carmen Silva/ Chico
9. Catatumbo
10. Chira
11. Chuy
12. Comau
13. Corantijn/ Courantyne
14. Cullen
15. Essequibo
16. Gallegos/ Chico
17. Jurado
18. La Plata
19. Lagoon Mirim
20. Lake Fagnano
21. Lake Titicaca-Poopo System
22. Maroni
23. Mataje
24. Mira
25. Oiapoque/ Oyupock
26. Orinoco
27. Palena
28. Pascua
29. Patia
30. Puelo
31. Rio Grande
32. San Martin
33. Seno Union/ Serrano
34. Tumbes
35. Valdivia
36. Yelcho
37. Zapaleri
38. Zarumilla

Amacuro Basin

Geography

Total drainage area (km^2)	3,719
No. of countries in basin	2
BCUs in basin	Guyana (GUY), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	1,138
Country at mouth	Venezuela, Bolivarian Republic Of
Average rainfall (mm/year)	2,515

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
AMCR_GUY		1,030.83				
AMCR_VEN		883.21				
Total in Basin	3.47	932.43			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
AMCR_GUY	0.12	0.00	0.03	0.00	0	0.10	166.67	
AMCR_VEN	0.23	0.00	0.10	0.00	0	0.13	566.65	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	0.35	0.00	0.13	0.00	0.00	0.23	311.03	0.01

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
AMCR_GUY	1	0.19	1	1.03	0.22			0	3,846.53	0	0.00
AMCR_VEN	3	0.81	0	0.14	1.67			0	14,414.75	0	0.00
Total in Basin	4	1.00	1	0.31	0.88	0.00	0.00	0	7,660.79	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AMCR_GUY	1		1		5	1			1	5	3		1	3	1
AMCR_VEN	1	1	1		5	1	2	2	1	5	3	4	1	2	3
River Basin	1	1	1	2	5	1	2	2	1	5	3		1	4	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
AMCR_GUY	4	4							3
AMCR_VEN	4	4	1	1			2	2	3
River Basin	4	5	1	1	2	2	2	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

Disclaimer

The results and information of factsheet is produced and maintained by the River Basins Component of the GEF Transboundary Water Assessment Programme (GEF TWAP).

GEF TWAP is the first global-scale assessment of all transboundary water systems. The TWAP consists of five independent indicator-based water system assessments and the linkages between them, including their socioeconomic and governance-related features. The United Nations Environment Programme (UNEP) is the implementing agency of TWAP. Project Coordination Unit (PCU) in Nairobi, Kenya coordinates the work of UNESCO-IHP, ILEC, UNEP-DHI and the IOC of UNESCO on Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems and Open Ocean respectively. Each executing partner engages a broad network of data and information rich partners with responsibilities either of a thematic or geographic nature. More on TWAP full size project at http://www.geftwap.org .

The TWAP River Basins component (TWAP RB) carried out a global comparison of 286 transboundary river basins, in order to enable the prioritisation of funds for basins at risk from a variety of issues, covering water quantity, water quality, ecosystems, governance and socio-economics. It also considered risks to deltas from threats of a transboundary nature, and considered the relative influence of lakes on these river basins. TWAP RB is an indicator–based assessment, allowing for an analysis of basins, based on risks to both societies and ecosystems. It also includes provisional outlook projections to 2030 and 2050 for a limited number of indicators.
Values given in the present fact-sheet represent an approximate guide only and should not replace recent local assessments.

Country Boundaries Under TWAP
TWAP RB assessment uses country delineations provided by FAO GAUL (Global Administrative Unit Layers) (FAO 2014). GAUL uses the International Boundary dataset of the UNCS (UN Cartographic Section) and inland boundaries are same for both datasets. Some differences occur in coastlines, where FAO GAUL dataset offers more detail.

Disputed areas
The GAUL project and original dataset maintains disputed areas in such a way to preserve national integrity for all disputing countries. The GAUL Set reports the international, first level and second level administrative boundaries delimiting, or falling within, the disputed areas in a way to enable the re-construction of the administrative units as they are specified by the individual disputing countries. Disputed areas are therefore shown as individual entities, not dependent from countries, with corresponding coding. Same approach has been taken by TWAP RB, reporting on disputed territories, as well as presentation of Basin Country Units.

Basin Delineation
TWAP RB assessment includes 286 transboundary river basins. Information on this layer and delineation methodology can be retrieved by downloading metadata sheet for the Basins layer from TWAP Rivers Data Portal at http://twap-rivers.org/indicators/ or by direct download from http://twap-rivers.org/assets/Basin%20and%20BCU%20Creation%20Documentation.pdf

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org . To view sources of data included in this Factsheet download the Factsheet Reference file at http://twap-rivers.org/assets/Factsheet_template_with_references.pdf.

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org .

Amazon Basin

Geography

Total drainage area (km^2)	5,888,269
No. of countries in basin	9
BCUs in basin	Bolivia, Plurinational State Of (BOL), Brazil (BRA), Colombia (COL), Ecuador (ECU), French Guiana (GUF), Guyana (GUY), Peru (PER), Suriname (SUR), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	32,163,919
Country at mouth	Brazil
Average rainfall (mm/year)	2,249

Governance

No. of treaties and agreements[1]	6
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	74
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
AMZN_BOL		475.24			2,284.04	17.50
AMZN_BRA		1,262.14			12,855.46	112.87
AMZN_COL		2,201.14			63.30	0.37
AMZN_ECU		736.22				
AMZN_GUF						
AMZN_GUY		878.93				
AMZN_PER		616.11			198.80	0.93
AMZN_SUR						

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

AMZN_VEN		2,254.09				
Total in Basin	6,540.45	1,110.76			15,401.60	131.66

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
AMZN_BOL	852.28	185.19	74.22	353.57	15	224.42	110.59	
AMZN_BRA	2,303.46	283.39	295.86	840.89	181	702.53	257.47	
AMZN_COL	336.58	48.99	44.17	0.00	11	232.48	193.48	
AMZN_ECU	1,414.69	287.58	39.53	303.92	357	426.34	507.91	
AMZN_GUF								
AMZN_GUY	0.43	0.13	0.19	0.00	0	0.11	108.42	
AMZN_PER	5,551.91	2,635.50	74.74	255.07	1,257	1,329.75	505.68	
AMZN_SUR								
AMZN_VEN	0.53	0.00	0.17	0.00	0	0.36	218.02	
Total in Basin	10,459.89	3,440.77	528.88	1,753.46	1,820.79	2,915.99	325.21	0.16

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
AMZN_BOL	713	0.12	7,707	10.82	1.64	0.00	100.00	4	2,867.64	2	2.81
AMZN_BRA	3,677	0.62	8,946	2.43	0.94	0.00	100.00	5	11,208.08	3	0.82
AMZN_COL	341	0.06	1,740	5.11	1.46	0.00	100.00	0	7,825.68	0	0.00
AMZN_ECU	132	0.02	2,785	21.09	1.49	0.00	100.00	4	5,720.18	0	0.00
AMZN_GUF	0	0.00	0	1.09	2.70			0		0	0.00
AMZN_GUY	13	0.00	4	0.31	0.22	100.00	0.00	0	3,846.53	0	0.00
AMZN_PER	961	0.16	10,979	11.42	1.07	7.92	92.08	8	6,659.81	3	3.12
AMZN_SUR	0	0.00	0	0.47	0.99			0	9,699.87	0	0.00
AMZN_VEN	52	0.01	2	0.05	1.67			0	14,414.75	0	0.00
Total in Basin	5,888	1.00	32,164	5.46	1.28	2.72	97.28	21	6,998.16	8	1.36

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AMZN_BOL	2	1	2		5	2	1	3	3	3	4	4	4	4	4
AMZN_BRA	1	1	1		5	2	1	3	2	3	4	2	1	3	3
AMZN_COL	2	1	1		5	1	1	3	3	3	4		1	3	3
AMZN_ECU	2	1	2		5	3	1	2	4	3	4	3	3	3	3
AMZN_GUF					5				2	5	3		1	2	1
AMZN_GUY	1	1	1		5	1	1	1	2	3	2		1	3	3
AMZN_PER	2	1	2		4	2	1	3	4	3	4	3	3	3	2
AMZN_SUR					5				2	5	2		1	3	1
AMZN_VEN	1	1	1		5	1	2	3	1	3	2	4	1	3	4
River Basin	2	1	2	2	5	2	1	3	5	3	4	3	3	4	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
AMZN_BOL	2	2	1	1			2	4	4
AMZN_BRA	2	2	1	1			1	1	4
AMZN_COL	2	2	1	1			1	2	4
AMZN_ECU	2	3	1	1			2	2	4
AMZN_GUF									3
AMZN_GUY	2	2	1	1			1	1	2
AMZN_PER	3	3	1	1			2	2	4
AMZN_SUR									2
AMZN_VEN	2	3	1	1			1	2	2
River Basin	2	3	1	1	2	2	2	2	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index

Basin/Delta	17	18	19	20	21
River Basin	1	2	2	1	3

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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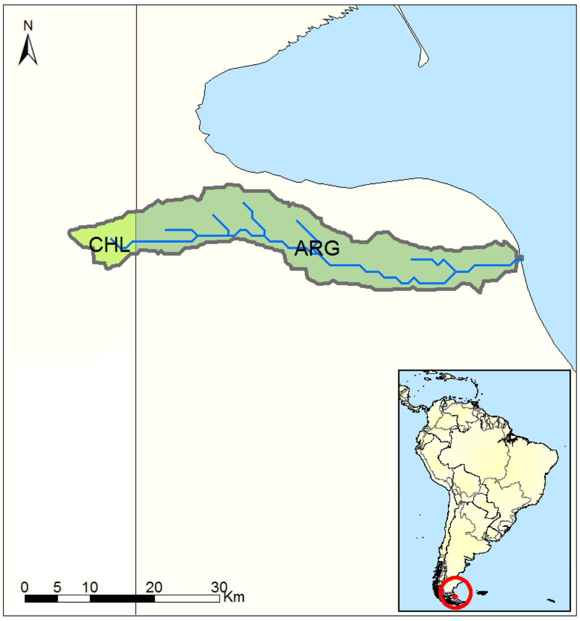
Aviles Basin



Geography

Total drainage area (km²)	296
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	1,729
Country at mouth	Argentina
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
AVLS_ARG						
AVLS_CHL						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
AVLS_ARG								
AVLS_CHL								

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Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
AVLS_ ARG	0	0.89	2	6.35	0.88			0	14,760.20	0	0.00
AVLS_ CHL	0	0.11	0	1.61	0.97			0	15,732.31	0	0.00
Total in Basin	0	1.00	2	5.84	0.87	0.00	0.00	0	14,788.82	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
AVLS_ARG					5				1	5	3	4	1	2	1
AVLS_CHL					2				1	5	3	2	1	2	1
River Basin					5				1	5	3	4	1	2	1

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
AVLS_ARG									3
AVLS_CHL									3
River Basin						1			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin					

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Aysen Basin

Geography

Total drainage area (km^2)	12,550
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	55,908
Country at mouth	Chile
Average rainfall (mm/year)	1,666

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
AYSN_ARG		591.29				
AYSN_CHL		1,238.56				
Total in Basin	14.65	1,166.99			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
AYSN_ARG	3.19	1.64	0.86	0.00	0	0.69	6,219.37	
AYSN_CHL	16.50	2.91	1.60	6.31	2	3.78	297.77	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	19.69	4.55	2.46	6.31	1.90	4.47	352.12	0.13

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
AYSN_ARG	1	0.06	1	0.70	0.88			0	14,760.20	0	0.00
AYSN_CHL	12	0.94	55	4.69	0.97	0.00	100.00	0	15,732.31	0	0.00
Total in Basin	13	1.00	56	4.45	0.88	0.00	99.08	0	15,723.39	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AYSN_ARG	1		2		5				2	5	3	4	1	2	2
AYSN_CHL	1	1	2		2		3	1	2	5	3	2	1	2	3
River Basin	1	1	2	2	2		3	1	2	5	3	2	1	2	3

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
AYSN_ARG	2	2							3
AYSN_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	2	2	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Baker Basin

Geography

Total drainage area (km²)	26,886
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	11,612
Country at mouth	Chile
Average rainfall (mm/year)	731

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	6
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
BAKR_ARG		169.72			1,019.52	239.50
BAKR_CHL		518.61			1,255.78	300.76
Total in Basin	11.25	418.47			2,275.30	540.27

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
BAKR_ARG	6.88	6.02	0.47	0.00	0	0.39	4,855.90	
BAKR_CHL	14.73	10.99	1.40	1.34	0	1.00	1,444.59	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	21.61	17.01	1.87	1.34	0.00	1.39	1,860.57	0.19

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
BAKR_ARG	7	0.24	1	0.22	0.88	0.00	100.00	0	14,760.20	0	0.00
BAKR_CHL	20	0.76	10	0.50	0.97			0	15,732.31	0	0.00
Total in Basin	27	1.00	12	0.43	0.88	0.00	12.19	0	15,613.78	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
BAKR_ARG	1	1	2		5		2	1	2	5	3	4	1	2	4
BAKR_CHL	2	1	2		2	1	2	1	2	5	3	2	1	2	4
River Basin	2	1	2	2	2	1	2	1	2	5	3	2	1	2	4

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
BAKR_ARG	2	2	1	1			1	2	3
BAKR_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	2	1	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	5				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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Barima Basin

Geography

Total drainage area (km^2)	923
No. of countries in basin	2
BCUs in basin	Guyana (GUY), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	110
Country at mouth	Venezuela, Bolivarian Republic Of
Average rainfall (mm/year)	2,603

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
BRMA_GUY						
BRMA_VEN		648.98				
Total in Basin	0.60	648.98			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
BRMA_GUY								
BRMA_VEN	0.15	0.00	0.09	0.00	0	0.06	1,804.46	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	0.15	0.00	0.09	0.00	0.00	0.06	1,330.08	0.02

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
BRMA_GUY	0	0.04	0	0.72	0.22			0	3,846.53	0	0.00
BRMA_VEN	1	0.96	0	0.09	1.67			0	14,414.75	0	0.00
Total in Basin	1	1.00	0	0.12	1.24	0.00	0.00	0	11,636.42	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
BRMA_GUY					5	4			1	5	3		1	3	1
BRMA_VEN	1		1		5	2			1	5	3	4	1	2	1
River Basin	1		1	2	5				1	5	3	5	1	4	1

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
BRMA_GUY							1	1	3
BRMA_VEN	3	4							3
River Basin	3	5			2	2	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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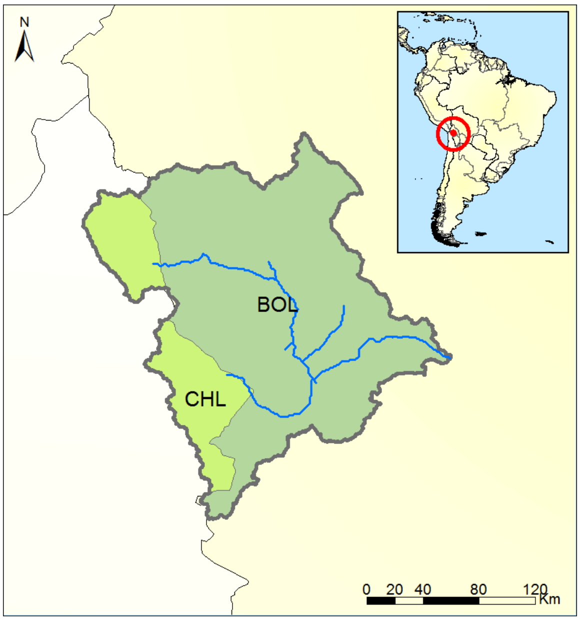
Cancoso/Lauca Basin



Geography

Total drainage area (km²)	32,882
No. of countries in basin	2
BCUs in basin	Bolivia, Plurinational State Of (BOL), Chile (CHL)
Population in basin (people)	54,956
Country at mouth	Bolivia, Plurinational State Of
Average rainfall (mm/year)	203

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
CNCS_BOL		5.70			183.70	0.37
CNCS_CHL		1.58				
Total in Basin	0.14	4.16			183.70	0.37

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CNCS_BOL	9.26	6.83	1.09	0.00	0	1.35	179.40	
CNCS_CHL	63.75	62.64	0.20	0.00	0	0.90	19,196.54	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	73.01	69.47	1.29	0.00	0.00	2.25	1,328.53	53.42

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
CNCS_BOL	26	0.80	52	1.96	1.64			0	2,867.64	0	0.00
CNCS_CHL	6	0.20	3	0.51	0.97			0	15,732.31	0	0.00
Total in Basin	33	1.00	55	1.67	1.61	0.00	0.00	0	3,645.00	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CNCS_BOL	3	1	2		5	4	1	1	2	5	3	4	1	4	5
CNCS_CHL	5	2	5		2				2	5	3	2	2	2	2
River Basin	5	1	3	3	5	4	1	1	2	5	3	4	1	4	5

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CNCS_BOL	5	5	1	1			2	4	3
CNCS_CHL	5	5	3	4			1	2	4
River Basin	5	5	1	1	4	3	2	4	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	4				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Carmen Silva/Chico Basin

Geography

Total drainage area (km^2)	2,065
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	8,573
Country at mouth	Argentina
Average rainfall (mm/year)	326

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
CHIC_ARG		33.00				
CHIC_CHL						
Total in Basin	0.07	33.00			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CHIC_ARG	2.48	0.00	0.22	0.00	1	1.46	318.23	
CHIC_CHL								

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	2.48	0.00	0.22	0.00	0.79	1.46	288.92	3.64

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CHIC_ARG	1	0.59	8	6.39	0.88			0	14,760.20	0	0.00
CHIC_CHL	1	0.41	1	0.93	0.97			0	15,732.31	0	0.00
Total in Basin	2	1.00	9	4.15	0.87	0.00	0.00	0	14,849.73	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHIC_ARG	2	5	1		5				1	5	3	4	1	2	4
CHIC_CHL					2				1	5	3	2	1	2	1
River Basin	2	5	1	2	5				1	5	3	3	1	2	3

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CHIC_ARG	3	2	5	5					3
CHIC_CHL									3
River Basin	3	3	4	4	3	2			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Catatumbo Basin

Geography

Total drainage area (km^2)	27,435
No. of countries in basin	2
BCUs in basin	Colombia (COL), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	1,808,743
Country at mouth	Venezuela, Bolivarian Republic Of
Average rainfall (mm/year)	1,858

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems
(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
CTTB_COL		906.52				
CTTB_VEN		605.46				
Total in Basin	19.71	718.53			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CTTB_COL	261.72	86.17	6.31	43.87	8	117.29	191.15	
CTTB_VEN	403.50	120.80	27.32	85.98	5	164.52	917.99	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	665.23	206.97	33.63	129.86	12.96	281.81	367.78	3.37

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CTTB_COL	17	0.60	1,369	82.91	1.46	0.48	99.52	1	7,825.68	0	0.00
CTTB_VEN	11	0.40	440	40.25	1.67	0.00	100.00	0	14,414.75	0	0.00
Total in Basin	27	1.00	1,809	65.93	1.34	0.36	99.64	1	9,426.91	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CTTB_COL	1	1	2		5	1	4	2	3	5	3		2	3	2
CTTB_VEN	1	1	2		5	2	4	2	3	5	3	4	1	2	2
River Basin	1	1	2	4	5	1	4	2	2	5	3		2	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CTTB_COL	3	2	1	1			1	2	3
CTTB_VEN	3	2	1	2			2	2	3
River Basin	3	3	1	1	4	5	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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Chira Basin

Geography

Total drainage area (km²)	17,684
No. of countries in basin	2
BCUs in basin	Ecuador (ECU), Peru (PER)
Population in basin (people)	697,123
Country at mouth	Peru
Average rainfall (mm/year)	548

Governance

No. of treaties and agreements[1]	3
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
CHIR_ECU		306.45				
CHIR_PER		136.80			102.60	0.64
Total in Basin	3.42	193.38			102.60	0.64

Water Withdrawals

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CHIR_ECU	170.13	141.39	4.92	0.00	3	20.63	793.02	
CHIR_PER	1,668.99	1,245.96	2.63	83.53	189	147.90	3,458.43	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	1,839.12	1,387.35	7.55	83.53	192.16	168.53	2,638.16	53.78

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CHIR_ECU	7	0.41	215	29.93	1.49	0.00	100.00	0	5,720.18	0	0.00
CHIR_PER	11	0.59	483	45.90	1.07	1.42	98.58	1	6,659.81	2	190.21
Total in Basin	18	1.00	697	39.42	1.37	0.98	99.02	1	6,370.64	2	113.10

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CHIR_ECU	2	3	2		5	1	3	2	3	3	3	3	1	2	3
CHIR_PER	5	5	4		4		4	2	3	3	3	3	2	3	5
River Basin	4	4	3	3	5	1	4	2	3	3	3	3	2	3	5

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	**1.Environmental water stress**		**2.Human water stress**		**4.Nutrient pollution**		**16.Change in population density**		**11.Hydropolitical tension**
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
CHIR_ECU	3	3	3	3			2	2	3
CHIR_PER	5	5	5	5			2	2	3
River Basin	5	5	4	4	3	4	2	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Basin Delineation
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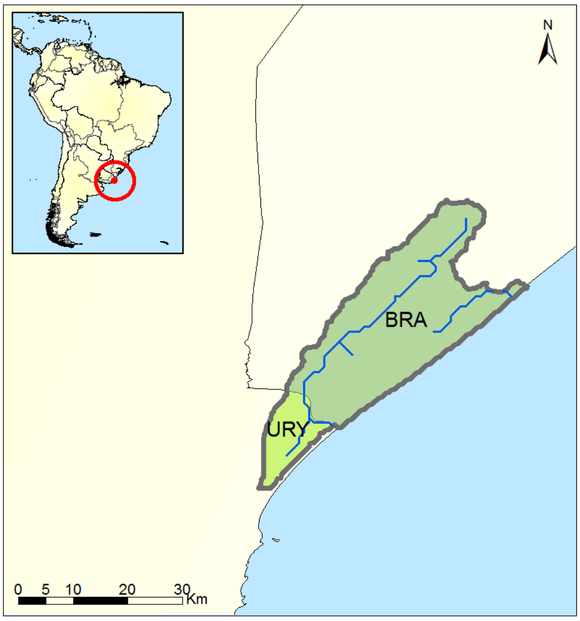
Chuy Basin



Geography

Total drainage area (km²)	722
No. of countries in basin	2
BCUs in basin	Brazil (BRA), Uruguay (URY)
Population in basin (people)	15,571
Country at mouth	Brazil, Uruguay
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	3
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
CHUY_BRA						
CHUY_URY						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CHUY_BRA								
CHUY_URY								

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[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CHUY_BRA	1	0.87	15	23.35	0.94			0	11,208.08	0	0.00
CHUY_URY	0	0.13	1	10.11	0.28	0.00	100.00	0	16,350.73	0	0.00
Total in Basin	1	1.00	16	21.58	0.82	0.00	6.28	0	11,531.26	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CHUY_BRA					5	5			2	4	2	2	1	3	2
CHUY_URY					5	5			2	4	2	2	1	2	1
River Basin				3	5				1	4	2	2	1	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
CHUY_BRA									2
CHUY_URY									2
River Basin					3	3			2

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin					

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Comau Basin

Geography

Total drainage area (km^2)	910
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	2,364
Country at mouth	Chile
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
COMA_ARG						
COMA_CHL						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
COMA_ARG								
COMA_CHL								

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[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
COMA_ARG	0	0.08	0	3.28	0.88			0	14,760.20	0	0.00
COMA_CHL	1	0.92	2	2.54	0.97			0	15,732.31	0	0.00
Total in Basin	1	1.00	2	2.60	0.88	0.00	0.00	0	15,632.30	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COMA_ARG					5	2			2	5	3	4	1	2	
COMA_CHL					2	2			2	5	3	2	1	2	4
River Basin				3	2				2	5	3	2	1	2	4

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
COMA_ARG									3
COMA_CHL							1	1	3
River Basin					3	3	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin					

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Corantijn/Courantyne Basin

Geography

Total drainage area (km^2)	64,001
No. of countries in basin	3
BCUs in basin	Brazil (BRA), Guyana (GUY), Suriname (SUR)
Population in basin (people)	111,299
Country at mouth	Guyana, Suriname
Average rainfall (mm/year)	2,152

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
CRTY_BRA						
CRTY_GUY		621.72				
CRTY_SUR		752.20			2,647.60	21.79
Total in Basin	45.57	712.02			2,647.60	21.79

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CRTY_BRA								

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CRTY_GUY	3.22	0.01	0.07	0.00	0	3.14	31.11	
CRTY_SUR	96.92	85.91	1.05	7.20	0	2.77	12,724.76	
Total in Basin	100.14	85.92	1.12	7.20	0.00	5.91	899.76	0.22

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CRTY_BRA	0	0.00	0	1.20	0.94			0	11,208.08	0	0.00
CRTY_GUY	26	0.41	103	3.91	0.22			0	3,846.53	0	0.00
CRTY_SUR	37	0.58	8	0.20	0.99			0	9,699.87	0	0.00
Total in Basin	64	1.00	111	1.74	0.56	0.00	0.00	0	4,261.25	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CRTY_BRA					5				2	5	3	2	1	3	1
CRTY_GUY	1	1	1		5	1	1	2	1	5	3		1	3	3
CRTY_SUR	1	1	2		5	1	1	2	1	5	3		4	3	2
River Basin	1	1	2	2	5	1	1	2	1	5	3		2	3	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CRTY_BRA									3
CRTY_GUY	2	3	1	1			1	1	3
CRTY_SUR	2	3	1	1			1	1	3
River Basin	2	3	1	1	2	2	1	1	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	2				

Indicators

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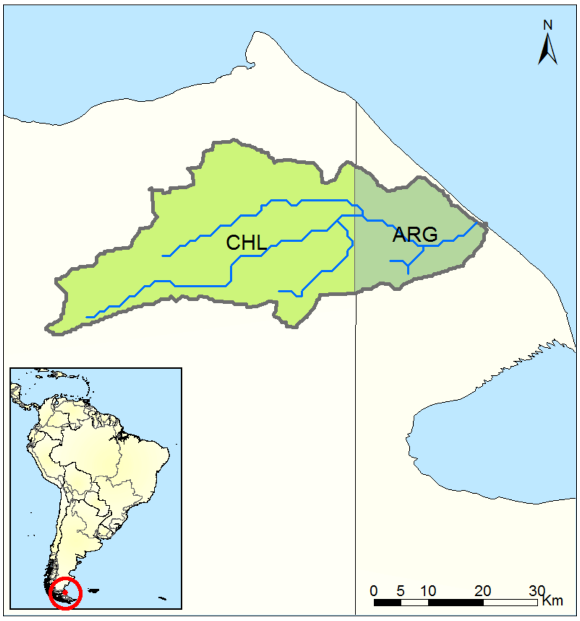
Cullen Basin



Geography

Total drainage area (km²)	917
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	1,514
Country at mouth	Argentina
Average rainfall (mm/year)	317

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
CULL_ARG						
CULL_CHL		25.50				
Total in Basin	0.02	25.50			0.00	0.00

Water Withdrawals

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CULL_ARG								
CULL_CHL	23.91	23.33	0.45	0.00	0	0.14	118,667.13	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	23.91	23.33	0.45	0.00	0.00	0.14	15,793.75	102.22

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
CULL_ARG	0	0.24	1	5.89	0.88			0	14,760.20	0	0.00
CULL_CHL	1	0.76	0	0.29	0.97			0	15,732.31	0	0.00
Total in Basin	1	1.00	2	1.65	0.87	0.00	0.00	0	14,889.59	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CULL_ARG					5				1	5	2	4	1	2	3
CULL_CHL	1	5	3		2				1	5	2	2	1	2	5
River Basin	1	5	3		5				1	5	2	3	1	2	3

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CULL_ARG									2
CULL_CHL	4	4	2	2					2
River Basin	4	5	5	5		5			2

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Essequibo Basin

Geography

Total drainage area (km²)	154,175
No. of countries in basin	3
BCUs in basin	Brazil (BRA), Guyana (GUY), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	205,427
Country at mouth	Guyana
Average rainfall (mm/year)	2,174

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
ESQB_BRA						
ESQB_GUY		1,110.77				
ESQB_VEN		732.62			25.75	0.77
Total in Basin	156.24	1,013.43			25.75	0.77

Water Withdrawals

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)

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ESQB_BRA								
ESQB_GUY	85.45	25.25	2.05	47.09	2	8.78	2,082.23	
ESQB_VEN	35.09	9.06	3.28	0.00	0	22.48	213.52	
Total in Basin	120.54	34.31	5.33	47.09	2.56	31.25	586.76	0.08

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
ESQB_BRA	0	0.00	0	0.76	0.94			0	11,208.08	0	0.00
ESQB_GUY	115	0.75	41	0.36	0.22	3.59	96.41	0	3,846.53	0	0.00
ESQB_VEN	39	0.25	164	4.22	0.99			0	14,414.75	0	0.00
Total in Basin	154	1.00	205	1.33	1.30	0.72	19.26	0	12,302.78	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ESQB_BRA					5				2	5	3	2	1	3	1
ESQB_GUY	1	1	2		5	3	1	2	2	5	5		4	3	4
ESQB_VEN	1	1	2		5	1	2	2	2	5	3	4	1	2	2
River Basin	1	1	2	2	5	2	1	2	1	5	4		3	4	3

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ESQB_BRA									3
ESQB_GUY	2	3	1	1			1	1	5
ESQB_VEN	2	3	1	1			2	3	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

River Basin	2	3	1	1	2	2	1	1	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

Indicators

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Gallegos/Chico Basin

Geography

Total drainage area (km²)	10,753
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	29,294
Country at mouth	Argentina
Average rainfall (mm/year)	626

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
GALG_ARG		69.04				
GALG_CHL		528.94				
Total in Basin	3.20	297.71			0.00	0.00

Water Withdrawals

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
GALG_ARG	4.73	0.55	0.44	0.00	1	2.68	217.98	
GALG_CHL	5.92	3.09	1.47	0.00	0	1.36	779.55	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	10.65	3.63	1.92	0.00	1.06	4.04	363.48	0.33

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
GALG_ARG	7	0.62	22	3.23	0.88			0	14,760.20	0	0.00
GALG_CHL	4	0.38	8	1.88	0.97			0	15,732.31	0	0.00
Total in Basin	11	1.00	29	2.72	0.87	0.00	0.00	0	15,012.07	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GALG_ARG	1	1	2		5		4	1	2	5	3	4	1	2	2
GALG_CHL	1	1	2		2			1	2	5	3	2	1	2	1
River Basin	1	1	2	2	4		4	1	2	5	3	3	1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
GALG_ARG	2	2	1	2			1	2	3
GALG_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	1	1	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	2				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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Jurado Basin

Geography

Total drainage area (km^2)	918
No. of countries in basin	2
BCUs in basin	Colombia (COL), Panama (PAN)
Population in basin (people)	4,570
Country at mouth	Colombia, Panama
Average rainfall (mm/year)	3,818

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
JURD_COL		2,573.37				
JURD_PAN		2,408.00				
Total in Basin	2.29	2,490.73			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
JURD_COL	1.85	0.00	0.70	0.00	0	1.16	534.85	
JURD_PAN	3.00	0.00	0.36	0.10	0	2.54	2,707.25	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	4.85	0.00	1.06	0.10	0.00	3.69	1,061.16	0.21

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
JURD_COL	1	0.70	3	5.39	1.46			0	7,825.68	0	0.00
JURD_PAN	0	0.30	1	4.03	1.65			0	11,036.81	0	0.00
Total in Basin	1	1.00	5	4.98	1.36	0.00	0.00	0	8,603.64	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JURD_COL	1	1	1		5		1	2	2	5	3		1	3	1
JURD_PAN	1		1		4				2	5	3	3	1	3	1
River Basin	1	1	1	2	5		1	2	1	5	3		1	3	1

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
JURD_COL	2	2	1	1			1	2	3
JURD_PAN	2	2							3
River Basin	2	2	1	1	2	2	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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La Plata Basin

Geography

Total drainage area (km^2)	2,926,937
No. of countries in basin	5
BCUs in basin	Argentina (ARG), Bolivia, Plurinational State Of (BOL), Brazil (BRA), Paraguay (PRY), Uruguay (URY)
Population in basin (people)	88,221,216
Country at mouth	Argentina, Uruguay
Average rainfall (mm/year)	1,358

Governance

No. of treaties and agreements[1]	23
No. of RBOs and Commissions[2]	6

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	61
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
LPTA_ARG		182.88			1,742.30	20.49
LPTA_BOL		79.40			117.35	1.58
LPTA_BRA		479.96			16,176.41	161.02
LPTA_PRY		261.47			1,549.44	13.26
LPTA_URY		554.68			2,339.00	18.09
Total in Basin	1,007.80	344.32			21,924.50	214.45

Water Withdrawals

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LPTA_ARG	11,053.77	4,651.16	394.22	3,367.41	1,009	1,631.96	908.69	
LPTA_BOL	417.61	268.14	21.45	86.51	2	39.84	308.79	
LPTA_BRA	18,888.08	4,655.75	1,260.16	3,474.76	3,305	6,192.01	282.07	
LPTA_PRY	610.46	199.18	118.97	0.47	57	235.24	88.30	
LPTA_URY	1,120.88	958.33	110.88	32.01	5	14.22	1,353.91	
Total in Basin	32,090.79	10,732.56	1,905.67	6,961.17	4,378.12	8,113.27	363.75	3.18

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
LPTA_ ARG	782	0.27	12,165	15.55	0.88	1.33	98.67	11	14,760.20	6	7.67
LPTA_ BOL	222	0.08	1,352	6.09	1.64	0.20	99.80	3	2,867.64	1	4.51
LPTA_ BRA	1,414	0.48	66,963	47.37	0.94	0.00	100.00	79	11,208.08	65	45.98
LPTA_ PRY	399	0.14	6,913	17.31	1.80	0.07	99.93	7	4,402.76	4	10.02
LPTA_ URY	110	0.04	828	7.54	0.28	2.59	97.41	0	16,350.73	3	27.31
Total in Basin	2,927	1.00	88,221	30.14	0.93	0.22	99.78	100	11,085.00	79	26.99

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
LPTA_ARG	2	1	2		5	2	4	2	3	2	3	4	4	2	4
LPTA_BOL	2	1	2		5	2	3	2	2	3	2	4	3	4	3
LPTA_BRA	2	1	2		5	1	4	2	3	2	3	2	5	3	2
LPTA_PRY	2	1	2		5	3	3	3	2	2	3		5	3	3
LPTA_URY	2	1	2		5	2	4	2	2	2	3	2	3	2	4
River Basin	2	1	2	3	5	2	4	2	3	2	3	3	5	3	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
LPTA_ARG	3	3	1	2			1	2	3
LPTA_BOL	3	3	1	1			2	4	2
LPTA_BRA	2	2	1	1			1	1	3
LPTA_PRY	2	2	1	1			2	3	3
LPTA_URY	3	3	1	1			1	1	3
River Basin	3	3	1	1	3	3	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1	3	2	2	3

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Lagoon Mirim Basin

Geography

Total drainage area (km^2)	56,157
No. of countries in basin	2
BCUs in basin	Brazil (BRA), Uruguay (URY)
Population in basin (people)	756,118
Country at mouth	Brazil, Uruguay
Average rainfall (mm/year)	1,408

Governance

No. of treaties and agreements[1]	4
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems
(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
LMRM_BRA		658.16			2,987.38	60.58
LMRM_URY		489.71			1,138.42	21.53
Total in Basin	31.45	560.07			4,125.80	82.11

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LMRM_BRA	642.82	226.06	22.46	299.08	31	63.81	1,240.35	
LMRM_URY	901.63	851.40	40.23	0.00	3	7.25	3,790.58	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	1,544.45	1,077.47	62.69	299.08	34.16	71.06	2,042.60	4.91

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
LMRM _BRA	24	0.42	518	21.97	0.94	0.00	100.00	1	11,208.08	0	0.00
LMRM _URY	33	0.58	238	7.30	0.28	7.15	92.85	0	16,350.73	0	0.00
Total in Basin	56	1.00	756	13.46	0.70	2.25	97.75	1	12,825.86	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LMRM_BRA	2	2	2		5	3	4	1	2	3	1	2	1	3	2
LMRM_URY	2	1	2		5	1	3		2	3	1	2	3	2	2
River Basin	2	1	2	4	5	2	4	1	2	3	1	2	2	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
LMRM_BRA	3	3	2	2			1	1	1
LMRM_URY	4	3	1	1			1	1	1
River Basin	3	3	1	2	4	4	1	1	1

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

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17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Lake Fagnano Basin

Geography

Total drainage area (km^2)	3,557
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	18,362
Country at mouth	Argentina, Chile
Average rainfall (mm/year)	593

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
LKFN_ARG		212.43			549.43	54.94
LKFN_CHL		457.09			39.27	3.93
Total in Basin	0.93	261.24			588.70	58.87

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LKFN_ARG	10.05	0.00	0.33	4.56	2	3.38	553.23	
LKFN_CHL	0.25	0.00	0.07	0.00	0	0.18	1,308.62	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	10.30	0.00	0.40	4.56	1.79	3.56	560.96	1.11

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
LKFN_ARG	3	0.86	18	5.95	0.88	100.00	0.00	0	14,760.20	0	0.00
LKFN_CHL	1	0.14	0	0.37	0.97			0	15,732.31	0	0.00
Total in Basin	4	1.00	18	5.16	0.87	98.98	0.00	0	14,770.15	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LKFN_ARG	1		1		5				1	5	3	4	1	2	1
LKFN_CHL	1		1		2				1	5	3	2	1	2	1
River Basin	1		1	2	5				1	5	3	4	1	2	1

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
LKFN_ARG	2	2							3
LKFN_CHL	2	2							3
River Basin	2	2			2	2			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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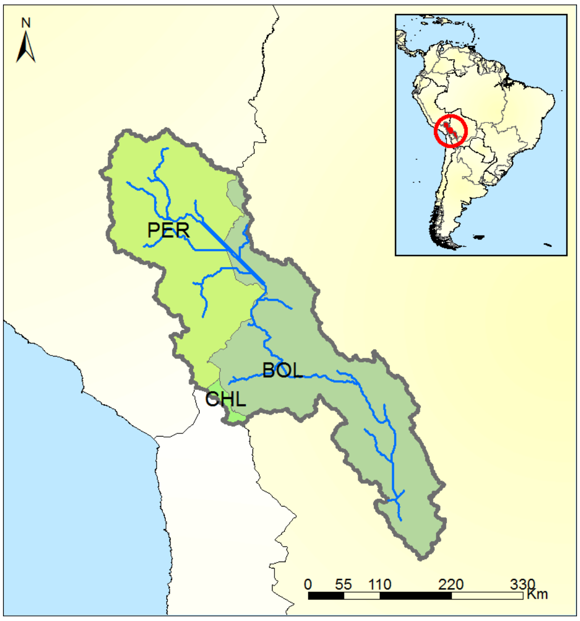
Lake Titicaca-Poopo System Basin



Geography

Total drainage area (km^2)	112,240
No. of countries in basin	3
BCUs in basin	Bolivia, Plurinational State Of (BOL), Chile (CHL), Peru (PER)
Population in basin (people)	2,446,064
Country at mouth	Bolivia, Plurinational State Of, Peru
Average rainfall (mm/year)	596

Governance

No. of treaties and agreements[1]	5
No. of RBOs and Commissions[2]	2

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
LKTC_BOL		108.73			4,589.39	443.72
LKTC_CHL						
LKTC_PER		192.83			5,258.51	717.51
Total in Basin	17.05	151.89			9,847.90	1,161.23

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LKTC_BOL	262.56	188.93	3.61	18.23	4	48.25	244.25	

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[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

LKTC_CHL								
LKTC_PER	491.22	134.39	10.68	12.50	169	164.77	358.52	
Total in Basin	753.78	323.31	14.29	30.73	172.43	213.01	308.16	4.42

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
LKTC_BOL	62	0.55	1,075	17.41	1.64	0.00	100.00	1	2,867.64	0	0.00
LKTC_CHL	1	0.01	1	0.73	0.97			0	15,732.31	0	0.00
LKTC_PER	49	0.44	1,370	27.87	1.07	6.02	93.98	2	6,659.81	1	20.34
Total in Basin	112	1.00	2,446	21.79	1.45	3.37	96.59	3	4,996.90	1	8.91

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
LKTC_BOL	2	1	2		5	3	2	1	3	3	1	4	3	4	4
LKTC_CHL					2	2			2	4	1	2	1	2	1
LKTC_PER	2	1	2		4	1	2	2	3	3	1	3	1	3	2
River Basin	2	1	2	3	5	2	2	1	3	3	1	4	2	4	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
LKTC_BOL	4	4	1	1			2	4	1
LKTC_CHL									1
LKTC_PER	3	3	1	1			2	2	1
River Basin	4	4	1	1	3	3	2	3	1

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	5				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Maroni Basin

Geography

Total drainage area (km^2)	66,116
No. of countries in basin	3
BCUs in basin	Brazil (BRA), French Guiana (GUF), Suriname (SUR)
Population in basin (people)	43,304
Country at mouth	French Guiana, Suriname
Average rainfall (mm/year)	2,422

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
MRNI_BRA						
MRNI_GUF		947.58				
MRNI_SUR		803.98				
Total in Basin	57.27	866.19			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
MRNI_BRA								

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MRNI_GUF	4.30	4.27	0.03	0.00	0	0.00	118.38	
MRNI_SUR	2.92	0.09	0.22	0.72	0	1.90	440.03	
Total in Basin	7.22	4.36	0.25	0.72	0.00	1.90	166.73	0.01

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
MRNI_BRA	0	0.01	0	0.97	0.94			0	11,208.08	0	0.00
MRNI_GUF	28	0.42	36	1.30	2.70	5.81	94.19	0		0	0.00
MRNI_SUR	38	0.57	7	0.18	0.99	0.00	100.00	0	9,699.87	0	0.00
Total in Basin	66	1.00	43	0.65	0.14	4.87	94.30	0	1,580.22	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
MRNI_BRA					5	1			1	5	3	2	1	3	1
MRNI_GUF	1	1	1		5	3	3	1	1	4	2		4	2	3
MRNI_SUR	1	1	1		5	2	3	1	1	4	2		1	3	5
River Basin	1	1	1	2	5	2	3	2	1	4	2		3	2	5

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
MRNI_BRA									3
MRNI_GUF	3	3	1	1			3	5	2
MRNI_SUR	2	3	1	1			2	2	2
River Basin	2	3	1	1	2	2	3	5	2

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

Indicators

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Mataje Basin

Geography

Total drainage area (km^2)	991
No. of countries in basin	2
BCUs in basin	Colombia (COL), Ecuador (ECU)
Population in basin (people)	42,739
Country at mouth	Colombia, Ecuador
Average rainfall (mm/year)	2,371

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
MTJE_COL						
MTJE_ECU		911.77				
Total in Basin	0.90	911.77			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
MTJE_COL								
MTJE_ECU	14.59	0.58	0.57	6.25	0	7.19	868.79	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	14.59	0.58	0.57	6.25	0.00	7.19	341.36	1.61

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
MTJE_COL	0	0.43	26	60.39	1.46			0	7,825.68	0	0.00
MTJE_ECU	1	0.57	17	29.92	1.49			0	5,720.18	0	0.00
Total in Basin	1	1.00	43	43.13	1.40	0.00	0.00	0	6,998.39	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MTJE_COL					5	5			1	5	3		1	3	2
MTJE_ECU	1	1	2		5	5	1	2	1	5	3	3	1	2	2
River Basin	1	1	2	3	5	5	1	2	1	5	3		1	3	2

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
MTJE_COL									3
MTJE_ECU	2	2	1	1					3
River Basin	2	2	1	1	3	3			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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Mira Basin

Geography

Total drainage area (km^2)	10,467
No. of countries in basin	2
BCUs in basin	Colombia (COL), Ecuador (ECU)
Population in basin (people)	625,224
Country at mouth	Colombia
Average rainfall (mm/year)	1,830

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
MIRA_COL		1,241.08				
MIRA_ECU		964.98				
Total in Basin	10.82	1,034.00			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
MIRA_COL	3.58	0.07	0.59	0.00	0	2.92	25.88	
MIRA_ECU	158.42	42.62	4.23	7.63	52	51.57	325.44	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	162.00	42.69	4.81	7.63	52.38	54.49	259.11	1.50

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
MIRA_COL	4	0.40	138	32.84	1.46	0.00	100.00	0	7,825.68	0	0.00
MIRA_ECU	6	0.60	487	77.87	1.49	0.00	100.00	1	5,720.18	0	0.00
Total in Basin	10	1.00	625	59.73	1.51	0.00	100.00	1	6,186.44	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
MIRA_COL	1	1	1		5	2	1	2	4	5	5		1	3	2
MIRA_ECU	1	1	2		5	1	1	1	4	5	5	3	1	3	2
River Basin	1	1	2	3	5	1	1	2	4	5	5		1	3	2

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
MIRA_COL	2	2	1	1			1	2	5
MIRA_ECU	4	4	1	1			2	2	5
River Basin	4	4	1	1	3	3	1	2	5

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Oiapoque/Oyupock Basin

Geography

Total drainage area (km^2)	25,994
No. of countries in basin	2
BCUs in basin	Brazil (BRA), French Guiana (GUF)
Population in basin (people)	10,904
Country at mouth	Brazil, French Guiana
Average rainfall (mm/year)	2,919

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
OYPK_BRA		1,459.43				
OYPK_GUF		1,334.01				
Total in Basin	36.20	1,392.57			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
OYPK_BRA	0.69	0.00	0.04	0.00	0	0.64	124.18	
OYPK_GUF	0.89	0.10	0.13	0.00	0	0.67	165.45	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	1.58	0.10	0.17	0.00	0.00	1.31	144.58	0.00

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
OYPK_BRA	13	0.49	6	0.44	0.94			0	11,208.08	0	0.00
OYPK_GUF	13	0.51	5	0.40	2.70	32.36	67.64	0		0	0.00
Total in Basin	26	1.00	11	0.42	0.43	15.99	33.44	0	5,667.61	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
OYPK_BRA	1	1	1		5	1	3	2	2	5	3	2	1	3	3
OYPK_GUF	1	1	1		5	2	2	1	2	5	3		1	2	2
River Basin	1	1	1	2	5	2	3	2	1	5	3		1	2	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
OYPK_BRA	2	2	1	1			1	2	3
OYPK_GUF	2	3	1	1			3	5	3
River Basin	2	3	1	1	2	1	2	3	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Orinoco Basin

Geography

Total drainage area (km²)	934,340
No. of countries in basin	4
BCUs in basin	Brazil (BRA), Colombia (COL), Guyana (GUY), Venezuela, Bolivarian Republic Of (VEN)
Population in basin (people)	12,165,297
Country at mouth	Venezuela, Bolivarian Republic Of
Average rainfall (mm/year)	2,273

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	14
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ORIN_BRA						
ORIN_COL		1,504.55			172.71	2.43
ORIN_GUY						
ORIN_VEN		1,001.27			1,633.05	36.45
Total in Basin	1,105.46	1,183.15			1,805.75	38.88

Water Withdrawals

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ORIN_BRA								
ORIN_COL	2,027.84	118.12	107.11	174.45	127	1,501.37	524.45	
ORIN_GUY								
ORIN_VEN	5,124.14	1,591.70	129.91	771.73	78	2,552.49	617.50	
Total in Basin	7,151.98	1,709.82	237.02	946.18	205.11	4,053.86	587.90	0.65

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ORIN_BRA	1	0.00	0	0.57	0.94			0	11,208.08	0	0.00
ORIN_COL	346	0.37	3,867	11.17	1.46	2.30	97.70	1	7,825.68	3	8.67
ORIN_GUY	0	0.00	0	0.32				0	3,846.53	0	0.00
ORIN_VEN	587	0.63	8,298	14.13	1.67	0.00	100.00	8	14,414.75	14	23.84
Total in Basin	934	1.00	12,165	13.02	1.43	0.73	99.27	9	12,320.37	17	18.19

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ORIN_BRA					5				1	5	3	2	1	3	1
ORIN_COL	2	1	2		5	3	3	3	3	5	3		3	3	2
ORIN_GUY					5				1	5	3		1	3	
ORIN_VEN	2	1	2		5	2	3	3	4	5	5	4	4	2	2
River Basin	2	1	2	2	5	3	3	3	4	5	4		4	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ORIN_BRA									3
ORIN_COL	3	3	1	1			1	2	3
ORIN_GUY									3
ORIN_VEN	3	3	1	1			2	3	5
River Basin	3	3	1	1	2	2	2	2	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1	3	2	1	3

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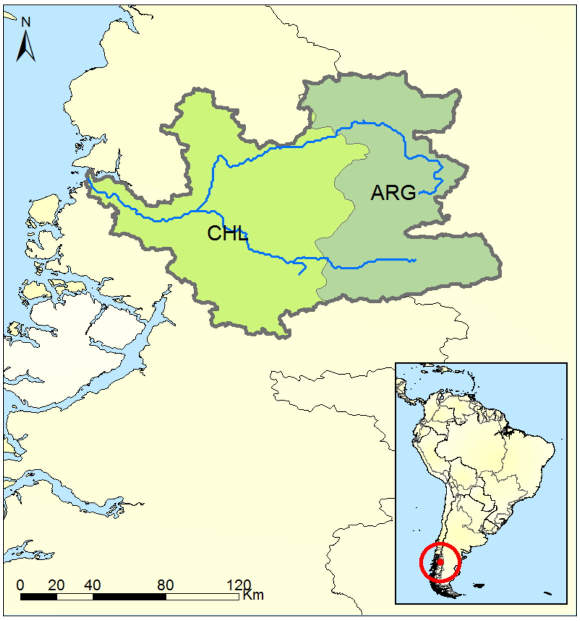
Palena Basin



Geography

Total drainage area (km^2)	13,230
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	12,945
Country at mouth	Chile
Average rainfall (mm/year)	2,776

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
PLNA_ARG		1,780.12			93.81	1.48
PLNA_CHL		2,570.49			42.99	0.68
Total in Basin	30.20	2,282.91			136.80	2.16

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PLNA_ARG	2.24	1.00	0.42	0.45	0	0.36	268.34	
PLNA_CHL	2.34	0.38	0.92	0.00	0	1.04	510.08	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	4.59	1.38	1.35	0.45	0.00	1.41	354.15	0.02

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
PLNA_ARG	6	0.44	8	1.44	0.88	100.00	0.00	0	14,760.20	0	0.00
PLNA_CHL	7	0.56	5	0.62	0.97			0	15,732.31	0	0.00
Total in Basin	13	1.00	13	0.98	0.88	64.50	0.00	0	15,105.26	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PLNA_ARG	1	1	1		5	1	2	1	1	5	3	4	1	2	1
PLNA_CHL	1	1	1		2	1	2	1	2	5	3	2	1	2	2
River Basin	1	1	1	2	4	1	2	2	2	5	3	3	1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
PLNA_ARG	2	2	1	1			1	2	3
PLNA_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	2	2	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	2				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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Pascua Basin

Geography

Total drainage area (km^2)	14,107
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	2,105
Country at mouth	Chile
Average rainfall (mm/year)	518

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
PSCU_ARG		222.61			483.48	200.64
PSCU_CHL		449.22			659.92	249.19
Total in Basin	4.51	319.75			1,143.40	449.84

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PSCU_ARG	0.90	0.25	0.38	0.00	0	0.27	553.24	
PSCU_CHL	0.47	0.20	0.09	0.10	0	0.09	1,001.21	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	1.38	0.45	0.46	0.10	0.00	0.37	653.92	0.03

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
PSCU_ARG	7	0.52	2	0.22	0.88			0	14,760.20	0	0.00
PSCU_CHL	7	0.48	0	0.07	0.97			0	15,732.31	0	0.00
Total in Basin	14	1.00	2	0.15	0.87	0.00	0.00	0	14,978.69	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
PSCU_ARG	1	1	1		5	1	1	1	2	5	3	4	1	2	2
PSCU_CHL	1	1	1		2	1	2	1	2	5	3	2	1	2	2
River Basin	1	1	1	2	4	1	1	1	1	5	3	3	1	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
PSCU_ARG	2	2	1	1			1	2	3
PSCU_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	2	2	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Patia Basin

Geography

Total drainage area (km^2)	22,303
No. of countries in basin	2
BCUs in basin	Colombia (COL), Ecuador (ECU)
Population in basin (people)	1,657,517
Country at mouth	Colombia
Average rainfall (mm/year)	2,210

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
PTIA_COL		1,209.38				
PTIA_ECU		292.48				
Total in Basin	25.27	1,132.94			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PTIA_COL	315.92	8.49	5.08	31.97	19	251.60	197.73	
PTIA_ECU	60.51	12.26	1.18	0.00	22	24.69	1,011.87	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	376.43	20.74	6.26	31.97	41.18	276.28	227.11	1.49

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
PTIA_COL	22	0.98	1,598	72.78	1.46	0.73	99.27	1	7,825.68	0	0.00
PTIA_ECU	0	0.02	60	171.07	1.49	0.00	100.00	0	5,720.18	0	0.00
Total in Basin	22	1.00	1,658	74.32	1.30	0.70	99.30	1	7,749.72	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
PTIA_COL	1	1	2		5	2	2	2	3	5	3		1	3	2
PTIA_ECU	1	1	2		5		2	1	3	5	3	3	1	3	2
River Basin	1	1	2	3	5	2	2	2	3	5	3		1	3	2

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
PTIA_COL	2	2	1	1			1	2	3
PTIA_ECU	2	2	1	2			1	2	3
River Basin	2	3	1	1	3	3	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Puelo Basin

Geography

Total drainage area (km^2)	9,163
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	100,922
Country at mouth	Chile
Average rainfall (mm/year)	1,479

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
PUEL_ARG		781.92			51.10	5.69
PUEL_CHL		1,806.23				
Total in Basin	9.52	1,038.74			51.10	5.69

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PUEL_ARG	57.81	25.61	0.91	11.04	7	12.80	602.48	
PUEL_CHL	9.85	0.01	0.52	0.00	5	4.03	1,983.79	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	67.67	25.61	1.43	11.04	12.75	16.83	670.47	0.71

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
PUEL_ARG	6	0.65	96	16.17	0.88	0.00	100.00	0	14,760.20	0	0.00
PUEL_CHL	3	0.35	5	1.54	0.97			0	15,732.31	0	0.00
Total in Basin	9	1.00	101	11.01	0.87	0.00	95.08	0	14,808.05	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
PUEL_ARG	1	1	2		5		2	1	2	5	3	4	1	2	2
PUEL_CHL	1	1	1		2		2	1	3	5	3	2	1	2	3
River Basin	1	1	2	3	5		2	2	2	5	3	3	1	2	2

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
PUEL_ARG	3	3	1	1			1	2	3
PUEL_CHL	3	3	1	1			1	1	3
River Basin	3	3	1	1	3	3	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

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Rio Grande (South America) Basin

Geography

Total drainage area (km^2)	8,632
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	26,755
Country at mouth	Argentina
Average rainfall (mm/year)	461

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	2
Large Marine Ecosystems	1

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All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
RGSA_ARG		126.92				
RGSA_CHL		139.01			213.80	2.62
Total in Basin	1.17	134.99			213.80	2.62

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
RGSA_ARG	25.29	0.00	0.37	20.91	1	2.61	1,008.26	
RGSA_CHL	8.44	6.84	1.01	0.00	0	0.59	5,059.61	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	33.73	6.84	1.38	20.91	1.40	3.20	1,260.87	2.89

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
RGSA_ARG	4	0.46	25	6.38	0.88	0.00	100.00	0	14,760.20	0	0.00
RGSA_CHL	5	0.54	2	0.35	0.97			0	15,732.31	0	0.00
Total in Basin	9	1.00	27	3.10	0.87	0.00	93.76	0	14,820.82	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RGSA_ARG	1	1	1		5		2	1	1	5	3	4	1	2	2
RGSA_CHL	1	1	2		2		2		1	5	3	2	1	2	1
River Basin	1	1	2	2	5		2	1	1	5	3	3	1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
RGSA_ARG	2	2	2	3			1	2	3
RGSA_CHL	2	2	1	1			1	2	3
River Basin	2	2	1	1	2	2	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	3				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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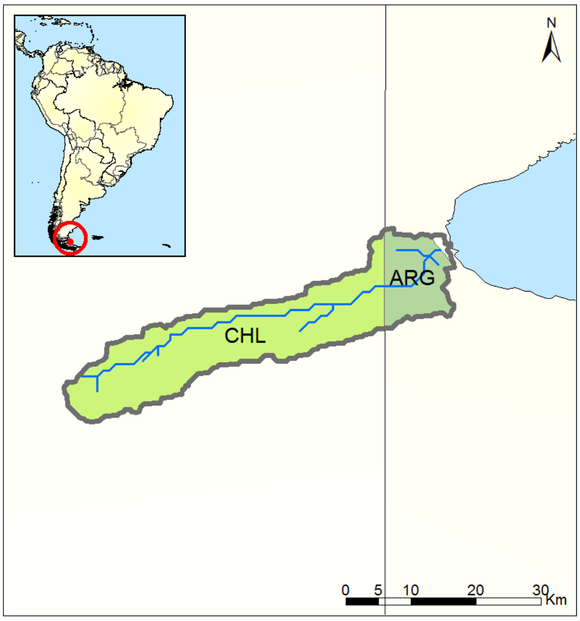
San Martin Basin



Geography

Total drainage area (km^2)	360
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	704
Country at mouth	Argentina
Average rainfall (mm/year)	352

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
SMAR_ARG						
SMAR_CHL		33.28				
Total in Basin	0.01	33.28			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
SMAR_ARG								
SMAR_CHL	18.90	17.45	1.10	0.00	0	0.36	65,323.98	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	18.90	17.45	1.10	0.00	0.00	0.36	26,836.48	157.79

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
SMAR_ARG	0	0.20	0	5.65	0.88			0	14,760.20	0	0.00
SMAR_CHL	0	0.80	0	1.01	0.97			0	15,732.31	0	0.00
Total in Basin	0	1.00	1	1.96	0.88	0.00	0.00	0	15,159.57	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SMAR_ARG					5				1	5	3	4	1	2	1
SMAR_CHL	2		3		2				1	5	3	2	1	2	5
River Basin	2		3		4				1	5	3	2	1	2	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
SMAR_ARG									3
SMAR_CHL	3	3							3
River Basin	3	3				1			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Seno Union/Serrano Basin

Geography

Total drainage area (km^2)	8,648
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	7,141
Country at mouth	Chile
Average rainfall (mm/year)	745

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
SENO_ARG		42.90				
SENO_CHL		696.36			281.60	15.82
Total in Basin	3.96	458.39			281.60	15.82

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
SENO_ARG	3.20	0.87	0.50	0.00	0	1.44	576.12	
SENO_CHL	34.43	2.82	0.55	30.19	0	0.87	21,668.79	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	37.63	3.69	1.05	30.19	0.39	2.31	5,269.75	0.95

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
SENO_ARG	2	0.22	6	2.96	0.88			0	14,760.20	0	0.00
SENO_CHL	7	0.78	2	0.23	0.97			0	15,732.31	0	0.00
Total in Basin	9	1.00	7	0.83	0.87	0.00	0.00	0	14,976.52	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SENO_ARG	1	1	2		5		3	1	2	5	3	4	1	2	4
SENO_CHL	1	1	2		2		3	1	3	5	3	2	1	2	2
River Basin	1	1	2	2	4		3	1	2	5	3	3	1	2	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
SENO_ARG	2	3	1	1			1	2	3
SENO_CHL	2	2	1	1			1	1	3
River Basin	2	2	1	1	2	1	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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Tumbes Basin

Geography

Total drainage area (km^2)	5,371
No. of countries in basin	2
BCUs in basin	Ecuador (ECU), Peru (PER)
Population in basin (people)	184,356
Country at mouth	Peru
Average rainfall (mm/year)	735

Governance

No. of treaties and agreements[1]	3
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
TUMB_ECU		364.77				
TUMB_PER		114.04				
Total in Basin	1.29	239.44			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
TUMB_ECU	703.32	480.63	4.43	108.41	54	55.46	6,021.47	
TUMB_PER	91.93	59.32	0.58	7.42	12	12.54	1,360.83	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	795.25	539.94	5.00	115.83	66.48	68.00	4,313.66	61.83

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
TUMB_ECU	4	0.68	117	32.17	1.49			0	5,720.18	0	0.00
TUMB_PER	2	0.32	68	38.82	1.07	4.47	95.53	0	6,659.81	0	0.00
Total in Basin	5	1.00	184	34.32	1.47	1.64	35.01	0	6,064.49	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TUMB_ECU	2	3	3		5	1	4	2	2	3	3	3	3	2	5
TUMB_PER	5		2		4	5			2	3	3	3	1	3	5
River Basin	4	3	3	2	5	2	4	2	2	3	3	3	2	3	5

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
TUMB_ECU	3	3	3	3			2	2	3
TUMB_PER	5	5							3
River Basin	5	5	3	4	5	5	2	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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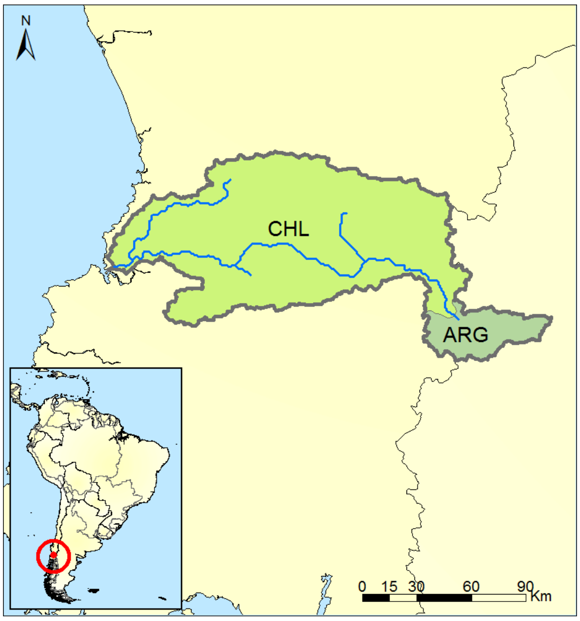
Valdivia Basin



Geography

Total drainage area (km^2)	10,239
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	188,351
Country at mouth	Chile
Average rainfall (mm/year)	1,972

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	9
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
VDVA_ARG		1,169.02			51.10	8.53
VDVA_CHL		1,419.26			314.40	40.24
Total in Basin	14.11	1,377.80			365.50	48.78

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
VDVA_ARG	12.58	0.38	0.89	5.29	3	3.17	1,621.55	
VDVA_CHL	304.18	81.43	14.95	57.52	96	54.52	1,684.34	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	316.76	81.81	15.84	62.81	98.62	57.69	1,681.75	2.25

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
VDVA_ARG	1	0.10	8	7.46	0.88	0.00	100.00	0	14,760.20	0	0.00
VDVA_CHL	9	0.90	181	19.63	0.97	0.00	100.00	1	15,732.31	0	0.00
Total in Basin	10	1.00	188	18.40	0.88	0.00	100.00	1	15,692.28	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VDVA_ARG	1	1	1		5		5	2	3	5	3	4	1	2	2
VDVA_CHL	1	1	2		2	1	4	1	3	5	3	2	2	2	3
River Basin	1	1	2	3	2	1	4	2	3	5	3	2	2	2	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
VDVA_ARG	2	3	1	1					3
VDVA_CHL	3	3	1	1			1	1	3
River Basin	2	3	1	1	4	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Yelcho Basin

Geography

Total drainage area (km²)	11,409
No. of countries in basin	2
BCUs in basin	Argentina (ARG), Chile (CHL)
Population in basin (people)	34,389
Country at mouth	Chile
Average rainfall (mm/year)	1,746

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
YELC_ARG		892.46			102.80	8.59
YELC_CHL		1,531.51			114.20	1.82
Total in Basin	14.22	1,246.73			217.00	10.41

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
YELC_ARG	18.53	9.13	0.23	5.27	1	2.79	632.20	
YELC_CHL	3.12	0.61	0.61	0.00	0	1.55	612.55	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	21.64	9.74	0.84	5.27	1.44	4.35	629.29	0.15

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
YELC_ ARG	7	0.64	29	4.03	0.88	3.83	96.17	0	14,760.20	1	137.41
YELC_ CHL	4	0.36	5	1.23	0.97			0	15,732.31	0	0.00
Total in Basin	11	1.00	34	3.01	0.87	3.26	81.95	0	14,904.00	1	87.65

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
YELC_ARG	3	1	2		5	2	3	1	3	5	3	4	1	2	3
YELC_CHL	2	1	1		2	2	3	1	2	5	3	2	1	2	1
River Basin	2	1	2	2	4	2	3	1	2	5	3	3	1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
YELC_ARG	4	4	1	1			1	2	3
YELC_CHL	2	3	1	1			1	2	3
River Basin	3	3	1	1	2	2	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	2				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Zapaleri Basin

Geography

Total drainage area (km^2)	2,507
No. of countries in basin	3
BCUs in basin	Argentina (ARG), Bolivia, Plurinational State Of (BOL), Chile (CHL)
Population in basin (people)	808
Country at mouth	Bolivia, Plurinational State Of
Average rainfall (mm/year)	254

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ZAPL_ARG						
ZAPL_BOL						
ZAPL_CHL		6.01				
Total in Basin	0.02	6.01			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ZAPL_ARG								

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ZAPL_BOL								
ZAPL_CHL	5.57	4.93	0.25	0.05	0	0.34	10,752.35	
Total in Basin	5.57	4.93	0.25	0.05	0.00	0.34	6,886.01	36.91

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ZAPL_ARG	0	0.19	0	0.27	0.88			0	14,760.20	0	0.00
ZAPL_BOL	1	0.22	0	0.30	1.64			0	2,867.64	0	0.00
ZAPL_CHL	1	0.59	1	0.35	0.97			0	15,732.31	0	0.00
Total in Basin	3	1.00	1	0.32	1.04	0.00	0.00	0	12,939.60	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ZAPL_ARG					5				1	5	3	4	1	3	1
ZAPL_BOL					5				1	5	3	4	1	5	
ZAPL_CHL	2		2		2				1	5	3	2	1	2	1
River Basin	2		2	3	3				1	5	3	2	1	3	5

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
ZAPL_ARG									3
ZAPL_BOL									3
ZAPL_CHL	3	4					1	1	3
River Basin	3	4			3	3	1	1	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	5				

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Zarumilla Basin

Geography

Total drainage area (km^2)	1,628
No. of countries in basin	2
BCUs in basin	Ecuador (ECU), Peru (PER)
Population in basin (people)	198,291
Country at mouth	Ecuador, Peru
Average rainfall (mm/year)	766

Governance

No. of treaties and agreements[1]	4
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

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All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ZARM_ECU						
ZARM_PER		296.72				
Total in Basin	0.48	296.72			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ZARM_ECU								
ZARM_PER	414.72	353.10	0.86	6.91	30	23.89	3,048.75	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	414.72	353.10	0.86	6.91	29.96	23.89	2,091.46	85.84

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ZARM_ECU	1	0.51	62	74.90	1.49	0.00	100.00	0	5,720.18	0	0.00
ZARM_PER	1	0.49	136	170.69	1.07	0.00	100.00	0	6,659.81	0	0.00
Total in Basin	2	1.00	198	121.78	1.38	0.00	100.00	0	6,364.77	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ZARM_ECU					5	5			2	3	1	3	1	2	1
ZARM_PER	3	5	3		4	5	4		2	3	1	3	1	3	5
River Basin	3	5	3	3	5	5	4	2	2	3	1	3	1	3	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ZARM_ECU									1
ZARM_PER	4	3	5	5			2	2	1
River Basin	4	4	5	5		5	2	2	1

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

Disclaimer

The results and information of factsheet is produced and maintained by the River Basins Component of the GEF Transboundary Water Assessment Programme (GEF TWAP).

GEF TWAP is the first global-scale assessment of all transboundary water systems. The TWAP consists of five independent indicator-based water system assessments and the linkages between them, including their socioeconomic and governance-related features. The United Nations Environment Programme (UNEP) is the implementing agency of TWAP. Project Coordination Unit (PCU) in Nairobi, Kenya coordinates the work of UNESCO-IHP, ILEC, UNEP-DHI and the IOC of UNESCO on Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems and Open Ocean respectively. Each executing partner engages a broad network of data and information rich partners with responsibilities either of a thematic or geographic nature. More on TWAP full size project at http://www.geftwap.org .

The TWAP River Basins component (TWAP RB) carried out a global comparison of 286 transboundary river basins, in order to enable the prioritisation of funds for basins at risk from a variety of issues, covering water quantity, water quality, ecosystems, governance and socio-economics. It also considered risks to deltas from threats of a transboundary nature, and considered the relative influence of lakes on these river basins. TWAP RB is an indicator–based assessment, allowing for an analysis of basins, based on risks to both societies and ecosystems. It also includes provisional outlook projections to 2030 and 2050 for a limited number of indicators.
Values given in the present fact-sheet represent an approximate guide only and should not replace recent local assessments.

Country Boundaries Under TWAP
TWAP RB assessment uses country delineations provided by FAO GAUL (Global Administrative Unit Layers) (FAO 2014). GAUL uses the International Boundary dataset of the UNCS (UN Cartographic Section) and inland boundaries are same for both datasets. Some differences occur in coastlines, where FAO GAUL dataset offers more detail.

Disputed areas
The GAUL project and original dataset maintains disputed areas in such a way to preserve national integrity for all disputing countries. The GAUL Set reports the international, first level and second level administrative boundaries delimiting, or falling within, the disputed areas in a way to enable the re-construction of the administrative units as they are specified by the individual disputing countries. Disputed areas are therefore shown as individual entities, not dependent from countries, with corresponding coding. Same approach has been taken by TWAP RB, reporting on disputed territories, as well as presentation of Basin Country Units.

Basin Delineation
TWAP RB assessment includes 286 transboundary river basins. Information on this layer and delineation methodology can be retrieved by downloading metadata sheet for the Basins layer from TWAP Rivers Data Portal at http://twap-rivers.org/indicators/ or by direct download from http://twap-rivers.org/assets/Basin%20and%20BCU%20Creation%20Documentation.pdf

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org . To view sources of data included in this Factsheet download the Factsheet Reference file at http://twap-rivers.org/assets/Factsheet_template_with_references.pdf.

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org .

1. LME 11 - Pacific Central American Coastal
2. LME 12 - Caribbean Sea
3. LME 13 - Humboldt Current
4. LME 14 - Patagonian Shelf
5. LME 15 - South Brazil Shelf
6. LME 16 - East Brazil Shelf
7. LME 17 - North Brazil Shelf

LME 11 – Pacific Central American Coastal

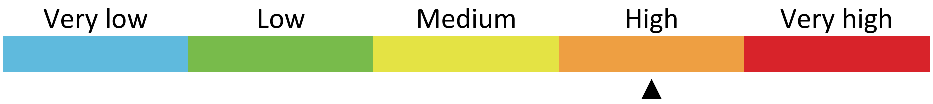
Bordering countries: Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru
LME Total area: 1,996,659 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

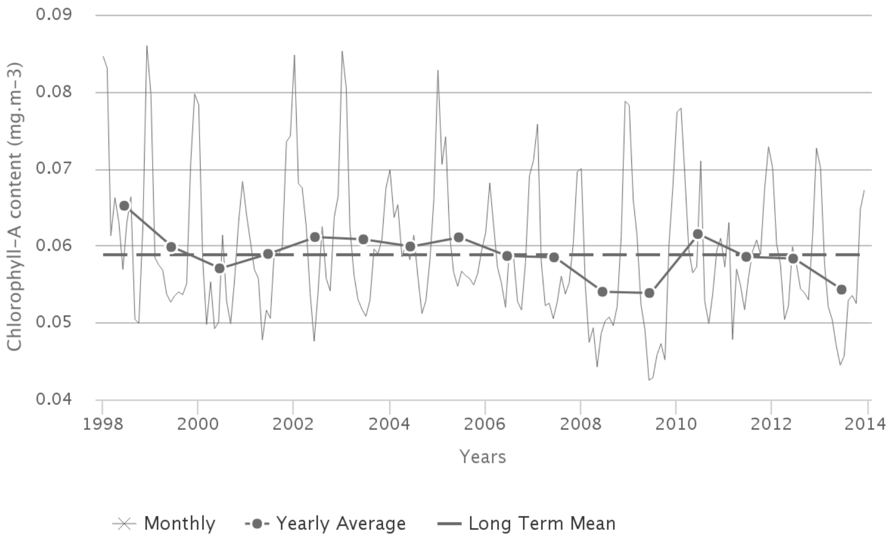


Productivity

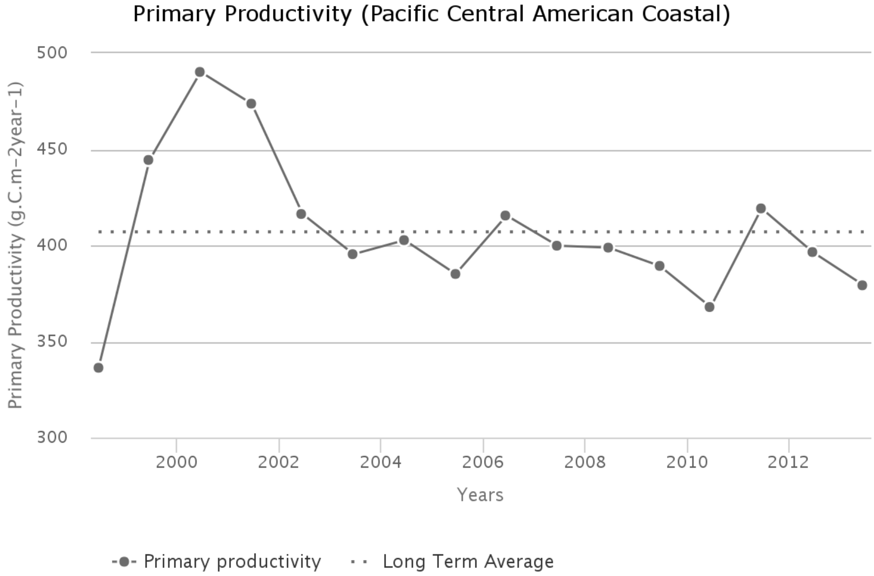
Chlorophyll-A

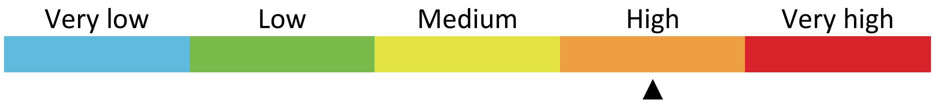
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.343 $mg.m^{-3}$) in March and a minimum (0.230 $mg.m^{-3}$) during August. The average CHL is 0.281 $mg.m^{-3}$. Maximum primary productivity (490 $g.C.m^{-2}.y^{-1}$) occurred during 2000 and minimum primary productivity (336 $g.C.m^{-2}.y^{-1}$) during 1998. There is a statistically insignificant increasing trend in Chlorophyll of 15.2 % from 2003 through 2013. The average primary productivity is 407 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 4 of 5 categories (with 1 = lowest and 5= highest).

Chlorophyll-A (Insular Pacific Hawaiian)



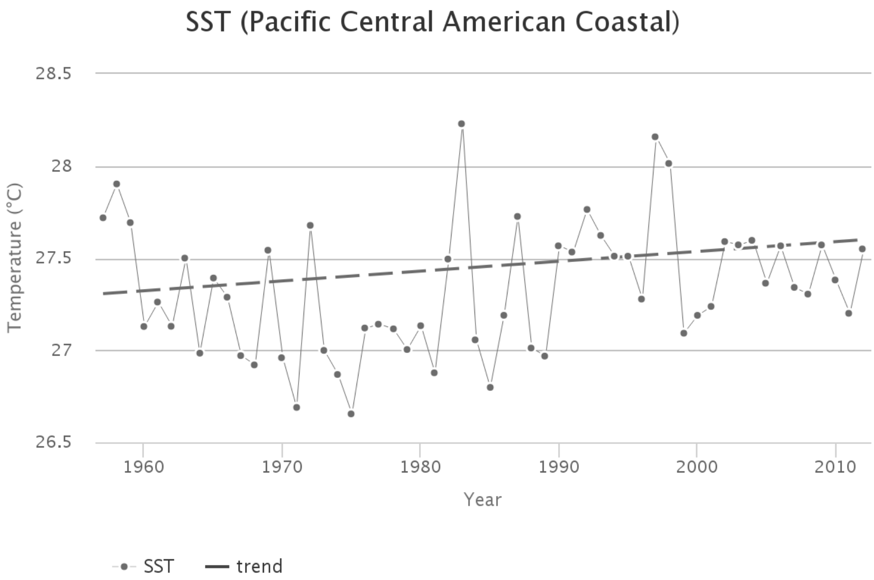
Primary productivity





Sea Surface Temperature

Between 1957 and 2012, the Pacific Central-American Coastal LME #11 has warmed by 0.27C, thus belonging to Category 4 (slow warming LME). The thermal history of this LME was non-monotonous. The cooling phase culminated in two minima, in 1971 and 1975, both associated with major La Niñas (National Weather Service/Climate Prediction Center, 2007), after which SST rose by approximately 1°C over the next 30 years. The absolute minimum of 1975 was synchronous with absolute minima in two other East Pacific LMEs: California Current LME #3 and Gulf of California LME #4. It also was roughly synchronous with the absolute minimum of 1974-1976 on the other side of the Central American Isthmus, in the Caribbean LME #12. The warming phase was accentuated by two sharp peaks, in 1983 and 1997, both associated with major El Niños (National Weather Service/Climate Prediction Center, 2007). Similar warm events were observed in other East Pacific LMEs, namely the Humboldt Current LME #13, Gulf of California LME #4, and California Current LME #3. All significant maxima and minima of SST observed in the Pacific Central-American Coastal LME #11 are associated with El Niños and La Niñas respectively (National Weather Service/Climate Prediction Center, 2007).

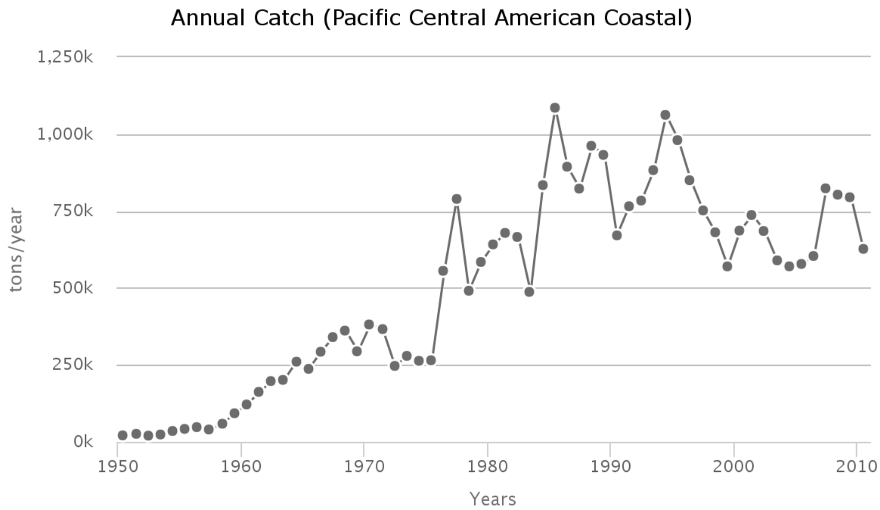


Fish and Fisheries

The Pacific Central-American Coastal LME is rich in both pelagic and demersal fisheries resources. The most valuable fisheries in the region are offshore tunas and coastal penaeid shrimps, whose landed fish bycatch is usually not reported. More than 50% of the reported shelf catches consists of small coastal pelagic species such as anchoveta (*Engraulis ringens* and *Cetengraulis mysticetus*), Pacific sardine (*Sardinops sagax*) and Pacific thread herring (*Opisthonema libertate*), most of which are used for fishmeal and fish-oil.

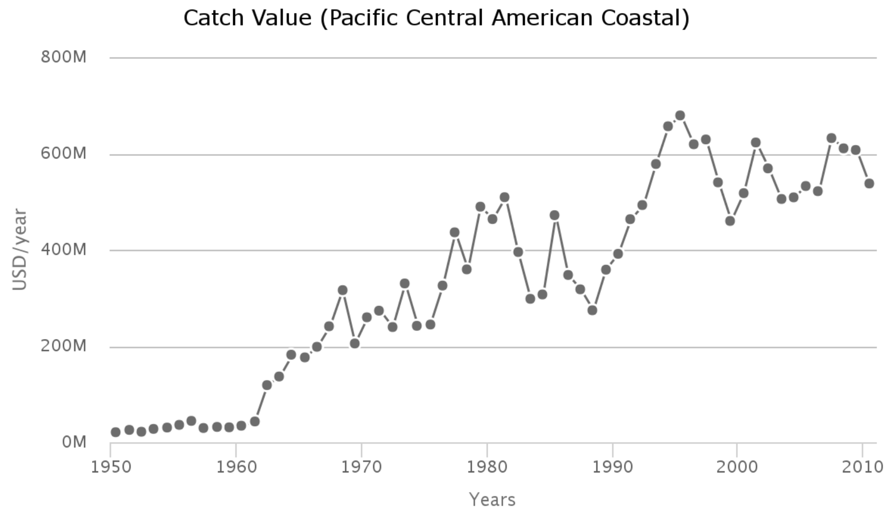
Annual Catch

Total reported landings have risen, with some fluctuations, to peak landings of 1 million t in 1985.



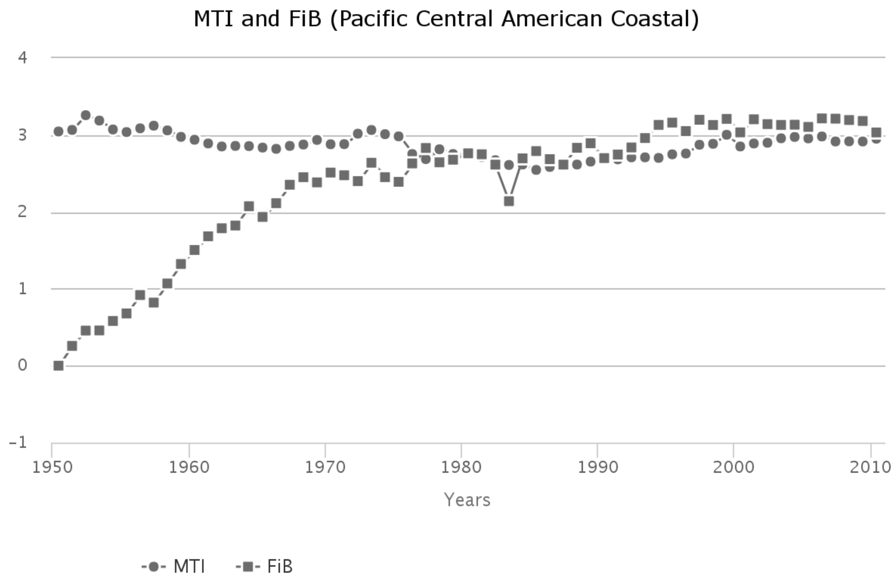
Catch value

Fluctuations in the value of the reported landings correspond with the landings, with a peak of 680 million US$ (in 2005 real US$) recorded in 1995.



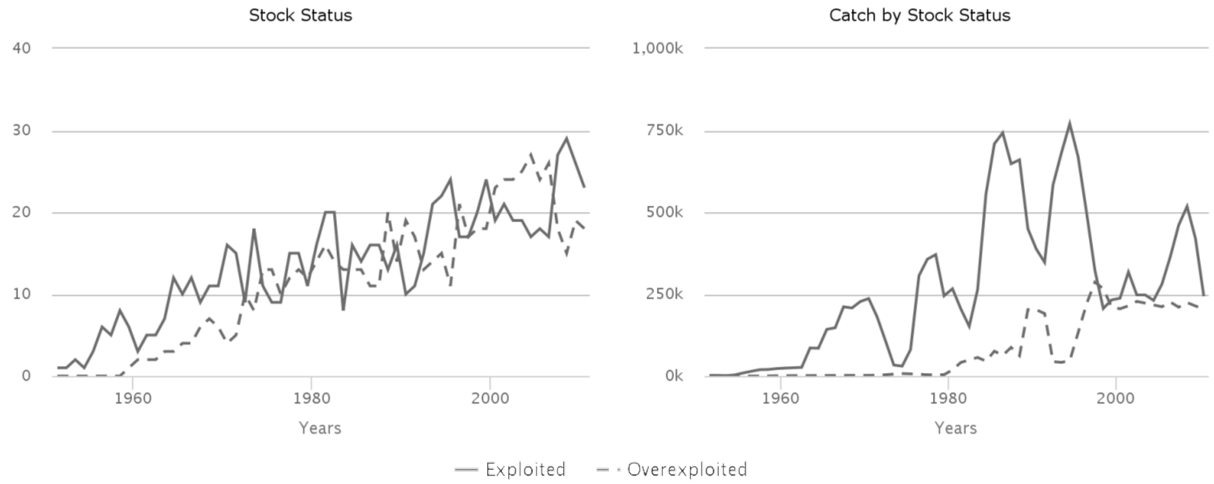
Marine Trophic Index and Fishing-in-Balance index

The MTI is relatively low, and shows a declining trend until the mid-1980s, after which a slight increasing trend became apparent. The FiB index has increased, indicating that whatever "fishing down" may be occurring in the LME would be masked by either the geographic (offshore) expansion of the fisheries or the incompleteness of the underlying catch statistics.



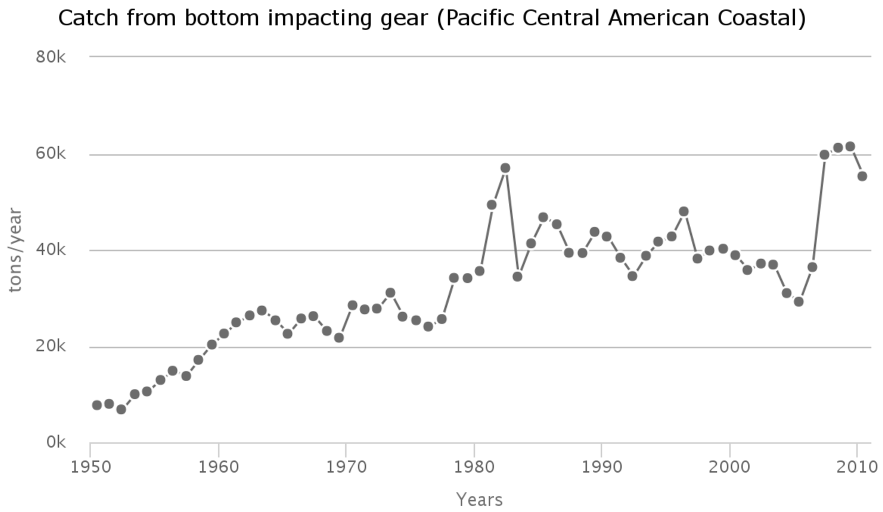
Stock status

The Stock-Catch Status Plots indicate that the number of collapsed and overexploited stocks are rapidly increasing in the LME. Approximately 40% of the reported landings are supplied by fully exploited stocks.



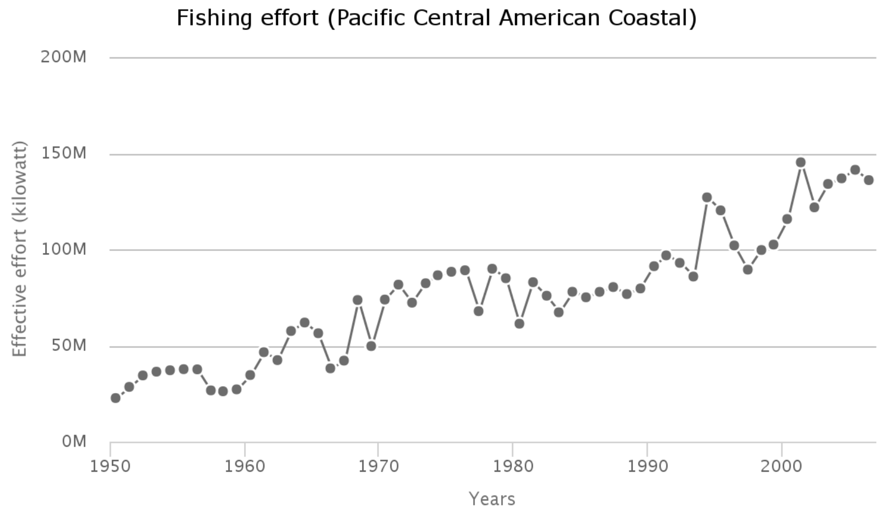
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch reaches its maximum at 40% in 1953 and then this percentage declined steadily. This percentage ranged between 5 and 9% in the recent decade.



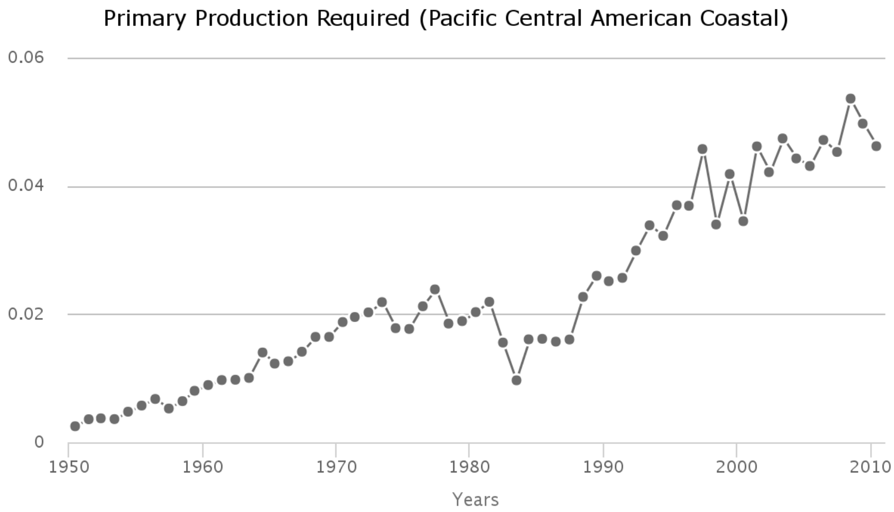
Fishing effort

The total effective effort increased steadily from around 30 million kW in the 1950s to its peak at 145 million kW in early 2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME reached 5% of the observed primary production in 2002.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	1	3	3	1	3	3	1	3

Legend: Very low Low Medium High Very high

POPs

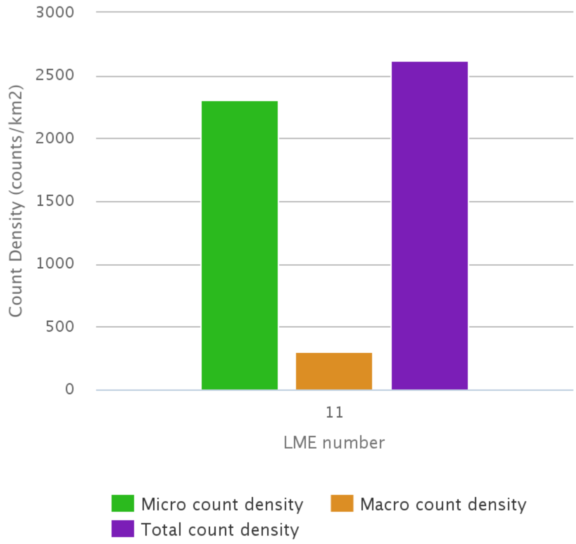
Data are available for only two samples at two locations in Costa Rica and Panama. These locations show low concentration for all the indicators. The average concentration (ng.g-1 of pellets) was 5 (range 2 – 7 ng.g-1) for PCBs, 5 (range 5 – 6 ng.g-1) for DDTs, and 0.1 (range 0.04 – 0.3 ng.g-1) for HCHs. The PCBs and HCHs averages correspond to risk category 1 and DDTs average corresponds to risk category 2, of the five risk categories (1 = lowest risk; 5 = highest risk). This is probably due to minimal anthropogenic activities involving the use of POPs (PCBs in industries and DDT and HCH pesticides in agriculture). More samples and locations are necessary to properly evaluate this LME.

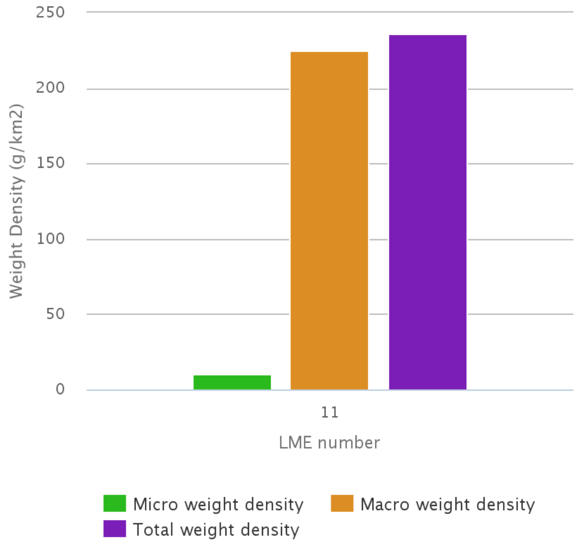
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
2	5	**1**	5	**2**	0.1	**1**

Legend: Very low Low Medium High Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively moderate levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 12 times lower that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





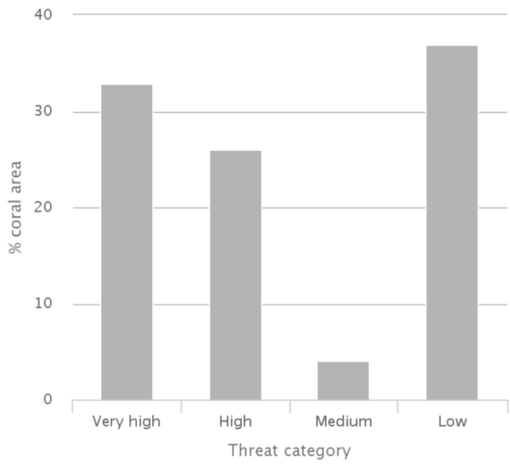
Ecosystem Health

Mangrove and coral cover

0.39% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.03% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 235. 7% of coral reefs cover is under very high threat, and 26% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 20% and 60% for very high and high threat categories respectively. By year 2030, 39% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 42% by 2050.

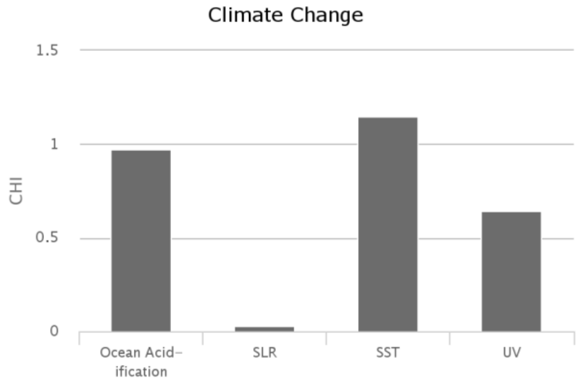


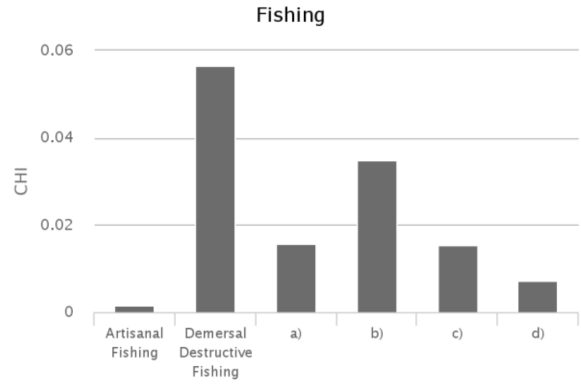
Marine Protected Area change

The Pacific Central-American Coastal LME experienced an increase in MPA coverage from 2,040 km^2 prior to 1983 to 29,444 km^{2}by 2014. This represents an increase of 1,343%, within the low category of MPA change.

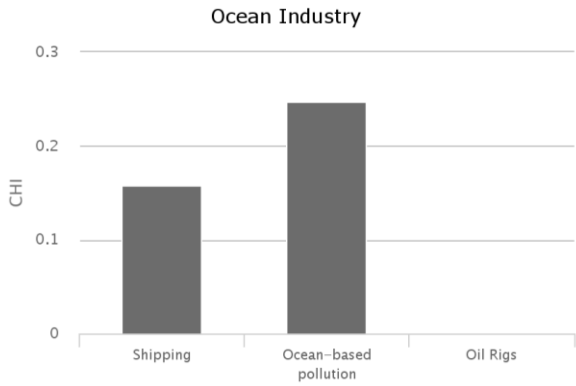
Cumulative Human Impact

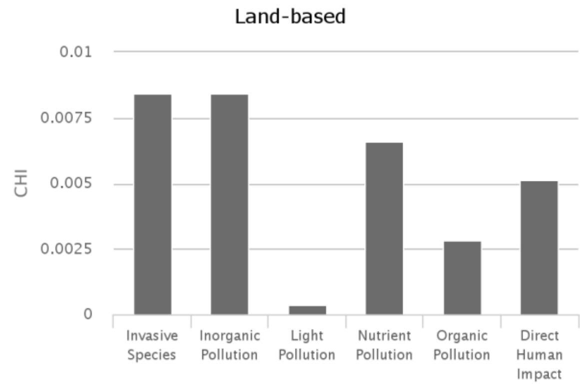
The Pacific Central-American Coastal LME experiences an average overall cumulative human impact (score 3.36; maximum LME score 5.22), but which is still well above the LME with the least cumulative impact. It falls in risk category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (0.97; maximum in other LMEs was 1.20), UV radiation (0.64; maximum in other LMEs was 0.76), and sea surface temperature (1.15; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, and demersal destructive commercial fishing.





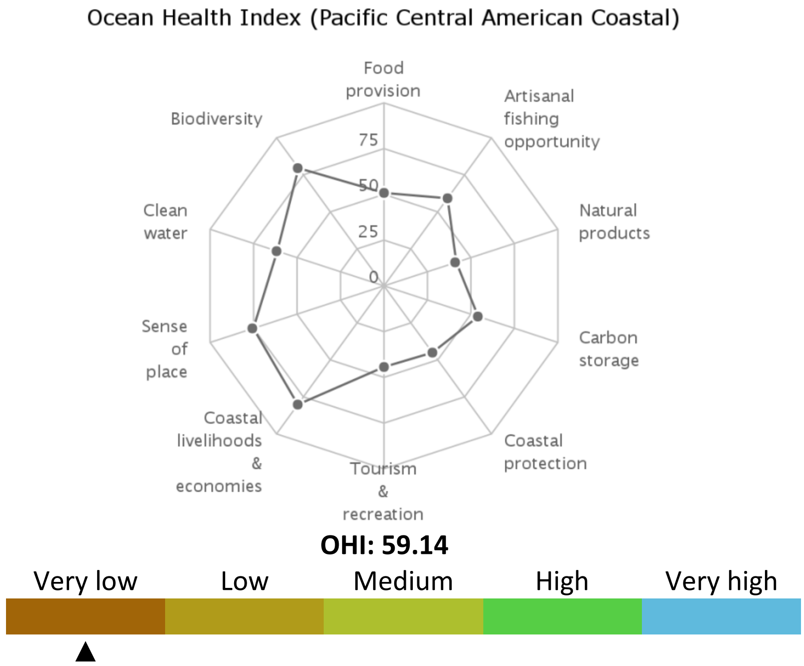
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





Ocean Health Index

The Pacific Central-American Coastal LME scores well below average on the Ocean Health Index compared to other LMEs (score 66 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is far from its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 remained unchanged compared to the previous year. This LME scores lowest on food provision, coastal protection, carbon storage, tourism & recreation, and iconic species goals and highest on artisanal fishing opportunities, coastal economies, and lasting special places goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the Pacific Central American Coastal LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area includes the Pacific coasts of southern Mexico, Central America, and the South American nations of Colombia, Ecuador and northernmost portion of Peru, covering a total of 585,973 km^2. A current population of 50 million is projected to almost double to 98 million in 2100, as reflected in density increasing from 86 persons per km^2 in 2010 to 167 per km^2 by 2100. About 47% of coastal population lives in rural areas, and is projected to increase in share to 52% in 2100.

Total population		Rural population	
2010	2100	2010	2100
50,320,369	97,859,738	23,824,558	50,535,113

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 44% of the LME's coastal dwellers. The Pacific Central American Coastal LME places in the very high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor
21,995,749

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Pacific Central American Coastal LME ranks in the medium revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $672 million for the period 2001-2010. Fish protein accounts for 7% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $48,482 million places it in the high revenue category. On average, LME-based tourism income contributes 12% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the Pacific Central American Coastal LME falls in the category with high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
672,041,692	6.9	48,482,410,060	11.9	0.8253

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day Pacific Central American Coastal LME HDI belongs to the low HDI and high-risk category. Based on an HDI of 0.693, this LME has an HDI Gap of 0.307, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The Pacific Central American Coastal LME is projected to assume a place with the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.6926	0.8934	0.5259

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index to the Pacific Central American Coastal LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is lowest, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.8157	0.4398	0.3978	0.6583

Legend: Very low | Low | Medium | High | Very high

Governance

Governance architecture

There are three separate transboundary arrangements for fisheries in general within the EEZ (CPPS, OLDESPECA and OSPESCA) as well as the arrangement for tuna and tuna-like species (IATTC). No integrating mechanisms, such as an overall policy coordinating organization for the LME, could be found. However, somewhat unique among LMEs, is the Secretariat for the Regional Seas Convention being housed at the Permanent Commission for the South Pacific (CPPS). While specific formal integration is not mentioned in the two Conventions, it is likely that the two Commissions have considerable informal linkages since the secretariats for both CPPS and the Lima Convention are within the same organization. Governance arrangements for this LME appear to be split along geographic lines with arrangements for the southern part of the LME being distinct from those for the northern part.

The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
53	**65**	**0.1**

Legend: Very low | Low | Medium | High | Very high

LME 12 – Caribbean Sea

Bordering countries: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Colombia, Commonwealth of Dominica, Costa Rica, Cuba, Dominican Republic, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, France (Martinique), Mexico, Montserrat, Netherland Antilles, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, United States Virgin Islands, Venezuela
LME Total area: 3,305,077 km^2
This LME is GEF eligible

List of indicators

LME overall risk

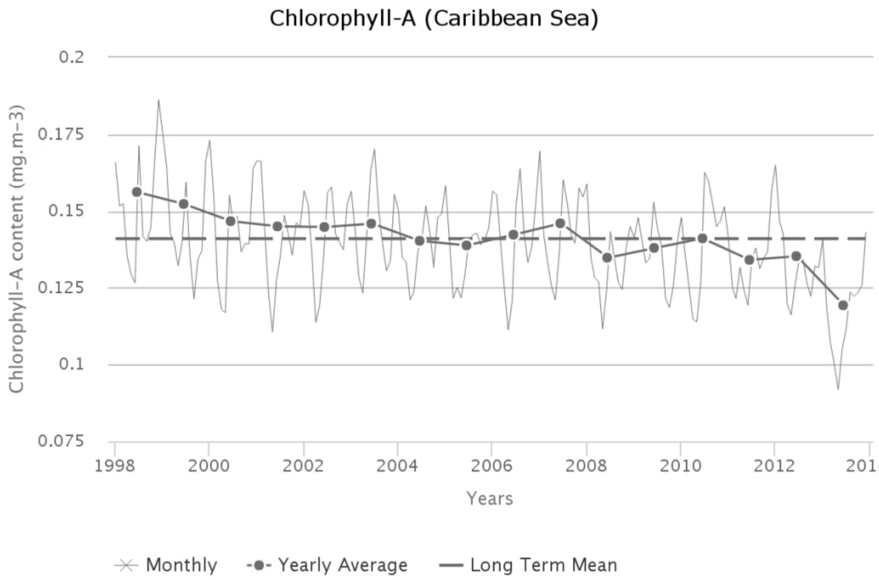
This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

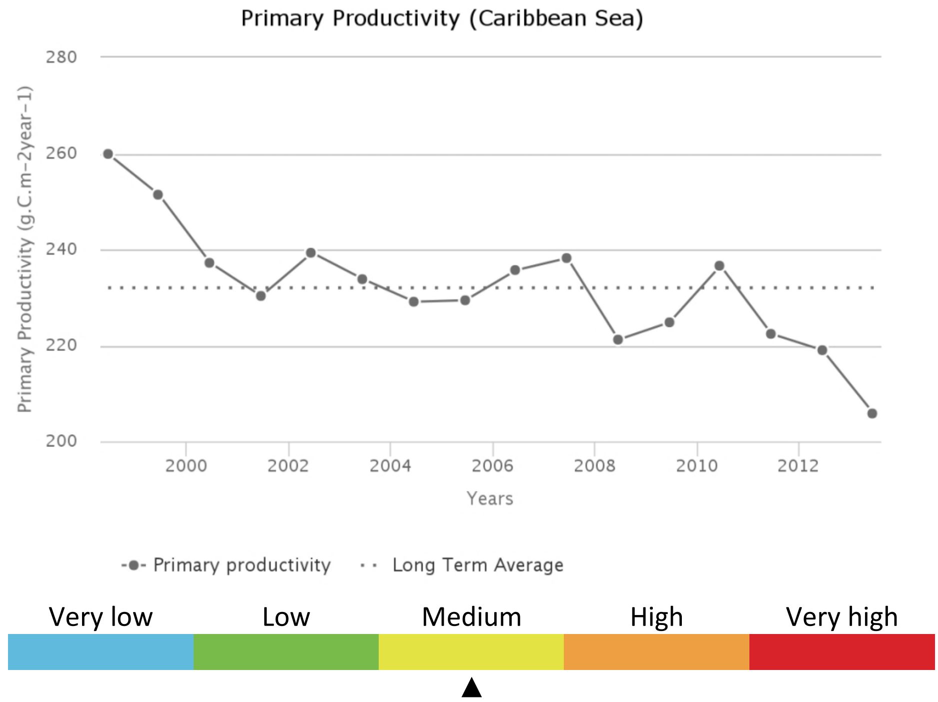
Productivity

Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.159 $mg.m^{-3}$) in January and a minimum (0.121 $mg.m^{-3}$) during May. The average CHL is 0.141 $mg.m^{-3}$. Maximum primary productivity (260 $g.C.m^{-2}.y^{-1}$) occurred during 1998 and minimum primary productivity (206 $g.C.m^{-2}.y^{-1}$) during 2013. There is a statistically insignificant increasing trend in Chlorophyll of 5.29 % from 2003 through 2013. The average primary productivity is 232 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).

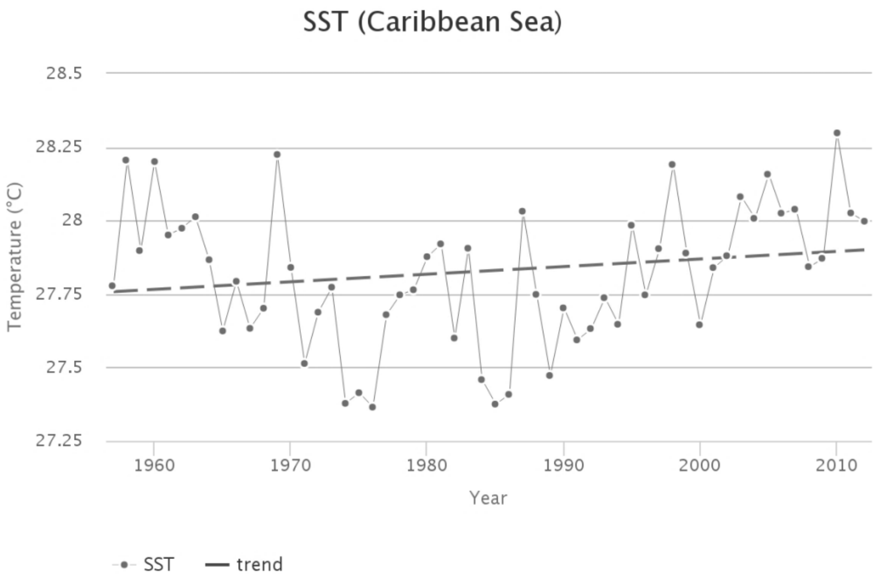


Primary productivity



Sea Surface Temperature

Between 1957 and 2012, the Caribbean Sea LME #12 has warmed by 0.15°C, thus belonging to Category 4 (slow warming LME). This LME went through three phases over the last 50 years: (1) cooling until 1974; (2) a cold phase with two cold spells, in 1974-1976 and 1984-1986; (3) warming since 1986. Using the year of 1985 as a true breakpoint, the post-1985 warming exceeded 0.9°C, from <27.4°C in 1985 to 28.3°C in 2010. Both cold spells were synchronous with cold events across the Central American Isthmus, in the Pacific Central-American Coastal LME #11. The first cooling period was interrupted by a major warm event (peak) of 1968-1970, when SST peaked at 28.2°C in 1969. This event was confined to the Caribbean Sea. None of adjacent LMEs experienced a pronounced warming in 1968-1970. All significant maxima and minima of SST in the Caribbean Sea correlate strongly with El Niños and La Niñas respectively (National Weather Service/Climate Prediction Center, 2007). This strong correlation is a good example of atmospheric teleconnections across the Central American Isthmus. This link is so strong that El Niños' and La Niñas' effects in the Caribbean Sea have comparable magnitudes with their counterparts in the Pacific Central-American Coastal LME #11 on the other side of the Isthmus.

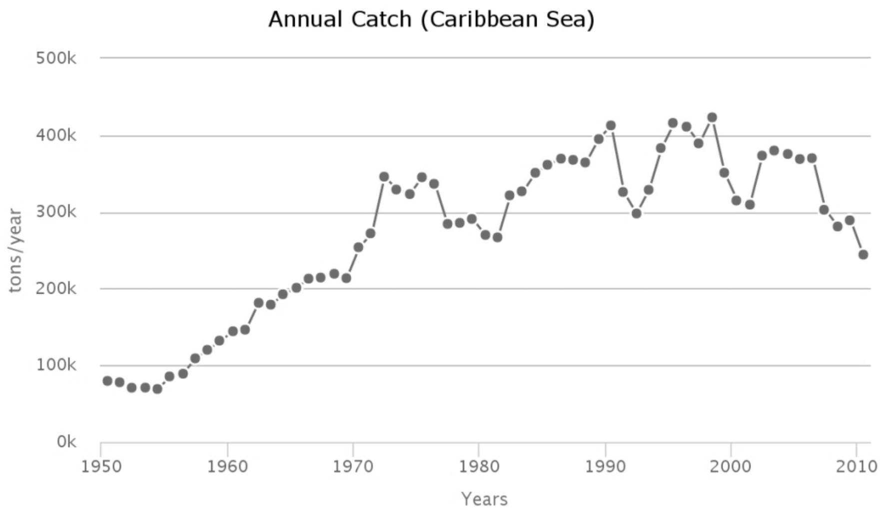


Fish and Fisheries

The fisheries of the Caribbean Sea LME are based on a diverse array of resources, and those of greatest importance are spiny lobster (*Panulirus argus*), queen conch (*Strombus gigas*), penaeid shrimps, reef fish, continental shelf demersal fish, deep slope and bank fish and large coastal pelagics such as king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), dolphinfish (*Coryphaena hippurus*) and amberjack (*Seriola spp.*). In addition, fisheries based on stocks of large oceanic fish such as yellowfin tuna, skipjack tuna, Atlantic blue marlin and swordfish, have expanded considerably.

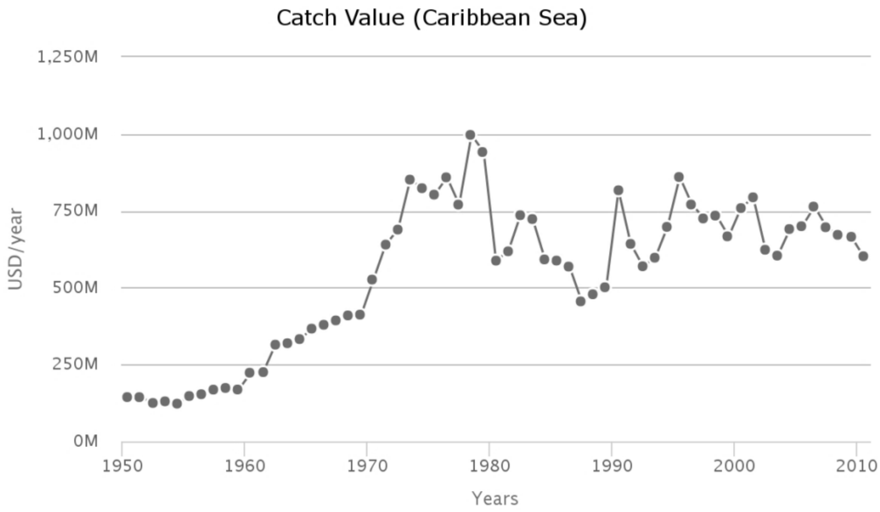
Annual Catch

Total reported landings in this LME, which is probably underestimated showed a general increase to about 430,000 t in the 1998, followed by a slight decline.



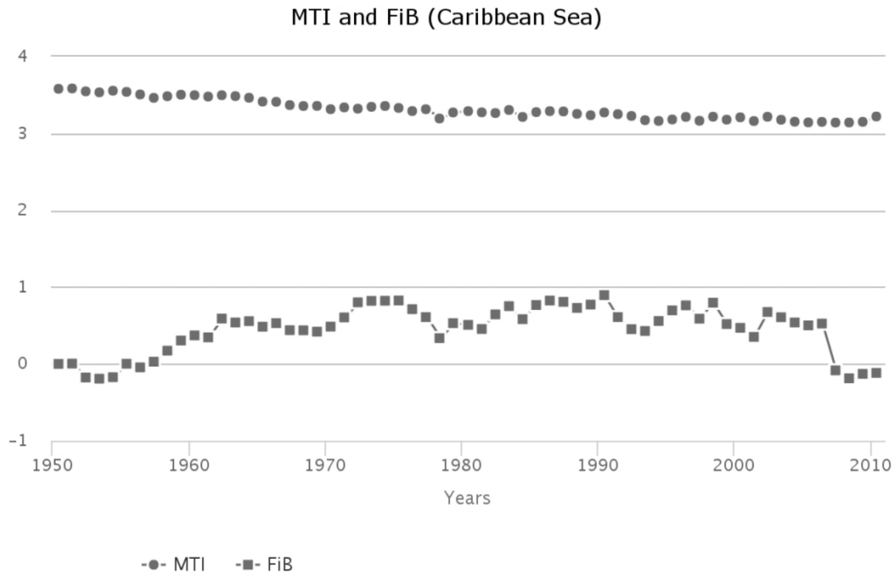
Catch value

The reported landings peaked at just under 1 billion US$ (in 2005 value) in 1978.



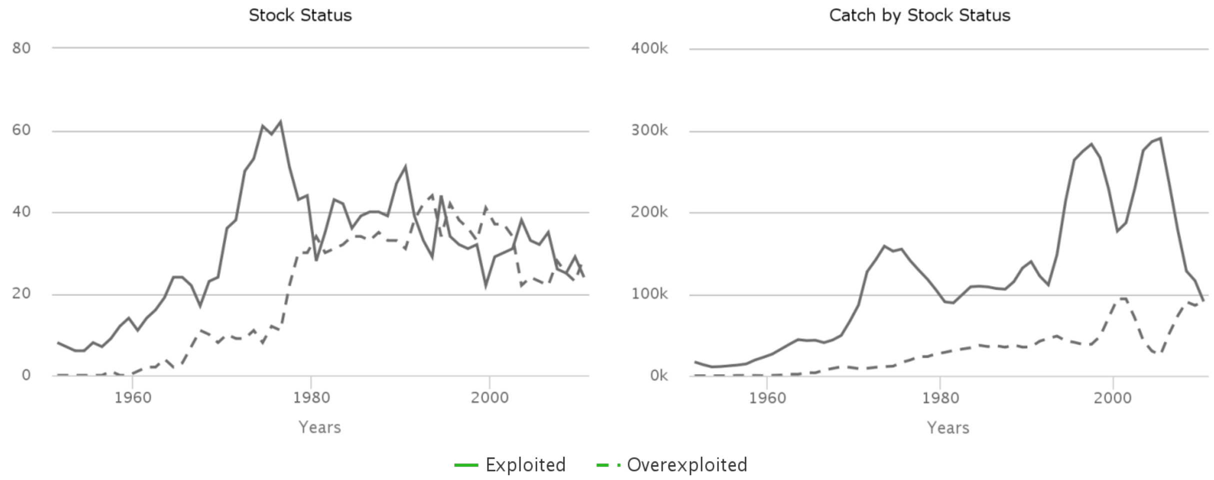
Marine Trophic Index and Fishing-in-Balance index

The decline of the MTI is almost linear over the reported period, representing a classic case of 'fishing down' of the food web in the LME. Indeed, the decline in the mean trophic level would have been greater than the expansion of the fisheries from the mid-1950 to the mid-1980s as implied by the increasing FiB index.



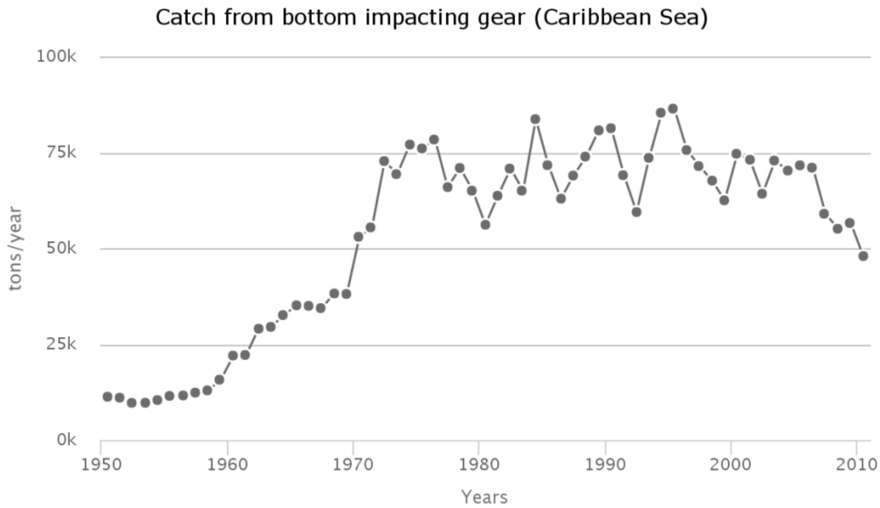
Stock status

The Stock-Catch Status Plots indicate that nearly 60% of the commercially exploited stocks in the LME are either overexploited or have collapsed and these stocks now contribute 50% of the reported landings.



Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased slightly from 11% in late 1950s to the peak at 25% in 1978. Then, this percentage fluctuated around 20% in the recent few decades.

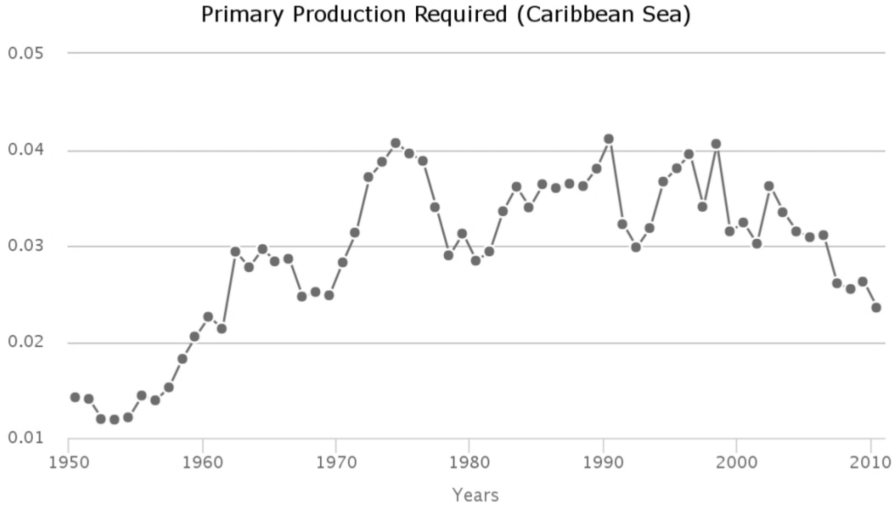


Fishing effort

The total effective effort continuously increased from around 40 million kW in the 1950s to its peak at 240 million kW in the mid- 2000s.

Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME reached 3% of the observed primary production in 1994, and fluctuated between 2.5 to 3% in recent years.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular nitrogen load) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the ratio of nutrients entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (Merged Nutrient Indicator) based on 2 sub-indicators: Nitrogen Load and Nutrient Ratio (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this increased to high in 2030 and remained high in 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this increased to high in 2030 and remained the same in 2050

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	1	3	4	1	4	4	1	4

Legend: Very low | Low | Medium | High | Very high

POPs

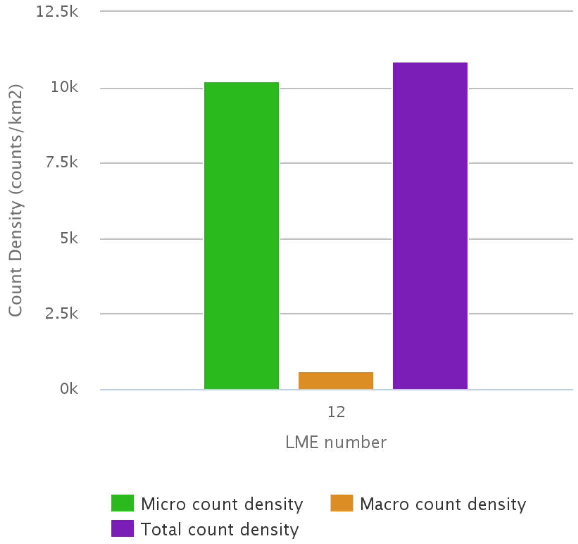
Data are available only for two samples at two locations in Barbados and Trinidad & Tobago. These locations show minimal concentration for all the indicators. The average concentration (ng.g^{-1} of pellets) was 4 (range 2 – 6 ng.g^{-1}) for PCBs, 3 (range 2 – 3 ng.g^{-1}) for DDTs, and 0.9 (range 0.8 – 1.1 ng.g^{-1}) for HCHs. All three averages correspond to risk category 1 of the five risk categories (1 = lowest risk; 5 = highest risk). This is probably due to minimal anthropogenic activities involving the use of POPs (PCBs in industries and DDT and HCH pesticides in agriculture).

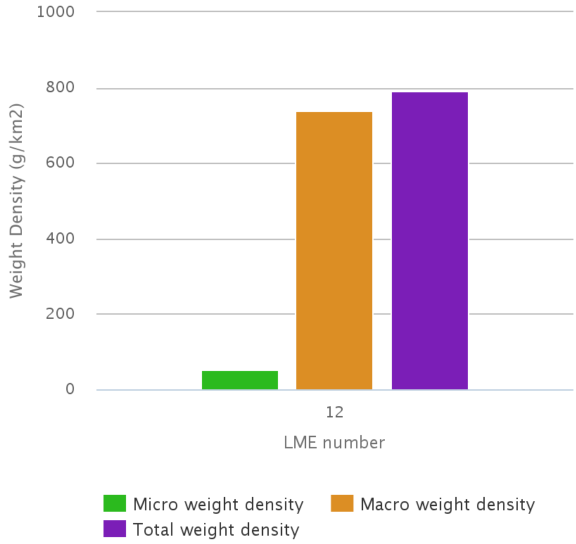
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
2	4	**1**	3	**1**	0.9	**1**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively high levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category there is good evidence from sea-based direct observations and towed nets to support this conclusion.





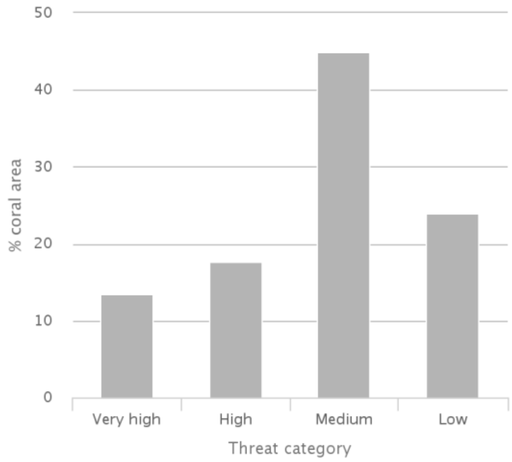
Ecosystem Health

Mangrove and coral cover

0.35% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.64% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 221. 13% of coral reefs cover is under very high threat, and 18% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 23% and 32% for very high and high threat categories respectively. By year 2030, 29% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 40% by 2050.

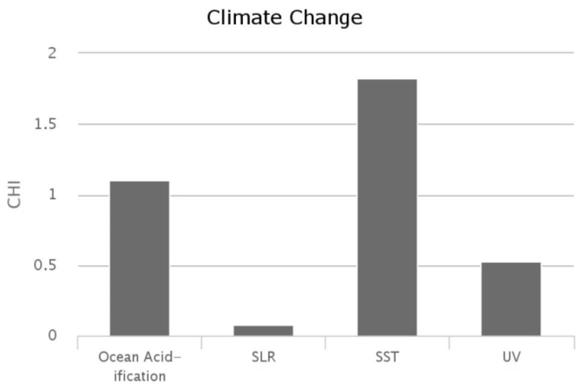


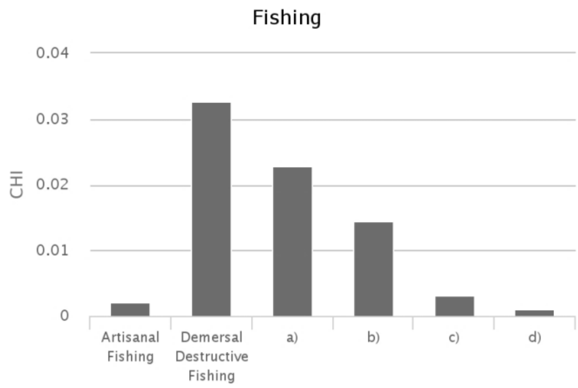
Marine Protected Area change

The Caribbean Sea LME experienced an increase in MPA coverage from 6,463 km^2 prior to 1983 to 143,096 km^2 by 2014. This represents an increase of 2,114%, within the medium category of MPA change.

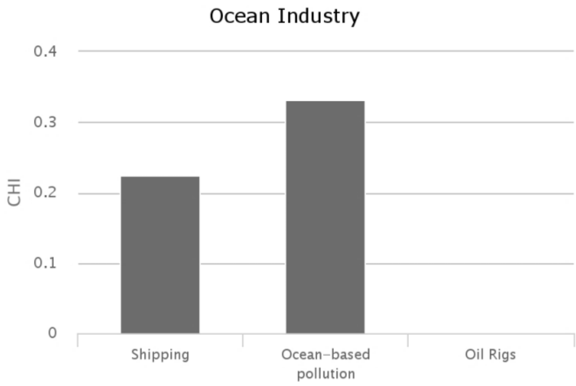
Cumulative Human Impact

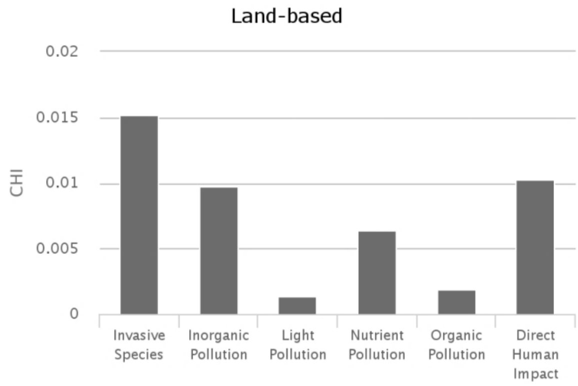
The Caribbean Sea LME experiences an above average overall cumulative human impact (score 4.21; maximum LME score 5.22), which is well above the LME with the least cumulative impact. It falls in risk category 4 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.11; maximum in other LMEs was 1.20), UV radiation (0.52; maximum in other LMEs was 0.76), and sea surface temperature (1.82; maximum in other LMEs was 2.16). Other key stressors include commercial shipping and ocean based pollution.

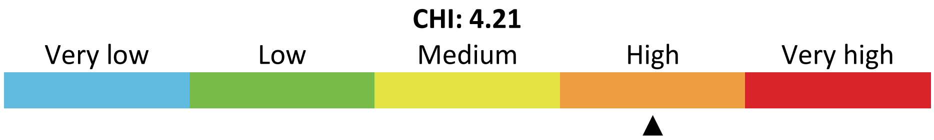




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

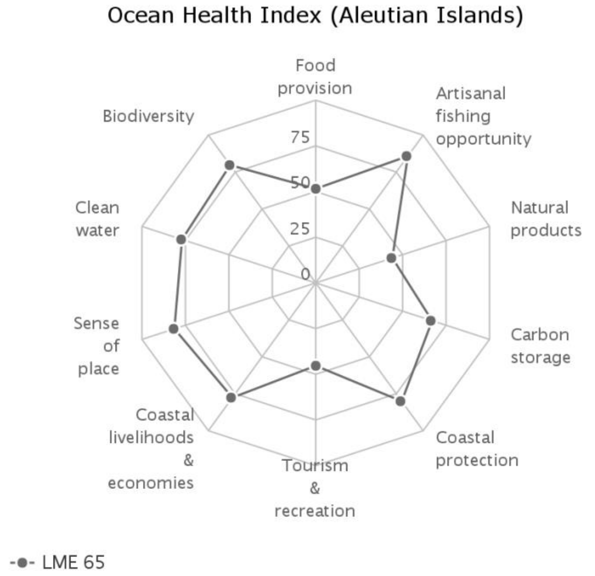


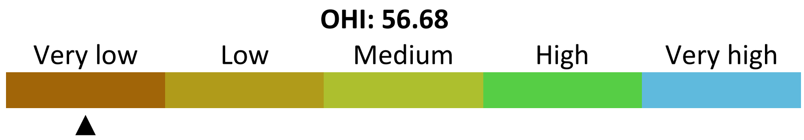




Ocean Health Index

The Caribbean Sea LME scores well below average on the Ocean Health Index compared to other LMEs (score 60 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is far from its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 remained unchanged compared to the previous year. This LME scores lowest on food provision, natural products, coastal protection and tourism & recreation goals and highest on artisanal fishing opportunities and coastal economies goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).





Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the Caribbean Sea LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area includes the eastern coast of the Yucatan Peninsula, the Atlantic coast of Central America, Colombia and Venezuela, and 24 Caribbean island states covering a total of 794,777 km^2. A current population of 84 million is projected to reach to 127 million in 2100, and density increasing from 106 persons per km^2 in 2010 to 159 per km^2 by 2100. About 42% of coastal population lives in rural areas, and is projected to increase in share to 46% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
84,263,359	126,576,916	35,485,511	58,003,582

Legend: Very low | Low | Medium | High | Very high

Coastal poor

The indigent population makes up 32% of the LME's coastal dwellers. The Caribbean Sea LME places in the very high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor
26,619,339

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Caribbean Sea LME ranks in the high revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $810 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $90,454 million places it in the very high revenue category. On average, LME-based tourism income contributes 18% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the Caribbean Sea LME falls in the category with medium risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
810,509,428	8.7	90,454,384,76018.0	18.0	0.7499

Legend:
Very low | Low | Medium | High | Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day Caribbean Sea LME HDI belongs to the medium HDI and high-risk category. Based on an HDI of 0.718, this LME has an HDI Gap of 0.282, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The Caribbean Sea LME is projected to assume a place with the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.7185	0.8970	0.5611

Legend:
Very low | Low | Medium | High | Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to

2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (*e.g.* overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index to the Caribbean Sea LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is lowest, and increases to high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.8389	0.4807	0.3944	0.6425

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

Three arrangements for transboundary fisheries in this LME - CRFM, OSPESCA and WECAFC - are connected. OLDEPESCA is minimally connected within the LME. None of the fisheries arrangements are connected with ICCAT. The arrangements for pollution and biodiversity that fall under the Cartagena Convention are connected via the CEP, but do not appear well connected with fisheries or with the IAC. No integrating mechanisms, such as an overall policy coordinating organization for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
53	**60**	**0.2**

Legend:

Very low | Low | Medium | High | Very high

LME 13 – Humboldt Current

Bordering countries: Chile, Peru
LME Total area: 2,619,386 km^2

List of indicators

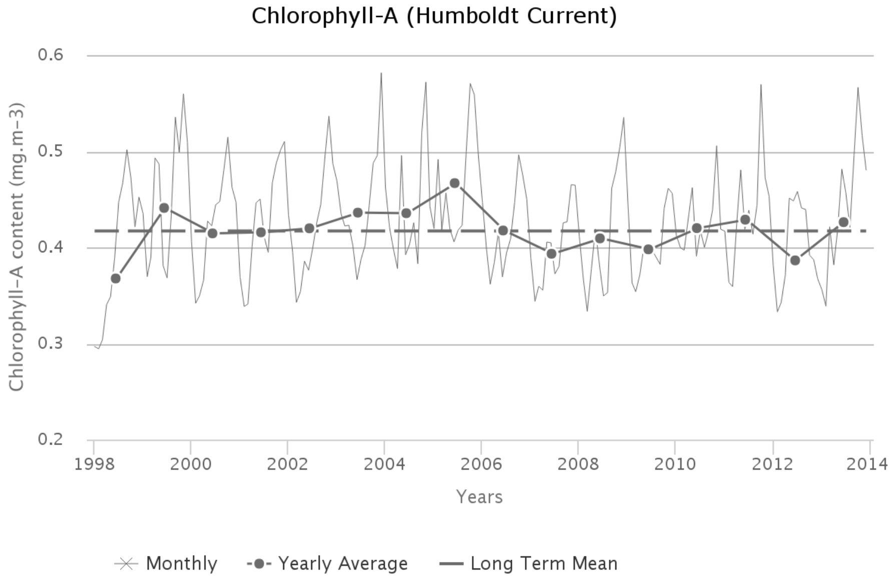
LME overall risk

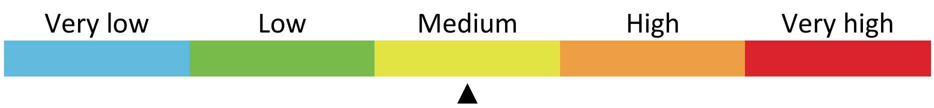
This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Productivity

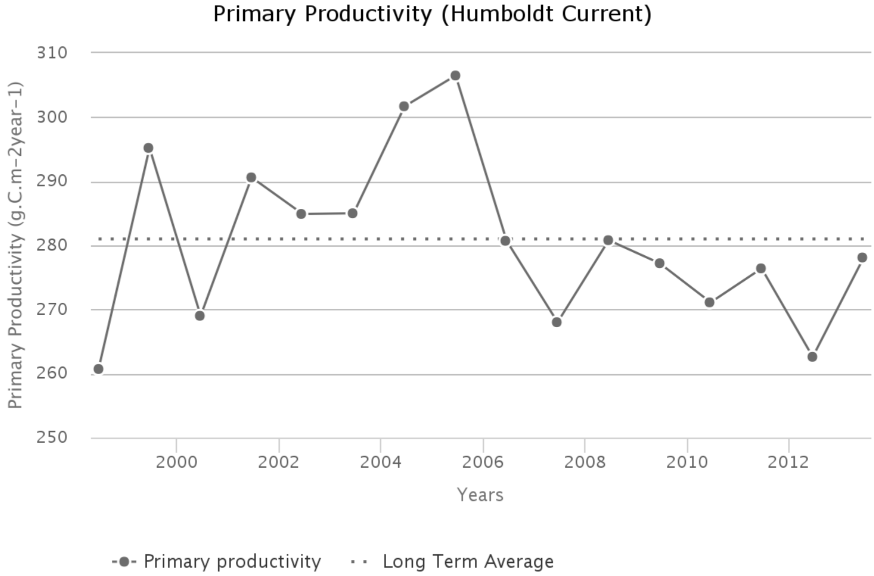
Chlorophyll-A

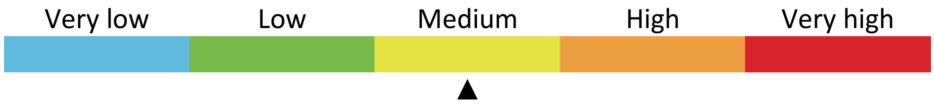
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.487 mg.m^{-3}) in October and a minimum (0.363 mg.m^{-3}) during March. The average CHL is 0.417 mg.m^{-3}. Maximum primary productivity (307 g.C.m^{-2}.y^{-1}) occurred during 2005 and minimum primary productivity (261 g.C.m^{-2}.y^{-1}) during 1998. There is a statistically insignificant decreasing trend in Chlorophyll of -17.6 % from 2003 through 2013. The average primary productivity is 281 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).





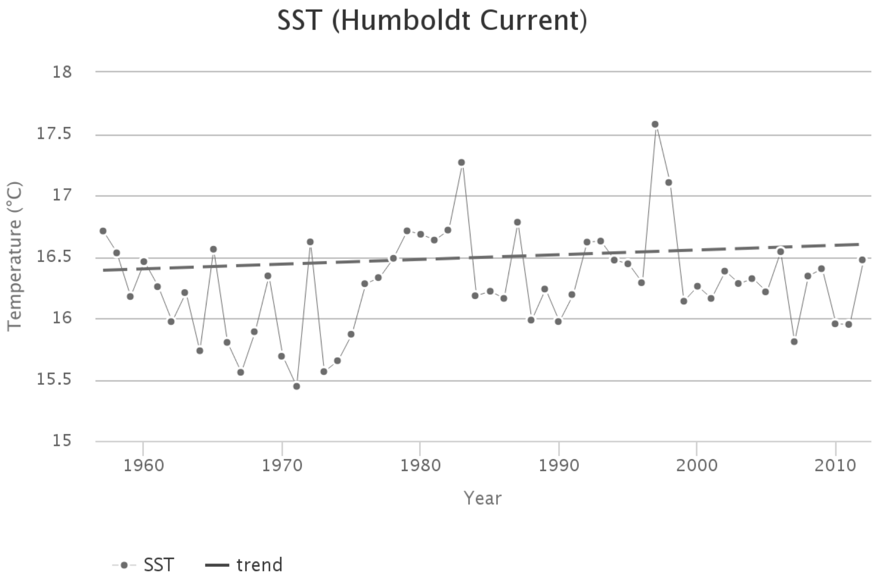
Primary productivity





Sea Surface Temperature

Between 1957 and 2012, the Humboldt Current LME #13 has warmed by 0.24°C, thus belonging to Category 4 (slow warming LME). This long-term warming trend was not uniform. It was punctuated by warm/cold events associated with El Niños and La Niñas, respectively, particularly by the El Niños 1983 and 1997. Because of the vast north-south extent of this LME, spatial variations within it are strong. The El Niños and La Niñas strongly affect the northern part of this LME (National Weather Service/Climate PredictionCenter, 2007) yet do not exert strong impact on it southern part. The Humboldt Current experienced a 1°C cooling in 1957-1973, followed by a decade-long warming, which culminated in 1983. These opposite trends represent two major oceanic regimes. The all-time El Niño-related peak of 17.6°C in 1997 was exceptional. From 1999 through 2012 SST remained rather low, <16.5°C.



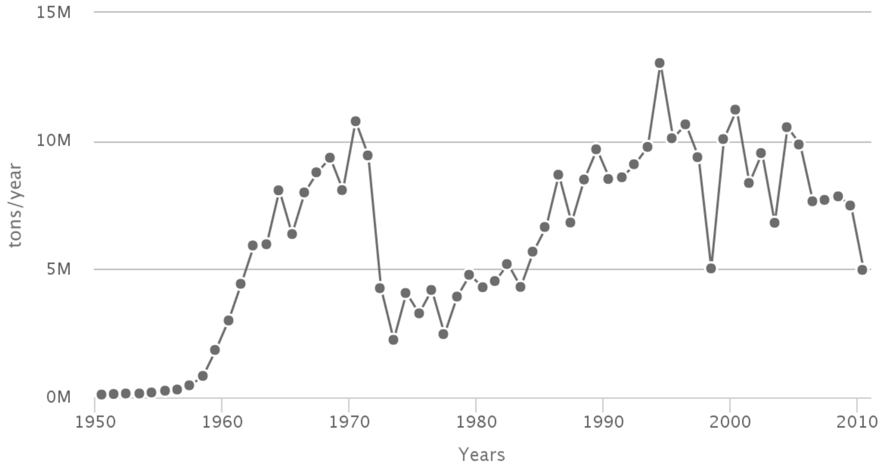
Fish and Fisheries

The Humboldt Current LME's high productivity supports the world's largest fisheries.

Annual Catch

In 1994, fisheries catches by Peru and Chile amounted to around 13 million t. These two countries account for 16% to 20% of the global fish catch, mostly in the form of small schooling pelagic fish such as sardines, anchovies (especially the 'anchoveta', *Engraulis ringens*) and mackerels. Total reported landings show considerable fluctuation, with two major peaks at over 10 million t and 13 million t in 1970 and 1994 respectively, which actual catches likely to be much higher.

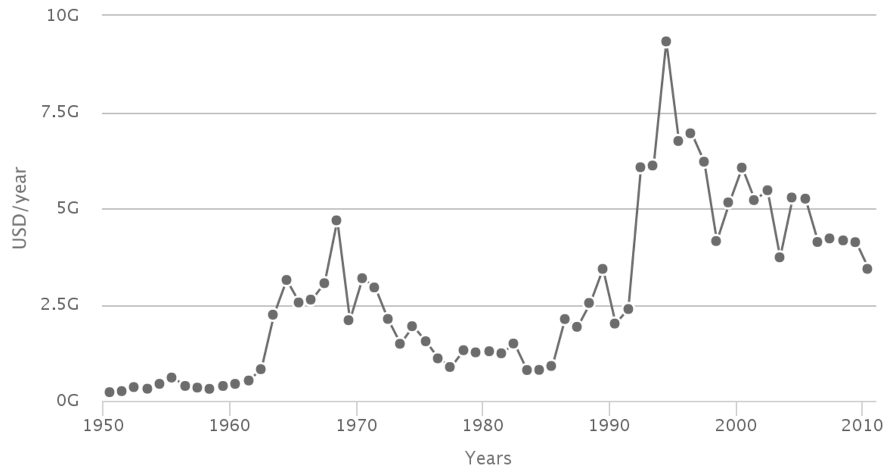
Annual Catch (Humboldt Current)



Catch value

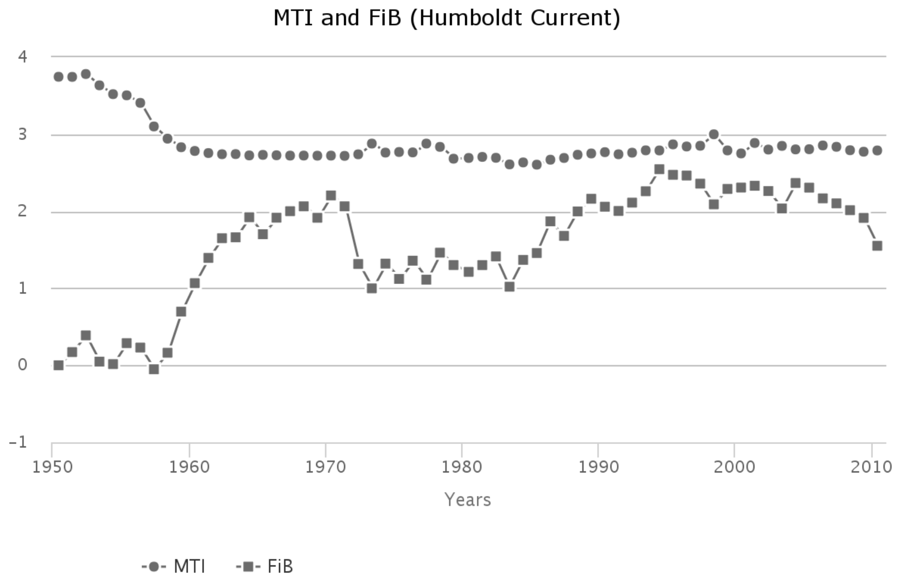
The value of the reported landings also fluctuates, reaching about 9 billion US$ (in 2005 real US$) in 1994.

Catch Value (Humboldt Current)



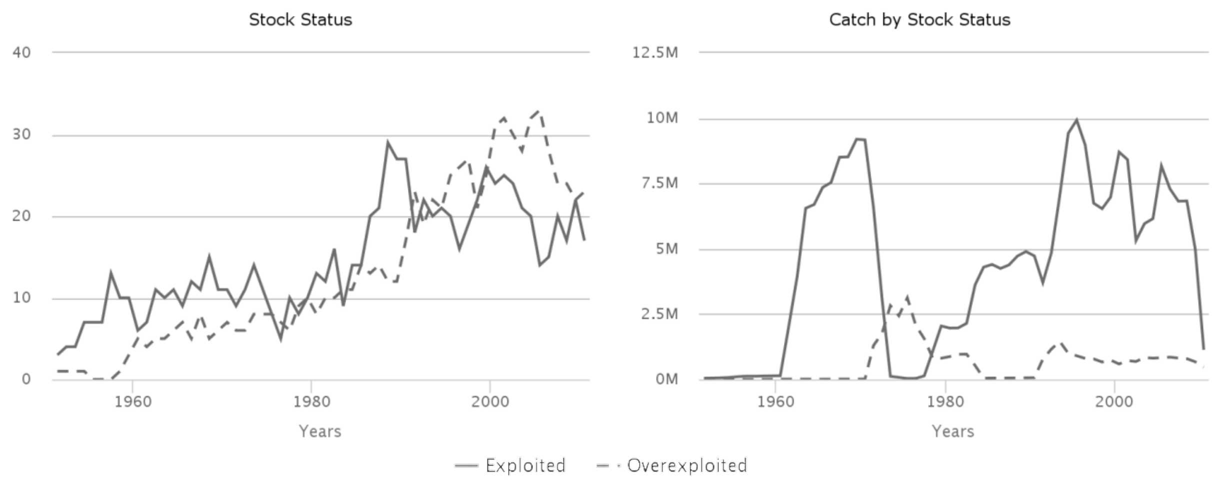
Marine Trophic Index and Fishing-in-Balance index

The MTI, in this system, which in the early 1950s looked like most other LMEs (MTI of about 3.4), plunged as soon as the fisheries for anchoveta, a low-trophic level species, took off. Indeed, for two decades, this fishery was the largest single-species fishery in the world, with some of its fluctuations in landings reflected in the FiB index. Because of the dominance of anchoveta in the landings of the LME, the MTI and FiB index are not currently informative as to the status of the ecosystem. However, their trends with the anchoveta removed, and thus reflecting the assemblage exploited by coastal fisheries, show strong signs of "fishing down".



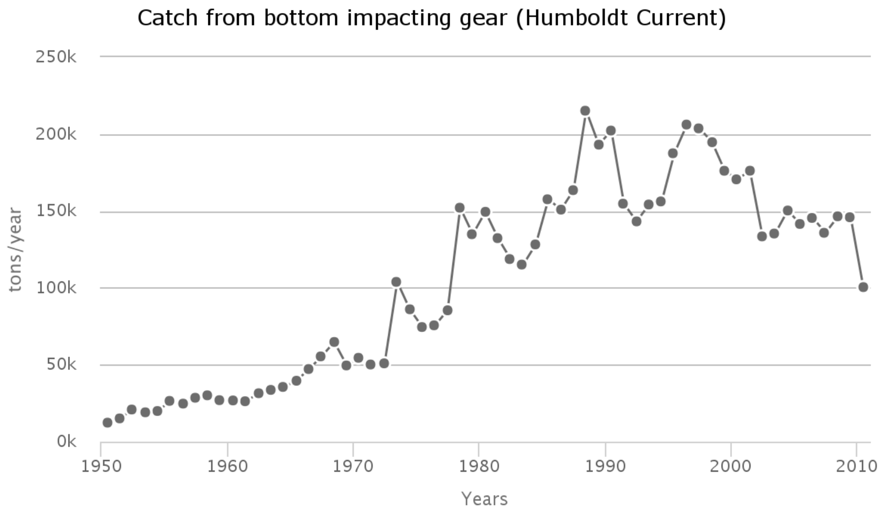
Stock status

The Stock-Catch Status Plots indicate that about 60% of commercially exploited stocks in the LME are either overexploited or have collapsed. This is, at least in part, a definitional artefact, because of the classification of anchoveta as an overexploited stock, having experienced its maximum catch in the early 1970s, even though its catches have recovered in recent years. Here again, the analysis may benefit from being conducted without the anchoveta catch (see www.seaaroundus.org).



Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch reached its peak at 13% in 1952 and then declined to less than 1% in the 1960s. In the recent decade, this percentage ranged between 1.4 and 2%.

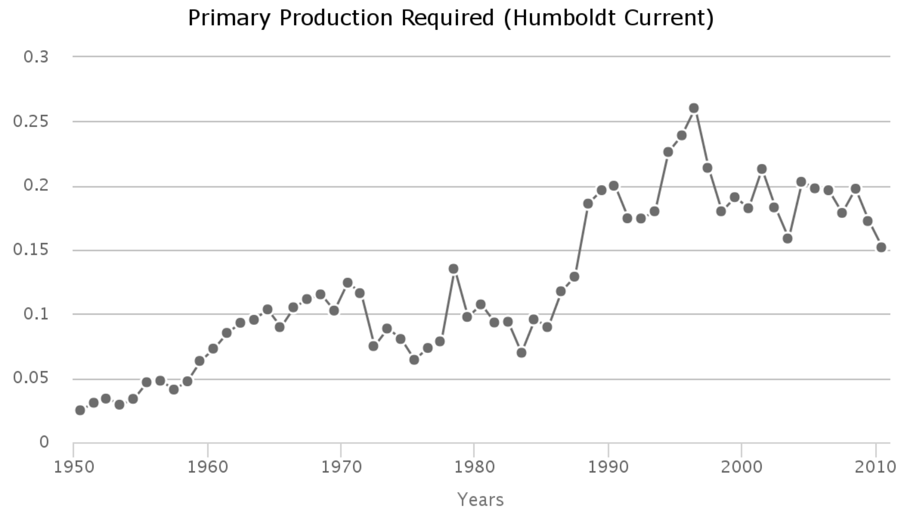


Fishing effort

The total effective effort continuously increased from around 15 million kW in the 1950s to its peak at 180 million kW in the mid- 2000s.

Primary Production Required

The primary production required (PPR) to sustain the reported landings reached 20% of the observed primary production in the LME in the mid-1990s, and has fluctuated around this level in recent years.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was low (level 2 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained low in 2030 and increased to moderate by 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and increased to low in 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this remained the same in 2030 and increased to moderate in 2050.

2000			**2030**			**2050**		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
2	1	2	2	1	2	3	2	3

Legend: Very low, Low, Medium, High, Very high

POPs

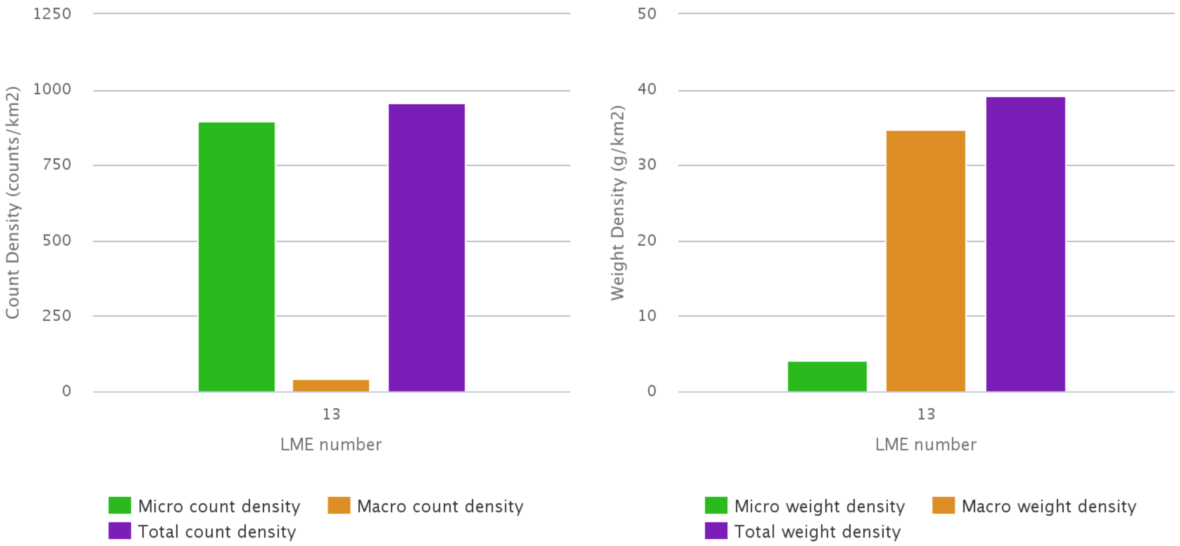
Data are available for three samples at three locations in Chile. These locations show low concentrations for all the indicators. The average concentration (ng.g^{-1} of pellets) was 29 (range 4 – 50 ng.g^{-1}) for PCBs, 8 (range 2 – 16 ng.g^{-1}) for DDTs, and 1.0 (range 0.2 – 2.5 ng.g^{-1}) for HCHs. The PCBs and DDTs averages correspond to risk category 2 and HCHs to risk category 1, of the five risk categories (1 = lowest risk; 5 = highest risk). Relatively higher PCB concentrations at San Vicente and San Antonio are probably due to proximity to large cities.

	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
3	29	**2**	8	**2**	1.0	**1**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km-2), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively low levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The low values are due to the relative remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be on average over 40 times lower that those LMEs with the highest values. There is evidence from sea-based direct observations and towed nets to support this conclusion.



Ecosystem Health

Mangrove and coral cover

0.0001% of this LME is covered by mangroves (US Geological Survey, 2011).

Reefs at risk

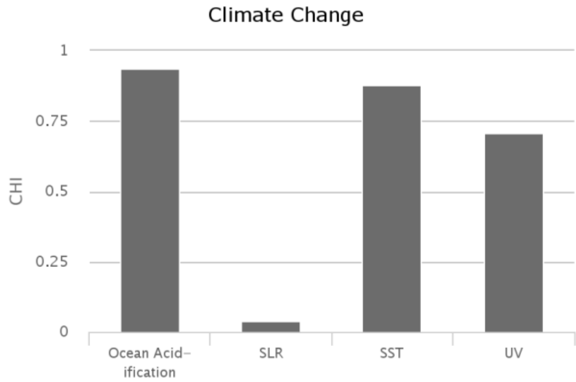
Not applicable.

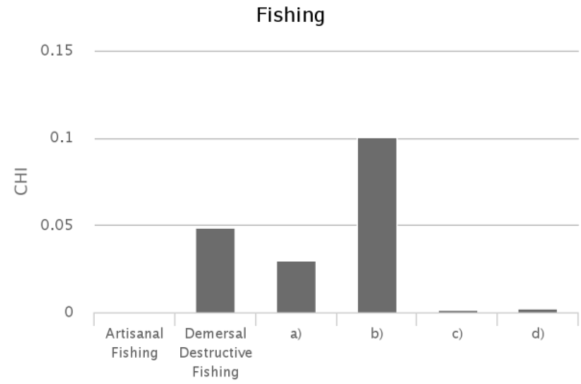
Marine Protected Area change

The Humboldt Current LME experienced an increase in MPA coverage from 2,463 km^2 prior to 1983 to 5,798 km^2 by 2014. This represents an increase of 135%, within the low category of MPA change.

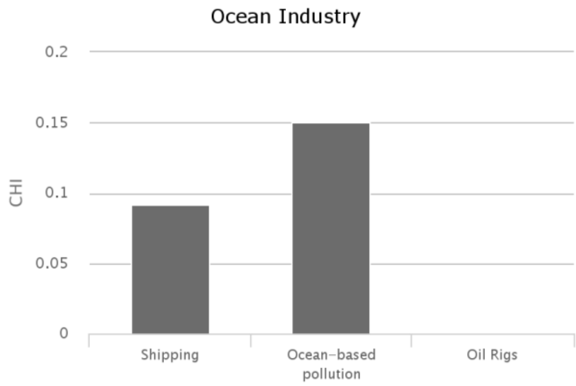
Cumulative Human Impact

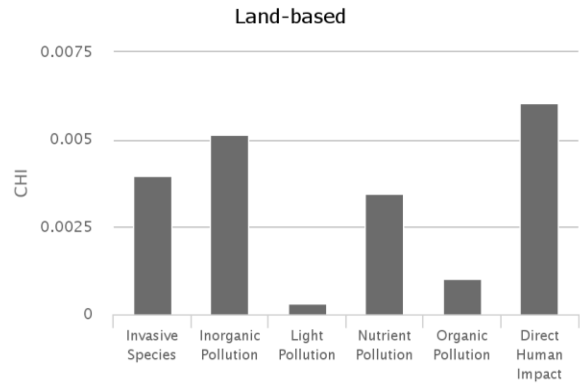
The Humboldt Current LME experiences below average overall cumulative human impact (score 3.01; maximum LME score 5.22), but which is still well above the LME with the least cumulative impact. It falls in risk category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (0.94; maximum in other LMEs was 1.20), UV radiation (0.71; maximum in other LMEs was 0.76), and sea surface temperature (0.88; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, and demersal destructive commercial fishing.

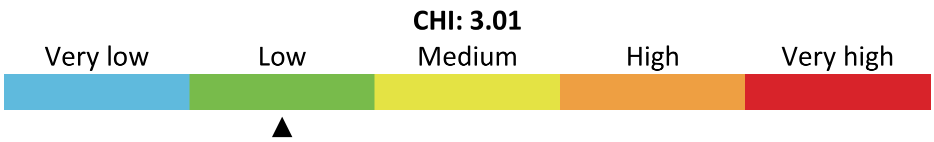




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

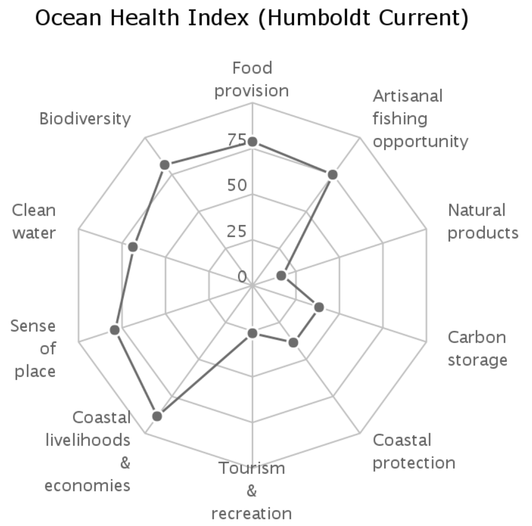






Ocean Health Index

The Humboldt Current LME scores below average on the Ocean Health Index compared to other LMEs (score 70 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 1 point compared to the previous year, due in large part to changes in the scores for natural products. This LME scores lowest on natural products, coastal protection, carbon storage, and tourism & recreation goals and highest on artisanal fishing opportunities, coastal livelihoods, and lasting special places goals. It falls in risk 3 of the five risk categories, which is an average level of risk (1 = lowest risk; 5 = highest risk).



OHI: 63.22

Very low | Low | Medium | High | Very high

Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the Humboldt Current LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area includes the Pacific coasts of Peru and Chile, and Argentina's Tierra del Fuego, covering a total of 725,678 km^2. A current population of 30 million is projected to more than double to 68 million in 2100, and density increasing from 42 persons per km^2 in 2010 to 94 per km^2 by 2100. About 31% of coastal population lives in rural areas, and is projected to decrease in share to 25% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
30,444,488	68,326,175	9,381,185	17,393,025

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 20% of the LME's coastal dwellers. The Humboldt Current LME places in the high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor
6,220,442

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Humboldt Current LME ranks in the very high revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $5,353 million for the period 2001-2010. Fish protein accounts for 16% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $25,715 million places it in the medium revenue category. On average, LME-based tourism income contributes 8% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the Humboldt Current LME falls in the category with medium risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
5,352,727,743	16.2	25,715,476,076	8.5	0.7753

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day Humboldt Current LME HDI belongs to the high HDI and high-risk category. Based on an HDI of 0.767, this LME has an HDI Gap of 0.233, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The Humboldt Current LME is projected to assume a place with the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the high-risk category (low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

HDI	HDI 2100	
	SSP1	SSP3
0.7674	0.9356	0.6196

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index to the Humboldt Current LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.6100	0.3636	0.3186	0.5810

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

The arrangements for major transboundary issues within the jurisdiction of the countries are well integrated with both the CPPS and the Lima Convention and its protocols having formal linkages. However, the two arrangements for high seas fisheries (IATTC and SPRFMO) do not appear to have any formal linkages with each other or with the "within country" arrangements for fisheries, pollution and biodiversity. Nevertheless, this LME has been assigned an overall integration score of 1.0 due to the presence of the Permanent Commission for the South Pacific (CPPS) with its ability to function as an overall policy coordinating organization for the key transboundary issues within the LME.

The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
50	**68**	**1**

Legend:

Very low | Low | Medium | High | Very high

LME 14 – Patagonian Shelf

Bordering countries: Argentina, Falkland Islands, Uruguay
LME Total area: 1,173,332 km^2

List of indicators

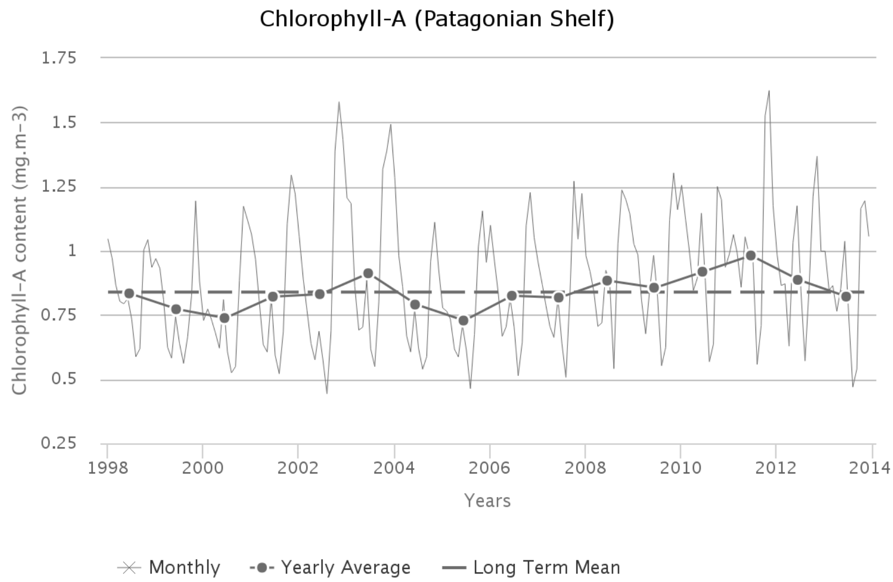
LME overall risk

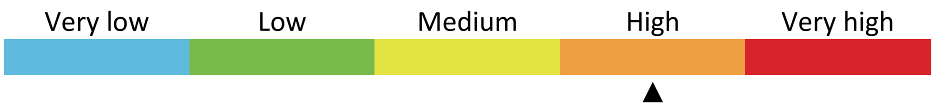
This LME falls in the cluster of LMEs that exhibit medium numbers of collapsed and overexploited fish stocks, as well as very high proportions of catch from bottom impacting gear.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Productivity

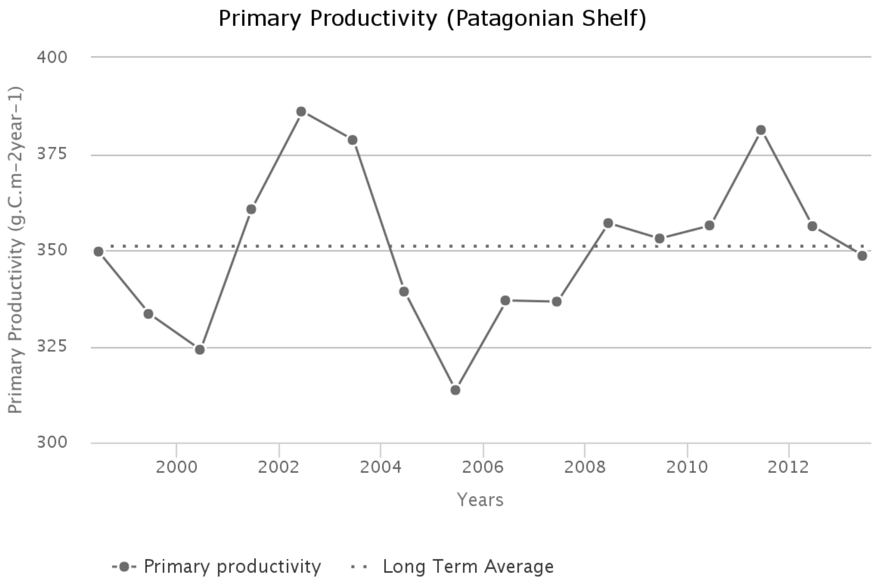
Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (1.22 mg.m^{-3}) in November and a minimum (0.518 mg.m^{-3}) during August. The average CHL is 0.839 mg.m^{-3}. Maximum primary productivity (386 g.C.m^{-2}.y^{-1}) occurred during 2002 and minimum primary productivity (314 g.C.m^{-2}.y^{-1}) during 2005. There is a statistically significant increasing trend in Chlorophyll of 19.9 % from 2003 through 2013. The average primary productivity is 351 g.C.m^{-2}.y^{-1}, which places this LME in Group 4 of 5 categories (with 1 = lowest and 5= highest).



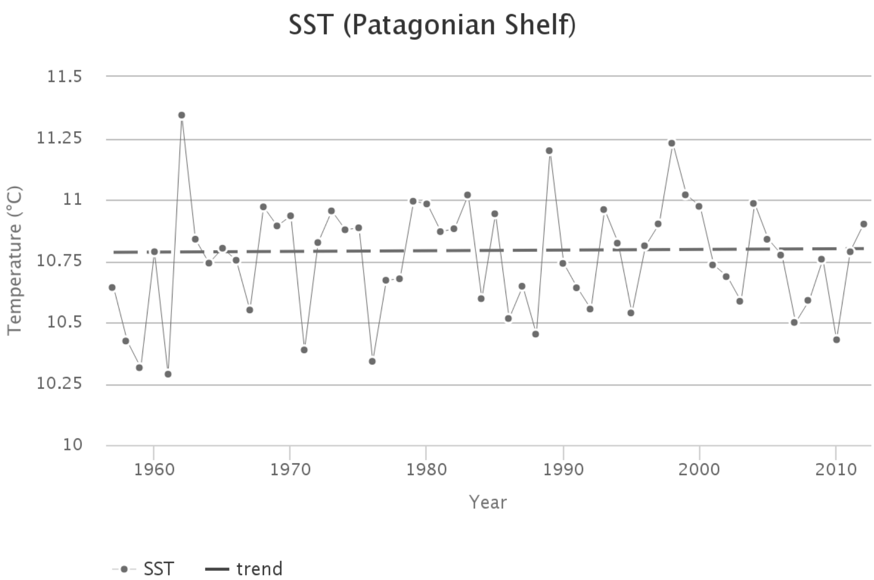


Primary productivity



Sea Surface Temperature

Between 1957 and 2012, the Patagonian Shelf LME #14 has warmed by 0.06°C, thus belonging to Category 4 (slow warming LME). The most dramatic event occurred in 1961-62, when SST rose from the all-time minimum of 10.3°C to the all-time maximum of >11.3°C. A slight increase of SST from 1957 until 1998, when SST peaked at 11.2°C, gave way to a cooling down to 10.4°C in 2010. The most likely cause of the observed stability of the Patagonian Shelf is the constant influx of subantarctic waters with the Falkland/Malvinas Current. Another possible cause of the Patagonian Shelf's thermal stability is an extremely rich pattern of oceanic fronts – sharp, narrow boundaries between relatively uniform water masses. Most fronts in this LME persist, albeit constantly evolving, year-round (Belkin et al., 2009). Moreover, the Patagonian Shelf is the only LME where rich frontal patterns exist year-round.

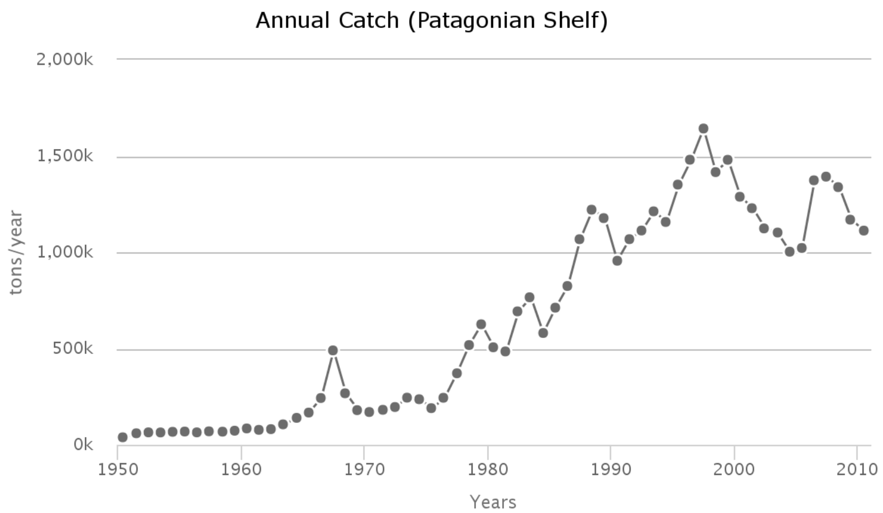


Fish and Fisheries

Fisheries in the Patagonian Shelf LME have undergone accelerated growth in the last decades involving mostly Argentine hake (*Merluccius hubbsi*), Argentine shortfin squid (*Illex argentinus*), southern blue whiting (*Micromesistius australis*), Patagonian grenadier (*Macruronus magellanicus*), and prawns (*Pleoticus muelleri*).

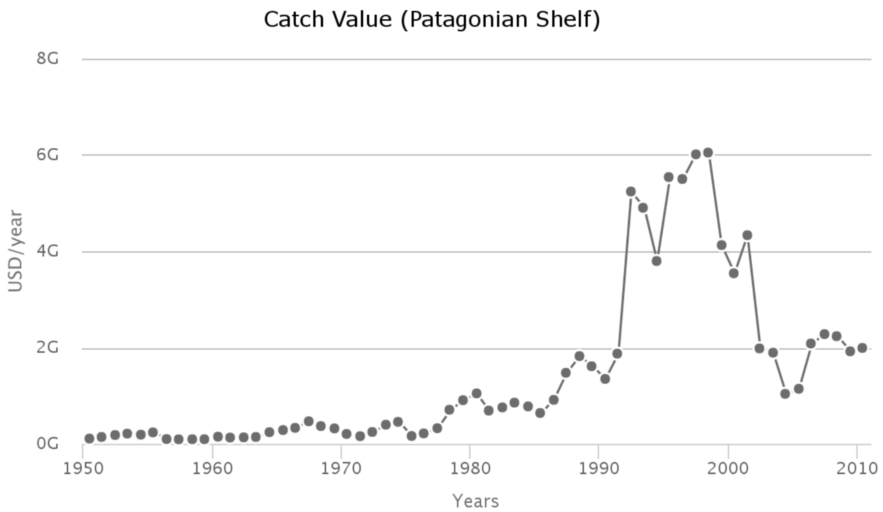
Annual Catch

Total reported landings have increased over the past three decades, recording 1.6 million tonnes in 1997 with Argentine hake and shortfin squid accounting for the majority share. The landings have since decline to about 1.3 million tonnes per year in recent years (2006 – 2010).



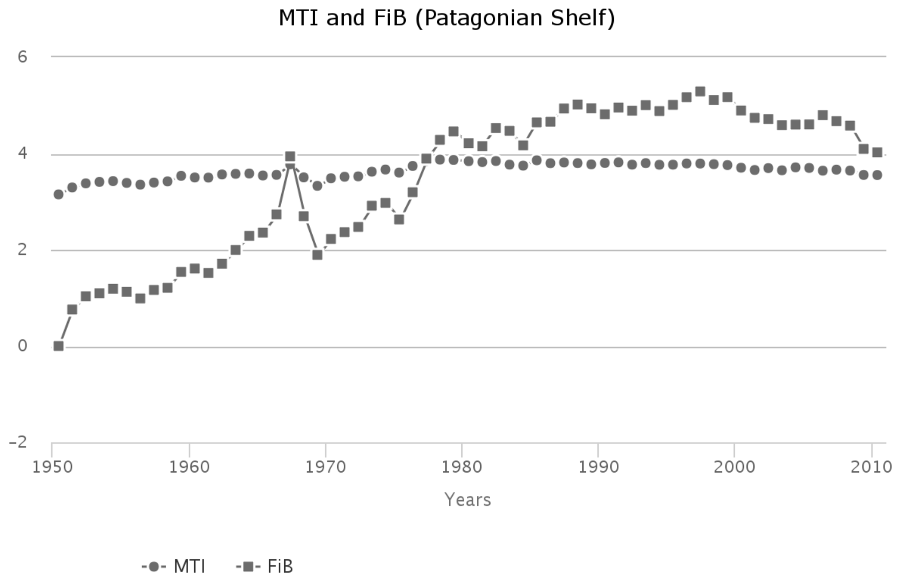
Catch value

The value of the reported landings reached a peak of 6 billion US$ recorded in 1998.



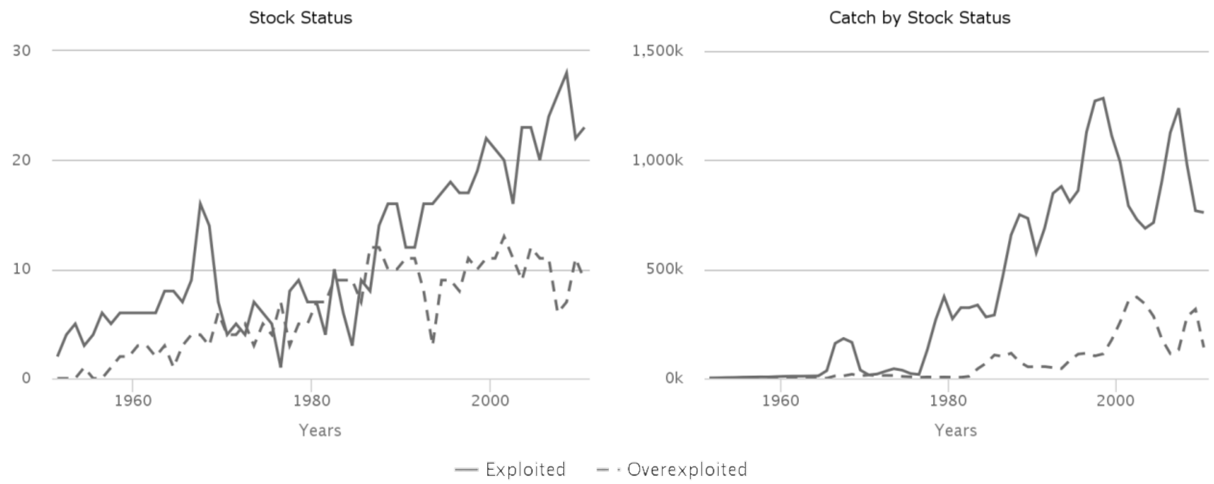
Marine Trophic Index and Fishing-in-Balance index

The MTI shows a decline since the late 1970s an indication of "fishing down" of the food web in the LME; over the same period, the FiB index has increased, implying that the increasing reported landings were due at least in part, to a geographic expansion of the fishery.



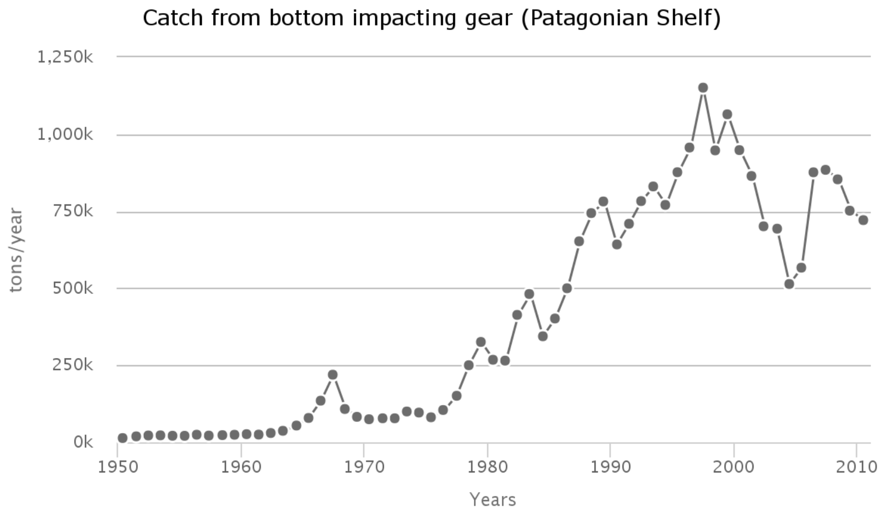
Stock status

The Stock-Catch Status Plots shows that about 50% of commercially exploited stocks in the LME are either overexploited or have collapsed, with about 80% of the reported landings supplied by fully exploited stocks. However, the transition from fully exploited to overexploited stocks in the early 2000s was rather abrupt.



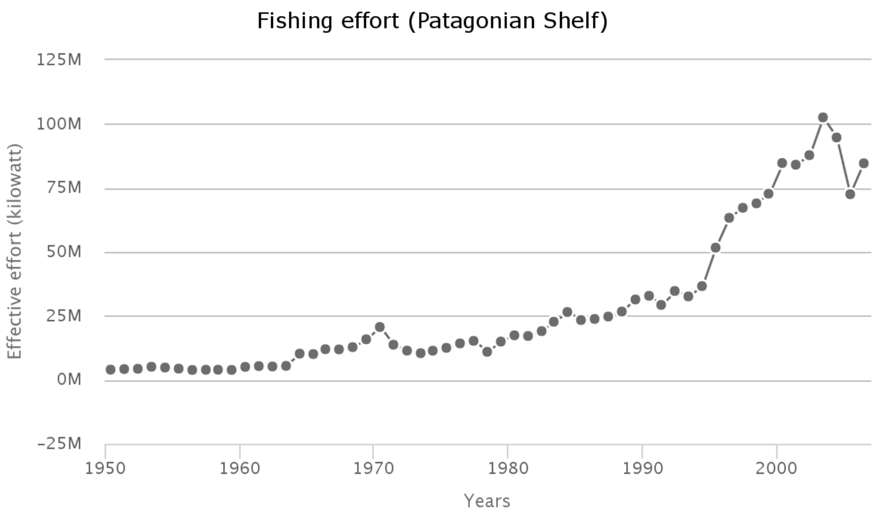
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from around 35% in the 1950s to its maximum at 74% in 2000. This percentage range between 50 to 70% in the recent decade.



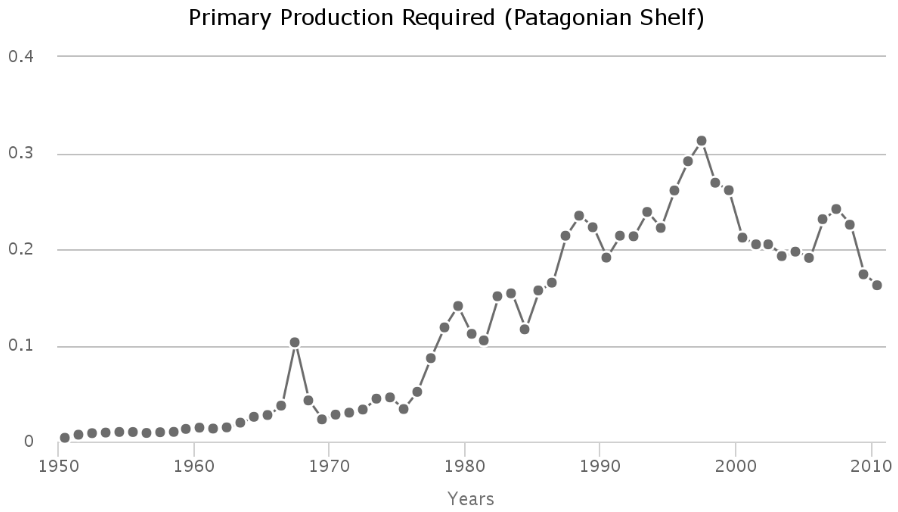
Fishing effort

The total effective effort increased steadily from around 5 million kW in the 1960s to its peak at 100 million kW the early 2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME reached 25% of the observed primary production in the mid-1990s, but has declined to 20% in recent years.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained moderate in 2030 and increased to high by 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and increased to high in 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	3	3	3	3	3	4	3	4

Legend: Very low, Low, Medium, High, Very high

POPs

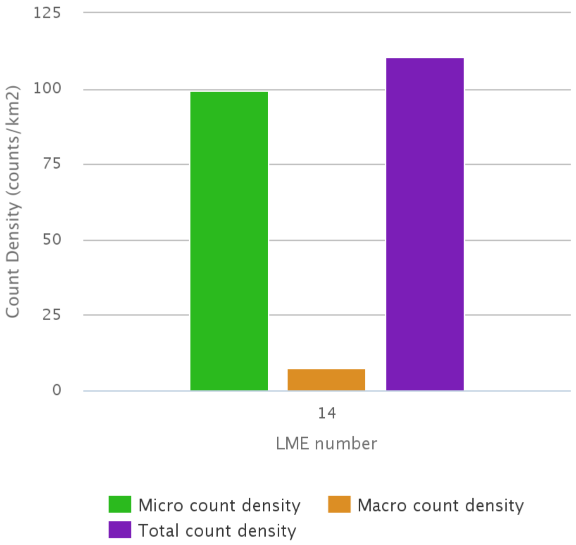
Data are available for two samples at one location from Uruguay and another from Buenos Aires, Argentina. The average concentration ($ng.g^{-1}$ of pellets) was 46 (range 0 – 93 $ng.g^{-1}$) for PCBs, 8 (range 0 – 16 $ng.g^{-1}$) for DDTs, and 0.2 (range 0.1 – 0.3 $ng.g^{-1}$) for HCHs. The PCBs and DDTs averages correspond to risk category 2 and HCHs to risk category 1, of the five risk categories (1 = lowest risk; 5 = highest risk). Minimal concentrations ($ng.g^{-1}$ of pellets) for all three indicators at the Uruguay location correspond to risk category 1, and this is due to the remoteness of the location. Moderate PCB concentration (93 $ng.g^{-1}$) in Argentina is probably due to the proximity to Buenos Aires. Pellets from more locations should be collected and analyzed to properly evaluate the LME.

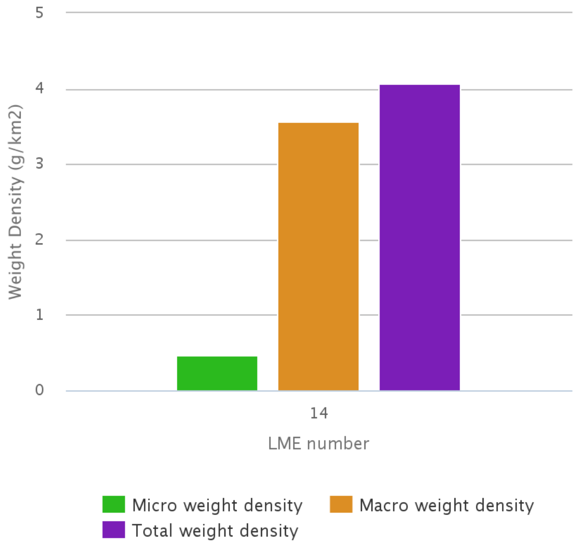
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
2	46	**2**	8	**2**	0.2	**1**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with the lowest plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The low values are due to the remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be over 400 times lower than those LMEs with the highest values. There is very limited evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

Mangrove and coral cover

Not applicable.

Reefs at risk

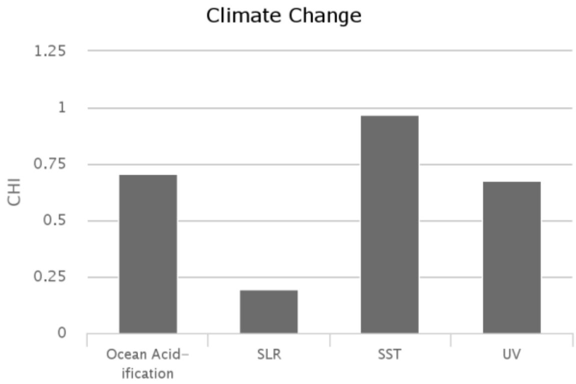
Not applicable.

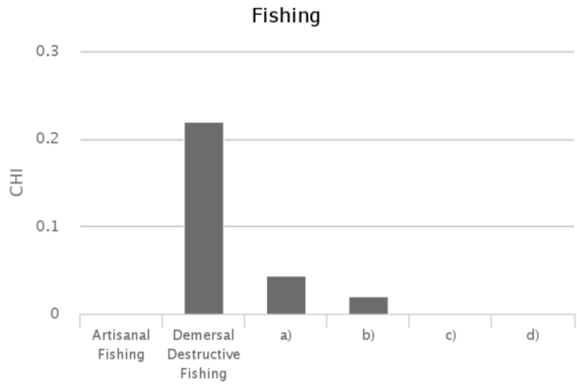
Marine Protected Area change

The Patagonian Shelf LME experienced an increase in MPA coverage from 1,045 km^2 prior to 1983 to 3,076 km^2 by 2014. This represents an increase of 194%, within the low category of MPA change.

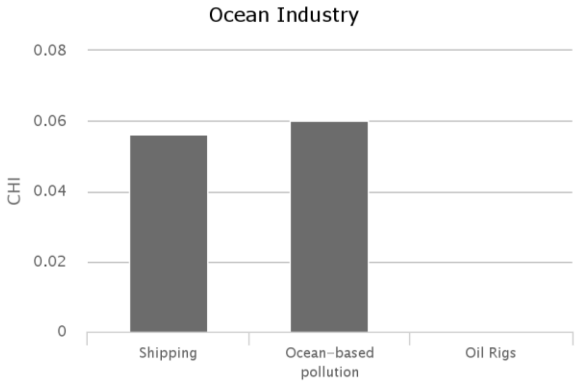
Cumulative Human Impact

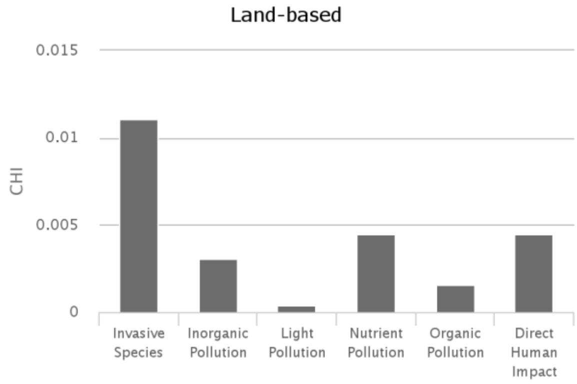
The Patagonian Shelf LME experiences below average overall cumulative human impact (score 2.98; maximum LME score 5.22), but which is still well above the LME with the least cumulative impact. It falls in risk category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (0.71; maximum in other LMEs was 1.20), UV radiation (0.68; maximum in other LMEs was 0.76), and sea surface temperature (0.97; maximum in other LMEs was 2.16). Other key stressors include sea level rise and demersal destructive commercial fishing.

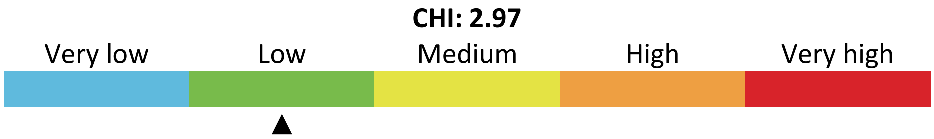




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing



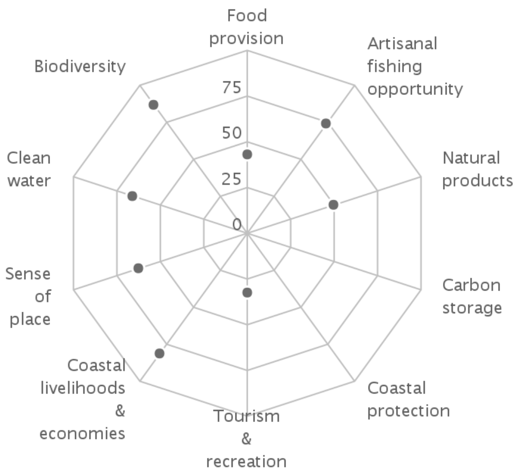




Ocean Health Index

The Patagonian Shelf LME scores below average on the Ocean Health Index compared to other LMEs (score 68 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 1 point compared to the previous year, due in large part to changes in the scores for food provision and clean waters. This LME scores lowest on food provision, tourism & recreation and lasting special places goals and highest on artisanal fishing opportunities and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high level of risk (1 = lowest risk; 5 = highest risk).

Ocean Health Index (Patagonian Shelf)



OHI: 62.27

Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the Patagonian Shelf LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area extends from Uruguay in the north to Tierra del Fuego in the south and covers a total of 463,855 km^2. A current population of 21 million is projected to almost double to 39 million in 2100, and density increasing from 44 persons per km^2 in 2010 to 83 per km^2 by 2100. About 10% of coastal population lives in rural areas, and is projected to increase in share to 19% in 2100.

Total population		Rural population	
2010	2100	2010	2100
20,519,841	38,646,210	1,954,299	7,192,813

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 13% of the LME's coastal dwellers. The Patagonian Shelf LME places in the low-risk category based on percentage and in the medium risk category using absolute number of coastal poor (present day estimate).

Coastal poor
2,743,353

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Patagonian Shelf LME ranks in the very high revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $2,486 million for the period 2001-2010. Fish protein accounts for 3% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $41,973 million places it in the high revenue category. On average, LME-based tourism income contributes 10% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the Patagonian Shelf LME falls in the category that is of high economic development, thus with low risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
2,486,143,862	3.0	41,973,814,380	10.0	0.7037

Legend: Very low | Low | Medium | High | Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day Patagonian Shelf LME HDI belongs to the high HDI and low-risk category. Based on an HDI of 0.799, this LME has an HDI Gap of 0.201, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The Patagonian Shelf LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.7986	0.9239	0.5881

Legend: Very low | Low | Medium | High | Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of

warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m x 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.
Present day climate threat index to the Patagonian Shelf LME is within the low-risk (low threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is medium. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.5020	0.3270	0.3462	0.6123

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

The two arrangements for high seas southern bluefin tuna and the large pelagics in the Atlantic (CCBST and ICCAT) are separate arrangements, as is the arrangement for sea turtles (IAC). However, the fisheries, pollution and biodiversity arrangements in the areas within the EEZ of Uruguay and Argentina appear to be well integrated as a result of the Treaty of the Rio de la Plata.
The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
50	**82**	**0.2**

Legend:

Very low | Low | Medium | High | Very high

LME 15 – South Brazil Shelf

Bordering country: Brazil.
LME Total area: 566,397 km^2

List of indicators

LME overall risk

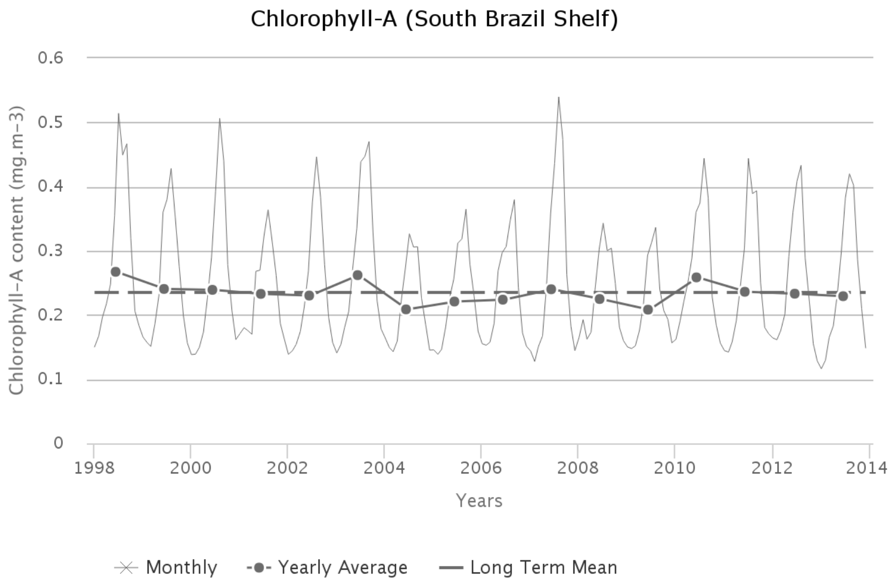
This LME falls in the cluster of LMEs that exhibit medium numbers of collapsed and overexploited fish stocks, as well as very high proportions of catch from bottom impacting gear.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Very low | Low | Medium | High | Very high

Productivity

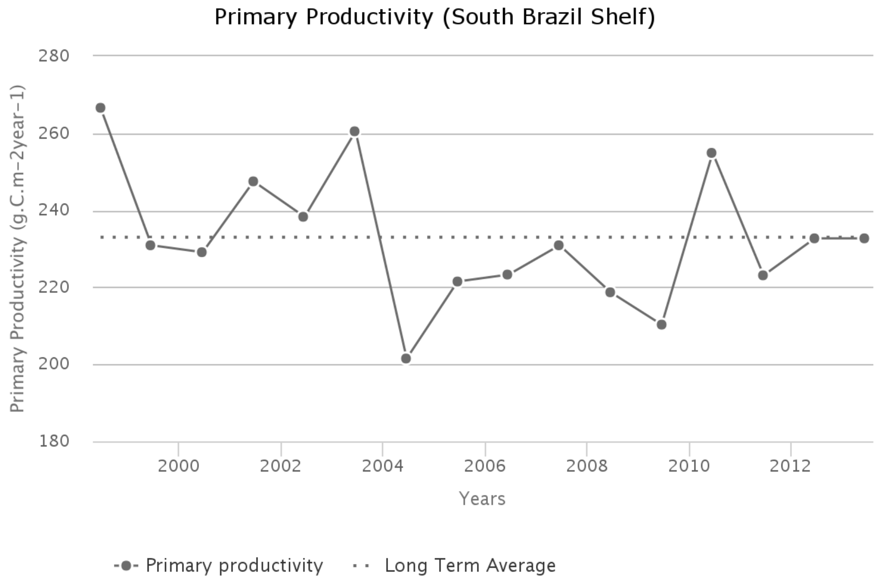
Chlorophyll-A

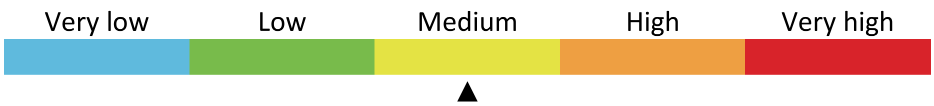
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.403 mg.m^{-3}) in August and a minimum (0.154 mg.m^{-3}) during January. The average CHL is 0.235 mg.m^{-3}. Maximum primary productivity (267 g.C.m^{-2}.y^{-1}) occurred during 1998 and minimum primary productivity (201 g.C.m^{-2}.y^{-1}) during 2004. There is a statistically insignificant increasing trend in Chlorophyll of 5.61 % from 2003 through 2013. The average primary productivity is 233 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).



Very low | Low | Medium | High | Very high

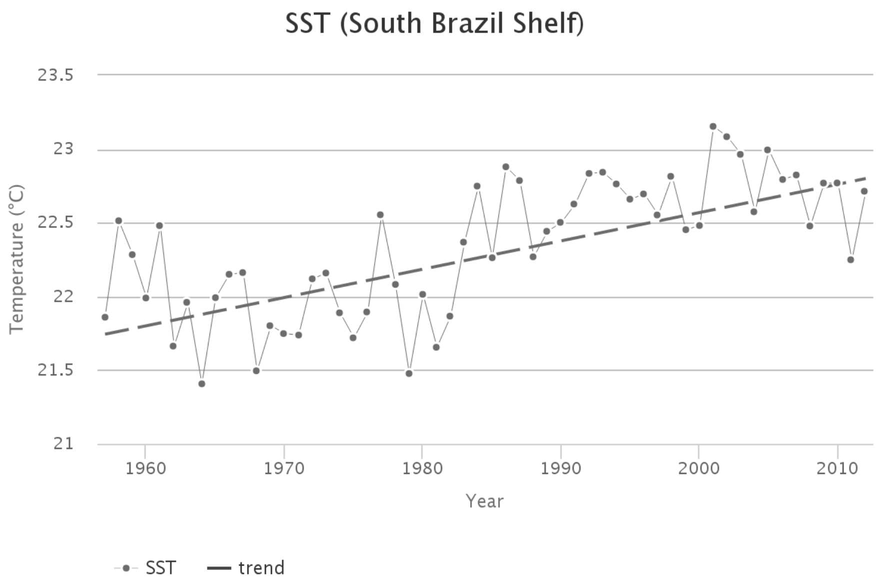
Primary productivity





Sea Surface Temperature

Between 1957 and 2012, the South Brazil Shelf LME #15 has warmed by 1.07°C, thus belonging to Category 2 (fast warming LME). The thermal history of this LME consisted of two epochs. The relatively cold epoch of the 1960s-1970s lasted through 1982, followed by abrupt transition to the warm epoch of the 1980s -1990s that culminated in the all-time maximum of >23.1°C in 2001. The recent SST reversal resulted in a cooling of >0.8°C over 10 years. The SST range between the near absolute minimum of 21.5°C in 1979 and the absolute maximum of >23.1°C in 2001 was >1.6°C in 22 years, similar to other Category 2 (fast warming) LMEs. The thermal history of the South Brazil Shelf LME #15 and adjacent East Brazil Shelf LME #16 are different despite these LMEs' proximity to one another. Divergent ocean currents east of Brazil explain this difference.

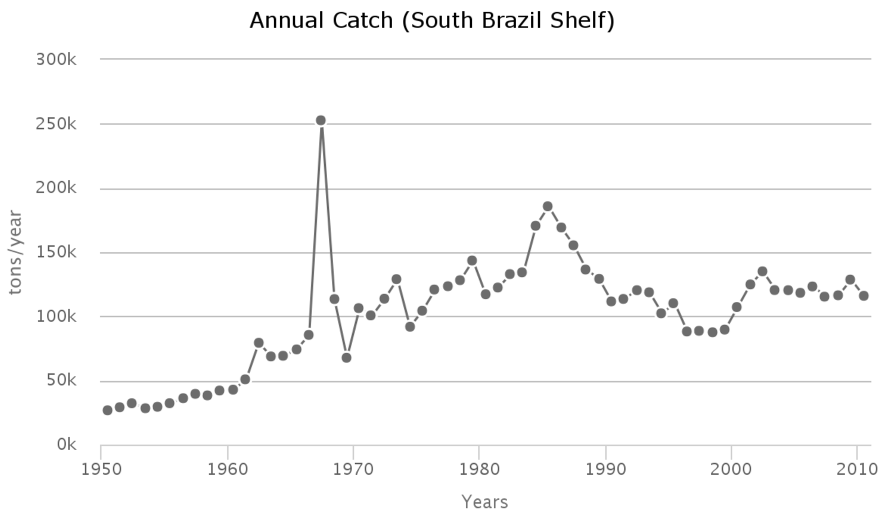


Fish and Fisheries

The South Brazilian Bight contributes about half of Brazil's commercial fisheries yield. Sardines and anchovies represent the most important groups in shelf catches, while the important demersal species are Argentine hake (*Merluccius hubbsi*), croakers (*Umbrina canosai*, *Micropogonias furnieri*) and shrimp. There is increasing expansion and importance of the oceanic fisheries in Brazil, particularly for tuna.

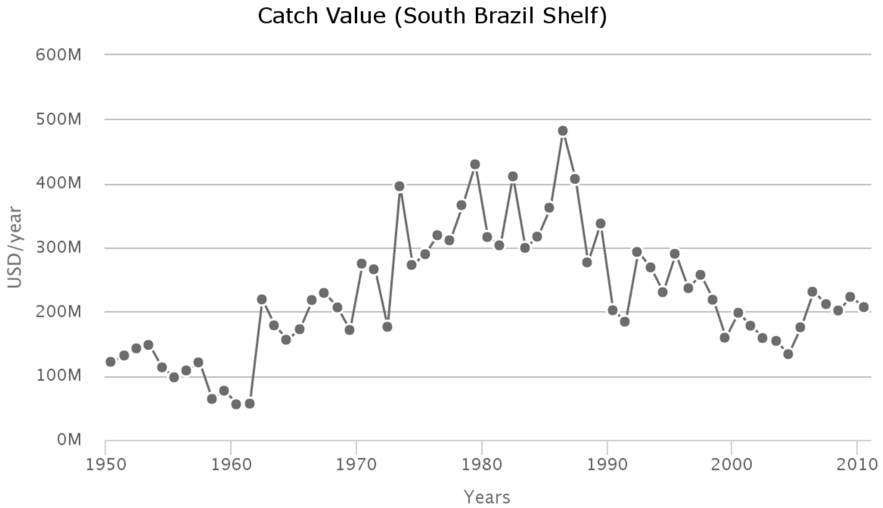
Annual Catch

Total reported landings showed an increase up to 1967, when landings peaked at 250,000 tonnes, but have since declined to 110,000 tonnes in recent years.



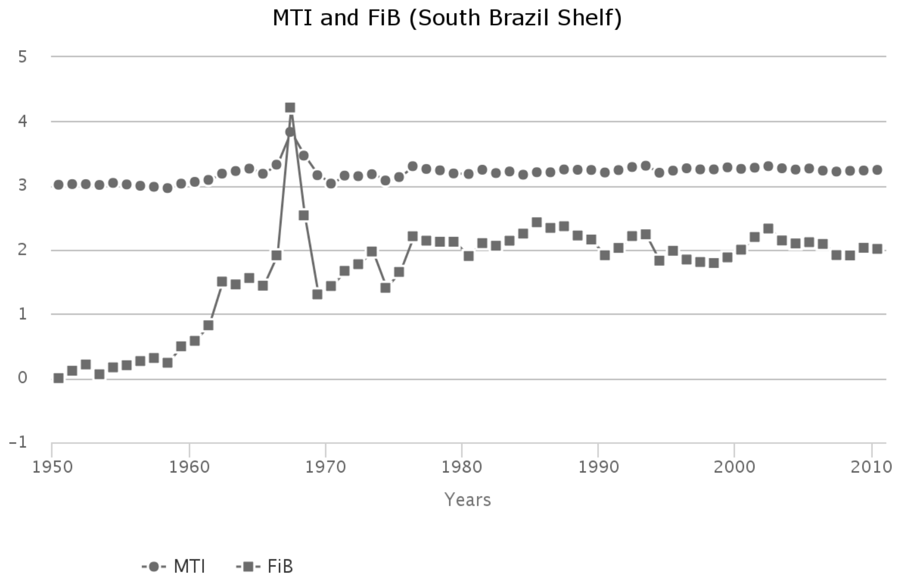
Catch value

The value of the reported landings reached about 480 million US$ (in 2005 real US$) in 1986, with crustaceans accounting for a significant fraction of this.



Marine Trophic Index and Fishing-in-Balance index

Both the MTI as well as the FiB index show an increase from the late 1950s. This pattern is indicative of the geographical expansion of the fisheries in the LME. These trends may imply that the targeting of higher trophic-level species could be masking any 'fishing down' effect in the catch.

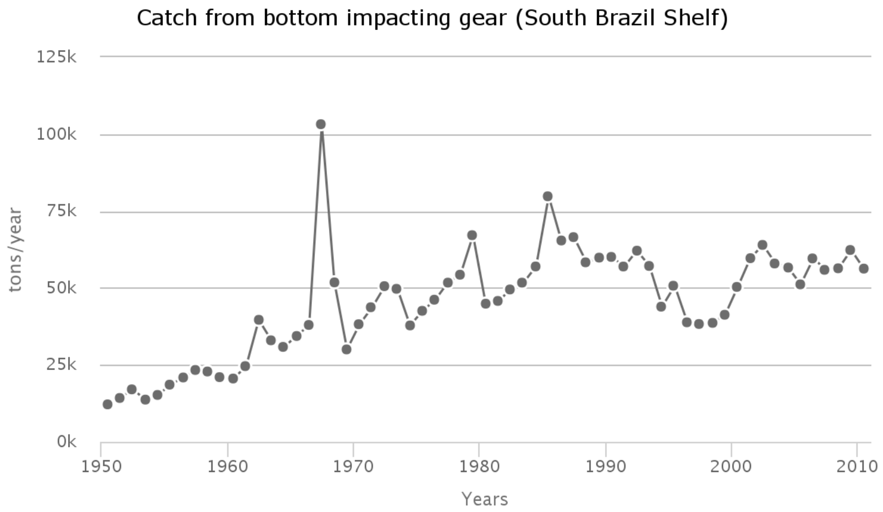


Stock status

The Stock-Catch Status Plots indicate that about 40% of commercially exploited stocks in the LME are either overexploited or have collapsed, with almost 50% of the reported landings supplied by fully exploited stocks.

Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch reaches its maximum at 60% in 1958 and then this percentage fluctuated between 30 to 55% in these few decades.

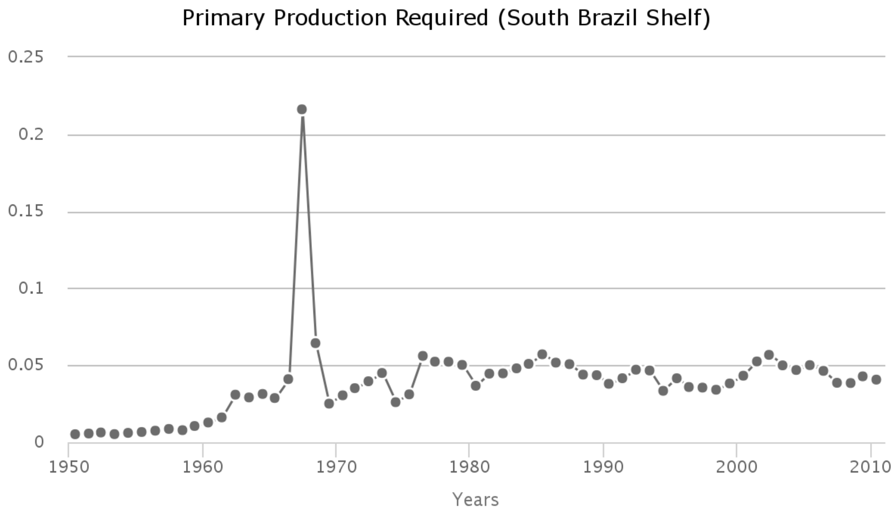


Fishing effort

The total effective effort increased from around 4 million kW in 1950 to its peak at 80 million kW in 2003.

Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME reached 12% of the observed primary production in the mid-1980s, and has fluctuated between 6 to 9% in recent years. This is probably an underestimate due to unreported landings.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was low (level 2 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained low in 2030 and increased to moderate by 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this increased to moderate in 2030 and increased further to high in 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this remained the same in 2030 and increased to high in 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
2	2	2	2	3	2	3	4	4

Legend: Very low, Low, Medium, High, Very high

POPs

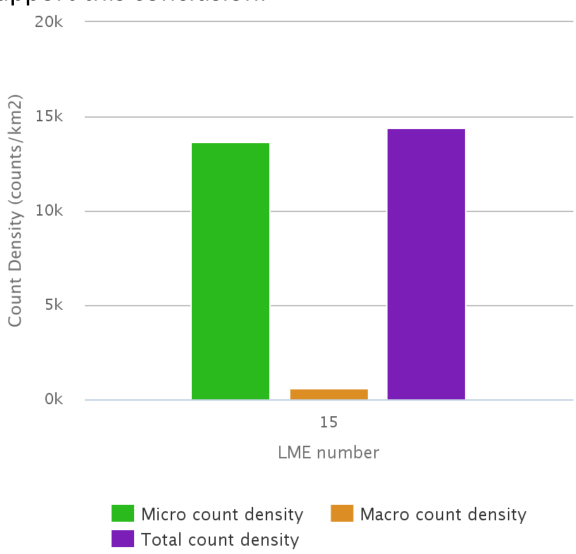
Eleven samples at 10 locations are available, mostly from the Sao Paulo coast. The coast is heavily impacted by PCBs (averaged concentration of PCBs of 1,759 ng.g^{-1} of pellets). This is one of the highest concentrations among all the locations sampled worldwide. It is worth noting that PCB concentrations rapidly increased from about 300 ng.g^{-1} in 2009 to about 3,000 ng.g^{-1} in 2012. The pollution level of PCBs in 2012 corresponds to category 5 of the five risk categories (1 = lowest risk; 5 = highest risk) and poses a high risk for consumption of seafood. There is urgent need to understand the latest pollution status, identify the sources of PCBs, and take necessary actions depending on the sources. The average DDTs concentration (25 ng.g^{-1} of pellets) is moderate in this LME, corresponding to risk category 3.

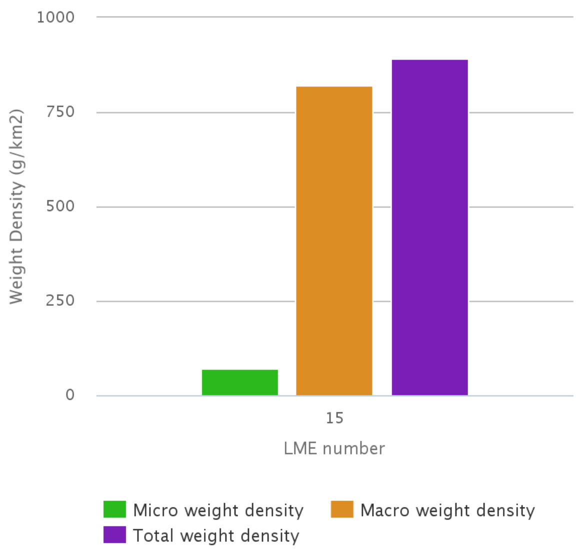
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
11	1759	5	25	3	2.4	2

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km-2), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively high levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 100 times higher that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

Mangrove and coral cover

0.12% of this LME is covered by mangroves (US Geological Survey, 2011).

Reefs at risk

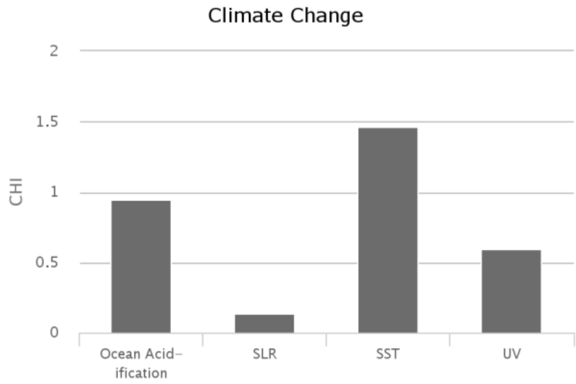
Not applicable.

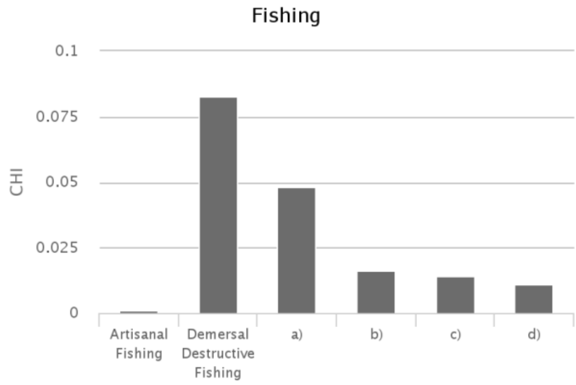
Marine Protected Area change

The South Brazil Shelf LME experienced an increase in MPA coverage from 55 km^2 prior to 1983 to 3,296 km^2 by 2014. This represents an increase of 5,903%, within the medium category of MPA change.

Cumulative Human Impact

The South Brazil Shelf LME experiences an above average overall cumulative human impact (score 3.89; maximum LME score 5.22), which is well above the LME with the least cumulative impact. It falls in risk category 4 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (0.94; maximum in other LMEs was 1.20), UV radiation (0.60; maximum in other LMEs was 0.76), and sea surface temperature (1.46; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, and demersal destructive commercial fishing.





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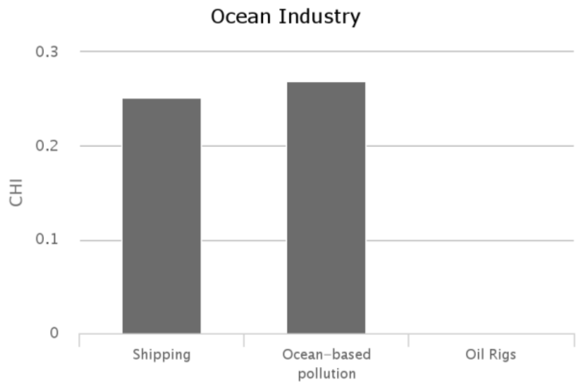
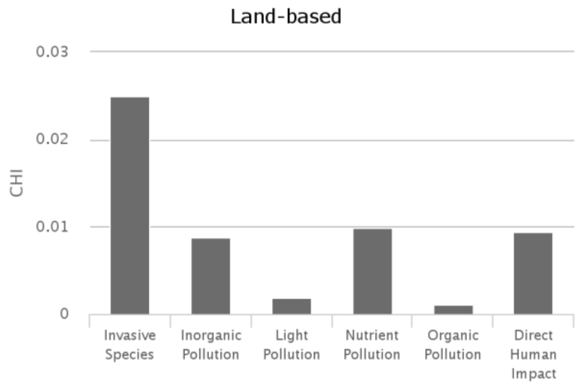
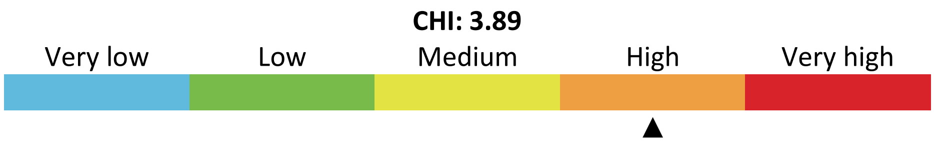
d) Pelagic Low Bycatch Fishing

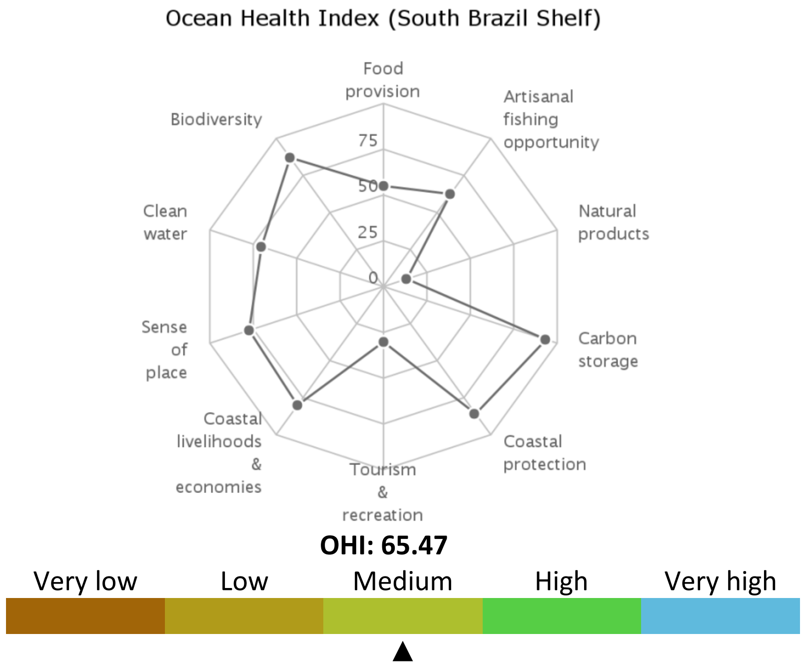






Ocean Health Index

The South Brazil Shelf LME scores below average on the Ocean Health Index compared to other LMEs (score 69 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 increased 2 points compared to the previous year, due in large part to changes in the scores for coastal livelihoods and clean waters. This LME scores lowest on mariculture, natural products, tourism & recreation and iconic species goals and highest on artisanal fishing opportunities, carbon storage, coastal economies, lasting special places and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the South Brazil Shelf LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area extends from Rio de Janeiro in the north to Rio Grande do Sul in the south and covers a total of 214,895 km^2. A current population of 57 million is projected to almost double to 108 million in 2100, and density increasing from 264 persons per km^2 in 2010 to 504 per km^2 by 2100. About 10% of coastal population lives in rural areas, and is projected to increase in share to 19% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
56,773,506	108,248,326	9,124,236	23,800,428

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 21% of the LME's coastal dwellers. The South Brazil Shelf LME places in the high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor
11,808,889

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The South Brazil Shelf LME ranks in the low revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $223 million for the period 2001-2010. Fish protein accounts for 5% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $113,066 million places it in the very high revenue category. On average, LME-based tourism income contributes 10% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the South Brazil Shelf LME falls in the category that is of high economic development, thus with low risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
223,115,104	5.4	113,067,000,000	9.8	0.6805

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day South Brazil Shelf LME HDI belongs to the medium HDI and medium-risk category. Based on an HDI of 0.739, this LME has an HDI Gap of 0.261, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The South Brazil Shelf LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.7394	0.8818	0.5205

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national

GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).
The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.
Present day climate threat index to the South Brazil Shelf LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.6627	0.3898	0.4147	0.6627

Legend:

Very low Low Medium High Very high

Governance

Governance architecture

For this LME neither of the two transboundary arrangements have any formal linkages although they both address highly migratory pelagic species, one of high commercial value and one for conservation purposes. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.
The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
100	**36**	**0**

Legend:

Very low Low Medium High Very high

LME 16 – East Brazil Shelf

Bordering country: Brazil.
LME Total area: 1,073,210 km^2

List of indicators

LME overall risk

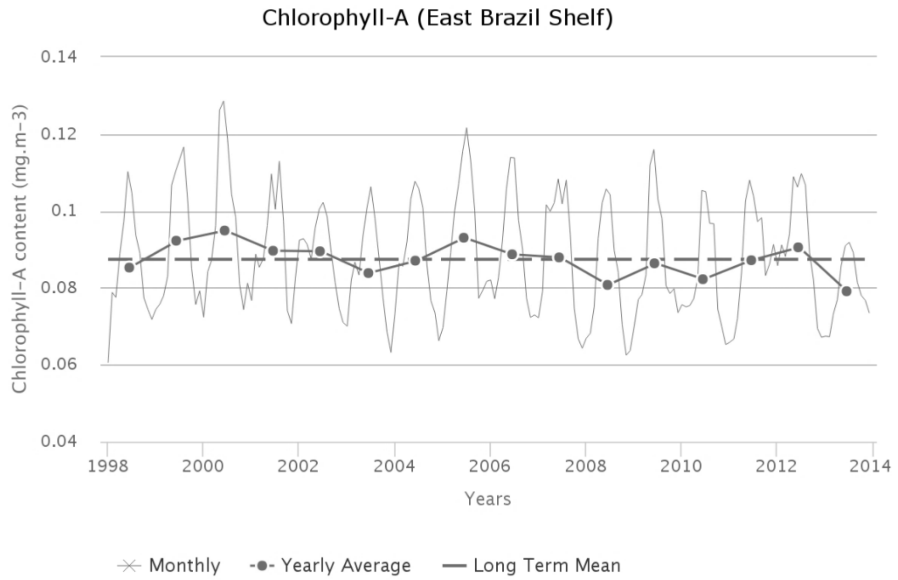
This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

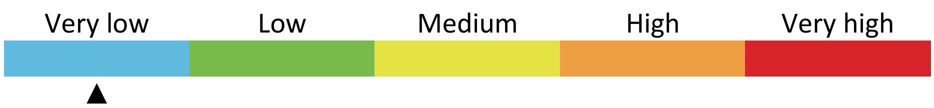
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Productivity

Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.107 $mg.m^{-3}$) in June and a minimum (0.0713 $mg.m^{-3}$) during December. The average CHL is 0.0874 $mg.m^{-3}$. Maximum primary productivity (146 $g.C.m^{-2}.y^{-1}$) occurred during 1999 and minimum primary productivity (119 $g.C.m^{-2}.y^{-1}$) during 2013. There is a statistically insignificant decreasing trend in Chlorophyll of -3.58 % from 2003 through 2013. The average primary productivity is 133 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 1 of 5 categories (with 1 = lowest and 5= highest).

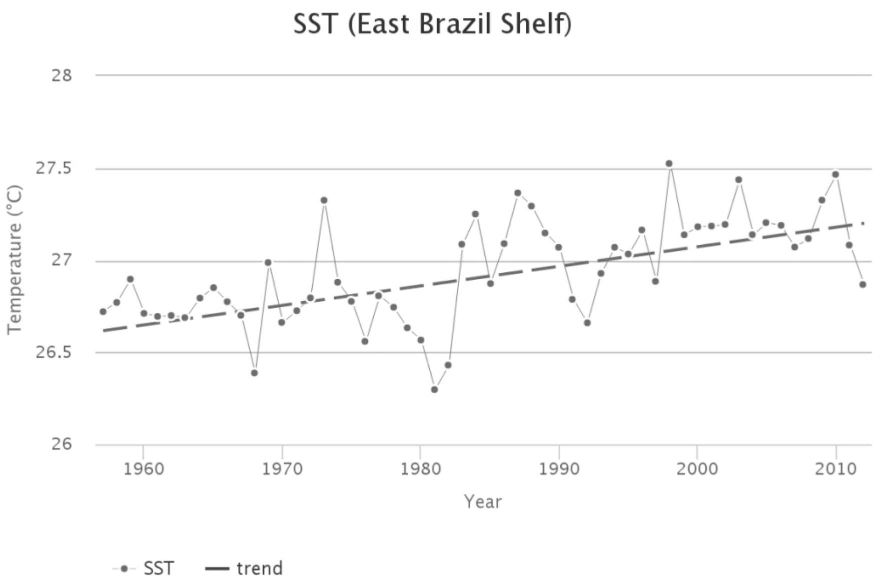




Primary productivity

Sea Surface Temperature

From 1957 to 2012, the East Brazil Shelf LME #16 has warmed by 0.59°C, thus belonging to Category 3 (moderate warming LME). The thermal history of the East Brazil Shelf has been quite non-uniform. The absolute maximum SST of 27.5°C was reached in 1998, after which SST decreased down to 26.9°C in 2012. The most significant events since 1957 were the SST drop down to 26.3°C in 1981 and the 1°C warming between 1981-84, the latter being similar to and largely concurrent with the South Brazil Shelf warming. The above-noted synchronism is however mostly limited to the early 1980s cold spell. Otherwise, the thermal histories of the South and East Brazil Shelf LMEs (respectively #15 and #16) correlate poorly. Divergent currents east of Brazil explain this discordance. Alongshore currents off the Brazilian coast flow in opposite directions, due south/southwest in the South Brazil Shelf LME and due northwest in the northern part of the East Brazil Shelf LME.

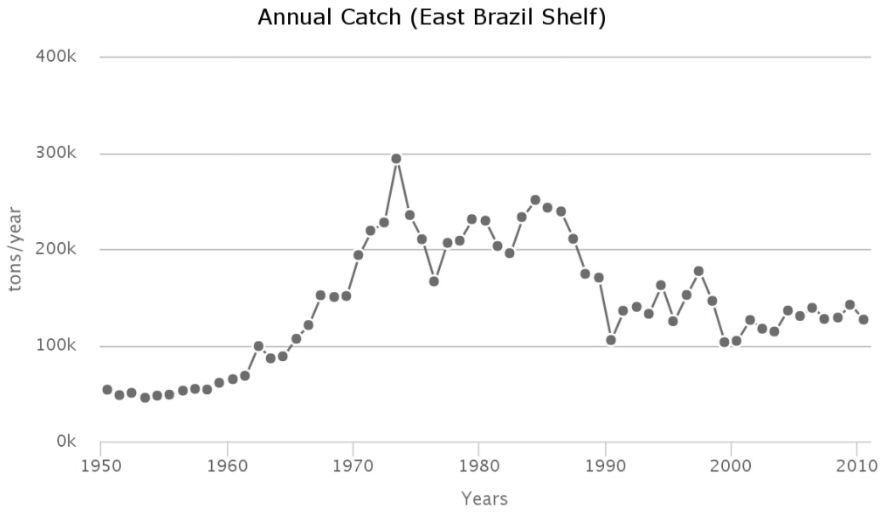


Fish and Fisheries

The fisheries of this LME are mainly artisanal, although commercial fisheries for lobster, shrimp and southern red snapper are significant in the states of Ceará, Rio Grande do Norte and Espírito Santo. Tuna (mainly bigeye) are fished in offshore areas and landed mainly in Rio Grande do Norte and Paraíba.Xxx

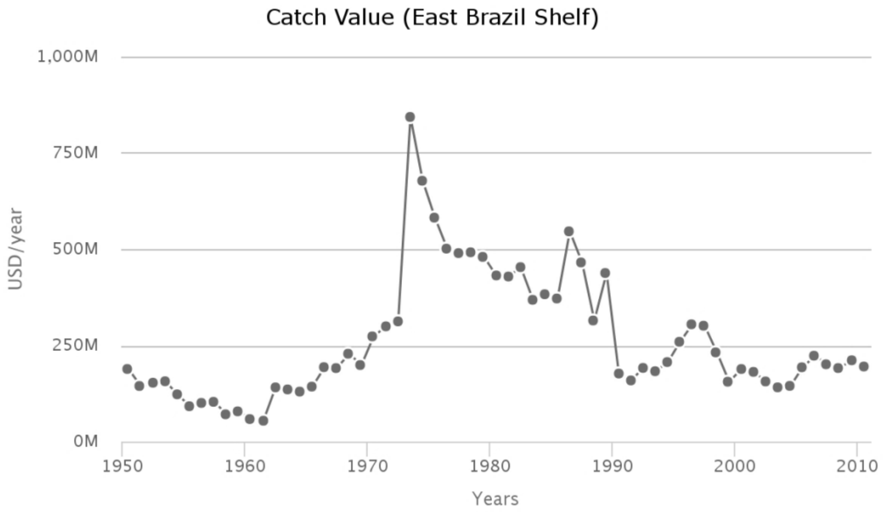
Annual Catch

Total reported landings in the LME increased to 300,000 tonnes in 1973 with Brazilian sardinella (Sardinella brasiliensis) accounting for two-thirds of the landings, but have declined over the past three decades, recording 130,000 tonnes in the recent years. However, a large quantity of fish bycatch from shrimp trawlers is not included in the underlying statistics.



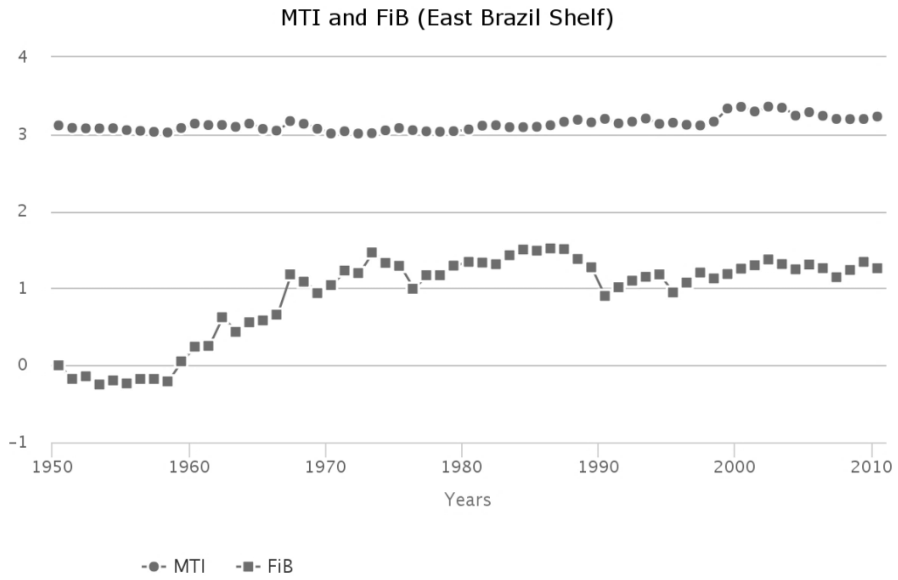
Catch value

The value of the reported landings peaked at 840 million US$ (in 2005 real US$) in 1973, with landings of crustaceans accounting for the large share.



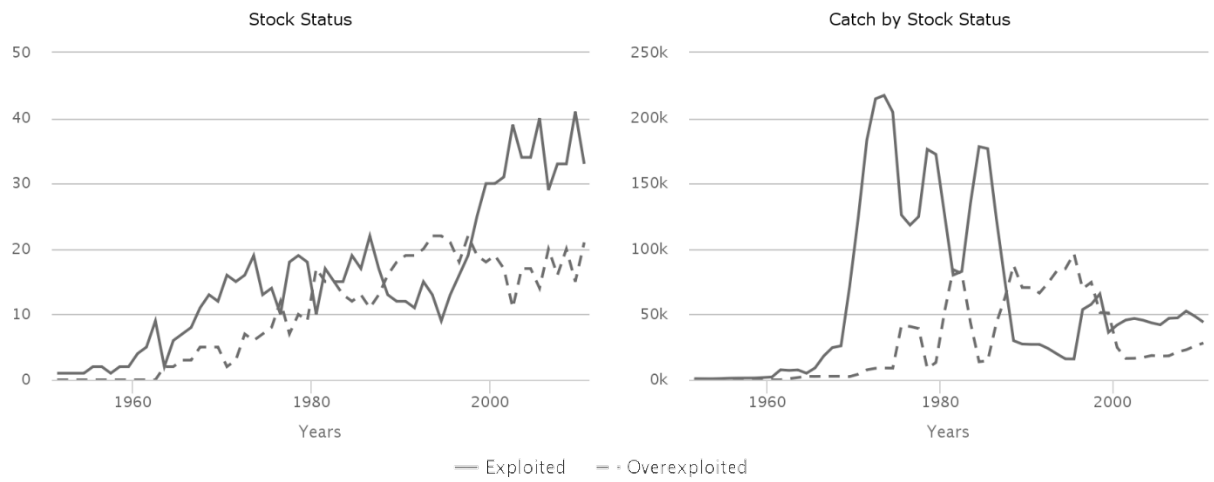
Marine Trophic Index and Fishing-in-Balance index

The MTI has remained level at around 3.1 until the late 1990s, when it shifted to around 3.3. Such a shift is likely due to the large decline in the landings of low trophic Brazilian sardinella recorded from 1997 to 1999. As for the FiB index, the expansion of the fisheries in the 1950s and 1960s is represented by an increase in the FiB index, though it has since been on a generally declining trend.



Stock status

The Stock-Catch Status Plots indicate that nearly 50% of commercially exploited stocks in the LME are either overexploited or have collapsed. A similar interpretation can also be made of the contribution to the reported landings biomass, where 20% of the landings are supplied by overexploited and collapsed stocks. However, given the quality of the underlying catch statistics, this diagnosis is tentative, even though its severity is likely to apply.



Catch from bottom impacting gear

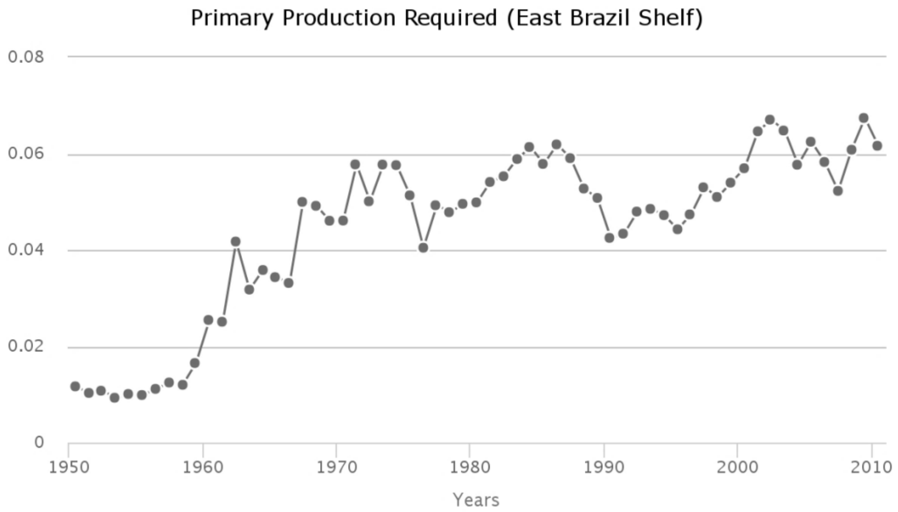
The percentage of catch from the bottom gear type to the total catch reached its first peak at 23% in 1966 and then declined to less than 10% in the 1970s. In the recent decade, this percentage fluctuated around 20%.

Fishing effort

The total effective effort continuously increased from around 10 million kW in the 1950s to its peak at 100 million kW in the late 1990s.

Primary Production Required

The primary production required (PPR) to sustain the reported landings for the LME reached 7% of the observed primary production in the early 1970s, and has fluctuated between 5 to 6% in recent years. This is probably an underestimate due to the large under-reporting of catch in the region.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular nitrogen load) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the ratio of nutrients entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (Merged Nutrient Indicator) based on 2 sub-indicators: Nitrogen Load and Nutrient Ratio (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was low (level 2 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and increased to high in 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			**2030**			**2050**		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
2	3	2	2	3	2	2	4	2

Legend:

Very low Low Medium High Very high

POPs

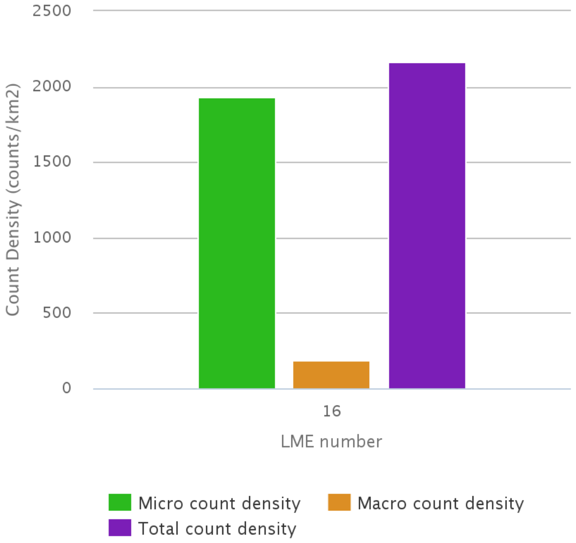
Only one sample is available for this LME from Morro de Sao Paulo. The location shows a concentration (ng.g^{-1} of pellets) of 65 for PCBs, 777 for DDTs, and 4.7 for HCHs. These correspond to risk category 3 for PCBs, 5 for DDTs, and 2 for HCHs, of the five risk categories (1 = lowest risk; 5 = highest risk). The concentration of DDTs (777 ng.g^{-1} of pellets) was the highest recorded among all the locations for which samples are available. Because of the subtropical climate, the application of DDT pesticide for Malaria control was suspected. More locations should be sampled and analyzed for proper evaluation of the LME.

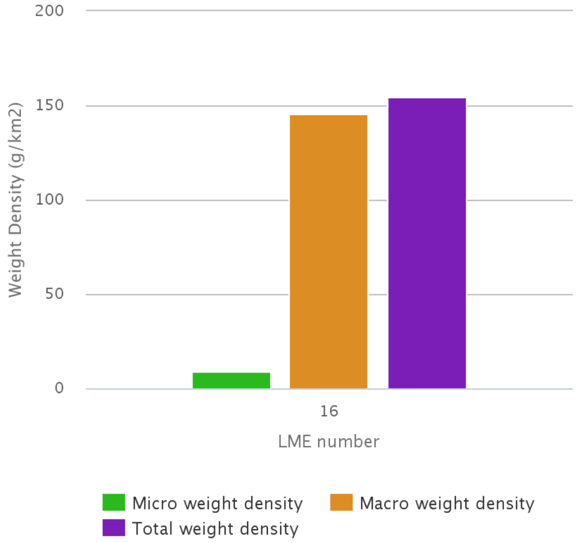
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
1	65	**3**	777	**5**	4.7	**2**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively low levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The low values are due to the relative remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be on average over 40 times lower that those LMEs with the highest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





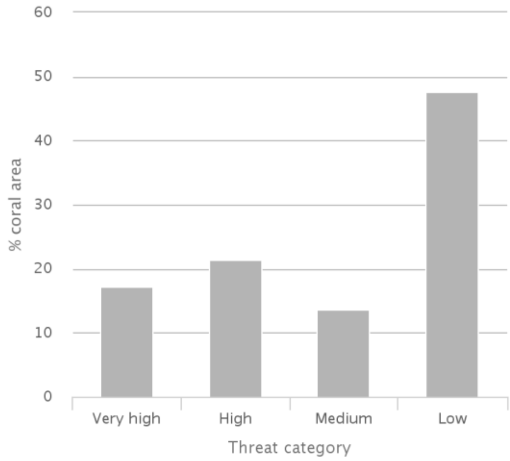
Ecosystem Health

Mangrove and coral cover

0.14% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.1% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 208. 17% of coral reefs cover is under very high threat, and 21% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 29% and 18% for very high and high threat categories respectively. By year 2030, 28% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 39% by 2050.

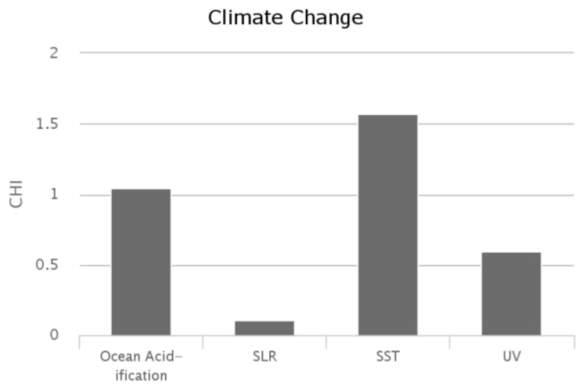


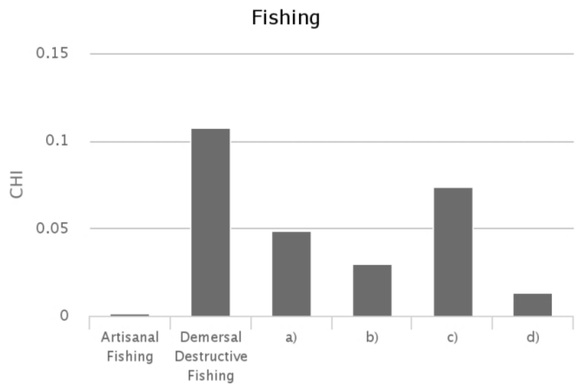
Marine Protected Area change

The East Brazil Shelf LME experienced an increase in MPA coverage from 354 km^2 prior to 1983 to 16,399 km^2 by 2014. This represents an increase of 4,536%, within the medium category of MPA change.

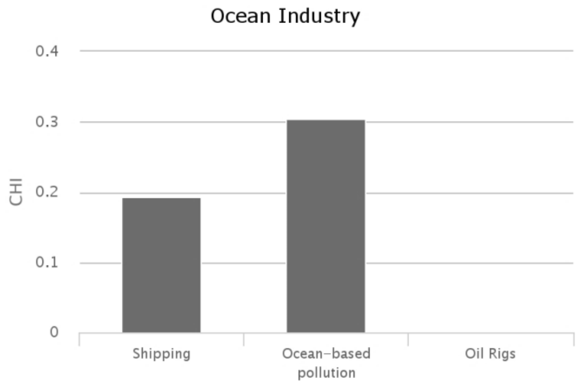
Cumulative Human Impact

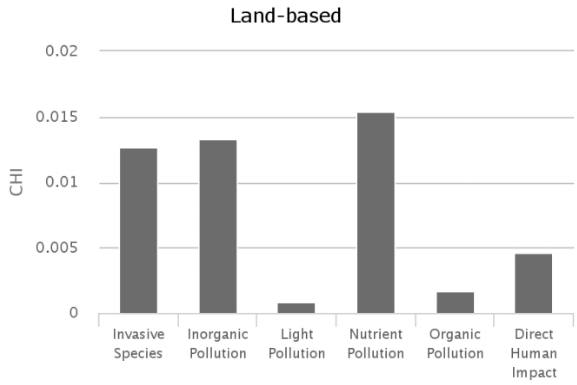
The East Brazil Shelf LME experiences well above average overall cumulative human impact (score 4.13; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 4 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.04; maximum in other LMEs was 1.20), UV radiation (0.60; maximum in other LMEs was 0.76), and sea surface temperature (1.57; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, pelagic high-bycatch commercial fishing, and demersal destructive commercial fishing.

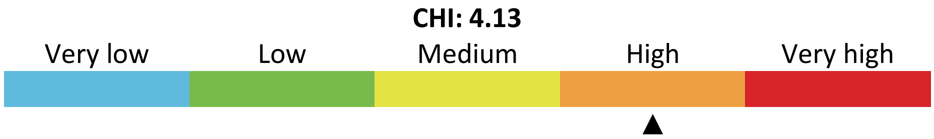




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

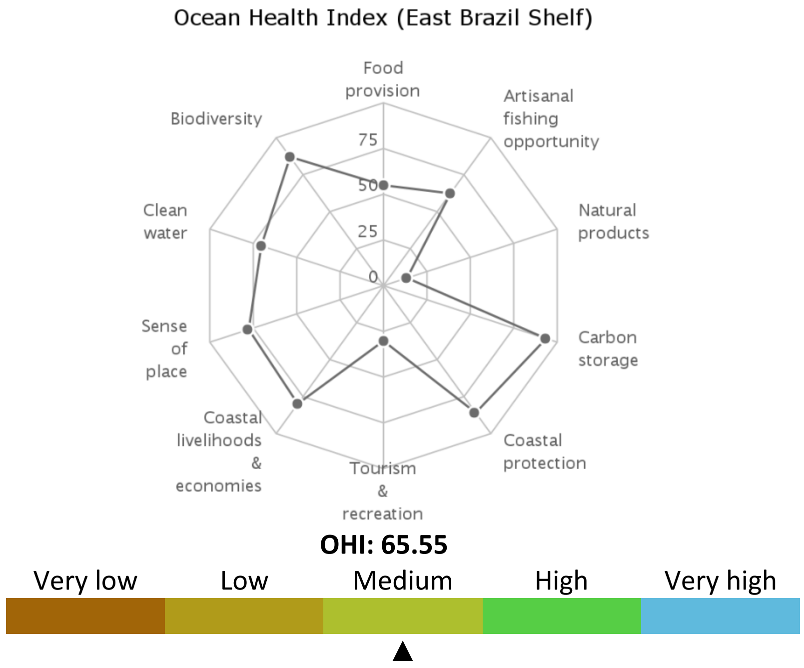






Ocean Health Index

The East Brazil Shelf LME scores below average on the Ocean Health Index compared to other LMEs (score 69 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 increased 2 points compared to the previous year, due in large part to changes in the scores for coastal livelihoods and clean waters. This LME scores lowest on food provision, natural products, tourism & recreation and iconic species goals and highest on artisanal fishing opportunities, carbon storage, coastal economies, lasting special places, and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the East Brazil Shelf LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area extends from Piaui in the north to Rio de Janeiro in the south and covers a total of 302,293 km^2. A current population of 34 million is projected to increase to 49 million in 2100, and density increasing from 113 persons per km^2 in 2010 to 162 per km^2 by 2100. About 38% of coastal population lives in rural areas, and is projected to increase in share to 40% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
34,010,597	49,074,792	13,070,152	19,666,877

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 21% of the LME's coastal dwellers. The East Brazil Shelf LME places in the high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor
7,074,204

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The East Brazil Shelf LME ranks in the low revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $218 million for the period 2001-2010. Fish protein accounts for 5% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$25,957 million places it in the medium revenue category. On average, LME-based tourism income contributes 10% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the East Brazil Shelf LME falls in the category that is of medium economic development, thus with medium risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
218,434,686	5.4	25,957,913,020	9.8	0.7592

Legend:
Very low Low Medium High Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day East Brazil Shelf LME HDI belongs to the medium HDI and medium-risk category. Based on an HDI of 0.739, this LME has an HDI Gap of 0.261, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The East Brazil Shelf LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.7394	0.8818	0.5205

Legend:
Very low Low Medium High Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index to the East Brazil Shelf LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is medium. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	Contemporary Threat	SSP1	SSP3
0.6562	0.3793	0.4074	0.6521

Legend: Very low, Low, Medium, High, Very high

LME 17 – North Brazil Shelf

Bordering countries: Brazil, France(French Guiana), Guyana, Suriname, Venezuela
LME Total area: 1,034,575 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit high percentages of rural coastal population, high numbers of collapsed and overexploited fish stocks, as well as high proportions of catch from bottom impacting gear.

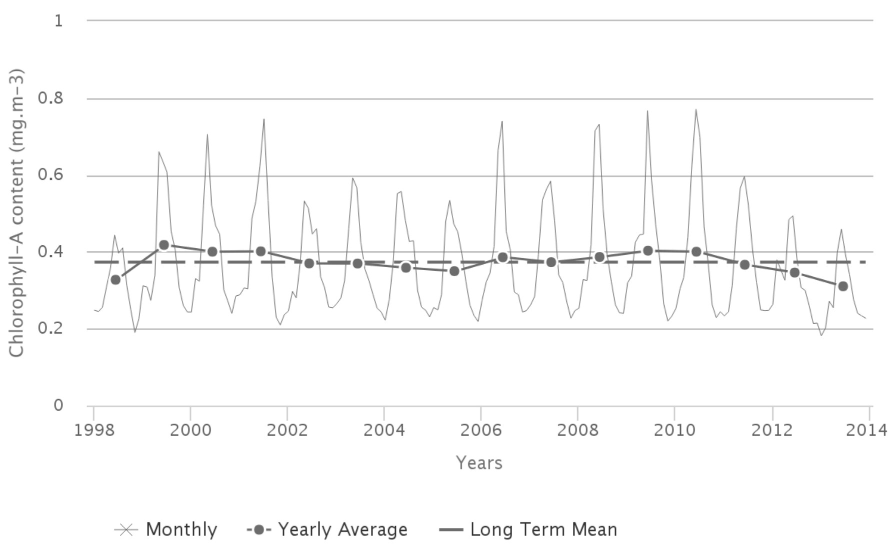
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

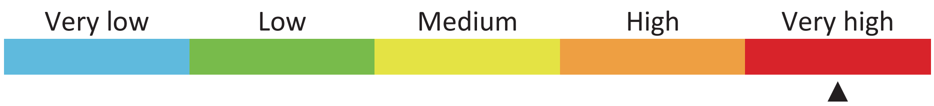
Productivity

Chlorophyll-A

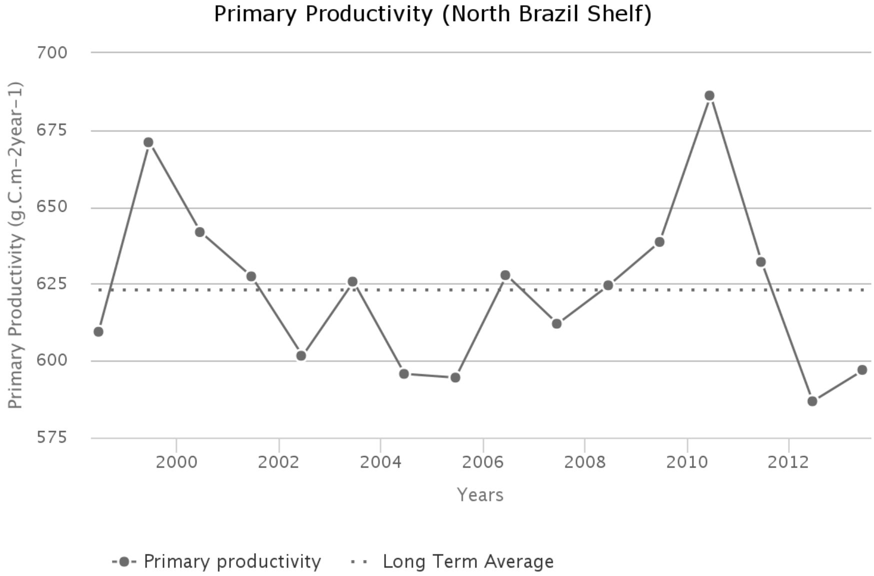
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.598 mg.m^{-3}) in June and a minimum (0.251 mg.m^{-3}) during November. The average CHL is 0.373 mg.m^{-3}. Maximum primary productivity (686 g.C.m^{-2}.y^{-1}) occurred during 2010 and minimum primary productivity (587 g.C.m^{-2}.y^{-1}) during 2012. There is a statistically insignificant increasing trend in Chlorophyll of 1.74 % from 2003 through 2013. The average primary productivity is 623 g.C.m^{-2}.y^{-1}, which places this LME in Group 5 of 5 categories (with 1 = lowest and 5= highest).

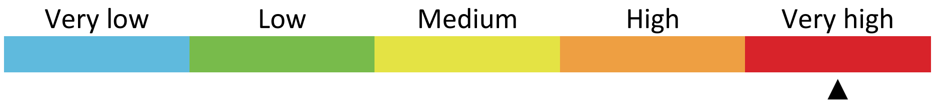
Chlorophyll-A (North Brazil Shelf)





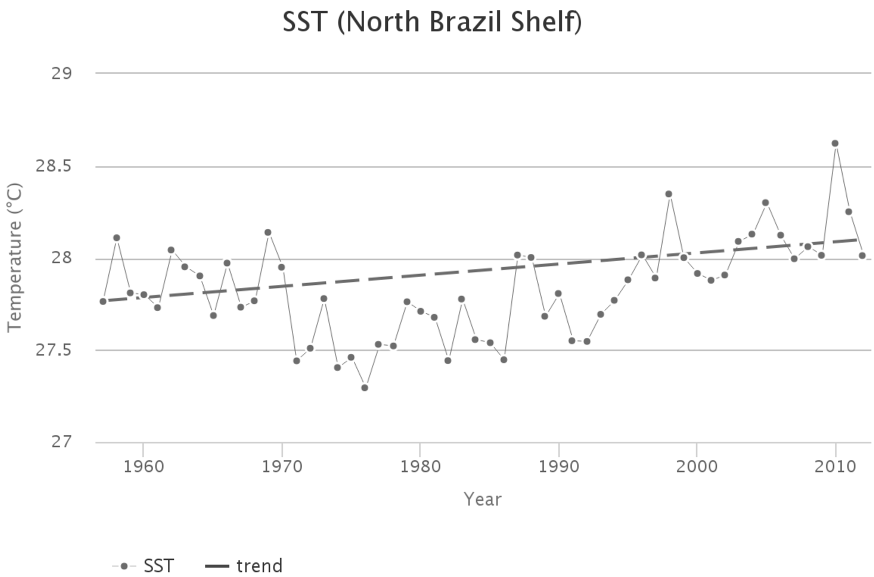
Primary productivity





Sea Surface Temperature

From 1957 to 2012, the North Brazil Shelf LME #17 has warmed by 0.38°C, thus belonging to Category 4 (slow warming LME). The cooling regime of 1957-1976 resulted in the all-time minimum of 27.3°C in 1976, after which a long-term warming peaked at 28.6°C in 2010. The long-term SST increase between 1957 and 2012 amounted to 0.38°C. The SST warming rate between the absolute minimum of 27.3°C in 1976 and the absolute maximum of 28.6°C in 2010 was 1.3°C in 34 years. The well-defined regime shift of 1976 (from cooling to warming) in the North Brazil Shelf LME was decoupled from events in the South Brazil Shelf LME, which can be explained by the divergent pattern of ocean circulation, with currents flowing in opposite directions, due south in the South Brazil Shelf LME and due north in the North Brazil Shelf LME. Among major events, the warm event of 2010 in the North Brazil Shelf LME had no counterpart in the South Brazil Shelf LME, where the SST peaked in 2001 and declined afterward.

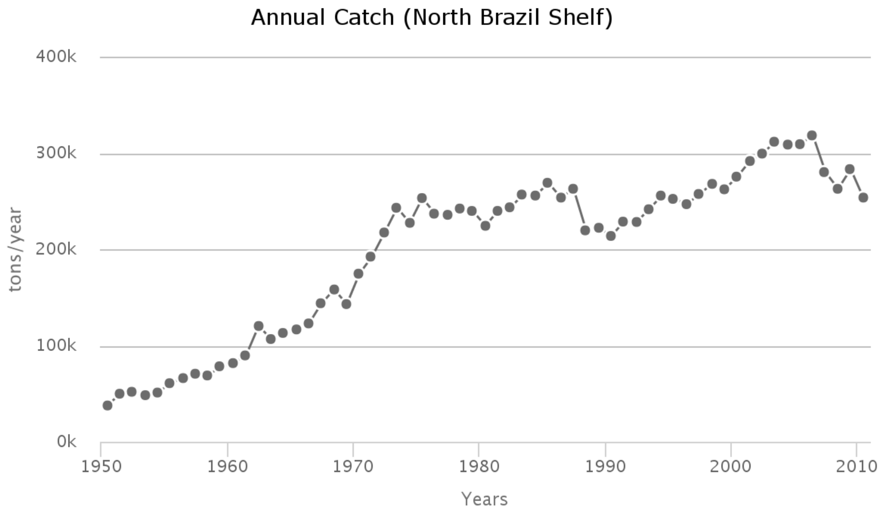


Fish and Fisheries

The multispecies and multigear fisheries of the North Brazil Shelf LME are targeted by both national and foreign fleets. Major exploited groups include a variety of groundfish such as weakfish (*Cynoscion sp.*), whitemouth croaker or corvina (*Micropogonias furnieri*) and sea catfish (*Arius sp.*). The shrimp resources, such as southern brown shrimp (*Penaeus subtilis*), pink spotted shrimp (*P. brasiliensis*), southern pink shrimp (*P. notialis*), southern white shrimp (*P. schmitti*) as well as the smaller seabob (*Xiphopenaeus kroyeri*) support one of the most important shrimp fisheries in the world. Tuna is also exploited.

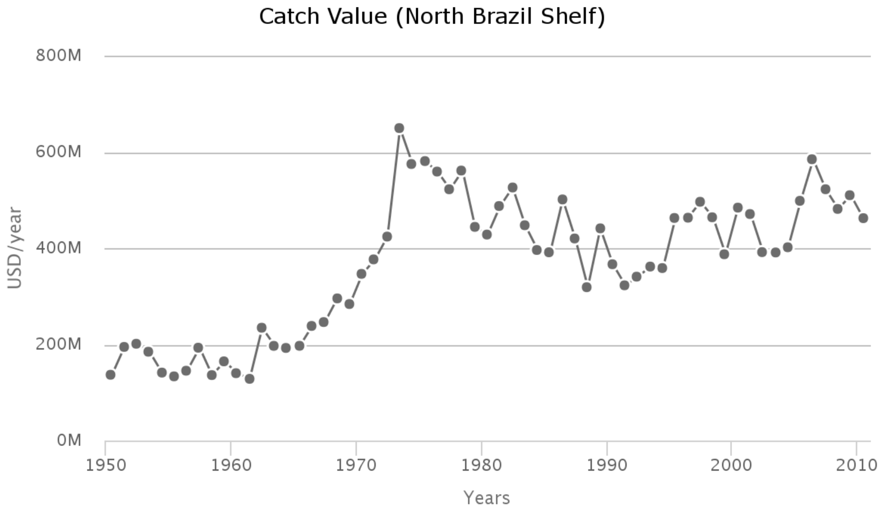
Annual Catch

Total reported landings in this LME increased steadily from 38,000 t in 1950 to 320,000 t in 2006.



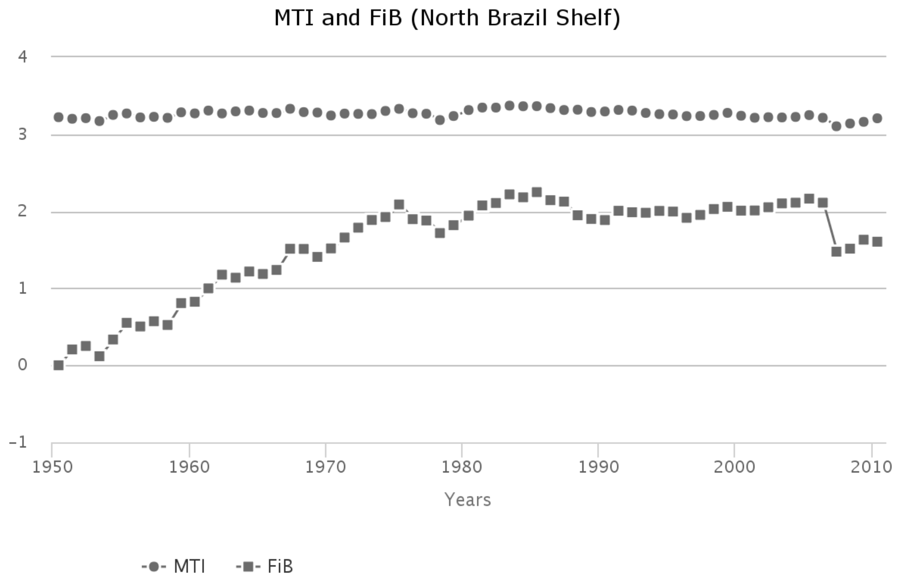
Catch value

The value of the reported landings reached 650 million US$ (in 2005 real US$) in 1973.



Marine Trophic Index and Fishing-in-Balance index

From the mid-1980s, the MTI has undergone a steady decline, a trend indicative of a 'fishing down' of the food webs in the LME, while the flatness of the FiB over the same period implies that the increase in the reported landings have not compensated for the decline in the mean trophic level.

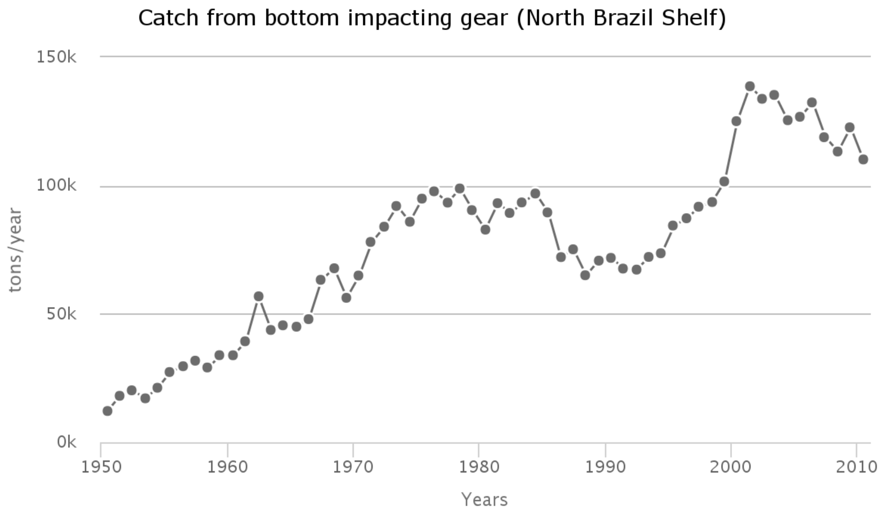


Stock status

The Stock-Catch Status Plots indicate that over 50% of commercially exploited stocks in the LME are either overexploited or have collapsed. However, about 70% of the reported landings come from fully exploited stocks.

Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch ranged between 28 and 48% in these 60 years.

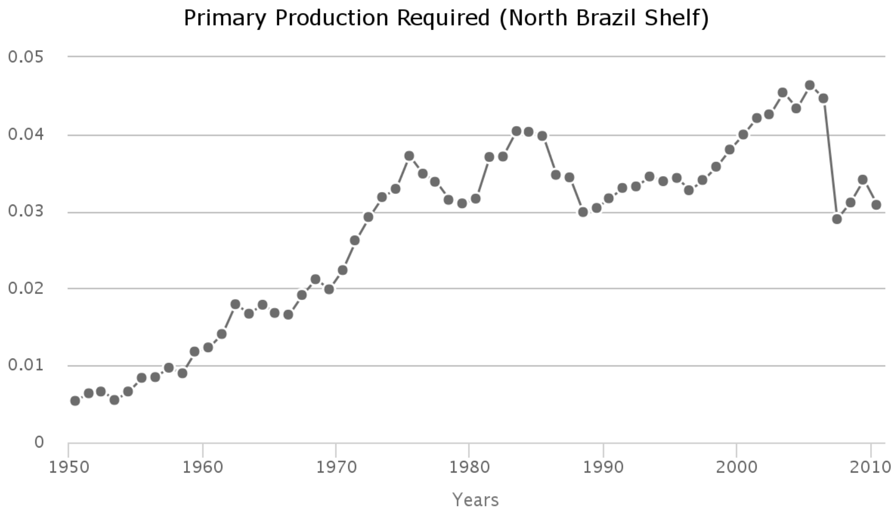


Fishing effort

The total effective effort continuously increased from around 10 million kW in the 1950s to its peak at 80 million kW in the mid-2000s.

Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME is low, currently at 3% of the observed primary production.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was very high. (level 5 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was very high (5). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

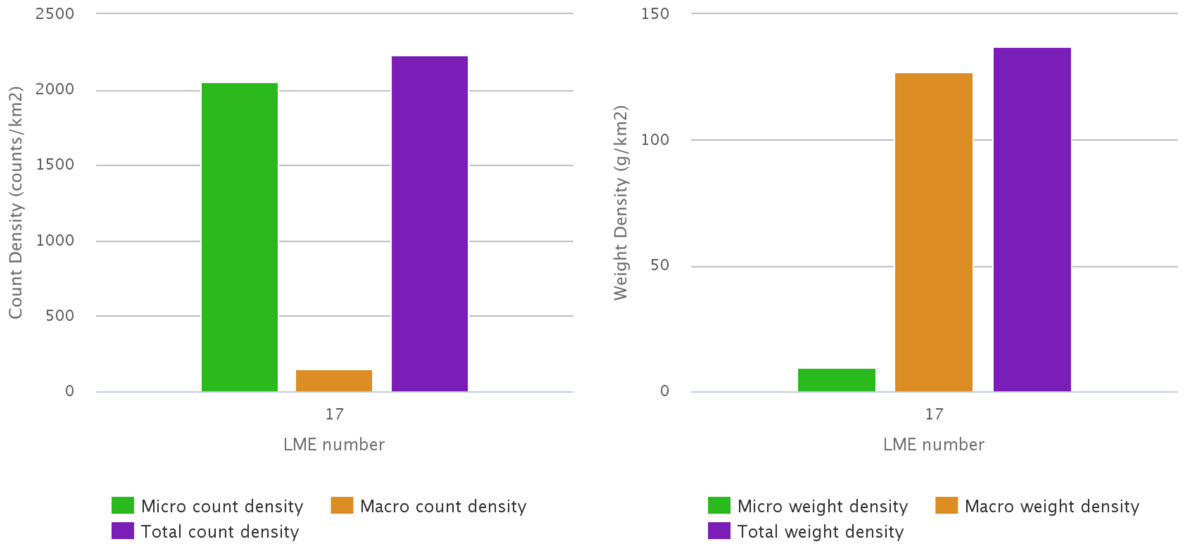
2000			**2030**			**2050**		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
5	1	5	5	1	5	5	1	5

Legend:

Very low · Low · Medium · High · Very high

POPs
No pellet samples were obtained from this LME.

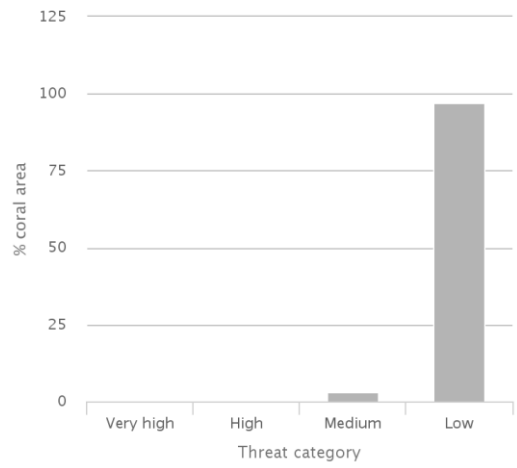
Plastic debris
Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively low levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The low values are due to the relative remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be on average over 40 times lower that those LMEs with the highest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.



Ecosystem Health

Mangrove and coral cover
The North Brazil Shelf has the highest mangrove coverage of any LME, at 10429 km2. This amounts to 0.98% the total area (US Geological Survey, 2011). 0.01% of this LME is covered by coral (Global Distribution of Coral Reefs, 2010).

Reefs at risk
This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 103. This is the lowest integrated threat score of any LME. 92% of coral reefs cover is under low threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), 97% of coral reef cover is rated at medium threat and 3% at high threat. These threat levels are not predicted to change by the year 2030 and 2050.

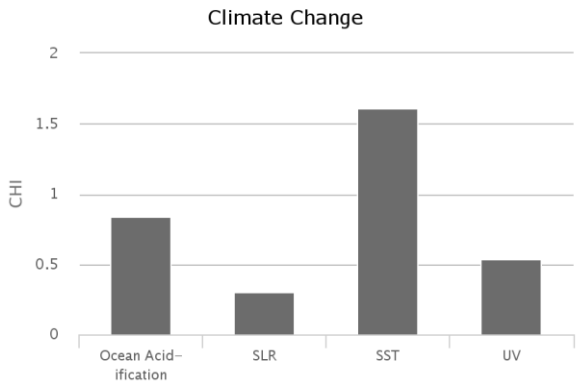


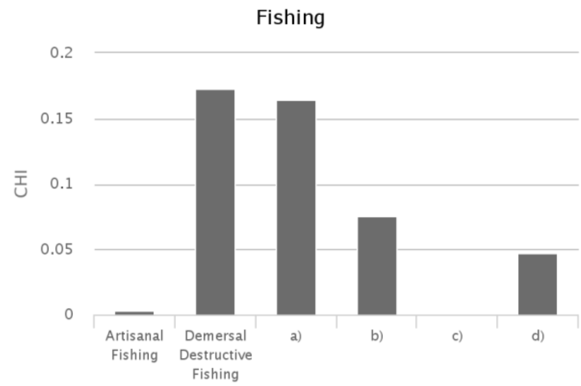
Marine Protected Area change

The North Brazil Shelf LME experienced an increase in MPA coverage from 3,312 km^2 prior to 1983 to 40,957 km^2 by 2014. This represents an increase of 11.4%, within the low category of MPA change.

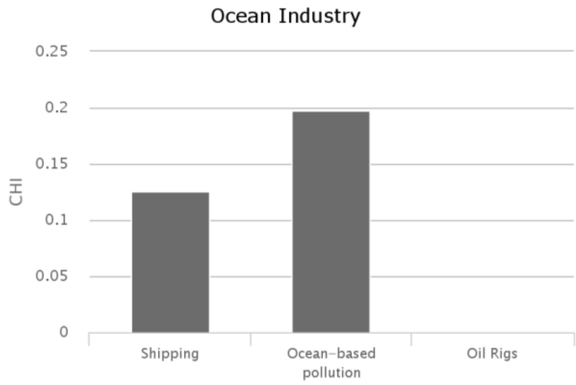
Cumulative Human Impact

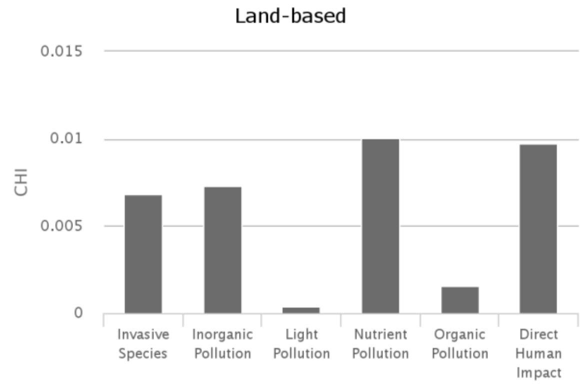
The North Brazil Shelf LME experiences an above average overall cumulative human impact (score 3.81; maximum LME score 5.22), which is well above the LME with the least cumulative impact. It falls in risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, all four connected to climate change have the highest average impact on the LME: sea surface temperature (1.61; maximum in other LMEs was 2.16), ocean acidification (0.84; maximum in other LMEs was 1.20), UV radiation (0.53; maximum in other LMEs was 0.76), and sea level rise (0.30; maximum in other LMEs was 0.71). Other key stressors include commercial shipping, ocean based pollution, and demersal destructive commercial fishing.

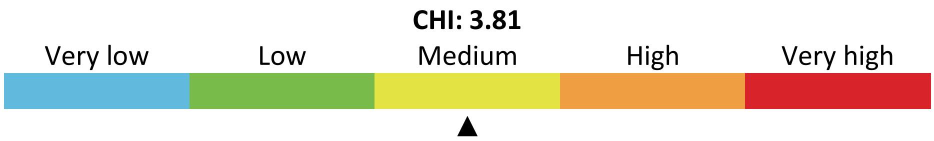




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

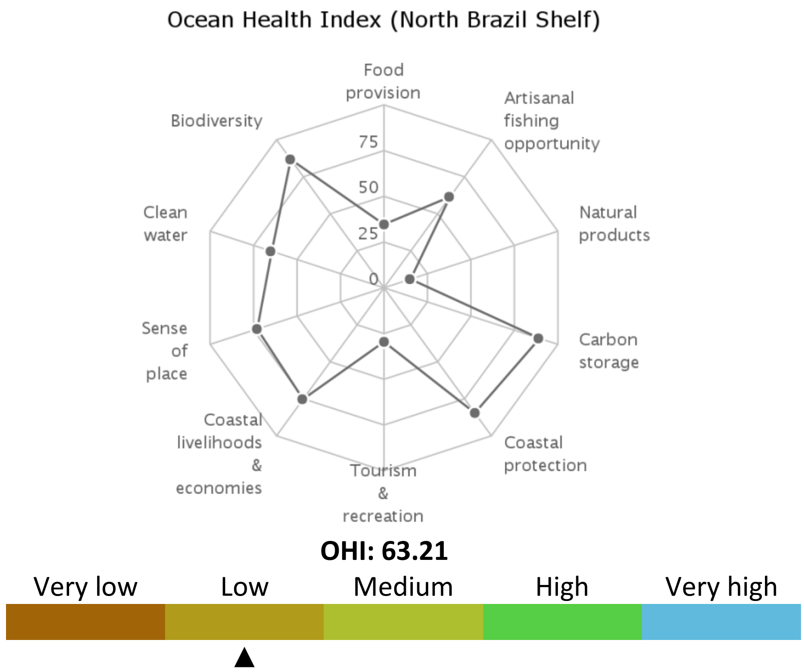






Ocean Health Index

The North Brazil Shelf LME scores below average on the Ocean Health Index compared to other LMEs (score 67 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 increased 2 points compared to the previous year, due in large part to changes in the scores for coastal livelihoods & economies and clean waters. This LME scores lowest on food provision, natural products, tourism & recreation, and iconic species goals and highest on artisanal fishing opportunities, carbon storage, and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the North Brazil Shelf LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The littoral area extends from eastern part of Venezuela in the west to the Brazilian State of Maranhão in the east and covers a total of 508,610 km^2. A current population of 9.6 million is projected to slightly increase to 10.9 million in 2100, and density increasing from 19 persons per km^2 in 2010 to 21 per km^2 by 2100. About 47% of coastal population lives in rural areas, and is projected to increase in share to 55% in 2100.

Total population		Rural population	
2010	2100	2010	2100
9,550,602	10,865,253	4,530,489	5,985,357

Legend: Very low, Low, Medium, High, Very high

Coastal poor:
The indigent population makes up 22% of the LME's coastal dwellers. The North Brazil Shelf LME places in the high-risk category based on percentage and in the medium risk category using absolute number of coastal poor (present day estimate).

Coastal poor
2,115,451

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The North Brazil Shelf LME ranks in the medium revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $561 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $6,541 million places it in the low revenue category. On average, LME-based tourism income contributes 9% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for the North Brazil Shelf LME falls in the category that is of lowest economic development, thus with very high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
560,943,311	8.7	6,540,765,380	9.5	0.8665

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day North Brazil Shelf LME HDI belongs to the medium HDI and medium-risk category. Based on an HDI of 0.731, this LME has an HDI Gap of 0.269, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.
HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). The North Brazil Shelf LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.7311	0.8433	0.5100

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to

2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index to the North Brazil Shelf LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	Contemporary Threat	SSP1	SSP3
0.7250	0.3957	0.4336	0.6395

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

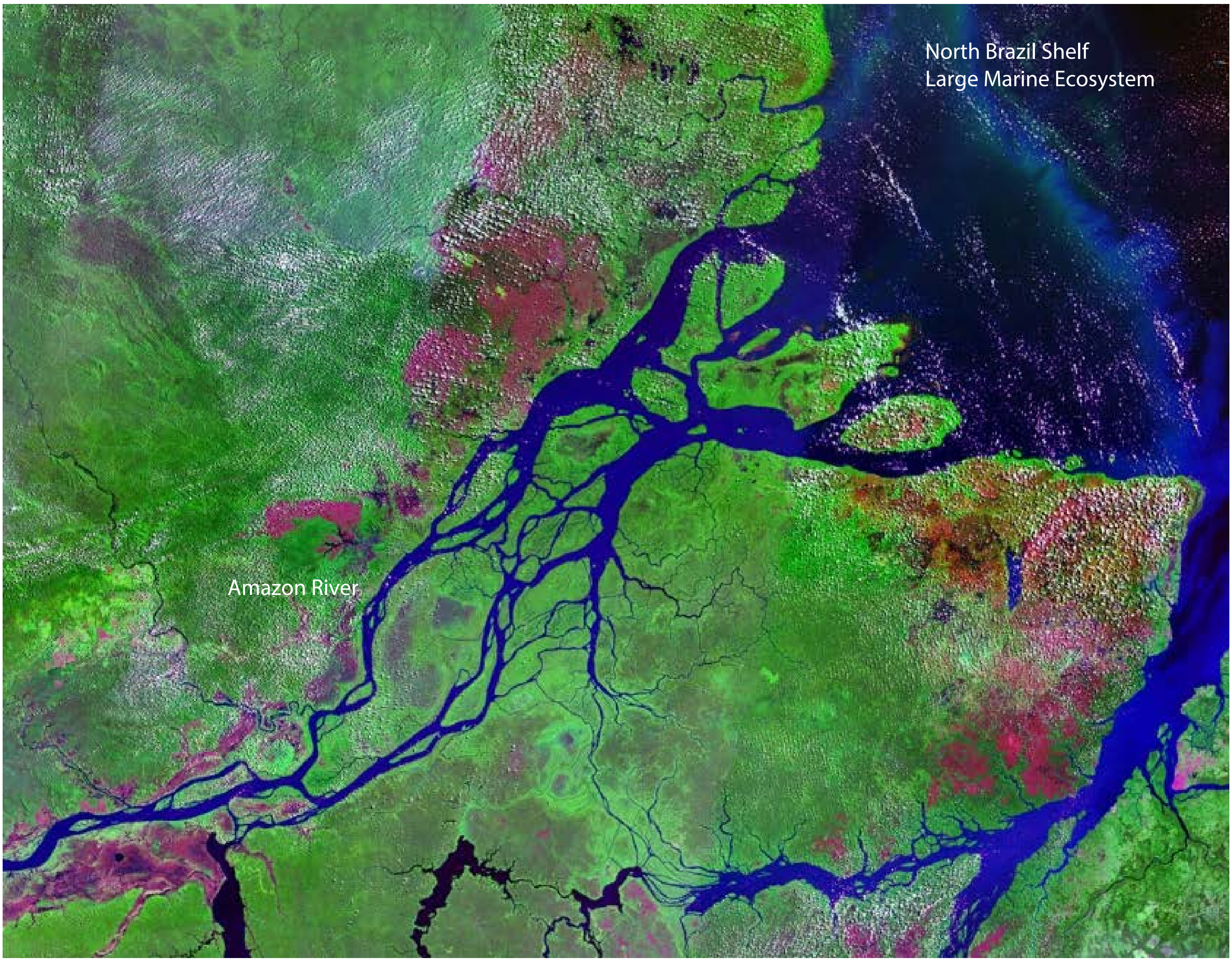
The two transboundary arrangements for fisheries (CRFM and WECAFC) in the areas within national jurisdiction are closely connected. So are the two arrangements for pollution and biodiversity that fall under the Cartagena Convention. However neither of these pairs appears to be integrated with each other or with the tuna arrangement (ICCAT) No integrating mechanisms, such as an overall policy coordinating organization for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
64	58	0.2

Legend:

Very low | Low | Medium | High | Very high



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United Nations Educational, Scientific and Cultural Organization
International Hydrological Programme

United Nations Educational, Scientific and Cultural Organization
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The water systems of the world – aquifers, lakes, rivers, large marine ecosystems, and open ocean- sustain the biosphere and underpin the socioeconomic wellbeing of the world's population. Many of these systems are shared by two or more nations. These transboundary waters, stretching over 71% of the planet's surface, in addition to the subsurface aquifers, comprise humanity's water heritage.

Recognizing the value of transboundary water systems and the reality that many of them continue to be degraded and managed in fragmented ways, the Global Environment Facility Transboundary Waters Assessment Programme (GEF TWAP) was developed. The Programme aims to provide a baseline assessment to identify and evaluate changes in these water systems caused by human activities and natural processes, and the consequences these may have on dependent human populations. The institutional partnerships forged in this assessment are envisioned to seed future transboundary assessments as well.

The final results of the GEF TWAP are presented in the following six volumes:
Volume 1 – ***Transboundary Aquifers and Groundwater Systems of Small Island Developing States: Status and Trends***
Volume 2 – ***Transboundary Lakes and Reservoirs: Status and Trends***
Volume 3 – ***Transboundary River Basins: Status and Trends***
Volume 4 – ***Large Marine Ecosystems: Status and Trends***
Volume 5 – ***The Open Ocean: Status and Trends***
Volume 6 – ***Transboundary Water Systems: Crosscutting Status and Trends***

A *Summary* for Policy Makers accompanies each volume. All TWAP publications are available for download at http://www.geftwap.org

This annex – Transboundary waters: A Global Compendium, Water System Information Sheets: Southern America, Volume 6-Annex C -- is one of 12 annexes to the Crosscutting Analysis discussed in Volume 6. The global compendium organized into 14 TWAP regions, compiles information sheets on 765 international water systems including the baseline values of quantitative indicators that were used to establish contemporary and relative risk levels at system and regional scales. Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

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