Expanding Puerto Rawson

Enhancing Fishery Capacity and Project Cargo Logistics

CEGM3000 Multi-Disciplinary Project

MP370

Delft University of Technology

TUDelft

Expanding Puerto Rawson

Enhancing Fishery Capacity and Project Cargo Logistics

by

MP370

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AADIP Asociación Argentina de Ingenieros Portuarios

Universidad Nacional de la Patagonia San Juan Bosco

PIANC · A.D. 1885 · AIPCN · Navigare Necesse

.UBA fiuba Facultad de Ingeniería

FAST TU Delft University Fund

egip escuela de graduados en ingeniería portuaria

INDUSTRIAS BASS

Preface

This report is the result of a multidisciplinary project undertaken by a team of six students from Delft University of Technology. The project was started in response to the growing demand for expanded port infrastructure in Puerto Rawson, a key fishing port on Argentina's southeastern coast. With a dynamic history and strategic importance to the regional economy, Puerto Rawson now faces both challenges and opportunities as it seeks to modernize its facilities to accommodate increased fishing activities and to support the growing wind energy sector.

Our approach emphasizes sustainability, balancing economic development with environmental preservation. The framework proposed in this report is not only a response to the needs of Puerto Rawson but also a forward-looking strategy that anticipates future demands and aligns with global sustainable development goals.

This project would not have been possible without the guidance and support of our supervisors and the input of various experts, whose contributions enriched our understanding of Puerto Rawson's context. We would like to express our gratitude to our direct supervisors Dr. José Antonílez, Dr. Hayo Hendrikse, ir. Sebastian Iglesias, Mg. Ing. Pablo Arecco, ir. Mathijs Buijs and Dr. Stefano Fazi for their guidance and encouragement throughout the project. We would also like to give a special thanks to Martin Castillo, Rodrigo Bastida Arias, Leandro Foletto, Fernando Iglesias, and other port authorities, for their assistance in Trelew and Puerto Rawson. Finally we would like to thank Bruno Maggiolo, Virginia Sy and Diego Walker for their knowledge and visions, helping our project take shape in Buenos Aires.

We hope this report offers a valuable foundation for the development of a resilient, efficient, and sustainable port at Puerto Rawson, driving meaningful impact in line with the port's potential and future needs.

MP370 *M.P. de Boorder, F.F.M. van Gool, S.R. Ledeboer, R.T. Rhemrev, T. Stukker, R.W. Wildschut*

Abstract

This report, titled *Expanding Puerto Rawson: Enhancing Fishery Capacity and Project Cargo Logistics*, presents a conceptual masterplan for the eco-friendly expansion of the Port of Rawson. The port's proximity to a region abundant in marine resources makes it an attractive location for expansion. However, the port is facing strategic expansion problems and it could fail to accommodate the rise in demand from the fishery industry. This report carefully maps out the gap between the expected rise in demand and the currently existing infrastructure. After that, two models are created to transform the rise in demand that is expected by 2030 & 2040, to nautical demands for the port, like number of berths and required waterway width. The results from these model in combination with a strategic overview of the landscape, were used to come up with three conceptual designs that eventually converged into one final conceptual design by conducting an MCA. This conceptual design, together with the port waste management plan, could enable an eco-friendly and future-ready expansion of the Port of Rawson.

Summary

The Port of Rawson, located on Argentina's Patagonian coast, is a critical fishing hub, particularly for shrimp industries. Given its strategic location near rich marine ecosystems, the port holds significant potential for economic growth. However, its current infrastructure is inadequate to handle the rising demand, leading to logistical constraints that impact both operational efficiency and environmental sustainability. This report outlines a conceptual master plan for the eco-friendly expansion of the Port of Rawson, aiming to address these challenges by enhancing capacity and integrating sustainable practices.

The main objective is to expand the port's fishery handling capacity to align with local needs and future growth targets, while ensuring that expansion is in line with environmental and technical standards. The port also seeks to diversify its operations by integrating renewable energy logistics, positioning itself as a regional hub for wind energy projects.

The existing limitations at Puerto Rawson include a shortage of berthing spaces, restricted operational areas for cargo handling, limited export possibilities, and insufficient equipment for efficient loading and unloading. These issues lead to overcrowding and logistical bottlenecks, particularly during peak fishing seasons. Additionally, the port lacks facilities to manage waste, essential for maintaining its ecological footprint. The expansion project addresses these deficiencies to enable sustainable growth and meet projected demands through 2040.

The report proposes a phased development plan to be implemented by 2030 and 2040. The initial phase focuses on expanding quay lengths, adding berths, and optimizing cargo handling areas to accommodate the growing shrimp, hake, and squid throughput. The second phase aims to enhance the port's ability to handle renewable energy cargo, such as wind turbines, supporting Chubut Province's renewable energy initiatives. This phased approach allows the port to gradually increase capacity while adapting to evolving logistical and environmental requirements.

Three conceptual designs were developed and assessed using a Multi-Criteria Analysis (MCA) based on factors such as cost, scalability, handling capacity, and environmental protection. The preferred option includes a quay extension to the south, expanded dredging, and a jetty on the existing breakwater, allowing for seamless integration with current operations while enabling future growth. In Phase I, the construction of a new breakwater is required to accommodate larger vessels while ensuring compliance with safety regulations and technical standards. The design incorporates eco-friendly materials and nature-inclusive features, such as bio-enhancing concrete, to support marine life around the port.

Environmental sustainability is central to the expansion strategy. The project aligns with several Sustainable Development Goals (SDGs), including promoting economic growth (SDG 8), building resilient infrastructure (SDG 9), fostering sustainable urban development (SDG 11), and conserving marine resources (SDG 14). Waste management is a priority, with plans to introduce waste reception facilities (WRFs) for both public and private sectors at the port. A waste delivery receipt system will also ensure regulatory compliance and transparency in waste handling. Furthermore, the expansion design incorporates eco-friendly features, such as tidal pools and oyster banks, to enhance water quality and support local biodiversity.

A comprehensive risk matrix has been developed to identify and mitigate technical, environmental, political, and financial risks. Key recommendations include conducting detailed soil investigations to avoid geotechnical issues and maintaining strong relationships with regulatory bodies to navigate potential policy shifts. Continuous monitoring and proactive management of risks are essential for the timely completion of the project.

The preferred design alternative, a southern quay extension with expanded dredging and a jetty on the existing breakwater, emerged as the preferred solution for the Port of Rawson's expansion after careful evaluation. This alternative balances scalability, environmental sustainability, and cost-effectiveness, allowing the port to accommodate increased fishing activities and larger vessels in both 2030 and

2040. The design also supports eco-friendly practices, incorporating bio-enhancing materials and nature-inclusive features that protect local marine ecosystems.

By adopting this approach, Puerto Rawson will meet logistical needs and expand into renewable energy logistics, aiding Argentina's wind energy sector. This strategic move strengthens the port's position by diversifying and lessening reliance on seasonal fisheries.

In summary, this master plan provides a sustainable and adaptable framework that ensures Puerto Rawson's long-term viability as a key port in Patagonia. The expansion will foster growth while safeguarding the environment, setting an example of sustainable port operations for the region.

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Nomenclature

λ_1	Arrival rate for Boundary Condition 1
λ_2	Arrival rate for Boundary Condition 2
$\mu_{duration}$	Mean trip duration [hrs]
ρ	Vessel utilization rate
$\sigma_{duration}$	Standard deviation of trip duration [hrs]
A_{TEU}	Area per Twenty-foot Equivalent Unit [m^2]
$BC1$	Boundary Condition 1 (2030)
$BC2$	Boundary Condition 2 (2040)
D_S	Draught of the vessel [m]
h_0	Guaranteed depth of the access channel [m]
L_1	Slowing-down trajectory length [m]
L_2	Fastening trajectory length [m]
L_3	Full-stop trajectory length [m]
L_q	Quay length [m]
L_S	Length of the largest ship [m]
$MRWT$	Maximum Relative Waiting Time
N_c	Total number of containers handled
r_{st}	Nominal stacking height
T	Tidal restriction [m]
$t_{d,\max}$	Maximum dwell time for containers [days]
W	Width of the access channel [m]
W_b	Bank clearance
W_p	Passing width
W_a	Additional width factors
W_{bm}	Maneuvering lane width
AC	Access Channel
AGP	Administration of Ports
ALDFG	Abandoned, Lost or Discarded Fishing Gear
BC	Boundary Condition
C.H.	Container Harbour
CAPEx	Capital Expenditure Cost
CEO	Chief Executive Officer
CFS	Container Freight Station
Coast	Shrimp Vessel from the Coastal (Yellow Fleet)
DESTEP	Demographic, Economic, Sociocultural, Technological, Ecological, and Political
DPI	Direction of Port Infrastructure
EMP	Environmental Management Plan
EPS	Expanded Polystyrene (Styrofoam)
F.H.	Fishing Harbour
GDP	Gross Domestic Product
GT	Gross Tonnage
H2	Hydrogen
HAT	Highest Astronomical Tide
HME	Harmful to the Marine Environment
IMO	International Maritime Organization
INIDEP	Instituto Nacional de Investigación y Desarrollo Pesquero
JIT	Just In Time
LAT	Lowest Astronomical Tide
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	Multi-Criteria Analysis
MDP	Multidisciplinary Project
MIEP	Ministry of Infrastructure, Energy, and Planning
MOP	Ministry of Public Works
MP	Multidisciplinary
MRWT	Maximum Relative Waiting Time
Nat	Shrimp Vessel from the National Fleet
NLS	Noxious Liquid Substances
PIANC	Permanent International Association for Navigation Congresses
PRF	Port Reception Facilities
PWMP	Port Waste Management Plan
SDG	Sustainable Development Goals
SGW	Ship-Generated Waste
SMB	Submerged Mooring Buoy
T.B.	Turning Basin
TEU	Twenty-foot Equivalent Unit
UNPSJB	National University of Southern Patagonia
WDR	Waste Delivery Receipt
WRF	Waste Reception Facilities
WRH	Waste Reception and Handling Plan
WTG	Wind Turbine Generators
YPF	Yacimientos Petrolíferos Fiscales

1 Introduction

1.1. Background

Puerto Rawson is a small fishing port located on the southeast coast of Argentina, Patagonia. It is located at an advantageous location on the coast, as it is close to an area very rich in shrimp and other marine resources. This location being rich in these marine resources, provides the port with major opportunities for expansion. Nevertheless, the port and its surrounding region must overcome various challenges to develop an efficient and environmentally friendly master plan for its expansion. Some of these challenges have already been mapped out by previous reviews and site studies (La Poutré et al., 2023).

1.1.1. History of the port

The port of Rawson was established in 1923 when a wooden dock was constructed to serve the local community. A significant development occurred in 1981 with the construction of the first quay on the northern bank. The port's growth continued with the construction of the first private dock on the southern side, Agropez-Conarpesa, around 2003. Starting a division into public and private quays in the harbour. A second public quay, Muelle Nuevo, was built in 2010. Notably, in 2016, a vessel capsized near the Elsa Bridge, and due to legal complications, the ship remained in the river. In 2018, Industrias Bass began expanding the port on the southern shore, with ongoing development efforts to date. The most recent extension of the first public quay (Murray Thomas Quay) occurred in 2022, further enhancing the port's capacity (del Vecchio, 2018).

The upriver port's hydraulic structures and breakwaters play a role in regulating water flow and protecting port access. The 'La Boca Toma' dam was constructed in 1919 to regulate water in the Chubut valley. Additionally, between 1943 and 1963, the Florentino Ameghino dam was built, for additional water retention. To safeguard port access, breakwaters were constructed on both the northern and southern sides. The northern breakwater, originally built in 1960, was extended in 2003 to a length of 544 meters, while the southern breakwater, built in 1974, was extended in 2002 to a total length of 800 meters. These hydraulic structures brought their own issues, discussed in the section below (H. J. Donini, 2021).

Erosion has long been a concern along the coast near Puerto Rawson, with documented cases as early as 1930, even before the construction of hydraulic structures. In 1942, the sea destroyed the first row of houses at Playa Unión, signalling the start of a significant coastal retreat. Between 1976 and 1996, the coastline retreated by 70 meters, a process accelerated by a major storm in 2002. The construction of a short breakwater between 2012 and 2016 led to sediment accumulation between the short and northern breakwaters Figure 3.1, but at the cost of increased erosion to the north of the short breakwater. The coastal profile consists of two distinct layers: an upper layer prone to erosion after storms, which can partially recover, and a lower layer, situated between -7 and -9 meters MOP, which suffers permanent loss during storm surges (H. J. Donini, 2021).

As history shows, outdated structures exist besides new structures preparing the port for the future.

The different types of infrastructure (new vs old & private vs public) can create issues between the visions of exploiters that threaten efficient port operations and the safety of the harbour.

1.1.2. Political context

The governance and regulation of Puerto Rawson have undergone significant changes over time. Between 1943 and 1991, Argentina's ports were owned and managed by the National State under the General Administration of Ports (AGP). However, a reform in 1989 transferred control to the provinces, and since 1991, Puerto Rawson has been governed by provincial laws(del Vecchio, 2018). Currently, the provincial governor and ministries, such as the Ministry of Infrastructure, Energy, and Planning (MIEP) and the Ministry of Environment, oversee the port's operations. Day-to-day management falls under the Direction of Port Infrastructure (DPI), while the Secretary of Fishing assists in maintaining the public side of the port. Fishing activities are governed by the Federal Fisheries Law, implemented in 2009 to regulate the maximum allowable catches for various species. As a result, Puerto Rawson must compete with neighbouring harbours to increase its incoming ships, as the total number of fishing vessels is capped. The waterway within the harbour is owned by the province of Chubut, with the northern docks falling under provincial responsibility. However, due to financial constraints, maintenance of these facilities has been insufficient in recent years.

1.1.3. Fishing industry

As fishing is a central industry in the province of Chubut, Puerto Rawson has been becoming a key hub for fishing activities in the last years as can be seen in Table 1.1. The 130 boats in the port consist of several vessels. The orange fleet, comprising small vessels ranging from 10 to 21 meters, and an artisanal fleet with vessels under 10 meters, operate out of Puerto Rawson, targeting species such as shrimp and occasionally hake. Additionally, the red fleet, which operates from the private port, also utilizes the port's waterway. The primary fishing season extends from October to March or April(del Vecchio, 2018), with shrimp being the most dominant catch. Puerto Rawson is the closest of all the Patagonian harbours to the richest seas in Argentina, making it a potential ideal port for fishing activities. Nearby, Puerto Madryn has a jetty capable of handling container throughput for export, although, in recent years, Puerto Rawson has increasingly focused on fishing and is seeking to expand its own export potential. In Table 1.1 it is visible that Rawson is attracting more ships(del Vecchio, 2018).

	Mar del Plata	**Puerto Madryn**	**Rawson**	**Comodoro Rivadavia**	**Caleta Paula**	**Puerto Deseado**
2011	1.56	24.91	23.29	4.48	11.87	32.98
2012	5.86	22.82	16.08	4.42	14.42	34.69
2013	3.61	27.34	20.26	4.70	10.98	31.54
2014	3.39	27.66	25.91	4.70	7.92	23.71
2015	7.07	23.19	26.75	2.80	9.00	26.59
2016	7.62	19.39	26.35	3.18	7.56	24.76
2017	3.62	24.97	31.01	6.71	2.79	18.68

Table 1.1: Percentages of caught fish per port per year (del Vecchio, 2018)

1.1.4. Ecosystem

Puerto Rawson is situated within a mid-latitude steppe climate, characterized by cold winters, warm summers, and semi-arid conditions. The region's vegetation primarily consists of short grasses due to limited rainfall, while trees and tall grasses are notably absent. The Patagonian steppe is marked by small, thorny plants that are well-adapted to the region's arid conditions (del Vecchio, 2018).

The coastal fauna includes a wide variety of birds and marine mammals. Birds such as the furnarius are commonly found around Playa Unión, along with colonies of sea lions that inhabit the port area near the docks. Sea lions also occasionally appear on the beaches of Puerto Rawson and Playa Unión. The Commerson's dolphin is one of the most notable marine mammals in the region, often spotted along the coast. Two types of shrimp are relevant to the ecosystem: Camarones, which are believed to have disappeared due to the construction of harbour shelters, and langoustines, which do not typically approach the coast.

While being just beside the UNESCO World Heritage of Guolvo Nuevo the population of marine mammals are under duress due to increasing fishing waste in the coastal areas. Plastic waste from the fishing industry has covered the coast along the Valdes Peninsula in Argentina's Patagonia, threatening the lives of sea lions, fish, penguins and whales and also endangering human health (Reuters, 2024).

1.2. Project brief

The port of Rawson is currently experiencing various problems, the context of which is given in chapter 1, specified by del Vecchio, 2018 and can be seen below. These issues are characterized by their impact on the public/private side and whether they influence the technical or strategic side of the port. This distribution was made for our two clients within this project.

Industrias Bass, a private contractor and land owner on the south side of Puerto Rawson wants to attract more fishing vessels. The CEO, Martin Castillo, organized a site visit and interview, which provided valuable insights for this report.
Province of Chubut, the owner and stakeholder of the northern public side of Puerto Rawson and the access channel of the harbour.

These clients and their wants and needs and how this impacts design decisions is further elaborated on in Appendix G.

- Shortage of berthing front length for fishing vessels that use the port. This is a public issue
- Lack of operational spaces behind the dock front, where the correct handling of the cargo can be carried out until its final disposal. This is a public issue and partly private due to the bad conditions of the roads and short turning areas for trucks.
- Lack of equipment for loading and unloading merchandise due to overcrowding. This is a public issue.
- Lack of planning of circulation linked to cargo handling and their interference with urban traffic. Public and private issues.
- Lack of complementary facilities to fishing operations, like, ice factories, wastewater treatment plants, maintenance workshops and boat repair, and fuel supply.
- Lack of maintenance of the port protection like the breakwaters and the entry channel. Public and private issues.
- Lack of waste management implementations and regulation in and around the port.
- Lack of sustainable design measures within the current port design.

Next to designing a port that can handle the current capacity more efficiently and with better cooperation between a public and private side, special boundary conditions were given to design for future growth. These boundary conditions were predefined for this project and should be interpreted as minimum design requirements throughout the project and were provided by the client.

Category	Phase I - 2030	Phase II - 2040
Shrimp	100 kt/y	200 kt/y
Squid	50 kt/y	100 kt/y
Hake	50 kt/y	100 kt/y
Others	-	100 kt/y
TEU's	20.000	60.000
Design Vessel	Container ship (e.g. Madrid Trader)	Panamax
Wind cargo	50 WTG/y	50 WTG/y

Table 1.2: Boundary Conditions

1.3. Objectives

The history of Puerto Rawson is marked by developments of quays, breakwaters, and dams, coupled with regulatory changes and the expansion of the fishing sector. Have introduced challenges such as erosion, maintenance issues, and competition within and with neighbouring harbours. As a result, Puerto Rawson reached a point where opportunities for expansion are balanced by the need to address persistent problems like sediment buildup, limited capacity, and regulatory constraints. Therefore the main objective of this report is to expand the fishery handling capacity in line with the local needs and realistic development goals, addressing both technical and environmental considerations.

This will be presented in a conceptual design for the expansion of the Port of Rawson. This design will address the key challenges identified, all while ensuring compliance with the boundary conditions set for 2030 and 2040 and strategic considerations. These boundary conditions include accommodating larger vessels, increasing shrimp, squid, and hake processing capacities, and expanding port logistics for project cargo like wind turbine components.

The report aims to consider the needs of various stakeholders, balance environmental sustainability with economic growth, and provide a robust plan for phased development. The outcome will be a flexible and scalable masterplan, ensuring that the port can meet future demands while enhancing its operational efficiency.

1.4. Scope

The scope of this report covers the comprehensive planning and design efforts required for the expansion of the Port of Rawson. It includes an in-depth analysis of current port operations, identification of infrastructure limitations, and projected needs for the port by the years 2030 and 2040. The study considers various factors such as:

- **Fishery expansion**: Addressing the growing demands for processing Argentine red shrimp, squid, and hake while maintaining sustainable fishing practices.
- **Project cargo handling**: Preparing the port for increased wind energy projects by facilitating the import, storage, and transport of wind turbine components.
- **Port infrastructure upgrades**: Proposing key improvements in docking facilities, crane capacities, and offloading systems to accommodate larger vessels and initiating a cargo handling area.
- **Environmental impact**: Ensuring that port developments align with environmental regulations and minimize ecological disruption.

For a smooth implementation of these various factors, a strategic plan is formed. The report outlines strategic phases for implementation, providing a clear roadmap for port development while accommodating potential future expansions. This strategic road map looks at broader societal goals and desired effects, to reach this they use an iterative process to determine the scope for these aspects. This is further elaborated on in section 1.5.

However, due to time-limiting considerations, and the previously carried out work by another group, Some aspects were also left out of the scope for this specific report.

- **Breakwater design**: designing a fitting breakwater for this specific port falls out of the scope. A parallel study is being carried out by another group, which focused on analyzing the sediment transport in and around the harbour, including a concept for the design of the breakwater.
- **Playa Uninion Erosion considerations**: the problem of erosion at the Playa Uninion, just north of the Port of Rawson, was also partly left out of the scope. Solving this problem falls mostly under the contents of the parallel working group.
- **(Extensive) Soil-investigation**: Besides visual inspection of the soil at the site, no new soil investigations were executed. A recommendation would be to include this before coming up with a master plan.
- **Hinterland**: most hinterland considerations were also left out of the scope due to time limitations.

1.5. Methodology

After the background study, an objective and problem statement was formed. This led to a scope after which the research phase could begin. The research phase consists of two parts, one which assesses the technical needs of the project and one which assesses the stakeholders' strategic needs. During the research phase, the scope was iteratively adjusted to create a specified deliverable. This process is visualized in Figure 1.1.

The design phase consists of the combining of the strategic and technical needs within the scope of the project. Different models and brainstorming tactics were used to create a strategic port plan and several design concepts. Both the strategic side and technical side were evaluated with a Multi-Criteria Analysis (MCA) which resulted in a complete MCA.

All the previous phases are combined to present the proposed master plan in phase three, results and discussion. Here a strategic Roadmap & strategy plan and a specified port design are delivered and examined. Through the process of expert opinions and group discussions, we critically analysed the end deliverables. Each of the three described phases has a different methodology for information gathering, processing and analysis which is described below for the technical (dark blue) and the strategical side (light blue) in Figure 1.1.

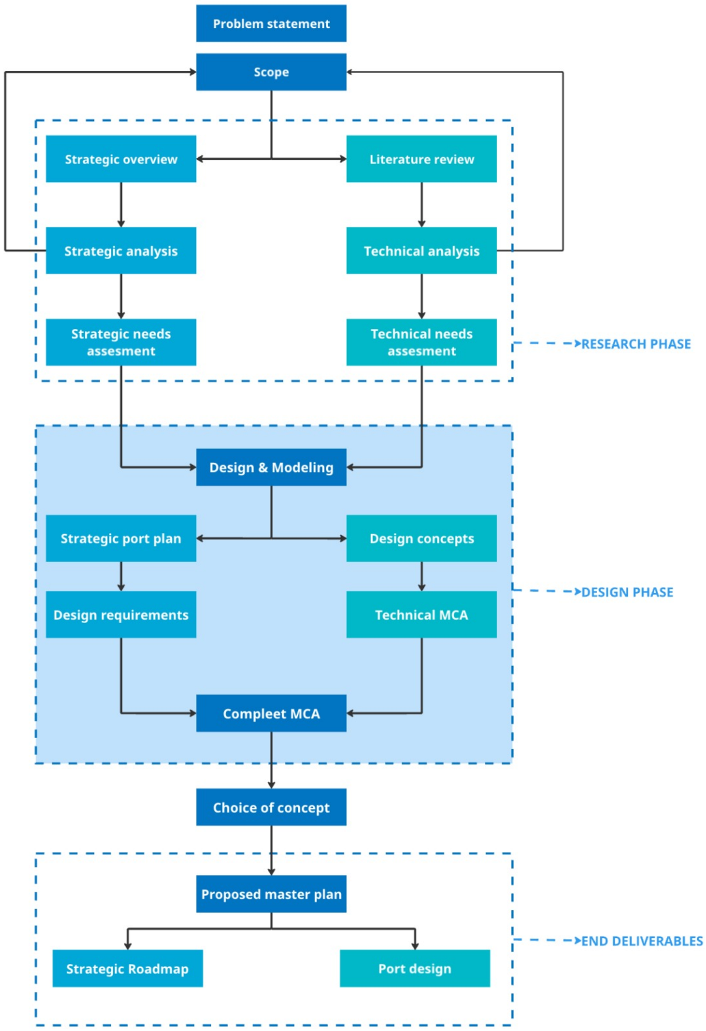


Figure 1.1: System analysis and content

1.5.1. Technical methodology

Research phase
In this part of the methodology, information gathering will be done through a desk study a site visit and expert interviews. Desk research is used to have an overview of available information and previous research for data and historical information about the harbour. The site visit is used to gather data on operational processes that take place in the harbour and to validate gathered information from the desk research. Expert interviews are used to fill in missing data and expectations for a future port design.

Design phase
Within the design phase, several modelling programs are used to support design choices. These programs consist mainly of Python including different packages and Excel for some data gathering and iterative design processes. The expected outcomes of the models are:

- Peak amount of vessel movements per time period within the season.
- Amount of berthing places in accordance with different operating speeds
- Quay wall sizes per vessel
- Total required quay wall
- Width of entry channel of the port

To evaluate the proposed concepts, a multi-criteria analysis (MCA) has been conducted. An MCA is a qualitative method that can be used to score and compare different interventions by assessing their performance. There are several reasons why an MCA was chosen. Conducting an MCA is time efficient and is less reliant on a large amount of data and resources than other evaluative methods, like a cost-benefit analysis. Also, within an MCA it is possible to use the input of stakeholders. This creates the possibility to rate a concept from different perspectives (Teotónio et al., 2022).

For the MCA, first, the criteria were identified. It was chosen to limit the number of criteria to keep it concise. The criteria were set up in collaboration with the client. This collaboration also led to the weighting of the MCA.

Results and discussion phase
Within this phase, the chosen concept was analysed using several methods, like, expert opinions and group discussions. Bringing experts together ensures that different viewpoints, including technical, operational, and environmental perspectives, are considered, leading to a more well-rounded design. Experts and group discussions also can identify potential issues or opportunities that might be overlooked by the core design team, such as logistical bottlenecks, environmental regulations, or community concerns. (Whiting et al., 2020) These methodologies were chosen for this phase because they are relatively easy to implement and time-efficient in comparison to data analysis/models to verify the outcome of the proposed master plan.

1.5.2. Strategic methodology

In order to develop the strategic aspect of the port expansion resulting in the port strategy plan, the Double Diamond methodology was used (Van Boeijen and Daalhuizen, 2010). The Double Diamond methodology is used for the strategic approach, as discussed in section 1.5, is visualized in Figure 1.2:

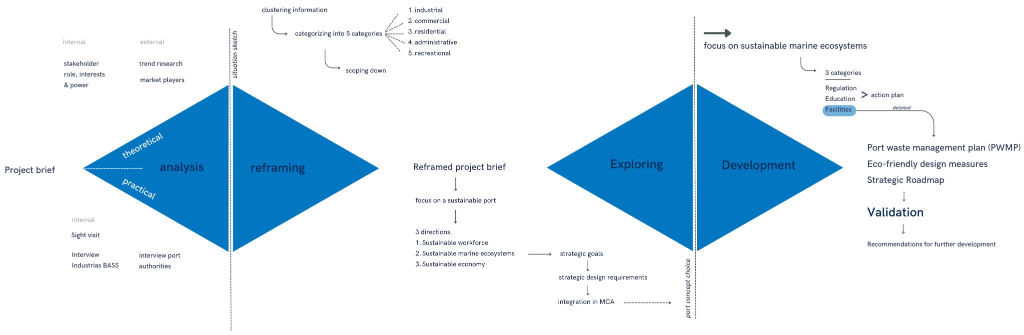


Figure 1.2: Double diamond methodology

Given that the initial project brief was highly technical, it was necessary to broaden its scope. This expansion begins with diverging into identifying, researching and understanding the initial problem, referred to as the analysis. The insights gained from this analysis were used to converge to define a clear problem to be solved. In other words; reframing the problem to unveil strategic opportunities.

A strategic focus was established with the aim of creating a sustainable port. This was followed by another diverging process, during which three specific subcategories within this strategic focus were further explored and reported. Design requirements were articulated and integrated into the Multi-Criteria Analysis (MCA) to guide the selection of a final port design concept. After this decision point, a further convergence was executed in which one of the three concepts was elaborated in detail, referred to as the development stage. The final deliverables included a Port Waste Management Plan, eco-friendly design measures, and a strategic roadmap, all of which were integrated into the overarching Port Masterplan.

2

Literature Review

The expansion of port infrastructure is a multifaceted challenge that requires balancing port feasibility with its economic growth, environmental sustainability, and effective stakeholder management. This literature review analyzes relevant studies that examine port expansion through various lenses, including technical challenges, environmental impacts, economic benefits, and stakeholder engagement. The review is structured to highlight gaps where future research could enhance the master plan's accuracy and applicability.

2.1. Technical literature review

2.1.1. Planning for Port Expansion: Lessons from Case Studies

Port expansion is a growing necessity as global trade volumes increase, especially with larger vessels requiring deeper and more extensive port infrastructures. This is directly relevant to Puerto Rawson. As Industrias Bass and the province of Chubut plan to expand the port infrastructure to accommodate modern shipping demands, insights from previous projects can provide important guidance for smaller ports (Godinho and Torres, 2021; Lagoudis et al., 2014; MDP251, 2020; MDP297, 2020). Numerous studies emphasize the importance of thorough pre-expansion planning. In the Rotterdam harbour case (ECOncrete, n.d.-b), the successful integration of urban and port development demonstrated that early-stage stakeholder involvement and adaptive planning were crucial in mitigating conflicts between industrial and urban interests.

Similarly, (Lagoudis et al., 2014) demonstrated how the long-term potential for capacity utilization should be considered alongside immediate needs in the Port expansion. Their work emphasizes the importance of anticipating future growth and ensuring ports remain scalable as trade volumes grow. This is especially relevant to Puerto Rawson, where balancing current demands with future expansion is key. More specifically this is mentioned in Del Vecchio's 2018 feasibility study of addressing local bottlenecks. The study identifies key needs for additional berthing areas, optimized access channels, and improved cargo handling to support seasonal fishing peaks. Applying these insights to the expansion plan can help reduce wait times and better accommodate current and future port demands.

In addition to these insights, several technical challenges encountered in other port expansion projects provide valuable lessons for our own. For instance, in the Scheveningen Harbour expansion (Munters, 2020), one of the significant challenges was managing sediment displacement and dredging activities. The port faced difficulties in predicting the full extent of sediment movement, which led to unforeseen delays and cost overruns. Moreover, environmental regulators raised concerns about the impact of dredging on local marine habitats, resulting in additional procedural hurdles. These issues underline the importance of detailed sediment analysis and environmental risk assessments before starting dredging operations in Puerto Rawson.

Similarly, Human Port faced bottlenecks due to underestimating storage capacity, which impacted cargo processing (Lagoudis et al., 2014). This case underscores the importance of planning for cold storage and handling facilities, ensuring Puerto Rawson's expansion can meet both current and future demands without operational bottlenecks.

By considering these cases, we gain valuable insights for Puerto Rawson, where careful planning, stakeholder engagement, and anticipating technical challenges will be crucial to the project's success.

2.2. Strategic Literature Review

2.2.1. Socio-economic factors

Port activities in Puerto Rawson, create significant job opportunities for the region. These activities directly employ over 1,400 people and indirectly support around 7,000 jobs, mainly through services such as logistics, transport, maintenance and fish processing which boost the local and regional economy (del Vecchio, 2018). The wool industry is also an important source of work and income in Chubut. Wool is a key export product, and it supports many rural communities and offers jobs in production, processing, and transport. This sector brings great value to the local economy and presents potential growth for port export opportunities (Taraborrelli, 2019).

Apart from livestock farming and wool Puerto Rawson is mainly known for fishing activities. These fishing activities are viral to Chubut's economy. The Chubut fishing industry, which is mainly distributed among Puerto Madryn, Trelew and Rawson is essential for employment and job creation in the area. This industry is also responsible for the majority of the export revenue in the area. Squid, hake and Patagonian shrimp make up around 75% of fish exports while supporting almost 23,000 working in the industry (Gaviola et al., 2022). This work stretches from marine harvesting to processing, with both salaried and self-employed workers, making fishing essential for local livelihoods.

Making ports efficient is key to supporting the local economy, especially during the down season. Research shows that a well-functioning port system can support economic growth, and partnerships between the government and private sector help keep ports modern and efficient. This boosts productivity, creates jobs, and strengthens economic confidence, which benefits the region (López-Bermúdez et al., 2019).

In addition to export, Rawson is open to tourism, which can be a big economic contributor to the area. This tourism is mainly located in Puerto Madryn, due to its marine activities in Peninsula Valdes. Thousands of visitors come each year for orca and whale watching, which fuels demand for local services and adds significantly to the local economy. Studies on whale-watching tourism show that this sector provides jobs and has potential for eco-tourism, offering both economic benefits and a way to protect local nature.

With the economic benefits from tourism, fishing, and industrial activities in Chubut, there are also environmental challenges. The growth in tourism, for example, has led to water pollution issues in Puerto Madryn, highlighting the need for sustainable practices to protect marine areas. Similarly, fishing is vulnerable to climate change, which can affect fish populations essential for both the economy and local biodiversity. Sustainable management is key to preserving these resources, especially given Patagonia's reliance on fish exports (Gaviola et al., 2022).

2.2.2. Environmental factors

Waste management includes two primary stages: collection and treatment. Collection involves gathering waste from various sources, while treatment reduces the waste volume or its harmful impact before disposal. Treatment can include processes like burning, recycling, or using chemicals, depending on the type of waste. Different waste types have their own collection and processing costs, with expenses covering collection, sorting, transport, and internal processing (Port of Rotterdam Authority, 2023).

Within ports waste management is essential. Especially waste generated on ships. In 1973 an international convention on the reception of waste was held, this convention was then called the International Convention on the Prevention of Pollution of Ships. In 1978 this convention was termed MARPOL, which was created by the International Maritime Organisation (IMO) (Olson, 1994). The MARPOL convention presents different annexes representing different types of waste found in ports and vessels. These annexes all need to be disposed of and treated differently (Organization, 2024). This waste collection can be done through either mobile means, such as vehicles or ships, or fixed facilities, like storage tanks. Different types of waste, including oil-based waste, cargo residue, and other ship-generated waste, are managed according to strict regulations. In Chubut, Argentina, Trelew, Puerto Madryn, and Rawson, which are cities near Puerto Rawson, have signed an agreement. In December 2005 they agreed to collaborate on waste collection and waste management. With the support of the Chubut government, this agreement promotes sustainable development and environmental protection, showing how local authorities can work together for better waste management (Zevallos et al., 2020).

Puerto Rawson is located near the mouth of the Chubut River. Which adds to river ecosystems. Within the Chubut River, a consideration of both agriculture and industrial waste need to be taken into account. The Chubut River in Argentina is one example where pesticides and herbicides from farming activities, carried by rainwater runoff, end up in the river and underground water sources. Mining and oil industries also contribute to pollution in the Chubut River, releasing substances like cyanide, which is toxic and hard to break down. This contamination threatens both the river's ecosystems and human health (Bensey and González, n.d.).

Not only the river is a source of water pollution and waste. In the sea, waste is mainly generated by vessels. Emitting household waste, oil spills and wastewater from cleaning the vessels. While a lot of problems appear from this type of waste, one of the most pressing in the area is eutrophication, which happens when excess nutrients like nitrogen and phosphorus lead to an overgrowth of algae (Bensey and González, n.d.). Algae blooms make the water cloudy, blocking sunlight and stopping photosynthesis in underwater plants. As oxygen levels drop, fish and other marine life can die, leading to a loss of biodiversity. Nutrient pollution in the ocean often comes from waste discharged by ships, runoff from farming, and industrial discharge.

To carry out possible minimization and compensation measures for the environmental impacts identified at each stage of the project, the contractor needs to develop an Environmental Management Plan (EMP) for the construction, operation, and possible dismantling phases (del Vecchio, 2018). This EMP should include a clear description of specific actions to reduce the environmental impacts of the work, particularly in critical areas. Puerto Rawson can be seen as a critical area, the relationship between the port and the city is both a place of connection and separation, where spaces and activities meet and interact (del Vecchio, 2018). However, this comes with some conflict. Since the construction of the Florentino Ameghino dam, sediment flow through the Chubut River has had a great impact on Playa Unión, located at the mouth of the river and in the city of Rawson. This has enlarged dissatisfaction with the expansion of Puerto Rawson.

Environmental sustainability is a recurring theme in port expansion literature. In Puerto Rawson, nature-based solutions have been proposed to mitigate potential harm to wildlife (La Poutré et al., 2023). One study of sediment management in the Port of Rio Grande found that using dredged material to expand coastal areas and create new land is a viable alternative for reducing environmental disruption (Ágora, 2020a, 2020b). This aligns with Munters' (Munters, 2020) work in Scheveningen Harbour, which emphasizes the role of sustainable practices in maintaining ecosystem integrity while enabling infrastructural growth. Another study on Puerto San Vicente (MDP251, 2020) emphasized the importance of protecting marine ecosystems during port expansion. These studies collectively emphasize the importance of integrating environmental assessments early in the planning process to ensure that sustainability is central, rather than an afterthought. In the case of Puerto Rawson, the completed environmental studies and nature-based solutions will guide the port's expansion.

2.2.3. Stakeholder Engagement and Organizational Challenges

Effective stakeholder engagement is critical for the success of port expansion projects. Multiple studies emphasize that early and continuous involvement of stakeholders, ranging from local communities to businesses and government bodies, can mitigate potential conflicts and ensure smoother implementation (Ágora, 2020a; Munters, 2020). For instance, the Scheveningen Harbour case study highlighted how conflicts between industrial interests and residential communities were resolved through proactive dialogue Similarly, in Puerto San Vicente, engaging local fishery communities helped mitigate concerns about environmental degradation (MDP251, 2020).

The Port of Rio Grande expansion (Ágora, 2020a) underscored the need for collaboration between environmental regulators, local authorities, and port operators to ensure dredging operations do not disrupt local ecosystems. These studies suggest that inclusive, participatory processes that account for the concerns of all involved parties are key to the success of port expansion projects.

2.3. Conclusion

In conclusion, this literature review highlights the multifaceted aspects of planning, environmental care, economic growth, and collaboration among stakeholders necessary for the successful expansion of Puerto Rawson. The findings emphasize that Chubut's economy heavily depends on multiple industries containing: port services, wool production, tourism, and fishing, all of which drive job creation, economic resilience, and regional growth. The review focuses on the importance of adopting sustainable practices and ensuring efficient port operations to balance the needs of economic progress while keeping environmental factors into account. By integrating these principles into the Puerto Rawson project, stakeholders can develop an infrastructure that is adaptable, sustainable, and beneficial to both the local economy and the ecosystem.

3
Current Situation Analysis

This chapter provides a detailed overview of the current situation in and around the port of Rawson. It will elaborate on both the physical infrastructure as well as the strategic landscape.

3.1. Existing Port Layout and Infrastructure

This section outlines the current state of the port infrastructure, both on the nautical and logistics sides. The port's layout, breakwaters, and quay configurations are essential components that ensure efficient port operations and enable expansion for future growth. The nautical infrastructure, including the dredging works and protection measures, ensures the safe and smooth navigation of vessels, while the logistics infrastructure facilitates the handling and storage of goods.

3.1.1. Port layout

The port layout is characterized by its division between the northern and southern riverbanks, which accommodate various quays for fishing vessels and future expansion. The port also features significant infrastructure developments, both in progress and planned, to support increased activity and diverse vessel types.

As shown in Figure 3.1, a low bridge located 1.3 kilometres upstream from the river mouth restricts vessel passage. The northern riverbank has two quays that serve as public fishing docks. There is room for expanding these docks between the old and new northern breakwaters, and on the northern riverbank, indicated in Figure 3.1 as quay C and D. The southern riverbank also has two active quays, in Figure 3.1 shown as quay E and F; these function as private fishing docks and leave room for development of multiple private docks. Additionally, three new quays (quays G, H, and I in Figure 3.1) are either under construction or planned for construction. All existing quays are used for the on- and offloading of coastal prawn vessels. Quay I, which is planned for construction by Industrias Bass, will accommodate both Jigger vessels (Poteros) and container feeder vessels (800 TEU), as stated in (Serman & Asociados S.A., 2019). The quays on the southern bank will all have their own handling facilities and storage space, the quays on the northern bank use the facilities in the town, visible in the top middle of Figure 3.1.

3.1.2. Nautical layout

To accommodate large vessels at Puerto Rawson, a new turning basin, access channel, and docking basins are being dredged, as shown in Figure 3.2. The construction of a small groyne is also planned, to protect the berthing of vessels in the port. The turning basin has a diameter that is twice the length of the largest vessel, allowing the vessels to manoeuvre within the port without tugboats.

The tidal levels in the region are as follows: Highest Astronomical Tide (HAT) is +3.52 [m] MOP, and Lowest Astronomical Tide (LAT) is -1.84 [m] MOP (La Poutré et al., 2023). Based on these levels, the turning basin and access channel are designed to have a depth of -6.0 [m] MOP. This allows for safe vessel manoeuvring during the high tide quadrant (at +1.77 [m] MOP), given a maximum container vessel draft of 7 meters. The depth on the container quay is -8.50 [m] MOP to prevent the vessel from

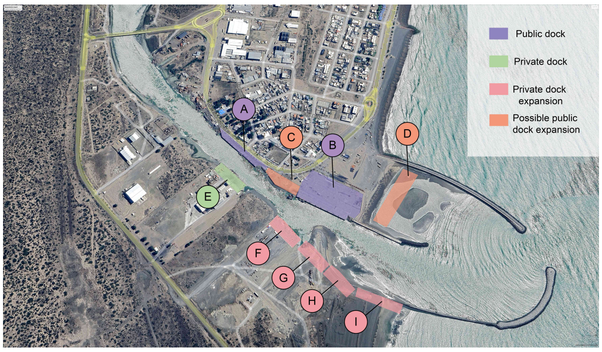


Figure 3.1: Port Layout planned (La Poutré et al., 2023)

stranding at low tide. The same functional tidal window (the high tide quadrant) will be used for the dimensioning of the waterways for the expansion. The dredging of the river mouth will improve traffic flow in the port, as the current channel becomes very narrow in front of quay B, as shown in Figure 3.1. The channel and berths require seasonal dredging since the port is at a river mouth and has some significant depth differences.

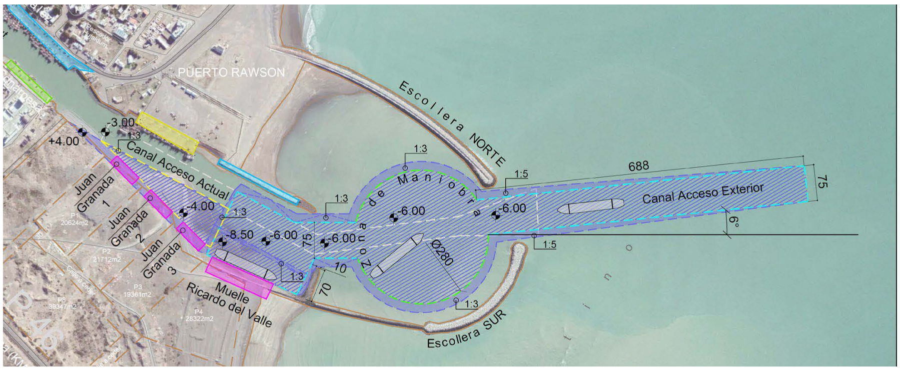


Figure 3.2: Nautical layout planned (Serman & Asociados S.A., 2019)

3.1.3. Breakwater

The breakwater can be divided into several sections: the northern, southern, new (2002), and old breakwaters. The old configuration consisting of smaller breakwaters, is clearly visible in Figure 3.2, as thinner lines compared to the newer thicker breakwaters. The new southern breakwater is an extension of the old one, while the new northern breakwater was built 250 meters north of the old northern breakwater. Additionally, a groyne was constructed 600 meters north of the new northern breakwater to mitigate shoreline erosion in that area. The old breakwater features an armour layer made of Akmon elements, supported by an underlayer of natural rock, and a scour protection system made of poured concrete, as was concluded during the field trip, shown in Appendix A. The armour elements were placed deliberately, rather than randomly, and the structure sustained significant damage over time. Akmons are breakwater elements which should be placed in a random manner to increase their permeability, increase energy dissipation, enhance the interlocking of elements, increase structural integrity, reduce risk of scour and reduce overtopping. The function of the old structure has been replaced by the new breakwater, in combination with the Restinga, making maintenance unnecessary. Removing the old breakwater is also unnecessary and very difficult due to the poured concrete scour protection underneath. The new breakwater features a randomly placed concrete armour layer made of Accropode elements.

3.2. Strategic analysis

This chapter covers the analysis of the strategic landscape of the port of Rawson. The goal of this analysis is to create a comprehensive understanding of the various factors influencing the port, its expansion and future direction. This involves combining theoretical knowledge, drawn from extensive research with practical insights gained from interviews, site visits, and observations. The analysis is split up into two components: an internal and external analysis.

3.2.1. Internal Analysis

The internal analysis focuses on what and who inside Puerto Rawson influences the port's operations and expansion.

Stakeholder roles, interests & power

A thorough stakeholder analysis was conducted by the previous MDP group's extensive research on the Puerto Rawson port expansion project. Their report provided valuable insights into the roles, interests, and demands of all relevant stakeholders involved in the project. Using their findings, we developed a comprehensive overview of the key stakeholders and their relationships to the port expansion. This overview is visualized in Figure 3.3, in Appendix G.

Further, a detailed breakdown of each stakeholder's role and specific interests or demands has been developed. In Appendix G a table is presented that summarizes the overview of stakeholders. The primary stakeholders in this project range from Industrias Bass, the lead investor and contractor, to governmental bodies such as the National Government and the Ministry of Infrastructure, Energy, and Planning of Chubut (MIEP). Local entities, including the inhabitants, public fisheries, and tourist companies, are also important to consider, given their varying degrees of influence and concerns regarding environmental and economic impacts.

This stakeholder analysis provides a crucial backdrop for the project's development, ensuring that all relevant perspectives are accounted for. However, as per the project's scope and instructions, stakeholder management will primarily focus on three key players: Industrias Bass, the Port Authorities and the National University of Southern Patagonia (UNPSJB). This focused approach means that while the broader stakeholder context informs the project's design, the demands and priorities of those entities will be prioritized in decision-making and implementation.

Sight visit and interviews

A site visit to the Puerto Rawson port was conducted to gather firsthand insights into the operational conditions and challenges faced by the current facilities and management. During the visit, we observed the existing infrastructure, engaged with local workers, and assessed the overall environment and interactions of the port area. This practical observation allowed us to gain a deeper understanding of the limitations and opportunities present at the site and surrounding environment.

During the visit to Puerto Rawson, two interviews were conducted. One with the port authorities (26/09/2024) and one with the CEO of Industrias Bass, Martin Castilo (27/09/2024). While the port authorities (primarily) regulate the public part of the port, Industrials Bass privately owns almost everything on the north side of the port. By conducting interviews with representatives from both the public and private sides of the port, a comprehensive understanding of the situation could be formed.

The interview with Industrias Bass was conducted in the form of a semi-structured interview, where a general interview script was used, but deviation was possible. The answers were recorded and translated into English. The full interview transcript including questions can be found in Appendix P.

The interview with the port authorities took on more of a free conversational format. For this reason, no recording or transcript of this interview was made.

Insights gained from this sight visit in Puerto Rawson have been important in informing the design requirements, ensuring they are grounded in the realities of the port's operational context. The most important ones have been summarized in the overview in Figure 3.3, the in depth overview can be found in Appendix G, Figure G.2 and Figure G.3.

Figure 3.3 presents the stakeholders visually, illustrating their connections to the port expansion project and each other, as well as their attitudes towards the expansion. This diagram helps map out how these stakeholders may influence the project or be affected by its progression, ranging from those with high interest and power to those with limited influence.

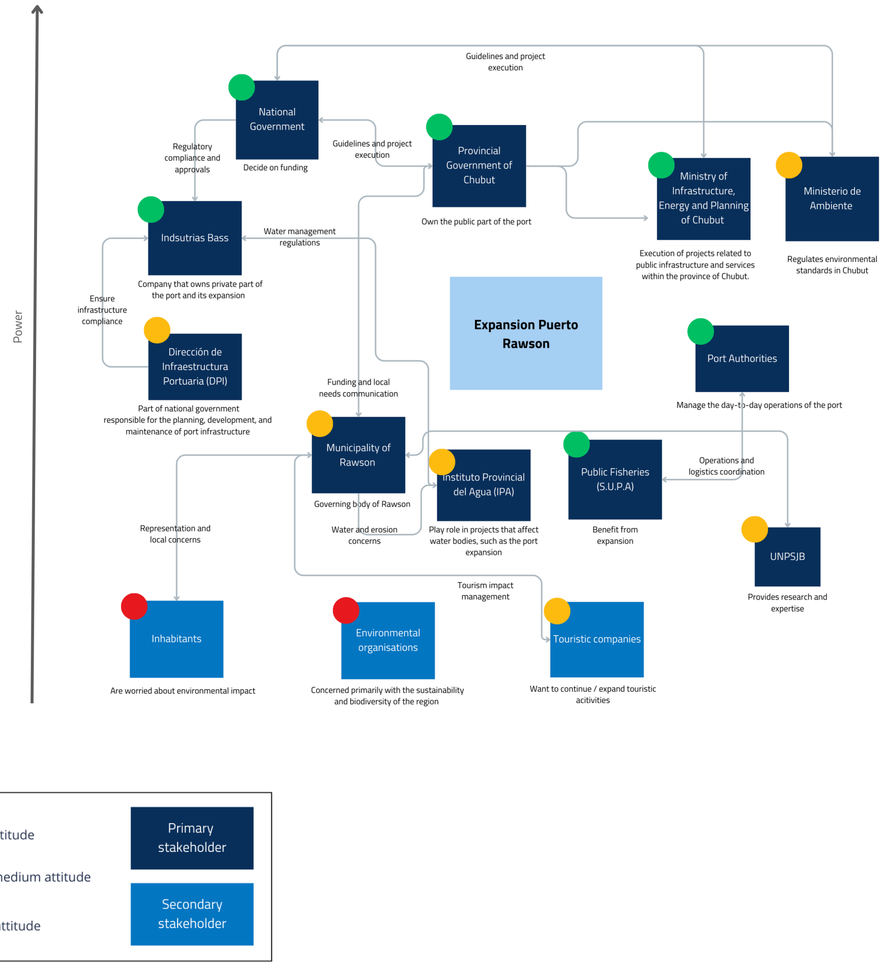


Figure 3.3: Stakeholder relations

3.2.2. External Analysis

In contrast, the external analysis explores current trends and market players that may impact the port expansion. This includes examining economic, social, and environmental trends that shape the context in which the project operates, as well as identifying relevant market players in the industry.

Trend Research

The trend research involved an in-depth examination of various socio-economic and environmental factors that are shaping the landscape of port operations and expansion in Puerto Rawson. By analysing existing literature and reports, we identified key trends.

The trends were researched following the six categories of the DESTEP Model: demographic, economic, sociocultural, technological, ecological, and political. By following this model, it was ensured that enough diverging was achieved.

The findings from this research have been synthesised into a framework for understanding how these trends may influence the strategic goals of the port expansion project. This framework forms the link between the trends and the technical objective of the port expansion. The framework for organising these trends is derived from (del Vecchio, 2018) and is made up of the following categories: industrial, commercial, residential, administrative, and recreational. These correspond to the different types of land uses in the port. Figure 3.4 shows the framework with trends.

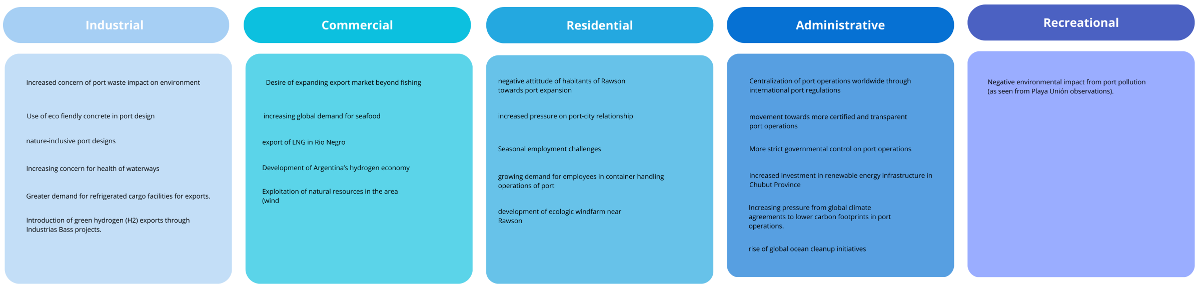


Figure 3.4: Trends

Market Players

An analysis of market players involved in the port operations was conducted to gain an understanding of the challenges and opportunities in the strategic landscape. The overview includes relevant fishing companies, processing plants, and ports in and close to Rawson. By understanding the landscape of market players, we can strategically position the Puerto Rawson expansion within the broader context of the industry.

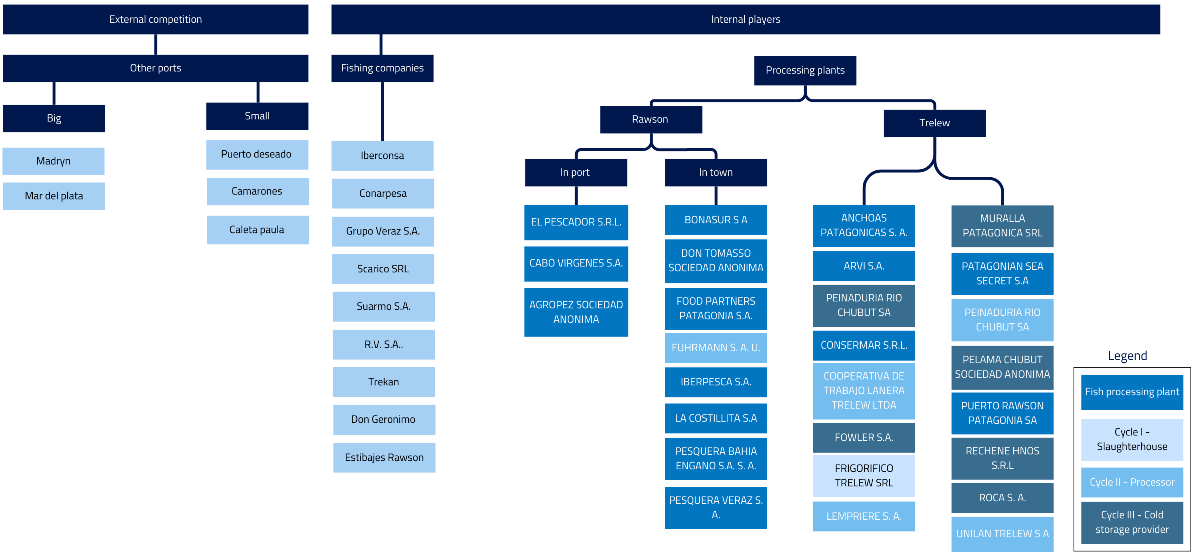


Figure 3.5: Market players

3.2.3. Situation sketch

The division of the port into public and private areas creates a complex operational landscape. This division, combined with limited publicly available information, makes a comprehensive understanding of the port's dynamics difficult.

To facilitate further research and provide clarity on the situation, an overview of the gathered information throughout the project has been compiled. This situation sketch can be seen in Figure 3.6.

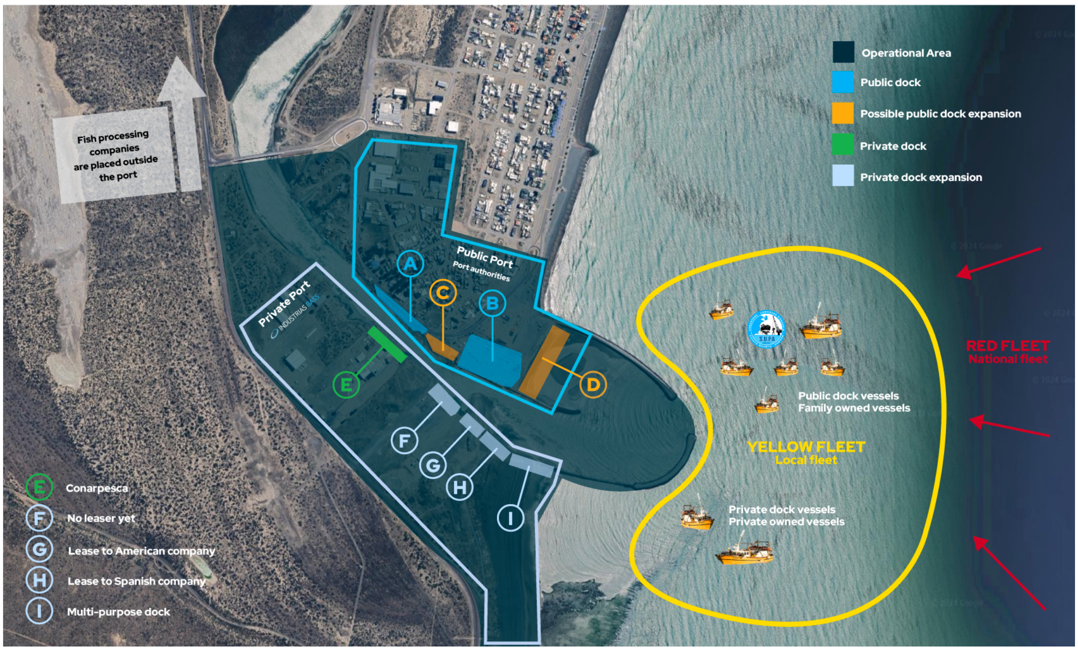


Figure 3.6: Situation sketch

Expanding the scope of the port expansion towards a strategic direction allows us to formulate certain strategic goals. This means that, apart from the technical requirements of the port expansion specified in section 1.2, we also establish certain strategic objectives that should be taken into account. Using these overarching categories, sustainable economy, sustainable marine ecosystem, and sustainable workforce, we can formulate the following objectives:

4

Needs Assessment

4.1. Technical Needs

The Port of Rawson, located in Chubut, Argentina, has become a vital hub for the fishing industry due to its proximity to rich marine ecosystems in the Argentine Sea. The region is known for its thriving populations of Argentine red shrimp (Pleoticus Muelleri), hake (Merluccius Hubbsi), and Argentine shortfin squid (Illex Argentinus), making it one of the most productive areas for Argentina's fishing sector (Seafood Media Group, 2024).

4.1.1. Fish Population and Potential

The Argentine red shrimp is the most valuable species caught at the port. Recent years have seen record-breaking landings. For example, in September 2024, 71.635 tons were exported at an average value of 5.638 dollars per ton (Seafood Media Group, 2024). This demonstrates the abundance and potential of shrimp in the region, driven by the shrimp's seasonal migration patterns. The shrimp industry is a key driver of Rawson's economy, with growing demand in international markets, particularly in Europe and Asia.

In addition to shrimp, hake is another cornerstone species for the local economy. Hake populations have been subject to careful monitoring to avoid overfishing, and sustainable quotas have helped maintain a healthy stock. Hake provides significant contributions to both domestic markets and exports, with demand remaining strong for processed products.

Furthermore, the Argentine shortfin squid is a common species in the waters near Puerto Rawson. While squid fisheries are subject to high yearly fluctuations, this species remains central to the area's fishing industry. Including squid in Rawson's fishing operations could help diversify the port's economic base, reducing its dependence on any one species. However, Argentina faces significant international competition in these waters. According to an INIDEP documentary (INIDEP, 2017), over 300 foreign fishing vessels target squid in the area. To maintain a leading role in squid exports, Argentina needs to improve its infrastructure and logistics for the squid fishery.

4.1.2. Potential for Wind farms

The Patagonia region, especially the areas surrounding the Port of Rawson, offers substantial potential for wind energy projects due to its strong and reliable winds. Consequently, there has been an increase in investments in renewable energy infrastructure in Chubut Province. In an interview with Industrias Bass, a local contractor who owns multiple parcels in this area, the future outlook for the region was discussed Appendix A. Topics included possible future local hydrogen production and export, powered by wind energy. This demonstrates the need for infrastructure to support the construction and logistics of these wind farms, making the Port of Rawson a suitable location for offloading general cargo.

4.1.3. Future Demand and Infrastructure

With the increasing global demand for seafood and favourable biological conditions in the Argentine Sea, the Port of Rawson is expected to see continued growth in fishery activities. This will likely necessitate further investment in port infrastructure to handle the projected increase in vessel traffic and seafood processing.

Sustainability initiatives will also play a key role in maintaining fish populations and ensuring long-term economic viability. By adhering to responsible fishing practices, the port can position itself as a leader in environmentally friendly seafood production & waste reduction, which is increasingly important in global markets.

In conclusion, the Port of Rawson is destined to continue its growth trajectory, supported by robust fish populations, increasing international demand and a large potential for wind farms in the area. Hence, this Port Masterplan will seek to supply the boundary conditions as described in Table 1.2.

4.2. Strategic Needs

It is important to recognize that the project objectives of the port expansion go beyond technical goals and boundary conditions. The strategic aspect of the port expansion and its future direction should be taken into account as well. That's why all insights gained from the analysis are used to reframe the initial project brief. The overview in Figure 4.1 illustrates the reframing of the project brief.

the **What** ?	Expand fishery handling capacity specifically through the use of reefer containers		
the **How** ?	Expand the port to accommodate more and larger vessels and create a container terminal		
the **Why** ?	To make the port more attractive for the national fleet resulting in and ensuring all year fishing — UNSJB	To attract more traffic to Rawson in order to create more economic activities and further develop the private port by increasing capacity for future expansion — Industrias Bass	Improving infrastructure for current fleet and thus optimizing operational efficency — Port authorities
the **What** ?	Ensure the longevity of the port expansion by implementing sustainable measures for both water management and work environments, while promoting economic growth to secure a prosperous future for the region.		
the **How** ?	The port will enhance its competitiveness by implementing sustainable infrastructure and efficient operations, attract investment, and provide long-term opportunities for the region, while aligning with global sustainability goals.		
the **Why** ?	Aligning both public and private port needs to ensure a sustainable port for both workers and citizens, while preserving the fertility of the Patagonian sea to safeguard the future of the fishing industry.		

Figure 4.1: Re-framed brief

Accordingly, the following future vision for the port expansion of Puerto Rawson can be formulated:

Future vision

Puerto Rawson thrives to become a valuable player among ports in Argentina by transforming communities through progressive mindsets and innovation while preserving Patagonian nature and safeguarding seas.

Figure 4.2

The re-framed project brief and future vision for the expansion of Puerto Rawson align closely with the Sustainable Development Goals (SDGs) number 8, 9, 11, and 14:

- **Decent Work and Economic Growth (SDG 8):** This goal emphasizes the promotion of sustained, inclusive, and sustainable economic growth, full employment, and decent work for all.
- **Industry, Innovation, and Infrastructure (SDG 9):** This goal emphasizes the development of efficient, sustainable infrastructure to support long-term growth.
- **Sustainable Cities and Communities (SDG 11):** SDG 11 promotes sustainable urban development by ensuring access to safe, inclusive, and resilient environments. The project addresses the port-city relationship, balancing operational needs with community well-being.
- **Life Below Water (SDG 14):** SDG 14 emphasizes the conservation and sustainable use of marine resources.

Figure 4.3: Sustainable development goals (United Nations, n.d.)

By integrating these sustainable development goals, Puerto Rawson will be able to contribute to working towards a more sustainable port and therefore a more sustainable future. They are able to take their corporate social responsibility within Rawson, Argentina and even Latin America in the future. This corporate social responsibility will help guide decision-making and could benefit the relationship between the port and the community. These goals could navigate residents of Rawson to help create sustainable cities and communities which could lead to economic growth. Looking at the bigger picture it could also benefit the port expansion. If inhabitants are not worrying about port expansions, decisions are more easily made.

4.2.1. The need for a sustainable focus

The reframed project brief makes sure the entire ecosystem surrounding the port is taken into account, both in terms of operations and future development. It ensures that the project serves not only short-term operational goals but also creates lasting value for future generations. In other words, it focuses on creating a sustainable port.

Sustainability in this context refers to the long-term viability of the port; ensuring that economic, environmental, and social systems remain in balance over time. This requires aligning public and private interests, expansion plans and safeguarding the fertility of the Patagonian Sea to preserve the future of the fishing industry, which serves as the backbone of the local economy. Without a sustainable focus, the expansion risks short-term success at the expense of long-term resilience.

4.2.2. Longevity: A Holistic Framework

In this context, long-term sustainability translates into three interconnected categories, as can be seen in Figure 4.4.

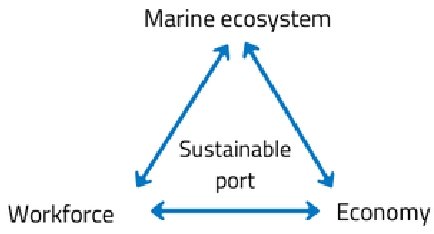


Figure 4.4: Holistic framework

1. **Sustainable economy:** Economic sustainability is about increasing economic resilience. This includes diversifying revenue streams beyond the fishing industry to reduce vulnerability to seasonal variations and external shocks, and reducing dependency.
2. **Sustainable marine ecosystem:** Environmental protection is essential to maintain the health of the marine ecosystem on which the fishing industry depends. This involves ensuring the water quality in and around Puerto Rawson remains up to standard.
3. **Sustainable workforce:** Sustainable workforce development is about creating an environment that provides enough work opportunities for the local community. This requires addressing the seasonality of jobs and creating opportunities beyond traditional fishing roles.

4.2.3. Strategic Goals

Expanding the scope of the port expansion towards a strategic direction allows us to formulate certain strategic goals. This means that, apart from the technical requirements of the port expansion specified in section 1.2, we also establish certain strategic objectives that should be taken into account. Using these overarching categories, sustainable economy, sustainable marine ecosystem, and sustainable workforce, we can formulate the following objectives:

- Adapting the port to future energy trends
- Expanding export opportunities
- Strengthening the competitive position of the port
- Leveraging community benefits through the port expansion by balancing job distribution
- Conserving local ecosystems in and around the port's waters

The strategic goals of the port expansion are not intended to be achieved all at once but are interrelated and evolve over time in response to external trends, developments, and project stages. As the port expansion progresses, different goals will become relevant at different stages. These developments can be seen in the roadmap in section subsection 8.3.4.

4.3. Needs conclusion

With the combined knowledge of chapter 3 and the topics that were elaborated upon in section 4.1, it can be noted that there exists a gap between the current infrastructure and the anticipated future growth in demand.

In the next chapter, the report will seek to quantify the gap between the current situation and the forecasted growth by the boundary conditions. It was concluded that an expansion of the port of Rawson is recommended.

5

Port Expansion Design & Options

This chapter contains the models and constraints that are used to gap the bridge between the fish data to the required nautical and port logistics' needs. The results from these models and constraints will later be used to set up 3 possible concepts.

5.1. Nautical Demand

The design of the port expansion was split into two demands, nautical demand & port logistics demand. Each of those demands was then split into further segments which eventually would result in the final nautical demand. Once the nautical demand is known, the switch can be made to the port-side demand. The models set up to determine the nautical demand can be found in the Appendix D, and the output is used to benchmark the main model used to determine the quay lengths.

5.1.1. Quay-length demand

To calculate the necessary quay lengths that meet the specified boundary conditions (as defined in Table 1.2), a model is needed to convert the total number of kilotons of fish caught into the corresponding number of required berths and its length.

A python model was set-up, that initially summarizes all dimensions and other properties per fish-vessel type. In total 6 different vessel types were assumed to represent the entire fleet. Table 5.3 shows some of the assumed values for the model. Table 5.3 shows only a part of all parameters that were introduced. In the appendix, the full model and all the assumed values can be found. In addition to this, Table 5.1, shows the qualitative assumptions that were made to simplify the model.

Besides the assumptions explained in Table 5.1, an assumption had to be made about the available offloading crane capacity. These assumptions followed from visual inspection and talking to local professionals during the visit to the Port of Rawson (Appendix A). These crane capacities also fit the expansion plans for the port, as seen in Table 5.2.

After setting up the initial parameters and calculating the required number of arrivals per vessel, the turnaround time could be calculated by summing up the departure time, offloading time and arrival times per vessel.

Queuing Model and Crane Capacity

A crucial aspect of the model is the simulation of vessel turnaround time at the quay, which is composed of the vessel's docking time, offloading time, departure time, and waste disposal time. To calculate the offloading time, the model requires the number of cranes assigned to each vessel type. For example, a national shrimp fishing vessel is assigned two cranes, each with a capacity of 50 tons per minute. The model calculates the total offloading time based on this crane capacity and the vessel's average cargo that they bring in per docking.

In addition, for larger vessels like the Panamax and Madrid Trader, the model computes offloading

Assumption	Justification
Six design vessels	Hake & 'Other' are caught using national shrimp vessels. Reducing the number of different vessel types from eight to six.
Hake is caught in shrimp off-season	During shrimp season, everyone wants to catch shrimp as it makes more money
Fish catch is spread out over the season	There are no major peaks in fish catch over the season
Fishing vessels can only arrive & leave during high tide	Because of the required depth. This was modelled by dividing the total time by 3. Simulating that they can only arrive 2x4 hours per 24-hour day.
Heavy lift, Panamax & Madrid Trader can be at the berth all day	These vessels will have a berth pocket where they can stay wet all day.
Modelling fish as general cargo	Similar handling process
Poisson distribution for the arrival of vessels	Usual for the arrival of vessels at ports (X. Wen, et al. 2024)
Erlang-2 distribution for service times	Usual for service times at ports (Simaiakis, 2014)

Table 5.1: Assumptions and Justifications for Vessel Quay-Length Model

Vessel type	Cranes/berth	Capacity /crane/hour	Total offloading capacity /hour
Squid	2	50 ton	100 ton
Shrimp National	2	50 ton	100 ton
Shrimp Coastal	1	15 ton	15 ton
Panamax	4	20 TEU	80 TEU
Madrid Trader	2	20 TEU	40 TEU
Heavy Lift	1	1 WTG	1 WTG

Table 5.2: Offloading capacities of various vessel types

times based on TEU (Twenty-foot Equivalent Unit) capacities, which are standard measurements in the shipping industry.

Utilization Rate (ρ) and Quay Usage

The model computes the *vessel utilization rate (ρ)* for both boundary conditions using queuing theory principles. The utilization rate is the ratio of the vessel arrival rate to the service rate. The arrival rate is defined as the total number of arrivals divided by the total season length, while the service rate is inversely proportional to the turnaround time.

- λ_1: Arrival rate for Boundary Condition 1 (2030).
- λ_2: Arrival rate for Boundary Condition 2 (2040).
- μ: The service rate, which is inversely proportional to the turnaround time.
- ρ: Vessel utilization rate, the ratio between the arrival rate and the service rate.

Simulation of Service Levels and Crane Requirements

The simulation is a key part of the model. Using the openqtsim library (M. van Koningsveld, 2021), the model simulates the arrival and service processes for each vessel under both boundary conditions. The simulation loops through different values of the number of cranes and berths and checks whether the service level requirements are met, based on the ratio of relative waiting time to service time (WT/ST). If the relative waiting time exceeds the allowed limit set by the service level, the simulation adjusts the number of cranes required to improve the service.

Design Vessels	Length [m]	Avg. Cargo	Turnaround [min]	BC2	Max. relative wait time
Hake	40.0	100 [t]	97	100 kt	10%
Squid	82.8	600 [t]	412	100 kt	10%
Shrimp (red)	40.0	100 [t]	97	150 kt	10%
Shrimp (yellow)	20.0	10 [t]	77	50 kt	10%
Madrid Trader	172.0	264 TEU	498	20.000 TEU	10%
Panamax	270.0	585 TEU	540	60.000 TEU	10%
Heavy Lift	138.0	-	222	-	10%

Table 5.3: Design vessels for quay-length model

The simulation is run multiple times for each vessel type and for both boundary conditions. The result is a detailed output that shows the optimal number of cranes and berths needed to meet service level requirements for each vessel under each boundary condition.

Quay Length Calculation

Once the simulations are complete, the model uses the results to compute the quay length required for each vessel under both boundary conditions. The model calculated the number of required berths to satisfy the relative wait time per vessel.

Figure 5.1 Shows the method of calculating the required quay-wall length for fishing vessels lined up behind each other. For the bigger vessels, with only one berth, Equation 5.1 was used, in accordance with PIANC guidelines (PIANC, 2024). Together they are used to convert the number of berths to a total quay length, as found in Table 5.4.

$$L_q = L_{s,\max} + 2 \cdot 15 \tag{5.1}$$

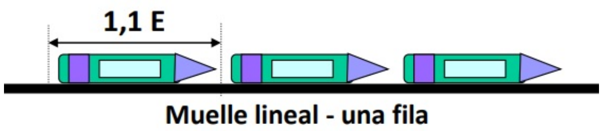


Figure 5.1: Fishing vessel berthing (EGIP, 2024)

Conclusion

The model gave the desired output of a first estimate of the required quay wall length. section E.1 will test whether the model has any sensitivities. See Table 5.4 for the discrete results.

Vessel Type	Berths BC1	Berths BC2	2030 Quay Length [m]	2040 Quay Length [m]
Hake	2	3	84	128
Squid	2	3	174	265
Shrimp (red)	3	5	128	216
Shrimp (yellow)	10	10	218	218
Other	0	13	0	284
Madrid Trader	1	1	202	202
Panamax	1	1	300	300
Heavy Lift	1	1	168	168

Table 5.4: Quay Length Projections for Different Vessel Types

5.1.2. Dimensions Access channel

This section presents the preliminary calculations to determine the dimensions of the waterways. Most dimensions are based on the guidelines from the Ports and Waterways manual (van Koningsveld et al., 2021) and the Port Designer's Handbook (Thoresen, 2014), which both refer to several PIANC guidelines. All these guidelines are elaborated in subsection F.1.1 of Appendix F. Also, the length of the dredged area for the access channel depends on the required depth. The bathymetry analysis, shown in Figure J.1 (Appendix J) derived from (La Poutré et al., 2023), gives the distance of the coastline where these values are reached, and the ships will be at open seas. In Figure J.1 it is visible that none of these values will be reached at the end of the bathymetry analysis, which means the values obtained in in this section are normative.

Length

The access channel ensures the fairway has adequate length, depth and width where needed, its dimensions are calculated taking into account weather conditions, seabed characteristics, and the types of vessels using the channel.

Width

The width of the access channel is determined by the size of the vessels and environmental factors like wind and wave height, both in the direction perpendicular to the access channel. The total width includes bank clearance, a manoeuvring lane, and additional width factors.

Depth

The depth (h_0) of the access channel depends on vessel characteristics and several environmental factors.

Dimensions overview

Following the PIANC guidelines and summarizing the calculated values, the resulting table is shown below. A slope of 1:2 was assumed between the head of the breakwater and the access channel:

Vessel	Length [m]	h_0 [m MOP]	Width at seabed [m]	Width at water level [m]
Poteros	152	-6.08	54	78
Madrid Trader	1223	-10.48	134	176
Panamax	1410	-13.48	151	205

Table 5.5: All dimensions access channel, see Appendix F

5.1.3. Dimensions sheltered waterway

Here, the width and depth of the waterway within the breakwaters are discussed. These dimensions differ from those of the access channel and will vary based on the vessels navigating specific sections. This variation impacts the number of dredged sections required within the port. The dimensions are based on the PIANC guidelines, with a full explanation available in subsection F.1.2 in Appendix F. All values are summarized in Table 5.6 and Table 5.7 below:

Vessel	Channel Width [m]
Yellow fleet	39.00
Red fleet	40.00
Poteros	52.60
Heavy Lift	76.38
Madrid Trader	86.80
Panamax	94.40

Table 5.6: Waterway widths per vessel

The values shown in Table 5.7 are rounded to show the actual depths that will be used in the design. In the design in chapter 8, the width of the berth pocket will be assumed to be twice the beam of the vessel and the length will be the length of the quay.

Vessel	Depth (berth pockets) [m MOP]		Depth (waterway) [m MOP]	
	Actual	Rounded	Actual	Rounded
Yellow fleet	-6.36	-6.50	-2.73	-3.00
Red fleet	-6.47	-6.50	-2.83	-3.00
Poteros	-7.98	-8.00	-4.33	-4.50
Heavy Lift	-12.40	-12.50	-8.73	-9.00
Madrid Trader	-12.41	-12.50	-8.73	-9.00
Panamax	-15.41	-15.50	-11.73	-12.00

Table 5.7: Depths per vessel with and without berth pocket

5.2. Port logistics demand

In this section, the areas of the different terminals are obtained, which are needed to derive the different concepts. The areas are divided into the different types of cargo that go through the port, these are fish cargo, general cargo (wind turbine generators) and containers (reefer containers).

5.2.1. Required Fishing Terminal Area

To determine the required terminal area for the fishing industry, a distinction has to be made between the different types of vessels that will berth the port. In section 1.2 the different quantities of cargo have been given that the port will handle. In phase one only shrimp, squid and hake are going through the port, in phase two another type of fish is added. The other fish species that will be handled by the port is interpreted to be sardines, considering that this is a species that is also currently handled by the port outside of the shrimp fishing season, according to a local expert (Rodrigo Bastida Arias). The different species are handled by three different types of vessels: squid is caught by Barcos de Poteros (jigger vessels), shrimp is caught by both the red fleet (industrial vessels) and the yellow fleet (coastal vessels), hake is caught by the red fleet, and sardines (other) are caught by the yellow fleet. The Poteros and Red fleet are both industrial vessels which have treatment facilities onboard, that allow for freezing and cleaning to happen onboard.

The area of the fish terminal is determined by the amount of storage needed, the type of treatment facility needed, space for auction and display, and the space for offices, these are given in Table 5.8. For the determination of the space, it is assumed that the fish is directly handled at the terminal, this area is behind the apron. These space requirements are derived assuming that all the fish is directly handled at the terminals at the quay, ensuring that the best possible service is given to the vessels that berth on these quays. The industrial vessels have treatment facilities onboard and therefore do not require preparation onshore.

Facility	Area $[m^2/t]$
Preparation	4
Display and auction	6
Equipment storage	4
Offices	4
Cold storage	1.5

Table 5.8: Two-column table with five rows

The area is relative to the tonnes of fish that are handled by the quay, this depends on the number of berths at the quay and the average tonnage that is brought in by the fishing vessels. The width of the apron is 12 meters, (Ligteringen, 2021); this is needed for the unloading of the vessels, handled by forklifts. The area of the apron is calculated by multiplying the quay length, obtained in subsection 5.1.1, by the apron width.

Species	Area Phase 1 $[m^2]$	Area Phase 2 $[m^2]$
Shrimp Yellow	4600	4600
Shrimp Red	6200	10400
Other (Sardines)	0	6000
Hake	4100	6200
Squid	20700	31100

Table 5.9: Terminal area per species of fish

The lengths of quays for these vessels are obtained in subsection 5.1.1, and together with the area required per species, the required conceptual dimensions for the fishing terminals are determined. These areas do not include areas for major and minor naval repairs.

5.2.2. Required Container Terminal Area

A container terminal in a port requires a specific amount of area due to the operational needs and logistical processes associated with container handling, storage, and transportation. PIANC guidelines are used to ensure the container terminal meets international standards. These steps are elaborated in subsection F.2.1 in Appendix F, the obtained values are shown in Table 5.10:

Phase	Vessel	Area [ha]
1	Madrid Trader	6.2
2	Panamax	17.4

Table 5.10: Container Terminal area

The exact terminal layout is not within the scope of this project. In the detailed design phase, a comprehensive plan for the layout of the terminal is made.

5.2.3. Required General Cargo Terminal Area

In the boundary conditions, the facilitation of wind turbine generators is included to allow for the construction of onshore wind farms. To ensure sufficient space is available for the transportation, storage, and loading/unloading of the components, this section outlines the necessary space requirements for the logistics involved. The calculations can be found in subsection F.2.2 in Appendix F.

Component	Maximum Stock	Calculated Stacking Area
Blades	63	6019 m2
Base Segments	35	5334 m2
Nacelles	20	835 m2
Hubs	20	1835 m2
Total Stacking Area (including separation)		**15441 m2**

Table 5.11: General cargo area

The calculated area is comparable with the area that was used in Puerto Madryn for the stocking of wind turbine parts (Eme and Smith, 2020). This is an indication that the model shows natural and valid behaviour. Due to additional areas required for unexpected shipments that need to be stored and additional safety margins like delayed shipment, strikes or bad weather. It is wise to dimension the required general cargo terminal area in the concept designs to balance these effects.

5.3. Recommendation from sensitivity analysis

A sensitivity analysis was carried out in order to expose over-sensitivities in the model and to find possible ways to save costs on the quay lengths. A more detailed overview can be found in Appendix E.

After extensive testing with the Maximum Relative Wait Time (MRWT) and its sensitivity, Table E.2 shows that by letting the MRWT for National Shrimp fishing vessels increase by 35%, (10% to 13.5%), 34% of the required quay wall for 2030 can be saved. Requiring 44m less quay wall to meet the set requirements. This will also be recommended to the client. However, this maintains a trade-off between the service offered and the costs saved.

Besides this, it was found that by accepting an increase in MRWT from 10% to 12% for squid vessels (a 20% increase), a 34% shorter quay wall would be required. Saving approximately 90 meters of quay wall. This might be considered interesting and will be recommended to pursue in the next design phase.

5.4. Technical Considerations

In this section, some of the technical and operational considerations that might influence the port design or the choice of design are elaborated.

One of the considerations that has arisen during the site investigation of Puerto Rawson, is the configuration of the existing breakwater. As mentioned in subsection 3.1.3 the old breakwater has a scour protection of poured concrete, therefore it is physically challenging to demolish the existing structure. Moreover, the sediment transported by the Chubut River is naturally collected between the old and new northern breakwater. When the expansion will proceed outside of the existing breakwater structure, it is beneficial to keep the old structure, this prevents sediment from the river flowing into the new port. The combination of these two factors makes demolishing the existing breakwaters a near-impossible task.

Plots on the private side of the riverbank, not owned by the client, have been excluded from consideration as usable land in the design concepts. To minimize environmental impact, the project aims to retain existing infrastructure wherever feasible, avoiding alterations unless absolutely necessary.

6 Port strategy plan

The following chapter presents the strategy plan for Rawson working towards a sustainable port.

As stated by (PIANC, 2014):

> *"A sustainable port is one in which the port authority together with port users, proactively and responsibly develops and operates, based on an economic green growth strategy, on the working with nature philosophy and on stakeholder participation, starting from a long-term vision on the area in which it is located and from its privileged position within the logistic chain, thus assuring development that anticipates the needs of future generations, for their own benefit and the prosperity of the region that it serves."*

To secure a sustainable future for Puerto Rawson, we have outlined a strategy focusing on three critical directions: Sustainable Workforce, Sustainable Economy, and Sustainable marine ecosystems, as outlined in subsection 4.2.2. These directions provide a framework for addressing the port's reliance on seasonal industries, ensuring environmental protection, and creating economic resilience. Together, they form the basis for a more inclusive development approach that benefits both the local community and the broader region.

The three strategic directions have been developed, outlining their findings, challenges, opportunities, and limitations. The complete information can be found in Appendix L.

While all pillars are crucial, this project has chosen to delve deeper into the last pillar: sustainable marine ecosystems, as it is key to successfully exploring and working towards the port's future vision.

This choice has been made due to the lack of data, high dependency on assumptions within pillars one and two, and the gap between the technical port design of this project. Within the Sustainable marine ecosystems pillar, it is most feasible to have an impact on port design, optimization, and efficiency while maintaining water quality and marine biodiversity.

6.1. Sustainable maritime ecosystem development

The sea receives various forms of waste: domestic and industrial wastewater, leaks from agricultural products, discards from fishing activities, oil discharges, and products discarded during boat cleaning. As a result, the pollution along the coasts of Puerto Madryn and Puerto Rawson is noticeable, both in observations and in satellite images (Sánchez et al., 2006). These three identified types of waste, which lead to toxins, which in turn lead to 970 total recorded dead whales in 2003 - 2023 are elaborated on in section N.1.

Figure 6.1: Waste types overview

6.2. Action plan

As mentioned in Appendix L, there are 3 opportunities acknowledged for improving waste management and water pollution. These opportunities are:

1. Regulation;
2. Education;
3. Facilities;

In this chapter, the potential solutions and implementations will be discussed for these opportunities. Regulation, education, and port facilities are essential to ensuring sustainable marine ecosystems for both present and future societies. Regulation, education, and facilities within the port are closely connected and dependent. Effective regulation is not able to thrive without the proper education of stakeholders on sustainable practices. Similarly, the success of port facilities in promoting sustainability depends on the regulatory framework and the knowledge of those operating within it. Each element supports the other, creating a complete system.

Besides the fact that the three opportunities have equal importance, due to time constraints and the scope of this project, regulation and education will be presented in the form of an action plan and the port facilities will be further elaborated on in section 8.3. This action plan consists of two design phases, outlined in the boundary conditions, and is divided into aims and actions. Additionally, the action plan addresses risks, timelines, and stakeholders.

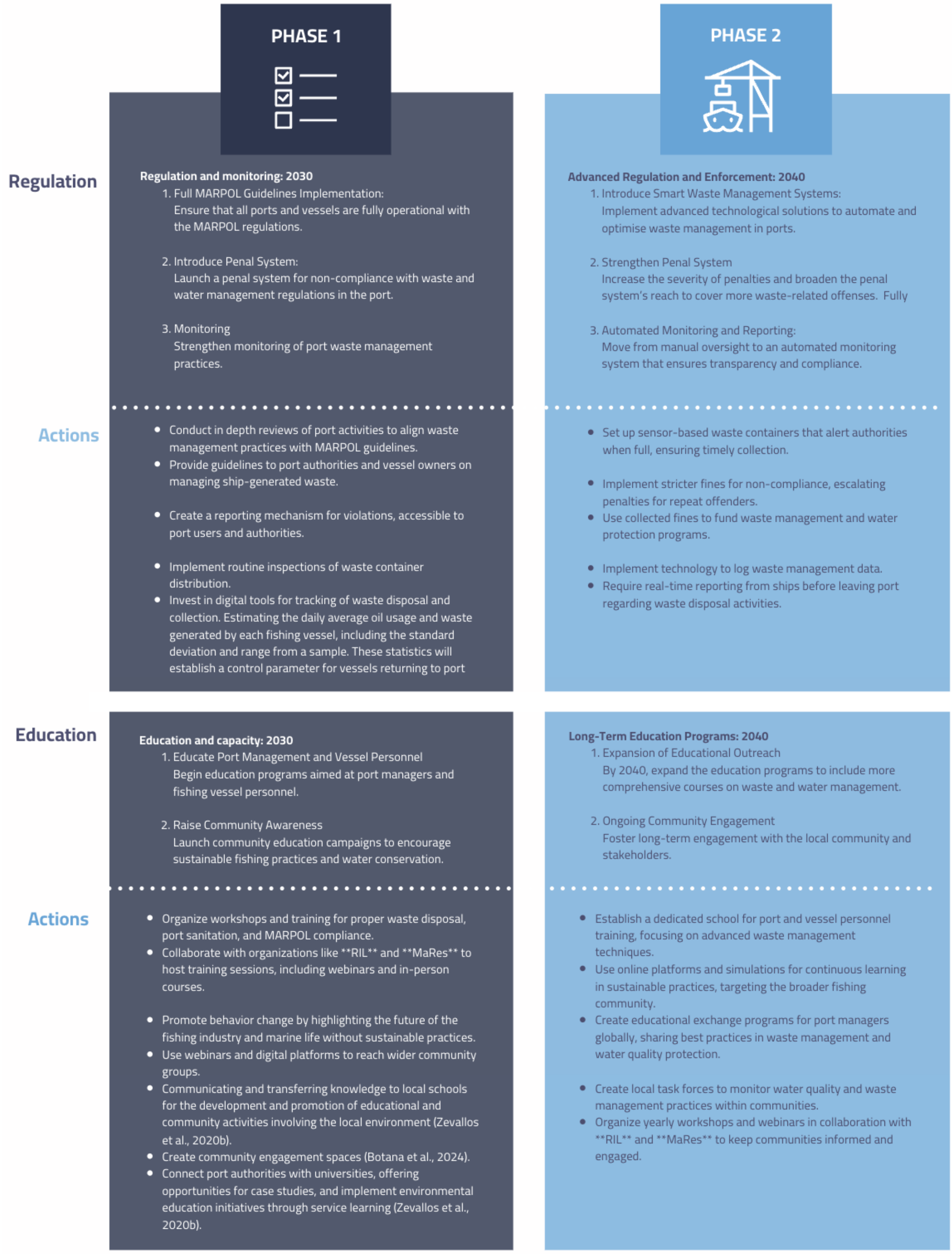


Figure 6.2: Action plan

Figure 6.3: Action plan

6.3. Design requirements

As explained in subsection 4.2.3, certain strategic goals were formulated to expand the scope of the port expansion beyond solely technical objectives. In order to integrate these strategic goals into the design of the port expansion, they must first be translated into design requirements. This means that they are actionable and can be assessed in a port concept. These design requirements can be found in the overview in Figure 6.4.

Figure 6.4: Design requirements

In order to align both the strategic and technical goals of the port expansion, an MCA is set up including both strategic design requirements as well as technical ones. To realise this, multiple strategic design requirements need to be categorised under overarching MCA criteria. These overarching criteria link back to the three sustainable directions worked out in the action plan. The division leading up towards these 3 resulting MCA criteria can be seen in Figure 6.5.

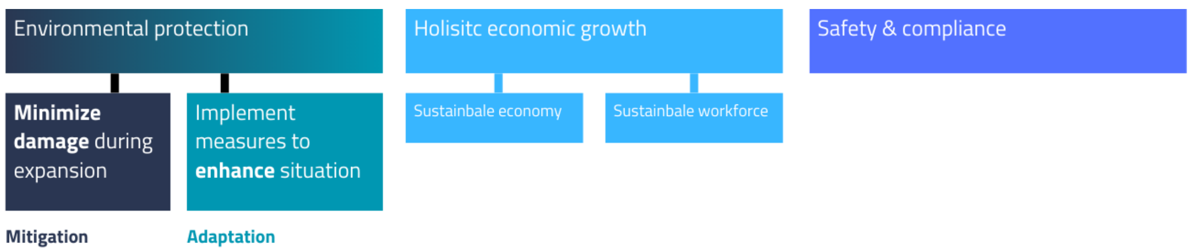


Figure 6.5: MCA criteria subdivision

1. **Environmental Protection**
   Contains all requirements focused on preserving the environment of and around the port of Rawson. This category is split into mitigation and adaptation, where the mitigating requirements aim to minimize the damage done during expansion, and the adaptation requirements focus on implementing measures to positively influence the environment.
2. **Holistic Economic Growth**
   Covers both economic diversification as well as sustainable workforce development. It includes requirements that lead to elevating the port's operational standards, strengthening its competitive position, and stimulating job and training opportunities.
3. **Safety & Compliance**
   Contains the more straightforward requirements that result from adhering to regulations, safety standards, and disruption guidelines.

6.4. Conclusion

The action plan presents regulation and education implementations within phase 1 and phase 2. These implementations outline actions necessary to ensure a sustainable maritime ecosystem in the port and its surrounding areas in the future. In section 6.2, these implementations are closely interconnected. These interconnections bring benefits and also introduce certain risks.

Key risks include slow regulation implementation and potential criticism, the possibility of penal systems causing boats to move to different ports, challenges in achieving national-level integration, and a lack of technology, personnel, and motivation for monitoring. Education also faces risks, such as high costs, low community participation, and not targeting the correct people. These implementations will also be taken into account when focusing on facility implementations.

In order to translate this action plan, strategic goals have been formulated. From these goals, design requirements have been created to make these goals actionable. While aligning strategic and technical goals is essential for the port expansion, MCA criteria have been created and have been implemented into the MCA analysis in Figure 7.4. These include Environmental protection, Holistic economic growth and Safety & Compliance.

7

Concepts & Choice of Design

This chapter aims to cover the transition from all the data that was acquired in the past chapters, to the concepts that emerged from this data & constraints. First, the data, constraints and recommendations that were used to come up with the concepts will be discussed. Afterwards, the concepts will be discussed one by one. After presenting all concepts, a Multi-Criteria Analysis will be conducted to evaluate the different options and select one for further development in the next chapter.

7.1. Data to concepts

Chapter section 5.1 outlines the nautical demand, which is essential for determining the dimensions and capacity of the port's infrastructure. Data gathered from vessel movement models section D.1 gives insights into future traffic, helping determine the number of berths and the quay length needed to handle projected vessel movements in 2030 and 2040. Furthermore, the quay-length demand subsection 5.1.1 and access channel dimensions subsection 5.1.2 directly influence the design of the port's nautical infrastructure, which must accommodate larger vessels and more frequent traffic.

The port logistics demand section 5.2 supplements this by specifying the required areas for various types of terminals, such as the fishing, container, and general cargo terminals. These requirements guide the spatial allocation for operational efficiency and capacity management in the conceptual design.

Furthermore, section E.1 provides valuable insights into possible ways to save CAPEX. The two recommendations that followed from this analysis, were adopted into the designs of the concepts. This means that in the first phase, 44m of the quay wall will be saved, and another 90 meters in phase II.

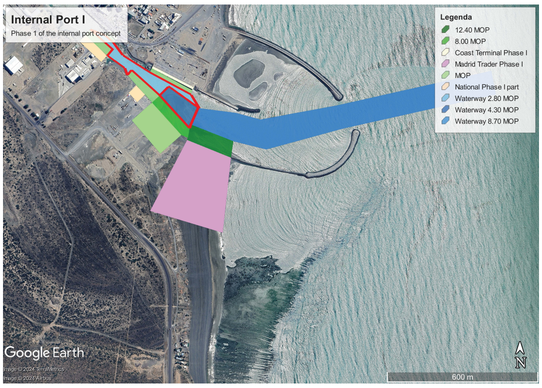
Together, these factors combined with the technical and environmental constraints that emerged from talks with the client and other stakeholders, lead to the design of the following concepts that will be discussed in section 7.2. It is important that all concepts have the same total quay length, as calculated in Figure 5.1.1. The main differences in the concepts are variations in locations per quay, which affect the required dredging operations, handling capacities, scalability and overall costs.

7.2. The Concepts

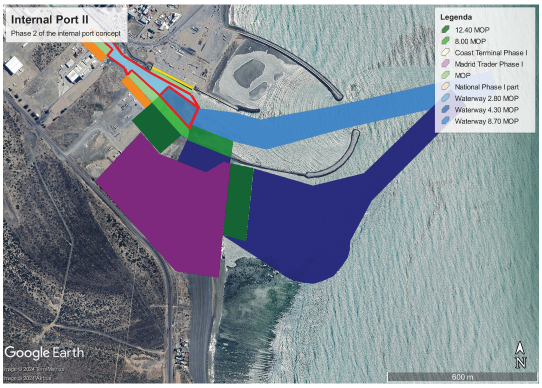
In the following subsections, the three different conceptual designs will be highlighted.

7.2.1. Internal Port

The first concept aims to provide the client with an option with the lowest CAPEX. The concept is named the 'The Internal Port' as it has most of its berthing spots inland of the port. This allows the concept to have lower CAPEX than the concepts that will be discussed later. However, this also comes with some disadvantages. The most important advantages and disadvantages are described in Table 7.1.



(a) Concept Internal port phase 1



(b) Concept Internal port phase 2

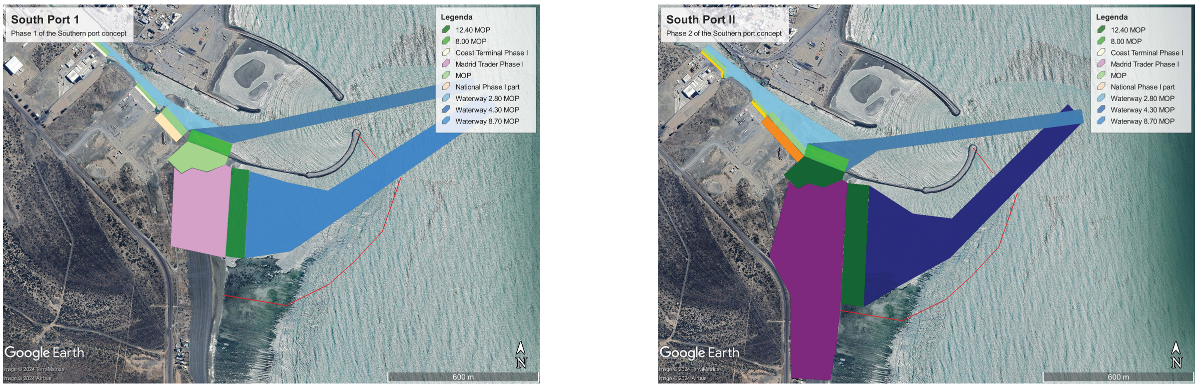
Figure 7.1: Comparison of Internal Port Concepts for Phases 1 and 2

Advantages	Disadvantages
+ Smallest expected CAPEX compared to other 2 concepts	- Limited scalability
+ Beneficial for the northern bank, due to shared market	- Congestion risks, as all cargo passes through the north (fishery, container, & general cargo)
+ Land south of original breakwater can remain intact for phase I	- Revenue shared with north side
	- Dependency on maintenance dredging with public north side
	- Inland river subject to sediment inflow
	- No change in breakwater shape, will not mitigate Playa Union erosion by 2030

Table 7.1: Comparison of advantages and disadvantages

7.2.2. South Port

The second concept is named 'The South Port', because it has the potential to draw the entire market to the privately owned south side of the port. The concept aims to provide exactly this to the client. This brings major opportunities to the developer, but it does come with higher costs. The advantages and disadvantages of the concept are further mapped out in Table 7.2.



(a) Concept Southern port phase 1

(b) Concept Southern port phase 2

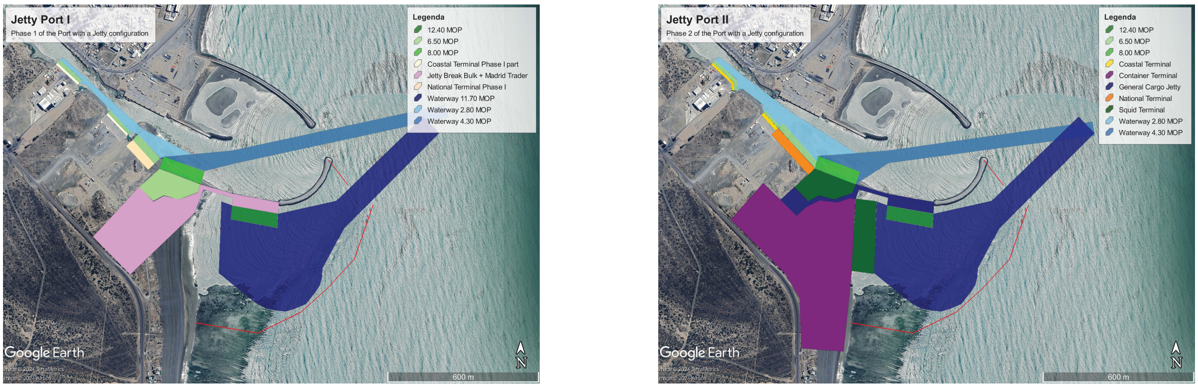
Figure 7.2: Comparison of Southern Port Concepts for Phases 1 and 2

Advantages	Disadvantages
+ Potential to take over 100% of the local fishery market	- Large CAPEX, also for first phase
+ High handling capacity, due to the double berth at the east quay	- Large volumes to be dredged
+ Unbothered fish industry in existing port	- Turning basin outside of sheltered area
+ No sediment flow from the river, filling the container and general cargo berth pockets and waterways	- Access channel direction is close to quay in phase II, less safe design
+ Change in breakwater shape can mitigate Playa Union erosion issues	

Table 7.2: Comparison of advantages and disadvantages

7.2.3. Jetty

The third and and final concept is called 'Jetty', because it will have a jetty on top of the old breakwater. The concept aims to provide a more out-of-the-box approach to the possibilities of expanding the port. Building a jetty on top of the old breakwater can have a lot of advantages, but it is not without risk. These advantages and disadvantages are highlighted in Table 7.3.



(a) Concept Jetty port phase 1

(b) Concept Jetty port phase 2

Figure 7.3: Comparison of Jetty Port Concepts for Phases 1 and 2

Advantages	Disadvantages
+ Cost saving by using the foundation of the old breakwater	- The Province of Chubut has to approve building on top of the breakwater
+ Reducing dredging costs by going further into the sea (dredging)	- Structural integrity of the old breakwater is not proven
+ Similar to 'South Port', could take over the entire market	- Combining container and general cargo handling at the same jetty quay could cause congestion risks due to limited space
+ The north side of the jetty could be used for fishery expansion	- Prone to spatial problems due to the concentration of different terminals at the beginning of the jetty (Bottleneck at the beginning of the old breakwater)
+ Unbothered fish industry in existing port	
+ Turning basin assisted by the pier reduces diameter turning basin	
+ Access channel does not directly approach one of the quays, reducing collision risk between ships and quays	
+ No sediment flow from the river, preventing filling of container and general cargo berth pockets and waterways	
+ Change in breakwater shape can mitigate Playa Union erosion issues	

Table 7.3: Comparison of advantages and disadvantages

7.3. Multi-Criteria Analysis

This chapter presents the Multi-Criteria Analysis (MCA) utilized to assess the various conceptual development plans for Puerto Rawson, discussed in the previous section. The MCA facilitates the comparison and selection of the most suitable option by evaluating several key criteria. The weights of these criteria were set by the client, Industrias Bass. A summary of the overall MCA and its criteria is provided in Appendix I.

7.3.1. MCA Result

When combining the criteria and weights, each concept is evaluated accordingly, and the total score is calculated. For example, in the case of costs, the Internal Port scores the highest (a 9) as it requires minimal dredging and fewer complex structures. On the other hand, the South Port scores the lowest in this category (a 4) due to the need for extensive dredging and a long new quay wall. After this process is completed for all criteria, and the weighted scores are summed up, we obtain the following figure:

CRITERION	WEIGHTS	ALTERNATIVES		
		INTERNAL PORT	SOUTHERN PORT	JETTY PORT
COSTS	14%	9	4	7
SCALABILITY	16%	3	9	7
HANDLING CAPACITY	16%	4	9	6
OPERATIONAL DISTURBANCE	8%	2	7	5
ENVIRONMENTAL PROTECTION	16%	6	4	8
HOLISTIC ECONOMIC GROWTH	14%	5	8	8
SAFETY & COMPLIANCE	16%	6	6	7
FINAL SCORE	100%	5.16	6.72	6.98
UNWEIGHTED SCORE	/	5.00	6.71	6.86

Figure 7.4: MCA result

From Figure 7.4, it follows that the concept 'Jetty' suits the client's wishes best. However, in order to validate the robustness of the MCA, a sensitivity analysis will be carried out in the following sub-chapter.

7.3.2. Sensitivity Analysis MCA

In Figure 7.4, one can see that the concept 'Jetty Port' is the preferred concept when using the current weight, selected by client Industrias Bass. In addition to that, when looking at the unweighted scores, the 'Jetty Port' still comes out as the preferred concept.

However, the scores for the weighted and the unweighted MCA are only 3.87% and 2.2% apart respectively. A simple sensitivity analysis shows that by making slight adjustments to the weights, another concept is preferred. This is shown in Figure I.1. This draws the conclusion that this current MCA is not robust. Therefore it would be recommended to further diversify the concepts or to perform a more detailed feasibility study in a future study.

8 Proposed Masterplan

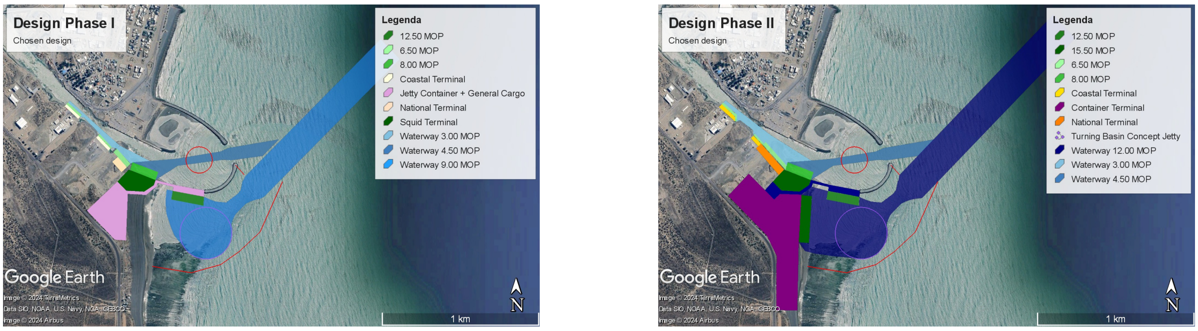
This chapter provides a detailed explanation of the preferred master plan that evolved from the selected concept, highlighting the improvements made along the way. It delves deeper into the design beyond the initial conceptual plan and outlines the strategic requirements essential for implementing an effective waste reduction plan.

8.1. Preferred Design Option

As previously mentioned in chapter 7, concept 'Jetty' was proven to fit the best to the client's wishes. However, the concept had some modifications before the final master plan was drawn up. These modifications were followed by expert reviews and results from the sensitivity analysis. These modifications include:

- **Safety**, the Panamax quay wall was moved south 10 meters, in order to have more safe operations and more margin in the turning basin.
- **Cost reduction**, following the recommendations from the sensitivity analysis in section E.1, the quay wall for the squid & national shrimp was shortened by accepting a slightly higher relative wait time.

After these modifications, the conceptual plan for the port-side layout now looks like this. In the appendix, a larger version of these port-layout designs can be found. The next sub-chapters will elaborate on the design requirements that are included into the preferred design option.



(a) Preferred port concept phase 1

(b) Preferred port concept phase 2

Figure 8.1: Comparison of 'Preferred' Port Concepts for Phases 1 and 2

8.1.1. Nautical requirements

To ensure enough space is available for vessel movements in and outside of the harbour, PIANC and other guidelines were followed to meet international standards. All calculations used to determine the values shown are provided in chapter 5.

Access Channel

Based on the boundary conditions and their corresponding number of vessels, and the focus on cost-effectiveness, a single lane was selected for the design after thorough discussions with experts. Figure K.1 provides a scaled layout. Table K.2 lists the dimensions of the selected access channel, for both Phase I and Phase II. These values are rounded up to reasonable values for the dredging industry. Note that for the fishing harbour, the largest vessel doesn't change for Phase II, for the container harbour it does.

Turning Basin

For navigational purposes, a turning basin will be established in the protected area of the harbour to enhance the workability period. Each harbour has its own maximum vessel size, leading to specific turning basin dimensions as shown in Table K.3. These values are rounded up to reasonable values for the dredging industry. It is important to note that the North Harbour (N.H.) lacks a pier to assist, thus needing a diameter of the turning basin (T.B.) of $2L_{poteros}$ (for both phases I & II). In contrast, the South Harbour (S.H.) will have a pier to aid in turning, resulting in a turning basin diameter of $1.2L_{max}$ (Madrid & Panamax) (van Koningsveld et al., 2021). These turning basins are also presented to scale in Figure K.1.

Harbour Waterway

To ensure safe navigation through the harbour, the dimensions of the sheltered waterways are determined based on the guidelines provided in the Port Designer's Handbook (Thoresen, 2014). The relevant (again: rounded) values are presented in Table K.4 and illustrated in Figure K.1 (to scale).

Component	Phase I			Phase II		
	Area [m²]	Area [ha]	Quay Length [m]	Area [m²]	Area [ha]	Quay Length [m]
Squid	20785.92	2.10	183	20785.92	2.10	183
Shrimp Nat	4156.0	0.45	88	10390.0	1.05	220
Shrimp Coast	4131.0	0.45	198	4131.0	0.45	198
Other	-	-	-	5967.0	0.60	286
General Cargo	-	-	-	11300.0	1.15	168
Container	-	-	-	173100.0	17.35	300
Combi Terminal	72570.0	7.25	202	-	-	-
Total Area	**101600.0**	**10.15**	**671**	**219700.0**	**21.20**	**1355**

Table 8.1: Area requirements and Quay lengths for Phase 1 and 2 (in m², ha and m)

All areas, lengths and other dimensions are mapped out in the Figure 8.2. All of its lengths and dimensions can be found in Appendix K.

Figure 8.2: Blueprint nautical side

8.1.2. Spatial requirements

In this section, the spatial requirements of the terminals are substantiated. The terminal areas calculated in section 5.2 are summarized in Table 8.1 and implemented into the final concept as shown in Figure K.2 and Figure 8.1.

The areas shown in Figure K.2 correspond to the values in Table 8.1, and are made in Google Earth to ensure that the scale is correct. The shape of the areas will differ in the detailed design, as mentioned in subsection 5.2.2. The container terminal areas are derived from subsection 5.2.2, the fishing terminal areas are derived from subsection 5.2.1 and finally, the general cargo area is calculated and derived from subsection 5.2.3, these are all of the needed areas in the subsequent phases.

In phase I the jetty on the old breakwater functions as a combined quay and terminal, subsequently in phase II the facilities already used for container storage can be added to the container terminal that is able to berth a Panamax vessel. The general cargo terminal in Phase II uses the same location as in Phase I, however, now the jetty and quay are solely used by heavy lift vessels.

8.1.3. Dredging Requirements & Recommendations

As seen in the past (sub-)chapters, a lot of capital and maintenance dredging will have to be carried out in order to realize the master plan. This subchapter aims to shine a short light upon a recommended dredging plan to realize the desired depths and widths of the waterways and berthing locations.

During the site visit, (Appendix A) a visual inspection around the area, resulted in the findings of large amounts of tuff stone. This is a hard soil type, compared to for instance sandy soils, but compared to other rocks, it is quite soft, with an m-value of around 13 (Miedema, 2019). Which confirms that dredging will be possible at the ports' location.

However, to achieve an effective dredging strategy, it would be recommended to expand on the preliminary findings related to soil composition, particularly the presence of tuffstone. A brief mention of sediment characteristics, such as grain size, density, and any potential contamination, would provide essential information. If further soil analysis would be carried out, the dredging could be executed in a more efficient manner. More importantly, the risk of doing undesired findings (such as harder stone or contaminated soil) would be reduced.

8.2. Improved Operations

This section emphasizes the progressive enhancements of the Port in chronological order, beginning with the developments slated for 2030 in subsection 8.2.1, followed by describing prospects of 2040 in subsection 8.2.2.

8.2.1. Phase 1 Improvements 2030

Until November 2024 the port will function as a single-purpose port, which is only able to handle fishery, the addition of a jetty in 2030 will allow for the handling of container and general cargo. As mentioned in subsection 3.1.1 the port is already projected to handle container cargo in the future, however, both the vessels and port will be able to handle significantly more following the expansion scenario of phase I. The throughput of 20,000 TEUs per year gives the chance to broaden the horizon of Puerto Rawson and increase its range of exports. The container vessels in Phase I will be able to handle more than twice the cargo of the container vessels in the current plans.

Moreover, the port will be able to handle general cargo, opening the door for renewable energy opportunities. The benchmark of 50 WTG's per year, can accelerate the construction of wind farms in the province. Furthermore, by migrating the other terminals away from the fishing terminals the fishery will be unbothered, and can therefore work more efficiently and safely.

The opportunity to handle poteros vessels will increase the diversity of the handled fish in the port, and together with the berth possibility of the red fleet (industrial vessels) the quantity of handled fish will increase dramatically. The new terminals have more facilities for directly processing the catch, this increases the range where the products can be sold.

8.2.2. Phase 2 Improvements 2040

With the master plan finished in 2040, the port will have major operational upgrades compared to the base situation in November 2024. The port has the potential to serve as a major fishing hub, benefiting from the rich marine life in the proximity.

The port will be able to accommodate all required vessels needed to satisfy the boundary conditions, while still offering good service to all vessels. In 2040, no vessel is expected to surpass the *relative maximum wait time* of 12%. Making sure that the port will grow without losing the competitive position it has by ensuring short wait times.

Moreover, by 2040 the port will be ready for green-energy projects, by being able to export liquid hydrogen or by importing WTG parts.

8.3. Port Facilities

8.3.1. Port Waste Management Plan

According to the Guidance Document on Developing Port Waste Management Plans, created by Van Den Dries, 2022, there is a lot that can be done within ports to prevent and minimize waste. This chapter uses this guideline to assess and develop a port waste management plan (PWMP) for Puerto Rawson.

As previously mentioned in section 6.1, we define 3 types of waste. Within the PWMP we will be focusing on Port waste. Waste within the industry is divided into multiple MARPOL Annexes. These annexes include Oil, NLS, Sewage, Garbage and air pollution-related waste. The different MARPOL Annexes and their waste types can be seen in Appendix M.

In addition to the MARPOL Annexes and their waste types, further elaboration on fishing as a source of marine litter is also necessary. Fishing vessels may intentionally or accidentally release waste, such as gloves, storage drums, EPS fish boxes, and personal items, into the marine environment (Van Den Dries, 2022).

Fishing gear is prone to loss and shows greater risks. They can cause entanglement or ingestion by marine life. Abandoned, Lost, or Discarded Fishing Gear (ALDFG), can occur floating or beneath the surface of the water. They can cause trouble for marine organisms.

PWMP preparation

The PWMP can function as a comprehensive resource for port operators and stakeholders. It integrates all necessary elements, processes, regulations, targets, and roles associated with the handling, collection, treatment, monitoring, and enforcement of ship-generated waste (SGW), including cargo residues (Van Den Dries, 2022).

The objectives of the PWMP are to:

- Minimize illegal discharge of waste from vessels;
- Ensure compliance from port users with waste management regulations and legal obligations;
- Engage with port users, ship agents, operators, waste contractors, and regulators in developing and implementing waste management strategies;
- Prevent waste generation whenever possible;
- Promote the reuse or recycling of waste if feasible.

In addition to providing adequate Port Reception Facilities (PRF), which are put in place to minimize SGW ending up in the seas, there are added complications that make it harder for PWMPs to succeed. One of these factors is the cost of using these facilities. They might discourage ships from properly disposing of their waste. Implementing indirect cost recovery systems can help prevent the financial factors to the discharge of waste at sea. By requiring ships to pay a waste fee, they are more likely to dispose of their waste in the correct way at the port. Effective monitoring of the PWMP is essential to ensure that the plan is properly implemented and that the PRF is operating as required (Van Den Dries, 2022).

It is important to mention that recycling is not a MARPOL requirement. It is a recommendation and it is left to the port how to handle this. Legally ships are able to hand in a mixture of waste as long as it is fit to the MARPOL Annex.

Puerto Rawson PWMP

The goal within Puerto Rawson is to create a comprehensive PWMP for the entire port. In collaboration with Girsu, the local waste processor, different types of waste collection will be introduced to optimize recycling and reuse. Currently, the public dock only has one container where all waste is collected. The situation at the private port is unknown as the docks are privately managed. By implementing proper waste collection and treatment, in collaboration with Girsu, the correct Port Reception Facilities (PRF) can be installed on the private side of the dock. This can be done through a Waste Reception and Handling Plan (WRH plan).

As mentioned in the guidance document, a distinction can be made between fishing ports and ports handling larger cargo ships. With the expansion of the port, Puerto Rawson will become both. Therefore, two different WRH plans are planned for implementation, including the necessary PRFs, for each side of the dock within the same PWMP.

Looking at the layout of Puerto Rawson and strategic considerations, the aim is to implement a WRH plan as mentioned in option B. This approach allows for the use of the same traffic, partnerships, and WRH while still tailoring them to the needs of both public and private docks.

Additionally the PWMP for the entire port proposes sustainable design measures for the dock designs. When designing the docks a slope in the quay side is implemented. This slope will limit the waste and waste water flowing from the docks into the sea. This will also minimize potential oil spills. By additionally adding a gutter into the docks from which the waste water can be transported to a designated area, it is possible to limit pollution. The maintenance on the docks itself will be executed by the dock owners.

PRF Public Dock - Public WRH plan

The WHR Plan within the public dock will determine the PRF of this part of the port. Compared to SGW from other shipping vessels, fishing vessels do not generate such diverse waste. Within this port, mobile collection facilities are not taken into account. All waste collection will be on the quayside of the dock and be placed in fixed reception facilities. Waste will be unloaded at the same time as the fish, this has been integrated into the model by adding 2 minutes of unloading time for the vessels.

While fishing vessels have limited types of waste, fishing ports are able to focus on Annex I (bilge water and waste oil) and Annex V (garbage, including fishing gear) of MARPOL. Organizing the collection of fishing vessels can be done in a quite simple manner. Appendix M shows all waste types, Fishing ports should be able to collect Annex I and Annex V, including categories A to I, excluding category G.

The use of waste containers on the quayside is an adequate PRF for garbage from fishing vessels. If waste is collected properly, meaning fishing vessels separate their waste in a proper way, skips will not be necessary to collect daily garbage from fishing vessels. Instead, a modular option has been chosen, selecting mobile waste containers instead of skips. In this way, dock personnel can move them easily, and there is no need for trucks to move the containers. For the public dock, the following different waste containers are proposed (Annex V):

- Plastics and cans
- Paper/cardboard
- Glass
- Residual waste
- Fishing gear
- Hazardous waste

Additionally, trucks for bilge water and drums for oil waste need to be put in place (Van Den Dries, 2022). This oily waste should be collected and transported to a licensed treatment facility (Helsinki City Environment Centre, 2005). Currently, Girsu is not licensed to process this waste, the assumption is made that in 2030, Phase 1, Girsu will be licensed to process this waste. Additionally, facilities for pumping sewage water from the vessels into the local sewage system should be put in place (Helsinki City Environment Centre, 2005). This is in line with preserving water quality.

An estimate is that fishing boats have 45-120 kg of waste if they are away for 5-10 days, as can be seen in Table 8.2. While these fishing vessels are not at sea permanently the estimation is made with the consideration that vessels generate less waste than vessels that are away for more days at a time.

Ship type **Ship type**	**Number of persons on board**	**Duration of voyage (in Arctic waters)**	**Amount of waste generated**
Cargo ship (>400 GT)	20	7-14 days	210-420 kg
Cargo ship	20	5-10 days	150-300 kg
Research vessel	25-50	10-30 days	375-2250 kg
Fishing vessel	6-8	5-10 days	45-120 kg
Exploration/offshore support vessel	10-15	7-14 days	105-315 kg
Cruise ship/passenger vessel	15-3000	7-15 days	210-90,000 kg
Cruise ship/passenger vessel	15-3000	15-30 days	450-180,000 kg

Table 8.2: Amount of MARPOL Annex V waste generated onboard a ship (Van Den Dries, 2022)

Estimated is that fishing boats have 45-120 kg of waste if they are away for 5-10 days. While these fishing vessels are not at sea permanently, the estimation is made with the consideration that vessels generate less waste than vessels that are away for more days at a time.

The public port is built up of two docks, and twelve containers would be needed to be able to serve both docks. The dock serves 130 vessels on the docks, as mentioned in chapter section D.1.

$$\frac{120}{5} \times \frac{130}{12} = 260\,\text{kg per container}$$

If separated correctly, the port should need only 1 waste container (360 kg) to cover a day's worth of waste from all ships. For the public dock, this means 12 waste containers in total are needed to cover the old and new private dock. This would mean that even on a day when a lot of waste is generated, the containers would be enough. It is acknowledged that waste is not distributed evenly, which is why a bigger, slightly more expensive container has been opted for.

PRF Private Dock - Private WRH plan

Looking at the private side of the port, it is not yet possible to determine all specifics on how many waste containers should be placed while not all data is present concerning private vessels. For the overall

WRH plan of the port, the private dock should take a few guidelines into account. All waste collection should be on the quayside of the dock and be placed in fixed reception facilities. Merchant seaports receive a broader variation of ship types. They should take the availability of covering all MARPOL Annexes into account. These annexes and their accompanying categories can be seen in Appendix M.

The same reception facilities are assumed for the Annex V waste:

- Plastics and cans
- Paper/cardboard
- Glass
- Residual waste
- Fishing gear
- Hazardous waste

While data on collection is limited, storing, transporting and processing of Annex I, Annex II, Annex IV and Annex VI, the assumption is made that the private port will facilitate the collection of these materials. This has also been confirmed by Sr. Castillo from Industrias Bass. Industrias Bass should make additional arrangements with either Girsu or another waste handling partner in order to collect, transport, process and discard waste from Annex II, IV and VI.

PRF Joint port - Joint WRH plan
It is acknowledged that many more types of waste are listed in Annex V. However, to be able to ensure Girsu's handling capacity, the decision has been made to keep six mainstream waste containers and place special waste containers, such as E-waste containers, in the WRH plan for the entire port, rather than making them dock-specific.

These bins will be placed between public and private dock territory and will serve the entire port. This is mainly done while not a lot of waste of this sort is generated on the yellow fleet vessels. The vessels do not use cooking oils and do not generate much E-waste, while not a lot of technology is present on these vessels. Therefore, there is no need to place facilities on each dock for these types of waste. On the occasion that this type of waste does need to be thrown away, it can be done in the designated area.

PWMP Overview
By combining the WRH plans of the public and private docks, along with the joint WRH plan of the port, the PWMP can be created. The PWMP has an operational area in which facilities are placed and waste is collected. This operational area includes adjacent businesses and organizations such as processing plants, port administration and restaurants as well as the public, private and joint WRH areas.

Cost recovery system
Providing adequate PRF may not be enough of an incentive for ships to manage their waste more responsibly. The cost of delivering waste is also an important factor to consider, as it can act as a discouragement.

That is why in the PWMP for Puerto Rawson, it is recommended to integrate a cost recovery system. A cost recovery system is a system designed to ensure that the costs of the operating PRF for the reception and treatment of the SGW are covered. Integrating a cost recovery system into the PWMP is not required by MARPOL, but is very common in (merchant) seaports. In the case of Puerto Rawson, where waste management is currently lacking, such a system is not only desirable but vital if ships are expected to accept these new waste management measures.

There are two types of cost recovery systems: direct and indirect. An indirect fee implies that: "a fee is paid by the ship for the provision of PRF, irrespective of the actual delivery of waste from the ship. Depending on the system, the fee can cover full (100%) or partial cost of the waste delivery." Whereas a direct fee system is generally linked to the amount of waste delivered to the PRF. (Van Den Dries, 2022)

As stated before, the private and public parts of the port handle different types of waste streams, translating into different MARPOL Annexes. Additionally, the different stakeholders involved and the

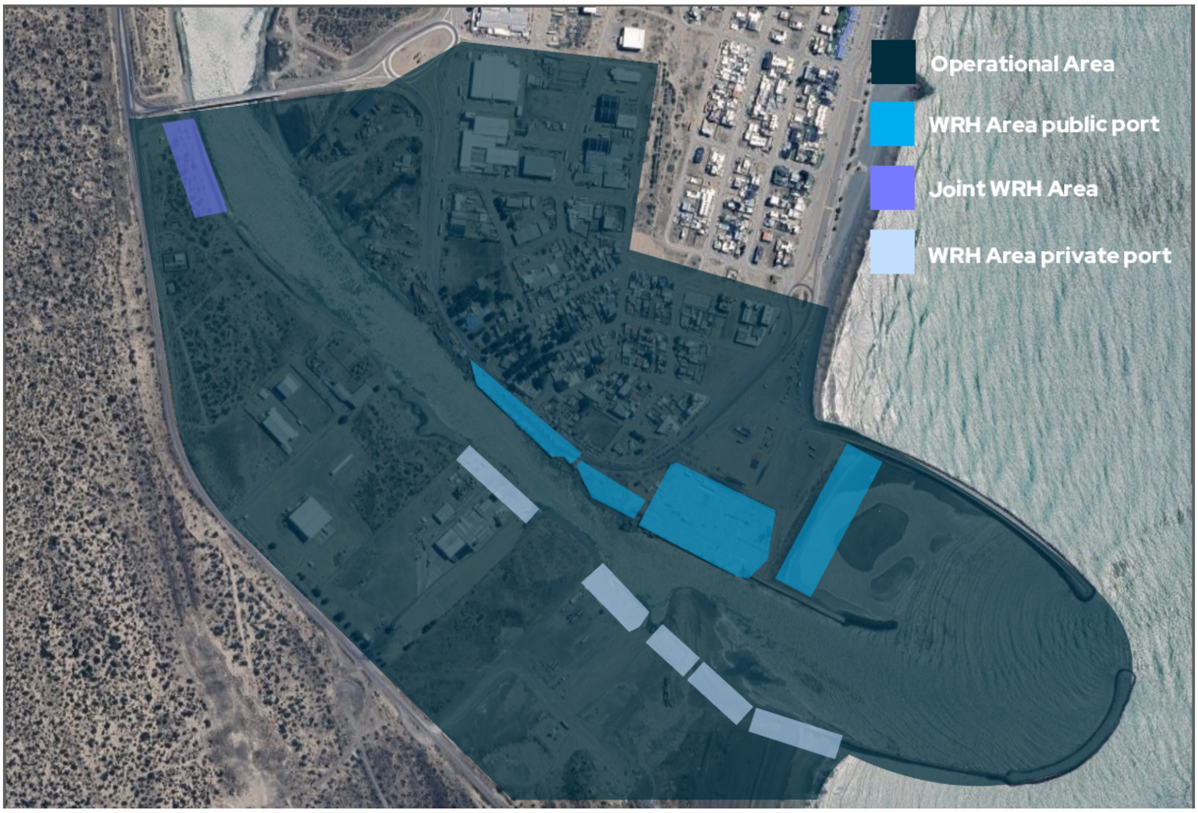


Figure 8.3: PWMP Overview & Operational Area

type of vessels using the facilities ask for a different approach for the two ports. It is thus advised to develop two different cost recovery systems.

As a result, the recommendations for cost recovery systems, as can be seen in Table M.2, are different. The two different WRHs, that fall under the collective PWMP, will each have a suitable cost recovery system.

For private, merchant seaports, corresponding with the expansion goals of the private part of the port, the following recommendations for cost recovery systems are identified per waste type by (Van Den Dries, 2022).

The private part of Puerto Rawson is likely used by larger commercial vessels or private operators who have a greater capacity to bear costs directly tied to the services they use. Additionally, they are commercial operators who are accustomed to paying directly for services based on consumption. That is why for this part, the cost recovery system should be more usage-based. Here, Puerto Rawson should implement a usage-based fee for waste reception facilities. This is in line with the recommendations established in Appendix M.

While more responsibility can be expected from the companies operating on the private side of Puerto Rawson, the direct cost recovery system still results in less incentive to not dump waste in the sea. That is why it is recommended to set up contractual agreements that specify responsibility, terms of service and frequency of waste collection.

As recommended by (Van Den Dries, 2022), an exception is made for garbage (part of MARPOL Annex V) and oily waste (part of MARPOL Annex I). Where a fixed indirect fee is advised for the former while the fee of the latter is linked to the amount delivered to PRF.

While the private side of the port aims to attract new types of fishing vessels and cargo ships, the public part of the port will still serve the same function; primarily a docking place for family-owned fishing vessels. That's why for this part, a cost recovery system that encourages compliance without placing too much of a financial burden on local fishers is ideal.

A standard fee could be imposed on all vessels using the dock, irrespective of whether they use the PFR for waste disposal. An indirect cost recovery system eliminates the economic advantage of dumping waste into the sea. “As ships are required to pay a waste fee irrespective whether they use the PRF or not, they might as well deliver the waste.” (Van Den Dries, 2022). Due to the large number of vessels docking on the public side, it is expected that this fee can stay low and manageable. However, the suggested alterations and improvements to the PRFs may require a significant investment from port authorities and waste management companies, an investment that might be too large for direct and indirect cost recovery systems to cover. To help manage this financial burden, the government should step in to help reduce the costs.

According to (Van Den Dries, 2022), there are several ways to do this. In the case of Puerto Rawson, the most relevant initiatives that can be set up by the government are:

- Implementing local tax reductions: exemptions for companies or port operators investing in new or upgraded port reception facilities (PRF) at Puerto Rawson. These could include reduced property taxes or lower import taxes on waste management equipment.
- Subsidies or guaranteed loan: The government could allocate funds specifically for port expansion and waste management infrastructure. Subsidies could be offered to cover a portion of the capital and operational costs of setting up waste reception facilities, particularly in the public part of the dock. If this is not feasible, a guaranteed loan will also make funding PRF more feasible.

Waste delivery receipt
The waste delivery receipt (WDR) is a document provided to the ship’s master by the port’s reception facilities after the waste has been delivered. It records the types and amounts of MARPOL waste/residues collected by the PRF. In essence, this receipt serves as proof of waste management compliance and can be used for regulatory checks.

For Puerto Rawson, the WDR will be crucial in the process of getting a grip on waste management. It forces all ships to report on their waste handling practices, aligning with the port’s desire for a more transparent, certified and regulated port. This aligns with the action plan in Figure 6.2

All ships docking at the port, both on the public and private side, must submit the WDR. The responsibility for providing the WDR to the ship lies with the overarching port administration. Apart from providing the ship’s master with the standardized IMO format for the WDR model (which can be found in Appendix M, the PWMP of Puerto Rawson should also clarify when and by whom the WDR should be completed.

In addition to its operational benefits, the WDR can help Puerto Rawson assess whether existing facilities are adequate or if and when additional facilities should be integrated into the port infrastructure.

8.3.2. Eco-Friendly design measures
In order to take into account the sustainability of the waters in Puerto Rawson, certain design decisions have to be integrated into the development stage of the port expansion. This chapter focuses on the implementation of nature-inclusive design elements into the construction of the quay wall and breakwater that enhance water quality.

Definition & Function
Three main ecological phenomena that have proven to enhance water quality and are relevant in the context of the port expansion of Rawson are oyster banks, tide pools and quay wall habitats.

- Oyster banks are structures formed by the accumulation of oysters, either naturally or artificially. They play a crucial role in marine ecosystems by providing habitat for marine species and improving water quality through filtration (Mulder et al., 2023).
- Tide pools are isolated pockets of seawater left behind as the tide ebbs, creating unique microhabitats that support diverse marine life, such as algae, molluscs, crustaceans, and fish (Beck et al., 2011).

- Quay wall habitats are artificial environments created by quay walls along waterfronts, offering attachment points for organisms like algae, barnacles, and invertebrates (Satyam and Thiruchitrambalam, 2018).

The analysis of the material selection, shape selection and possible partners from these suggested ecological phenomena can be found in section N.2. In the figures below the suggested options and their impact can be seen.

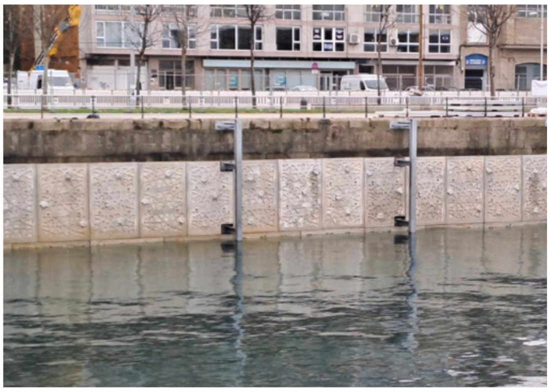


Figure 8.4: Seawall panels installed at the Port of Vigo (ECOncrete, 2024)

Figure 8.5: Fish feeding off algae growth on the seawall in the Port of Vigo (ECOncrete, 2024)

Figure 8.6: Fish feeding off algae growth on the seawall in the Port of Vigo (ECOncrete, 2024)

Impacts on water quality

The integration of the mentioned design decisions is expected to lead to the formation of oyster banks, tide pools and quay wall habitats, which have significant positive impacts on water quality. These phenomena collectively enhance the marine environment through various ecological functions. The interrelatedness of these processes and their relation with the previously mentioned design interventions is illustrated in the schematic overview in Figure 8.7.

- **Pollutant filtration**: One of the primary benefits of oyster banks is their ability to filter pollutants from the water. This natural filtration process not only improves water clarity but also contributes to a healthier aquatic environment by reducing the concentrations of harmful substances. A single oyster can filter up to 200 litres of water per day (Ermgassen et al., 2012). Additionally, the integration of tide pools and quay wall habitats further enhances pollutant filtration. Research has shown that these combined measures can significantly reduce levels of nitrogen, phosphorus, and other contaminants in coastal waters (Carstensen et al., 2020).
- **Nutrient cycling**: The integration of oyster banks within the port's design will facilitate nutrient

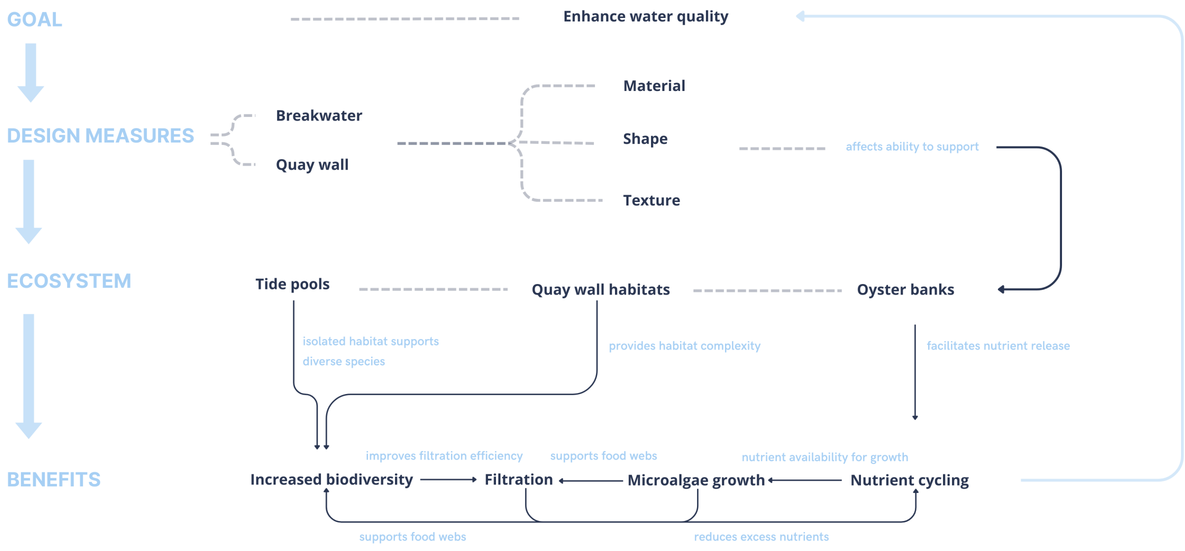


Figure 8.7: Relations design measures - ecosystem - benefits

cycling and improve the resilience of the marine ecosystem against nutrient overloads. By consuming phytoplankton and other organic materials, oysters help maintain balanced nutrient levels in the water (Ray and Fulweiler, 2020). Additionally, tide pools and quay wall habitats provide environments suited for specific marine habitats. These habitats host a variety of organisms, including algae, bacteria, and small invertebrates, which break down organic matter and recycle nutrients like nitrogen and phosphorus (Zimnicki et al., 2020).

- **Microalgae growth**: Tide pools and quay wall habitats promote the growth of microalgae. These habitats offer surfaces for microalgae to attach to and thrive, benefiting from the nutrient-rich waters. Microalgae demonstrate great potential for wastewater treatment: they show great efficiency in nutrient removal, heavy metal sequestration, and overall water quality enhancement. This is due to the natural ability of microalgae to absorb and transform pollutants (Satyam and Thiruchitrambalam, 2018).
- **Increased biodiversity**: Tide pools, oyster banks, and quay wall habitats support a wide range of species. All three of these habitats lead to increased biodiversity, which is essential for a stable and resilient ecosystem. Research has shown that the presence of diverse marine life can significantly improve water quality. A higher marine biodiversity increases the efficiency of nutrient cycling and pollutant removal processes (Pugh and Field, 2022). Thus, the increased biodiversity improves ecosystem health and resilience, making it more capable of withstanding environmental stressors and maintaining water quality.

In conclusion, the integration of design measures that support the formation of oyster banks, tide pools, and quay wall habitats is expected to result in substantial benefits for water quality.

Benefits Beyond Water Quality Enhancement

Implementing these design decisions not only positively influences water quality but also brings additional benefits to the project.

- **Reduced material costs**: Since the material quantities in the construction elements are reduced, the unit prices can be significantly lower. For instance, for large breakwaters, the XblocPlus design demonstrates a 57% reduction in costs compared to traditional rock designs (Xbloc, 2022).
- **Increased durability of the structures**: The attached organisms act as biological glue, enhancing the strength and durability of structures, thereby adding to their stability and longevity (ECOncrete, n.d.-a). Consequently, less maintenance is needed.
- **Reduced CO2 emissions**: CO2 emissions for material production, transportation, and installation are significantly lower. For instance, an XblocPlus design achieves a 28% reduction in CO2

emissions compared to conventional materials (Xbloc, 2022).

Consultation with MDP366 In order to integrate part of these design measures, a multidisciplinary approach with MDP366 is required. This team is responsible for developing the breakwater design for the expansion of Puerto Rawson. Due to faculty requirements and their personal project objectives, they are obliged to use the same armour elements as the current breakwater. However, validation of the implementation of the proposed breakwater design decisions was still possible. Feasibility was confirmed by MDP366

8.3.3. Detailed strategic design requirements

As the aspect sustainable marine ecosystem has been worked out in more detail, subsequently, the design requirements of this direction can be more specific. For the execution of the master plan, the requirements addressing eco-friendly design measures and waste management facilities have been worked out in more depth and can be found in Figure 8.8.

Waste management facilities The design requirements integrate the complete PWMP, while a distinction is made for the PRFs on the private and public sides of the port.

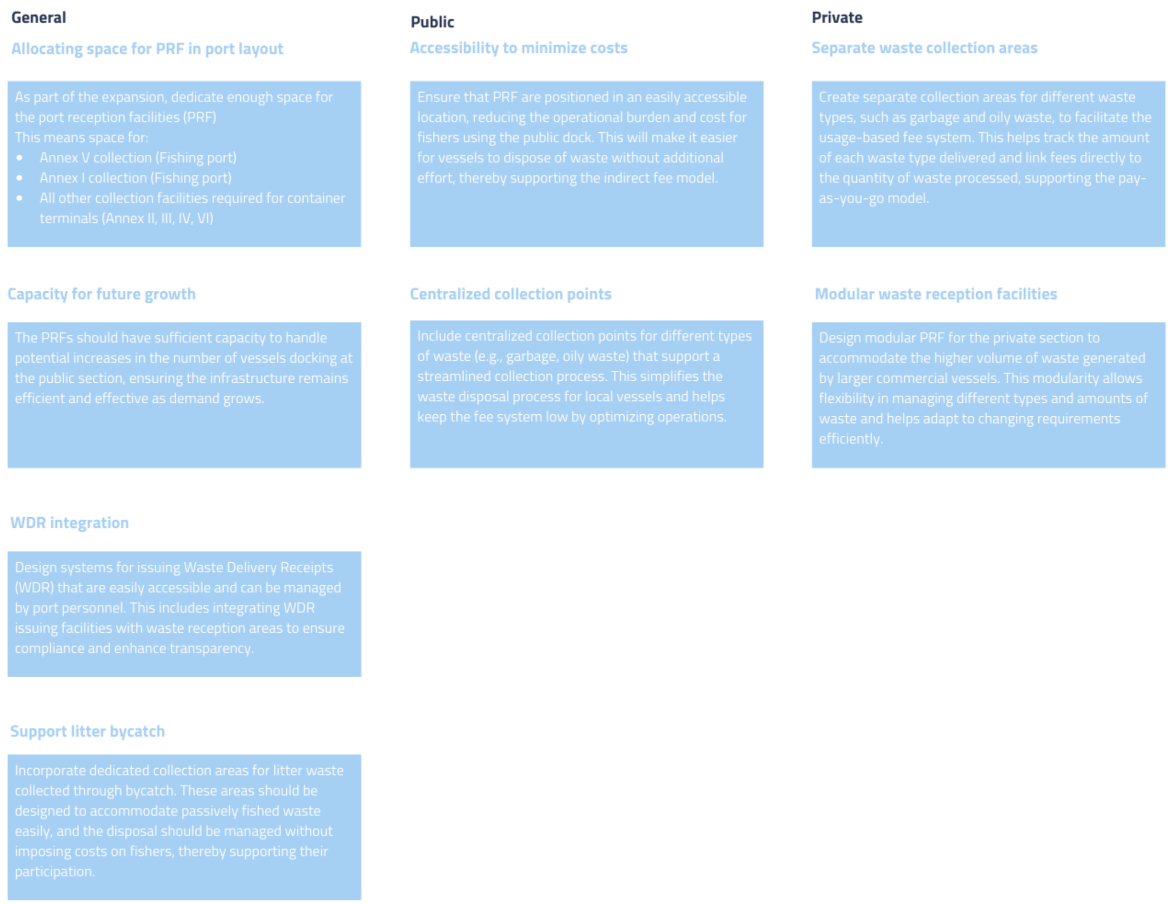


Figure 8.8: Waste management facilities

Integration of ecosystem-friendly design measures The design requirements integrate the nature-inclusive design elements. The implementation of some sub-parts of these requirements go beyond the scope of this project, as it touches upon detailed breakwater design. It is recommended that they are integrated into a new iteration of the parallel project on the new breakwater for Puerto Rawson. Section subsection 8.3.2 touches upon this.

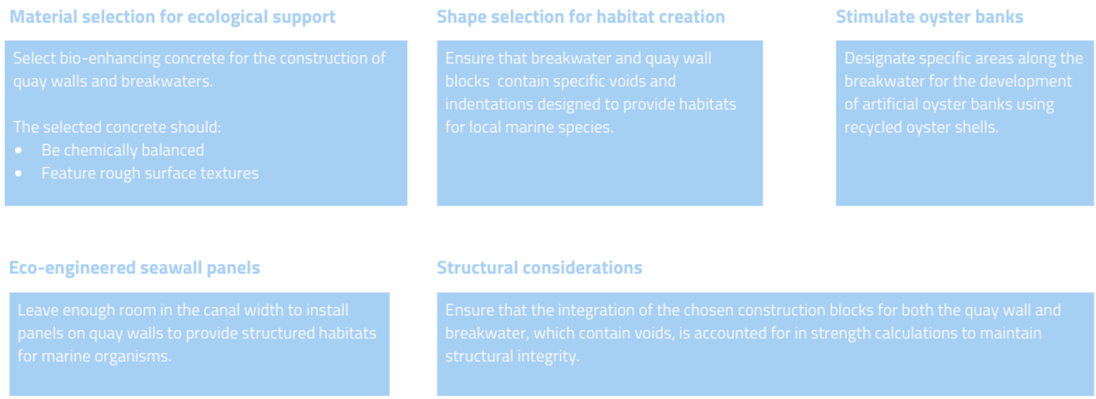


Figure 8.9: Integration of ecosystem-friendly design measures

8.3.4. Strategic roadmap

The roadmap presented in Appendix R integrates the technical and strategic objectives of the port, mapping them out along a timeline.

The roadmap for the expansion of Puerto Rawson is structured into three phases, each containing important steps in the journey to create a sustainable port.

The first phase (Navigating Towards Progress) is focused on laying a solid foundation for what's to come. It is focused on tackling existing issues in port operations while gearing up for more sustainable practices. With the initial infrastructure upgrades completed, phase 2 (Foundations of Sustainability) marks the beginning of meaningful changes toward sustainability. Phase 3 (Growth & Green Innovation) envisions a fully expanded port. It is focused on exploiting the new to its fullest and creating long-term value.

The ultimate future vision of the roadmap (as formulated in Figure 4.2) is: "Puerto Rawson thrives to become a valuable player among ports in Argentina by transforming communities through progressive mindsets and innovation while preserving Patagonian nature and safeguarding seas."

Explanation of the sections

- **Concept:** This section illustrates how the expansion construction activities are divided into phases. It details which vessels the port should be able to accommodate, categorized by cargo type.
- **Goals:** For each of the strategic goals, as formulated in section subsection 4.2.3, specific sub-goals per phase are outlined. The sub-goals correspond with the type of cargo expansion planned for each phase, as well as significant trends and developments. These sub-goals include measurable numeric targets to track progress.

  N.B.: While ambitious, these targets are set to guide the port toward its long-term strategic vision, even if they are not directly linked to the initial boundary conditions of the project
- **Trends & developments:** This section shows how both internal and external trends and developments are spread out over time. They serve as input for strategic planning and are derived from academic sources as well as conversations with relevant stakeholders. The origins of the trends and developments are detailed throughout the report; for references, please refer to the relevant sections.
- **Development:** The three pillars of sustainable marine ecosystems—regulation, education, and facilities—are elaborated here. It outlines the consecutive actions proposed to achieve the strategic and technical goals, with an outline of which stakeholders are important to involve in each phase.
- **Business:** This section presents the proposed value exchange for each phase. The value exchange for phases two and three are very similar. Within these two phases, the ambition arises to go from a local to a provincial level. The value exchange between the two phases will remain the same,

along with potential partners that could be interesting to collaborate with during this phase of the expansion.

8.3.5. Conclusion

To conclude, while implementing the PWMP, the development of a cost recovery system is critical for the ongoing success of waste management in Puerto Rawson. By making a distinction between the approaches for the private and public WRH plans and therefore, promoting responsible waste disposal, collection, and securing necessary funding through the government of Chubut, the port can enhance its environmental performance and ensure compliance with MARPOL regulations.

In addition, eco-friendly design measures will enhance pollutant filtration, facilitate nutrient cycling, and promote biodiversity, all of which are crucial for sustaining a healthy marine ecosystem. The benefits of these design interventions include reduced material costs and lower CO2 emissions associated with construction.

The strategic roadmap shows an approach with multiple phases, to address current operational challenges while moving toward more sustainable practices and a future vision. By balancing economic growth and eco-friendly design measures, Puerto Rawson aims to become a leading example of sustainable port development. This will not only be beneficial for the local community but also contribute to sustainability goals in the entire province. Through these strategies, Puerto Rawson can strengthen its position among ports in Argentina support a healthier marine environment and support the long-term viability of the port and its stakeholders.

8.4. Risk & Mitigation

Port expansion projects like the one proposed for Puerto Rawson inherently face a range of risks, spanning technical, environmental, political, and financial domains. Key risks identified throughout this project are crucial to address for a successful implementation of the expansion plan. A comprehensive Risk Assessment Matrix (Appendix Q outlines these risks, focusing on both technical and non-technical categories, and offers detailed mitigation strategies.

One of the most significant non-technical risks involves sudden policy shifts by the provincial government that could impede progress, especially in terms of permits and dredging approvals. Besides this, political resistance or regulatory changes could temporarily or permanently halt work, posing a threat to the project timeline. To mitigate this risk, early negotiations and maintaining close relationships with both ruling and opposition political figures will be key, ensuring sustained support throughout the project's lifespan. In addition, risk-full assumptions have been made. In order to validate these risk full assumptions, a map has been created, this map can be found in Appendix O. In this map, assumptions with a high-risk factor are shown. These assumptions, if not true, have a high impact on the success rate of the strategy presented.

In order to validate these risk-full assumptions, a validation plan has been created. This plan has been shared with the most important stakeholders of both the public and the private port. Due to a lack of response, no conclusions have been drawn from these validation questions. The in-depth validation plan can be seen in Appendix O.

In terms of technical risks, geotechnical issues such as unforeseen soil conditions could delay construction and increase costs. To prevent such delays, it is essential to conduct extensive soil investigations prior to construction to ensure appropriate foundation techniques are used.

In conclusion, mitigating the identified risks requires a combination of early stakeholder engagement, robust financial planning, technical assessments, and environmental sustainability measures. More detailed descriptions of each identified risk and their corresponding mitigation strategies are available in the Risk Matrix found in Appendix Q. Continuous monitoring and proactive management of these risks will be crucial in ensuring the smooth and timely completion of the Puerto Rawson port expansion project.

9 Conclusions & Recommendations

9.1. Conclusion

Puerto Rawson has undertaken an expansion project to address its current operational limitations and support long-term regional growth. With increasing global demand for Argentine seafood and expanding renewable energy projects, the port and therefore Industrias Bass, has the potential to reinforce its role as a hub for both fishery logistics and wind energy. Currently, the port's limited infrastructure is facing constraints, which limit its capacity to accommodate peak fishing seasons for a coastal shrimp fleet. The goal of the proposed master plan is to expand the fishery handling capacity in line with the local needs and realistic development goals, addressing both technical and environmental considerations as stated in the chapter 1.

These infrastructure challenges consist of a shortage of berthing areas, a lack of operational spaces behind the dock front, insufficient equipment for loading and unloading, overcrowding and therefore limited circulation of cargo, a lack of complementary facilities and maintenance, as well as a seasonal workforce and a lack of waste management.

Alongside these issues, Puerto Rawson's expansion plan aims to double fishery throughput by 2030, followed by further capacity increases by 2040 in shrimp, hake, and squid. Additionally, the project specifies the capacity to handle 50 wind turbines annually to accommodate the increased demand for renewable energy while diversifying Puerto Rawson's operational portfolio.

Therefore, the proposed master plan consists of designated areas for several key components that were modelled, calculated, and researched in chapter 7 and chapter 8. The key components include:

- Expanding quay lengths and optimizing cargo handling areas.
- Adding additional berths and storage areas to reduce wait times, minimize congestion during peak seasons, and accommodate fluctuations in fishery demand.
- Stacking and transferring wind turbine components.

All while mitigating the impact of increased waste on wildlife, addressing the seasonal workforce, and managing infrastructural limitations due to the division between private and public quays within the port.

To account for these demands, the expansion plans consisted of three primary design scenarios, each evaluated through a Multi-Criteria Analysis. Among the proposed concepts, 'Jetty Port', which includes a quay extension to the south with expanded dredging and a jetty on the existing breakwater, yielded the highest overall score. The preferred alternative scored well on environmental protection and safety and compliance, which were important to the client.

Scenario 'Jetty' has been further developed into a final design, including technical specifications for quay extensions and reinforcement, dredging needs, environmental safeguards, and a financial projection for phased development as can be seen in chapter 8. Key technical design elements are detailed in

Appendix K. Quay dimensions and channel depths have been planned to accommodate large vessels, balancing dredging costs with a reliable tidal access window for optimal operational continuity in order to comply with the expected growth.

Environmental considerations also play a role in the final design. Given the protected marine life surrounding Puerto Rawson, the project includes a waste management plan aligned with Sustainable Development Goals (SDGs) through centralizing waste through a PWMP, which aims to preserve the local marine biodiversity while promoting a sustainable fishing industry. These measures ensure that Puerto Rawson not only meets immediate demand but also sustains its natural resources for future economic resilience. Which can be ensured as early investment in a sustainable port causes overall benefits in water quality on the long term.

Key risks were identified throughout this project that are crucial to address for a successful implementation of the expansion plan. These were split into technical and non-technical risks alongside with suggested mitigating strategies.

Through these efforts, the proposed master plan for a future Puerto Rawson serves as a model of sustainable port operations in Patagonia, supporting growth by enhancing service levels by lowering the MRWT of vessels, a better waste collection system, and long-term profitability.

9.2. Discussion

Throughout the Puerto Rawson expansion project, several challenges and limitations were encountered, impacting the technological depth of the project and the accuracy of certain design elements.

One of the primary constraints during the project was data accessibility, particularly regarding port-specific metrics and environmental conditions for strategic purposes. Although previous studies provided baseline information, much of the data, such as vessel movement statistics, regional wave conditions, and current operational practices, was either unavailable or generalized across broader areas rather than specific to Puerto Rawson. To mitigate this, the project relied on a combination of secondary data, expert opinions, and stakeholder interviews during the field trip. However, assumptions had to be made in the absence of precise figures, particularly for environmental impacts, costs and fishery demand forecasting.

A cultural challenge was the adjustment to a different culture, which took time and effort. The new language, political system, organizational structures, and other factors required adaptation, resulting in an iterative process. These new perspectives on how things work in Argentina had to be incorporated, sometimes slowing down project progress.

Language barriers and regional context also presented limitations, as most relevant literature was originally in Spanish, requiring translation. While this facilitated general understanding, nuances in technical terminology and local regulations may have been partially lost in translation.

Additionally, during stakeholder interviews, the need for translation sometimes affected the clarity of responses, particularly when discussing technical details. To address this, follow-up discussions and on-the-spot translation apps were used to ensure the interpretations were correct. These practices caused some general delays in the project, as well as potential variations in interpretation.

Cultural and organizational differences influenced the project timeline, For example on how to approach stakeholders. An specific example of this was that Argentina's regulatory landscape differs significantly from that of other regions, particularly regarding public-private partnerships in port infrastructure. The iterative process required to align the technical design recommendations with local political and regulatory considerations sometimes slowed project progress.

Furthermore, the MCA used to evaluate potential design scenarios encountered several limitations. Given the project's conceptual nature and time constraints, the MCA was based, for some accounts, on estimated criteria rather than fully verified quantitative data.

Finally, certain technical components, such as the quay and dredging designs, had to be based on conservative assumptions due to the lack of updated structural and geotechnical data for the region. For instance, dredging requirements are estimated on visual findings due to a lack of structural information about the amount and specs of tuff stone. By doing so, safety is guaranteed but potentially not fully optimized.

9.3. Recommendations

Throughout this project, an analysis of current practices and preliminary designs were developed to address the Port of Puerto Rawson's expansion needs. The following recommendations outline considerations for potential next steps or future research groups.

- **Build upon provided models** to create a more detailed representation of incoming vessels and processing of these ships. Specific areas to focus on would be the waiting time created by the lack of space in the channel, prioritizing incoming and outgoing vessels, and using call times for large vessels. Additionally, investigate how these factors impact the required berthing area while maintaining relative waiting times for all vessels.
- **Conduct a comprehensive financial feasibility** to check the feasibility of the proposed design. For example, extensive dredging is needed for the chosen port design, particularly for the turning basin and access channel. Collaborating with nearby ports for equipment procurement could reduce costs, as dredging vessels are in limited supply in Patagonia. These decision have an large impact in an eventually choice for a final design as dredging cost can increase the total cost enormously.
- **Introduce more diverse alternatives** in order to create a more robust MCA. Using all the calculated minimum lengths, depths, terminal areas it is possible to design more out of the box scenario's to look for more differentiation. This would also lead to an more robust MCA in accordance with the grading performed by several stakeholders. As described in Figure 7.4
- **Port-side optimizations**, including access roads, transport routes, traffic, and deeper investigation in the required complementary facilities, should be done to improve land-side operations. Optimizing these elements could provide new business opportunities between the public and private sectors.
- **Waste management**, with the anticipated increase in throughput, the port's waste management measures must be enhanced. Further examination of the PWMP is needed to ensure the success of this plan. This includes the participation of private fishery companies. Additionally, this includes adopting waste-reduction technologies for fish processing and installing treatment systems for runoff from new infrastructure, such as sloped quays. Recycling initiatives for vessel waste would help meet local and international environmental standards
- **Asses the impact of implementing eco-friendly design measures**, such as those for the breakwater and quay wall, on critical factors like cost, structural strength, and construction time. These considerations should be integrated early in the design process to ensure that the benefits of sustainability are balanced with operational efficiency and long-term durability.
- **Sustainable port strategies** Additional research on regulation and education opportunities, is recommended. Assumptions made within the action plan should be validated and additional stakeholder management should be executed. Additionally the local workforce and need for employment should be looked into in order to ensure the expansion and its operational feasibility.
- **Examine the proposed master plan** against current and future legislation and stakeholders. For this project a scope was formed to focus on the technical requirement of the port expansion. This led to certain design choices which can be influenced by political decisions. An example is the southern side of the current breakwater. If legislation changes and the breakwater could be removed. Then for phase two it would be suggested to changed to a port design with only one internal port which is less spatially spread out. Given example is reason to conduct a in depth research how current future and legislation and stake holders can impact the port expansion master plan.

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A

Field Trip

As part of our master plan for the expansion of Puerto Rawson, a field trip was conducted to the harbour. The primary objective of the visit was to collect essential data regarding the port's current infrastructure, traffic flow, fishery throughput, vessel data and environmental conditions through contact and interviews with local port authorities. This data has been used to assess the necessity and feasibility of our proposed expansions and improvements, including dredging activities, upgrades to existing docking facilities and constructing new quays for larger vessels stated in our boundary conditions. By gathering real-world observations and measurements, we aim to provide a more accurate analysis for the master plan of Puerto Rawson. This appendix provides a description of the field trip and concludes with a summary of the collected data.

We would like to thank Fernando, Rodrigo, Leandro, Martin Castillo and everyone else involved for their time, local expertise, and comprehensive tour of the harbour.

A.1. Harbour visit

Northern Harbour

Our trip began with a tour of the northern harbour. The northern harbour has two quays: an older quay designated for smaller vessels and a newer quay for larger vessels. Local port authorities guided us through the public areas of the dock, where we collected data on vessel sizes, trip durations, and the number of trips per day for the traditional fishing fleet.

Figure A.1: Tour Northern Harbour

Southern Harbour

In addition to the tour of the Northern Harbour, we also visited the Southern Harbour. In this area, Industrias Bass is conducting ongoing construction on new quays and dredging for the southern expansion. It was very interesting to observe this process up close.

(a) New Quay Construction

(b) Dredging works

Figure A.2: Southern Harbour Visit

A.2. Visit of the Restinga

In addition to visiting the Harbour Areas, Rodrigo arranged for us to visit a viewpoint of the Restinga. This viewpoint provided a clear perspective on the scale of the Restinga and offered a beautiful view overall.

Figure A.3: Restinga Visit

A.3. Interview with Martin Castillo

Before our visit, we contacted Martin Castillo, the CEO of Industrias Bass, a local contractor who owns several parcels in the harbour and is heavily involved in the harbour expansion. He invited us to his office in Trelew and arranged an interview with us. This meeting proved to be very valuable, providing us with important data and insights into his vision for the harbour. Overall, it was a productive discussion. He shared information regarding the fishing fleet, local challenges, and various risks associated with the project. Thank you, Martin!

Figure A.4: Meeting Sr. Castillo

A.4. Overview Field Trip Findings

Attribute	La Flota Amarilla	La Flota Rioja	Barcos de Artesenales
Length [m]	11-21	21-48	0 - 11
Width [m]	4.5	5	3.5
Draught [m]	3-3.5	3.5-4	2
Trip Duration [days]	1	7	0.5
Offloading Time [hrs]	1-2	3-4	1

Table A.1: Vessel Data Field Trip

B

Interview transcript Sr. Castillo

Is there a (long term) vision or mission towards which the port is working? Who/which parties is/are contributing to this mission?

For the strategic aspect, there is a vision or mission for the expansion of the port. What countries like ours lack is innovation and infrastructure. That is, we shouldn't think that it can't be done. I've traveled through Holland, or the Netherlands, many times, and honestly, it seems incredible to me how in the middle of nowhere there's a canal and a ship passes through. I'm like that, passing by, huge ships. We have land, land, land, and more land, and not a single canal. The concept is fantastic to me—understanding that with work, with investment, you can build a country like the one you have. Clearly, when you see Holland, or the Netherlands, and then you look at Patagonia where there are thousands of square kilometers with nothing. What we lack is vision, investment, determination, and the will to make our country more like the Netherlands. So, that's our mission, to generate development where before it was thought nothing could be done, and we are doing our best. This is a project I've been thinking about for 15 years. I spent 5 years negotiating to buy the land. All this time, I've been navigating the ups and downs of our country to make things possible. It's not easy, but I think by applying a little of the Dutch mentality, or Netherlands' mentality—I don't know how to put it—I believe all this is possible, and we're going to have a country that can generate more and more added value, instead of just producing raw materials, which is our great challenge. We have the problem, or what we call the curse, of raw materials. That is, we can't get away from just exporting crude oil.

What are the main personal objectives of expansion?

Show that it is possible.

What is your relationship with the port authorities?

No good, we have a good relationship. Eh... In some way, we've generated our own policy, our own development, our own activity, and we don't depend on the public port. We depend on the environmental authorities, or the ones with restrictions, which is called the Provincial Water Institute, which is Equipal, and they are the ones who own the river. It's not the port, but rather an entity that manages all the water in the province. It's called IPA. Yes, perfect, yes. Provincial Water Institute. They are the ones who have to approve our projects. Also the environmental authorities. But once it's approved by those two, we don't depend on the third one. So, we have a good relationship, but it's not a relationship of dependency. They do their things, and we have ours. Who has to approve the projects? IPA, which is the Provincial Water Institute. And the environmental authorities. The Ministry of the Environment. The one that handles the environmental matters for the whole province. Ministry of the Environment. Environment.

Who are your biggest clients?

Our clients are today the most important fishing companies. We don't have many clients. These three, well, actually, the first dock, the big one that you saw, ah, you weren't there, the big dock you didn't see.

This is the first one. This is the second one that they also built. And this is the one we are working on now. We sell it through leasing. Do you know what leasing is? Well, this dock was returned to us. It's back with us. And this year we are going to operate it ourselves. And it's for sale. When someone comes along, it will be sold. This one has been sold to an American company. And this one was sold to a Spanish company. This one will be sold at some point. Whoever wins the bid. And this one, which is Ricardo del Valle, the multipurpose one, our idea is to keep it and operate it. Not sell it. Because it has a port crane, it's a much more expensive dock, and it's the one that will give the place its dynamic. So, we are thinking of not selling it. To keep it for ourselves. But also, because of the vision—going back to the vision. For us, cities first develop the port, then the houses, and then the economy. I don't know if you understand, but I hope so. Today we are developing a new port, we are going to develop the industry, and we are going to build housing. Oh, with a Dutch construction system, as well. Which we have here. So, we have all this to develop. I have a video in Spanish, which I can show you if you want, but we have a development plan for the next 150 years. So, I don't know if I'll live long enough to see it through. This is the beginning—the port is the starting point of the development process we're envisioning.

Do you see new business opportunities within the port? Do you see yourself exporting anything other than fish?

Argentina has very large wind generation processes for hydrogen. Our idea is for the electrolysis plants to be located here. They will be situated here. There will be very large power lines, electroducts, that will come here. Very large electric lines. And from there, the idea is that it will be processed and exported via a monobuoy. The hydrogen will go on ships and be exported through a monobuoy. But that depends a lot. The projects involve German capital, Polish capital. And there's also a very large company from Norway. Norway. Norway. Norway, what is Norway? Norway. Yes, we are... in contact. A lot... A lot... All along this Argentine coast, basically this entire region, you have some of the best, most consistent winds on the continent. You have good winds in the north and at sea. So, it's very expensive to put a turbine at sea, almost three times more than putting one on land. Here, if there's something in abundance, it's land and wind—consistent wind. The wind farm you saw in Rawson, and the same one in Madryn, I don't know if you're familiar with it, the one on the road to Madryn, they have between 53% and 58% of the time producing energy. This is a record. On land, they are among the highest-producing wind farms. Only those in the North Sea produce more, but they are far away. But there isn't much electricity consumption in the region, right? No, because for it to be considered green... It's a big challenge to export electricity, right? No, it's an advantage. Because for hydrogen to be considered green, 100% green... You understand? The energy has to be generated, transported, processed—in other words, the hydrogen is produced... Yes. And it's not connected to the normal electric grid. It's isolated. Yes, isolated. It's not connected to the grid, so it doesn't matter what the country's consumption is, because it has to be 100% separate from the local grid to certify it as green. 100% green. So, it's an opportunity because it's going to be generated... The project is for it to be generated in the center of the province, in this area, where there's the most wind, even more than on the coast. It's transported to the port... No, with the power line.

What does the port have in place regarding waste management?

We comply with the provincial regulations. We don't manage the environmental aspect; that's handled by the provincial authority. Although we are thinking of transforming into the "Blue Port," following European standards like those in Lugro, it's a project we have planned based on the dredging process. We are offering the State to grant us the concession for the waterway, to give us control of the waterway for a certain time. The waterway goes from the last dock, which is here, to the outside, covering this whole area. We're asking them to give it to us without the State paying anything, and we would charge the ships and handle the dredging and maintenance of the channel. If we do that, we also want to transform the management, not just environmentally, but also by implementing quality standards, safety standards, and everything related to the European standards in Lugro. But it's a step that still depends on us getting the concession for the waterway. Does that make sense?

What strategies does the port employ to reduce the amount of waste generated by vessels docking at the facility?

As I mentioned, here we're given the concession for the entire waterway by the State. This is public—the waterway is public. We are taking on the concession for each of these for 30 years. We operate and maintain them. And we charge the ships for entering and exiting. Just like in the Netherlands. So, in this case, yes, we will implement policies to improve waste management, continuous improvement, and several other matters related to traffic control and many things that today are done as they are. So, at this point, things are starting to get more organized. You are witnessing a process of change, a transition from everything being public to the private sector beginning to play an important role and have a significant presence.

In fact, there are now more private docks than public ones. Today, there are more private docks than public ones. Whereas before, everything was public, and there was no private sector. Five years ago, there were no private docks. It was all public. And that's why there were fewer rules, and things were a bit looser. But there's concern that this could also affect the public sector. They don't operate the same way we do. They worry a lot about this. That's why there's a bit of caution. Yes, I understand. And it's a big part of the concern. Yes, indeed. It's a big part of the concern, but it's something to be mindful of.

There is awareness of the damage that is happening, and I believe that in the near future, best practices will improve. Again, I think the active participation of the private sector will help improve these issues. Today, we're really in a bad situation, very bad. There isn't much... people have started to become aware of what's being caused, and practices are beginning to be implemented to reduce pollution, especially plastic pollution, which is horrible. Again, I think this public-private management approach is improving, and it's going to create significant momentum because the companies that buy in, which are the largest ones, have environmental responsibilities to uphold and can't continue doing the reckless things they've been doing. So, I think in the short term, things will continue to change quickly. But it will likely take some time.

C

Catch background data

C.1. Catch per species

Table C.1: Fishing Data by Year and Species (Tonnage) del Vecchio, 2018

Years	Prawn	Hake	Roosterfish	Grouper	Anchovy	Squid	Total Annual
2000	2909.2	3470.1	78.2	53.1	1.6	21.2	6827.9
2001	10134.7	1443	42.5	29.5	194.9	0	12537.1
2002	2907.9	10789.4	45.6	59.3	101.9	0.9	14509.7
2003	2030.6	8122.2	24.9	62.1	842	0	11518.6
2004	2008.7	11950.8	52.6	47.5	398.8	30.3	14913.4
2005	748.6	17227.9	155.3	325.8	609.5	10.6	20369
2006	5735.3	4546.3	51.33	45.3	27.6	14.4	10867.1
2007	6901	6510	130.1	86.4	13.4	26.6	13937.6
2008	3762.8	6201.5	366.7	302.6	268.3	4.6	11999.7
2009	3956.7	4431.4	272.3	212.9	56.2	4.4	10499.6
2010	14406.6	3170.2	24.2	15.8	292.8	3.7	18332.6
2011	19316.6	3372.1	32.4	104.6	0	0	23331.8
2012	12851.2	2680.3	90.6	57.1	0	5	15768.4
2013	20399.7	287.2	100.2	88.2	13.6	0	20964
2014	33456.2	95.9	93.9	46.5	146.6	0.1	33639.2
2015	38204.6	67	96.7	15.3	552.7	0.1	38893.6
2016	47015.7	69.5	76.9	54.7	201.6	0	47507.5
2017	74904.6	9.1	0.6	6.3	0	0	74925.2

Table C.2: Fishing Data by Year and Species (Percentages) del Vecchio, 2018

Years	% Shrimp	% Hake	% Roosterfish	% Grouper	% Anchovy	% Squid
2000	42.6	50.8	1.1	0.7777	0.023	0.3105
2001	80.8	11.5	0.3	0.2353	2.854	0
2002	20	74.4	0.3	0.4087	1.492	0.0062
2003	17.6	70.5	0.2	0.5391	12.32	0.0139
2004	13.5	80.1	0.4	0.3185	5.841	0.2032
2005	3.7	84.6	0.8	1.5995	8.927	0.0520
2006	52.8	41.8	0.5	0.4169	0.404	0.1325
2007	49.5	46.7	0.9	0.6199	0.196	0.1909
2008	31.4	51.7	3.1	2.5217	3.929	0.0750
2009	37.7	42.2	2.6	2.0277	0.535	0.0438
2010	78.6	17.3	0.1	0.0862	1.5972	0.0202
2011	82.8	14.5	0.1	0.4483	0	0
2012	81.5	17	0.6	0.3621	0	0.0317
2013	97.3	1.4	0.5	0.4207	0.199	0
2014	99.5	0.3	0.3	0.1371	0.447	0.0002
2015	98.7	0.2	0.2	0.0393	1.42	0.0003
2016	99	0.1	0.2	0.1151	0.4247	0
2017	100	0	0	0.0084	0	0

C.2. Catch per port

Table C.3: Fishing Data by Year and Ports (Tonnage) del Vecchio, 2018

Years	Mar del Plata	Puerto Madryn	Rawson	Comodoro Rivadavia	Caleta Paula	Puerto Deseado	Total Annual
2000	41.5	5316.8	2909.2	1396.5	9812.7	17512.3	37150
2001	198.3	24415.4	10134.7	7225.8	9744.6	25662.9	78859.2
2002	411.5	9355.4	2907.9	6940	14417.3	16704.9	51419.3
2003	431.1	8003.4	2030.6	11179.9	10974	19935.6	52901.5
2004	24.5	3605.8	2008.7	2437.4	5766.7	32387.3	27129.9
2005	36.2	1194.1	748.6	1089	4168.5	33832.2	7482.2
2006	763	8135.1	5735.3	5976.9	6007.5	17691.1	44405.3
2007	899.2	13124.8	6901	4193.4	7287.2	15128.9	47616.8
2008	987.5	10847.9	3762.8	3259.2	6843.2	21077.1	47406.2
2009	934.1	10973.8	3956.7	2711.5	9328.2	24762.3	53693
2010	561.5	15565.6	14406.6	5767.4	9420.7	23886.9	72398.3
2011	1292.5	20657.2	19316.6	3712.9	8158.4	29278.6	82921.9
2012	4682	18235.2	12851.2	2051	11526.5	31749.9	79926.9
2013	3637.7	27525.6	20399.7	2051	11052.3	31749.9	100675
2014	4373.3	35715.4	33456.2	6062.9	10226.8	30605.3	129103.7
2015	10092.2	33113.6	38204.6	4002.3	12858.4	37970.7	142796
2016	13589.5	34601.6	47015.7	5674	13499.2	44182.5	178454.6
2017	8741.9	60311.5	74904.6	16206.3	6731.1	45116	241513.6

Table C.4: Fishing Data by Year and Ports (Percentages) del Vecchio, 2018

Years	% Mar del Plata	% Puerto Madryn	% Rawson	% Comodoro Rivadavia	% Caleta Paula	% Puerto Deseado
2000	0.11	14.31	7.83	3.76	26.41	47.14
2001	0.25	30.96	12.85	9.16	12.36	32.54
2002	0.80	18.19	5.66	13.50	28.04	32.49
2003	0.81	15.13	3.84	21.13	20.74	37.68
2004	0.09	13.29	7.40	8.98	21.26	48.37
2005	0.48	15.96	10.01	14.56	12.57	44.60
2006	1.72	18.32	12.91	13.46	13.52	39.84
2007	1.89	27.56	14.49	8.81	15.31	31.77
2008	2.08	22.88	7.94	6.87	14.44	44.46
2009	1.74	20.44	7.37	5.05	17.37	46.12
2010	0.77	21.43	19.75	7.97	12.91	32.98
2011	1.56	24.91	23.29	4.48	9.84	34.91
2012	5.85	22.82	16.08	2.57	14.42	31.71
2013	3.61	27.34	20.28	2.04	10.98	31.54
2014	3.39	27.66	25.91	4.70	7.92	23.71
2015	7.07	23.19	26.75	2.80	9.00	26.59
2016	7.62	19.39	31.35	3.18	7.56	24.76
2017	3.62	24.97	31.01	6.71	2.79	18.68

D Models

In this appendix, various models are shown used to verify assumptions made for the input of the OpenQTSim package. The first model represents the arrivals and departures of the Argentine National fleet, which Puerto Rawson aims to attract, using the southern private quay walls. The second model focuses on the vessel movements of smaller ships that use the northern public quay walls. The third model simulates the arrival and departure of heavy lift vessels needed to supply parts for wind turbine construction in the region's hinterland.

D.1. Modelling vessel traffic

To model the incoming and outgoing vessels for the boundary conditions set for 2030 and 2040 (Table 1.2), four different models were created. The first three are set up to predict the vessel movements of the fishery and heavy lift vessels, the final model uses the *openqtsim* (M. van Koningsveld, 2021) to model vessel congestion at the berthings.

The first model represents the arrivals and departures of the Argentine National fleet, which Puerto Rawson aims to attract, using the southern private quay walls.

The second model focuses on the vessel movements of smaller ships that use the northern public quay walls. The third model simulates the arrival and departure of heavy lift vessels needed to supply parts for wind turbine construction in the region's hinterland. The fourth model couples a simulation of the channel, harbour and vessel traffic with the busiest week and checks if the maximum waiting times are not exceeded.

D.1.1. Model 1

Important assumptions for model 1 are:

- Trip durations are modelled using a normal distribution.
- Squid fleet characteristics (mean, standard deviation, capacity) are based on a data analysis performed on the dataset provided by INIDEP (et al., 2022).
- Shrimp fleet characteristics are obtained through interviews with Martin Castillo.
- Hake fleet characteristics are based on the ratio between capacities and trip durations of the other vessel types.
- To determine the busiest week, we assume it occurs when all vessel types are active during their respective peak seasons at the same time.

The first model simulates the movements of the larger fishing fleet. At the start of the season, it deploys the fleet and sets the trip duration for each vessel. This duration follows a normal distribution, based on the average and standard deviation of trip lengths obtained from data analysis (et al., 2022) and interviews. Once the ships return, they are assigned a handling time (based on interviews), wait until this time is complete, and then begin a new trip. The input of this model is shown in the table below:

Vessel	Hake	Squid	Shrimp
$\mu_{duration}$ [hrs]	240	521	168
$\sigma_{duration}$ [hrs]	60	130	42
Number of vessels [-]	15	21	35
Handling time [hrs]	10	20	4
Capacity [tons]	250	500	100

Table D.1: Model 1 input

The model accounts for the uncertainties in fishing vessel movements over a three-month period. It covers all larger types of fishing vessels, each with specific trip durations, handling times, and capacities. The model generates three arrays (one for each vessel type) showing the number of vessels per hour, starting from the first departure. This insight is important as uncertainty caused by capture rates can create a peak demand. When these arrays are plotted over time (departures blue and arrivals red), they produce the figures shown below:

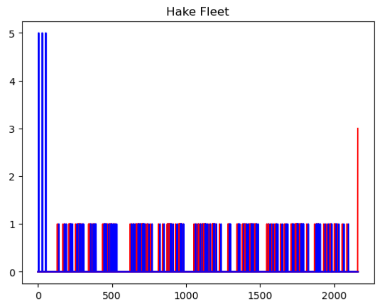


Figure D.1: Hake Fleet Fishing Cycle

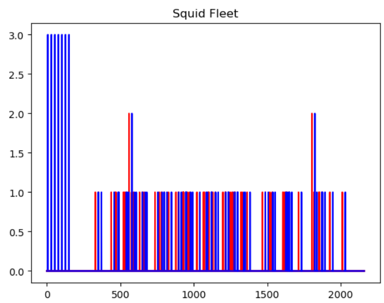


Figure D.2: Squid Fleet Fishing Cycle

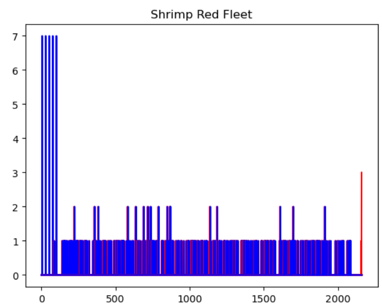


Figure D.3: Shrimp Fleet Fishing Cycle

Over a three-month period (2160 hours), the average **number of trips** per vessel type is approximately 8 for hake, 3 for squid, and 11 for shrimp. After organizing all the arrays and iterating through them to find the **busiest week**, defined as the 7 consecutive days (or 168 hours) with the highest number of vessels, the indices and counts of the number of vessels for each type during this period are obtained. The result is:

- Busiest week: day 75 till day 82 (or hour 1818 till hour 1985.)
- Amount of hake vessels this week: 7.
- Amount of squid vessels this week: 7.
- Amount of shrimp vessels this week: 13.

These numbers enable an estimation of the amount of quays needed to facilitate berthing for all ships.

D.1.2. Model 2

Within model two, the coastal vessels of the shrimp fleet are modelled. This fleet consists of 130 boats with sizes ranging from 9 to 21 meters. These boats only operate in the high season of shrimp and therefore work around the clock, making use of the public docks in the harbour and coming in at the same time. It is interesting to create a model to understand their behaviour and the hindrances they can create for larger ships.

Key assumptions for Model 2 are:

- The current fleet of small shrimp vessels will not increase in the future. This is due to several factors: limited space from the slow development of public quay walls, larger vessels moving to private docks when entrepreneurs purchase new boats, and a limited capacity to build only two small vessels per year, which is just enough to maintain the current fleet size.
- Vessel arrival and departure times remain consistent with current operations, based on the two daily high tides. The future scenario assumes the channel is fully dredged, making this timing constraint unnecessary. However, the limited crew size and lack of shift work mean it's not practical to increase the number of daily trips to three (even though this would be possible during peak shrimp season).
- The model includes 130 ships, matching the current fleet, consisting of two types of shrimp vessels: 9-meter boats with a turnaround time of 1 hour, and 17-meter boats with a turnaround time of 2 hours.
- Ship arrivals and departures follow a uniform random distribution within their potential time windows.

Figure D.4 shows the combined arrivals and departures of shrimp vessels. Due to the random uniform distribution of the arrivals and departures, there are occasional peaks in the number of vessels at certain times. When combined with other vessel types, these peaks can become more significant, as seen in Figures D.5 and D.6. It's crucial to track these peaks to avoid increased waiting times in the harbour channel, especially during peak demand from other vessel types.

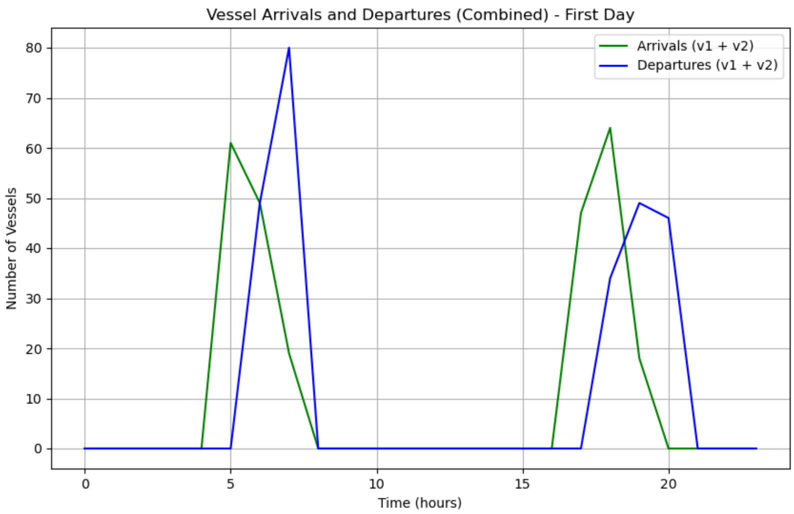


Figure D.4: Current Situation

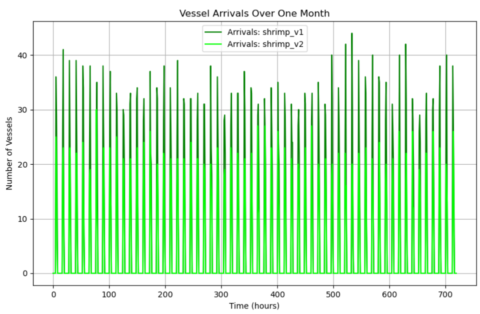


Figure D.5: Arrivals per month

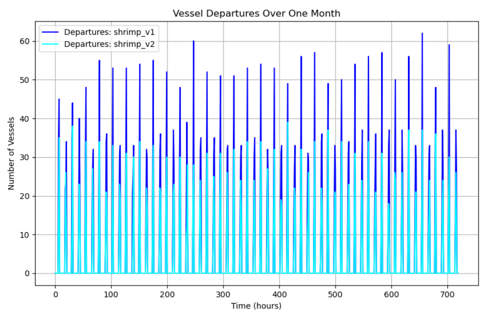


Figure D.6: Departures per month

These outputs represent the current behaviour of the coastal fleet. These outcomes were not taken into account as the model described in Table 5.4 assumes higher catch rates for the coastal fleet for the boundary conditions of 2030 and 2040. For further development of these models, the predicted information of the model above can be used in order to simulate the occupation of the channel used by vessels on the public side.

D.1.3. Model 3

The expansion of the port at Puerto Rawson is focused on supporting the logistical requirements for two main sectors: fisheries and wind energy. The wind energy project involves the transportation of wind turbine components, which requires an estimation of stacking area requirements subsection 5.2.3 and shipping frequencies. Model three presents a simulation-based model used to estimate the number of ships needed over a given period. The used input can be seen in Table D.2

Parameter	Value	Notes	Sources
Annual Wind Turbines	50 turbines	Target for construction per year	Client specifications
Parts per Wind Turbine	Blades: 3 Base Segments: 5 Nacelles: 1 Hubs: 1	Standard parts per wind turbine	Gamesa, 2021; Mathew, 2006
Part Dimensions	Blades: 61.7m x 4m Base Segments: 23.4m x 4m Nacelles: 3.8m x 5.2m Hubs: 12.8m x 4.2m	Dimensions affect stacking area	Gamesa, 2021; Systems, 2020
Ship Capacities	Blades: 60Base Segments: 15Nacelles: 15Hubs: 15	Maximum parts per ship	Council, 2020
Safety Margin	1 meter	Buffer around parts for safe stacking	for Waterborne Transport Infrastructure, 2016
Overlap Factor (Blades)	0.5 overlap	Allows for efficient stacking	WindEurope, 2019
Separation Margin	10 meters	Distance between part types for safety	for Waterborne Transport Infrastructure, 2016
Dwell Time	Blades: mean 4 weeks, σ 0.5 Base Segments: mean 2 weeks, σ 0.5 Nacelles/Hubs: mean 4 weeks, σ 0.5	Average storage time	Eme and Smith, 2020; (IEA), 2021
Restocking Threshold	Blades/Base Segments: 5% stock remaining Nacelles/Hubs: 20%	Ship arrival trigger	Chopra and Meindl, 2012

Table D.2: Model Input Parameters

With the chosen input, the base segments did not deplete over the course of the simulation (52 weeks). This means that the goal of building 50 wind turbines per year would become unfeasible when minimizing the break bulk storage area. Upon further research, this behaviour aligns with real-world practices observed at Puerto Madryn, where base segments are manufactured on-site to avoid transportation bottlenecks (Eme and Smith, 2020). This practice significantly reduces the need for frequent base segment shipments, naturally leading to lower stock levels in the model.

This occurs because the stochastic dwell times applied to certain parts (particularly wind turbine parts and nacelles) were too long compared to industry averages. According to (Eme and Smith, 2020) and ((IEA), 2021), average dwell times for wind turbine components should typically range between 2-6 weeks. Correcting the dwell time distribution would reduce the extended storage times observed in the simulation. When a site location, a manufacturer and insights into their logistics and available heavy-lift ships are determined, it becomes possible to estimate the arrivals more precisely. While this simulation provides valuable insights, it does not account for real-world uncertainties such as weather delays, labour shortages, and equipment breakdowns. This means availability of storage space and transport capacity may not hold true in a fully operational port environment.

Model Component	Description
Stock Simulation	Tracks stock levels of blades, base segments, nacelles, and hubs over time.
Shipping Logic	Ships arrive when the stock falls below a threshold. Quantity depends on ship capacity.
Dwell Time Distribution	Normally distributed dwell time simulates parts staying in storage.
Maximum Stock Tracking	Tracks maximum stock for each part to calculate stacking area.
The calculation of trips	Arrivals of different parts gets summed over the simulation time.

Table D.3: Model Components and Functions

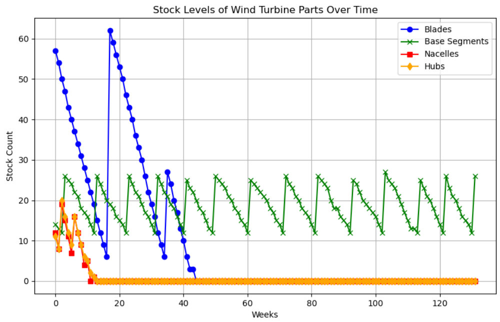


Figure D.7: Wind turbines parts over time

The simulation results highlight several interesting aspects of port logistics for Puerto Rawson's wind turbine project

The model suggests that shipments should arrive every 15–20 weeks for blades and base segments to maintain optimal stock levels without substantial delays. This frequency aligns with industry best practices for just-in-time (JIT) delivery in environments with cyclical demand (WindEurope, 2019). However, given the higher risk of stockouts for blades, increasing the shipment frequency slightly may provide a more robust supply chain, reducing the risk of assembly delays.

In the initial phase of the port's development, the heavy-lift vessels transporting wind turbine components will share entry access with other port traffic, which could lead to increased waiting times for docking. This shared entry could potentially exceed the acceptable relative waiting time for the other vessels. The current prediction of 21 vessel arrivals needed to achieve the wind turbine construction target was confirmed by consulting with an expert (Rodrigo Bastida Arias). This comparison was made with vessel arrivals at Puerto Madryn, a nearby port that manages similar logistics. To ensure that these vessels can dock without excessive delays, additional berthing facilities may be needed. The required berthing capacity for the planned arrivals is detailed in Table 5.4

E

Sensitivity Analysis

E.1. Sensitivity Analysis

In order to verify the robustness of the model that was created and elaborated upon in subsection 5.1.1, a sensitivity analysis was carried out. The sensitivity analysis tested the sensitivity of all parameters in the model and aims to expose over-sensitivities and opportunities for cost-reduction.

In the table below, one can see the results for one of the design vessels, the coastal shrimp vessels. The results for all the other design vessels and the positive 10% adjustments can be found in the appendix. One can see that not a single adjustment gives an over-sensitive result (a result of more than 10% change).

The analysis gives rather logical results. In all cases, decreasing average ship length results in a 10% shorter quay wall. Some other adjustments do not give a result at all, because the number of required berths doesn't change by changing a parameter by 10%. The overall analysis shows that no over-sensitivity was found in the model.

Adjustment (-10%)	Old Quay	New Quay Length	Δ%
Crane capacity	218	218	0%
Docking time	218	218	0%
Departure time	218	218	0%
Avg. Cargo	218	218	0%
Ship length	218	196.2	-10%
Boundary condition	218	196	-10%
Season length	218	240	+10%
Max. rel. wait time	218	218	0%

Table E.1: Shrimp Coast Quay Length Adjustments

Even though the table above does not show any significant results. The model will dig deeper into one parameter of the model. The *Maximum relative wait time* (MRWT), as that parameter can have a major impact. By allowing the maximum relative wait time to go up, the client might reduce CAPEX significantly. The next subchapter will explore these opportunities.

E.1.1. Opportunities

As mentioned, the sensitivity analysis model can also be used to highlight possible cost-reducing adjustments. Out of all the parameters in the model, the 'Maximum relative wait time' is the most interesting to look for this more opportunities. This is because of various reasons:

- **Managable**, a port can make quick adjustments in regard to MRWT's. For example, vessel dimensions would take more time to change.
- **Non-linearity**, the MRWT is not linear in the model, making it interesting to dig deeper into.

- **Cost-free**, adjusting the MRWT does not cost the client any money. In contrast to for example crane capacity.

In collaboration with the client, it was agreed that the objective is to provide competitive service for the port. Therefore, the analysis was limited to an MRWT of 20%, which represents a 100% increase from the initial relative wait time of 10%.

The results for both the 2030 and 2040 boundary conditions are presented in the tables below. The '% to switch' column shows at which increase, the number of berths were reduced. It can be noted that for most vessel types, the number of berths didn't go down after increasing the MRWT by 100%. However, it can be seen that some vessel types can have a reduced number of berths by increasing the MRWT by less than 100%. In section 5.3, the recommendations derived from the overall analysis will be discussed.

Table E.2: Max. Relative wait time sensitivity (2030)

Vessel type	Old quay [m]	% to switch	New quay [m]	Δ%
Hake	84	>100%	84	0%
Squid	174	>100%	174	0%
Shrimp National	128	35%	84	-34%
Shrimp Coastal	218	20%	196	-10%
Madrid Trader	187	>100%	187	0%
Heavy Lift	153	>100%	153	0%

Table E.3: Max. Relative wait time sensitivity (2040)

Vessel type	Old quay [m]	% to switch	New quay [m]	Δ%
Hake	128	>100%	128	0%
Squid	265	20%	174	-34%
Shrimp National	216	90%	172	-20%
Shrimp Coastal	218	25%	196	-10%
Panamax	285	>100%	285	0%
Heavy Lift	153	>100%	153	0%

Aanpassing (-10%)	Old Quay	New Quay Length	Δ%
Crane capacity	128	128	0%
Docking time	128	128	0%
Departure time	128	128	0%
Avg. Cargo	128	128	0%
Ship length	128	115.2	-10%
Boundary condition	128	128	0%
Season length	128	128	0%
Max. wait time	128	128	0%

Table E.4: Shrimp National Quay Adjustments

Adjustment (-10%)	Old Quay	New Quay Length	Δ%
Crane capacity	218	218	0%
Docking time	218	218	0%
Departure time	218	218	0%
Avg. Cargo	218	218	0%
Ship length	218	196.2	-10%
Boundary condition	218	196	-10%
Season length	218	240	+10%
Max. wait time	218	218	0%

Table E.5: Shrimp Coast Quay Adjustments

Aanpassing (10%)	Old Quay	New Quay Length	Δ%
Crane capacity	174	174	0%
Docking time	174	174	0%
Departure time	174	174	0%
Avg. Cargo	174	174	0%
Ship length	174	156.5	-10%
Boundary condition	174	174	0%
Season length	174	174	0%
Max. wait time	174	174	0%

Table E.6: Squid Quay Adjustments

Aanpassing (-10%)	Old Quay	New Quay Length	Δ%
Crane capacity	84	84	0%
Docking time	84	84	0%
Departure time	84	84	0%
Avg. Cargo	84	84	0%
Ship length	84	75.6	-10%
Boundary condition	84	84	0%
Season length	84	84	0%
Max. wait time	84	84	0%

Table E.7: Hake Quay Adjustments

Aanpassing (10%)	Old Quay	New Quay Length	Δ%
Crane capacity	187	187	0%
Docking time	187	187	0%
Departure time	187	187	0%
Avg. Cargo	187	187	0%
Ship length	187	168.3	-10%
Boundary condition	187	187	0%
Season length	187	187	0%
Max. wait time	187	187	0%

Table E.8: Madrid Trader Quay Adjustments

Aanpassing (-10%)	Old Quay	New Quay Length	Δ%
Crane capacity	153	153	0%
Docking time	153	153	0%
Departure time	153	153	0%
Avg. Cargo	153	153	0%
Ship length	153	138	-10%
Boundary condition	153	153	0%
Season length	153	153	0%
Max. wait time	153	153	0%

Table E.9: Heavy Lift Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	128	128	0%
Docking time	128	128	0%
Departure time	128	128	0%
Avg. Cargo	128	128	0%
Ship length	128	141	+10%
Boundary condition	128	128	0%
Season length	128	128	0%
Max. wait time	128	128	0%

Table E.10: Shrimp National Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	218	218	0%
Docking time	218	218	0%
Departure time	218	218	0%
Avg. Cargo	218	218	0%
Ship length	218	240	+10%
Boundary condition	218	218	0%
Season length	218	196	-10%
Max. wait time	218	218	0%

Table E.11: Shrimp Coast Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	174	174	0%
Docking time	174	174	0%
Departure time	174	174	0%
Avg. Cargo	174	174	0%
Ship length	174	191	+10%
Boundary condition	174	174	0%
Season length	174	174	0%
Max. wait time	174	174	0%

Table E.12: Squid Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	285	285	0%
Docking time	285	285	0%
Departure time	285	285	0%
Avg. Cargo	285	285	0%
Ship length	285	314	+10%
Boundary condition	285	285	0%
Season length	285	285	0%
Max. wait time	285	285	0%

Table E.13: Panamax Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	84	84	0%
Docking time	84	84	0%
Departure time	84	84	0%
Avg. Cargo	84	84	0%
Ship length	84	92	+10%
Boundary condition	84	84	0%
Season length	84	84	0%
Max. wait time	84	84	0%

Table E.14: Hake Quay Adjustments

Aanpassing (+10%)	Old Quay	New Quay Length	Δ%
Crane capacity	153	153	0%
Docking time	153	153	0%
Departure time	153	153	0%
Avg. Cargo	153	153	0%
Ship length	153	169	+10%
Boundary condition	153	153	0%
Season length	153	153	0%
Max. wait time	153	153	0%

Table E.15: Heavy Lift Quay Adjustments

F

PIANC Guidelines

This appendix elaborates on all PIANC guidelines utilized in the report to determine the nautical dimensions and required terminal areas.

F.1. Nautical areas

In this section, the nautical areas and corresponding PIANC guidelines are discussed.

F.1.1. Access Channel

First, the guidelines regarding the access channel dimensions are elaborated.

Length

The length of the access channel is designed to allow vessels to safely come to a complete stop. This distance exists in a slowing-down trajectory, a fastening trajectory, and a full-stop trajectory.

The deceleration section, which allows the vessel to slow down to a speed where tugboats can be attached, is calculated as follows:

$$L_1 = 0.75(V_{s,\text{cross current}} - V_{s,\text{min}})L_s \tag{F.1}$$

In this context, $V_{s,\text{cross current}}$ refers to the vessel's speed as it enters the sheltered zone, which is set to four times the cross-current velocity at the harbour entrance. $V_{s,\text{min}}$ is the vessel's speed after decelerating, with a value of 3 knots (1.5 m/s) used here. L_S represents the length of the largest ship that the access channel can accommodate.

The fastening trajectory is designed for tugboats to attach to the vessel, which typically takes 10 minutes (600 seconds). The distance for this trajectory is calculated using the formula:

$$L_2 = V_{s,\text{min}} * 600 \tag{F.2}$$

The final part of the access channel is the full-stop trajectory, where the vessel comes to a complete stop. The distance for this is typically $L_3 = 1.5L_S$. When all trajectories are summed together one obtains the full length of the access channel:

$$L_1 + L_2 + L_3 = 0.75(V_{s,\text{cross current}} - V_{s,\text{min}})L_s + V_{s,\text{min}} * 600 + 1.5L_S \tag{F.3}$$

Vessel	Length Vessel [m]	Length Access Channel [m]
Poteros	82.8	1056
Madrid Trader	172	1223
Panamax	270	1407

Table F.1: Results width AC

Width

Various factors come into play when determining the width. For double lanes, the passing distance between vessels must also be considered. These elements are displayed in the formulas and figure below:

$$W = W_{bm} + \sum W_a + 2W_b \tag{F.4}$$

$$W = 2(W_{bm} + \sum W_a + W_b) + W_p \tag{F.5}$$

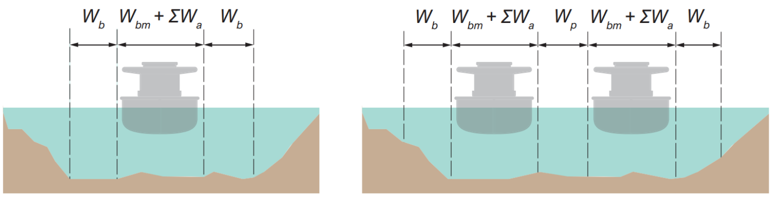
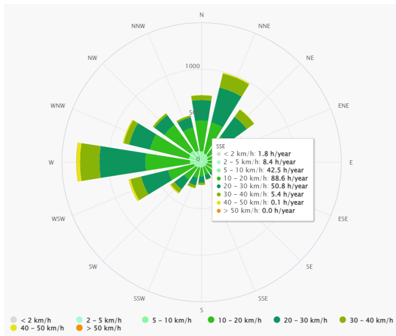


Figure F.1: Channel Width Figure (van Koningsveld et al., 2021)

For the manoeuvring lane (W_{bm}), a typical value of 1.5 times the beam (B_S) of the largest ship is used. For bank clearance with sloping banks, a value of $W_b = 0.3B_S$ is applied. For the passing width (W_p), with a speed limit of 8 knots in the channel, a value of $1.2B_S$ is used. Additional width may be required based on several factors, as shown in the figure below.

Contributing factor	Condition	Width additions W_a
cross-wind	15 – 33 kn	0.6 B_s
	33 – 48 kn	1.1 B_s
cross-current	0.2 – 0.5 kn	0.3 B_s
	0.5 – 1.5 kn	1.0 B_s
	1.2 – 2.0 kn	1.6 B_s
long-current	1.5 – 3.0 kn	0.2 B_s
	> 3.0 kn	0.4 B_s
wave height	1 – 3 m	0.5 B_s
	> 3 m	1.0 B_s
seabed composition	soft sediment	0.1 B_s
	hard material	0.2 B_s
under keel clearance	$1.25 < h_0/D_s < 1.5$	0.1 B_s
	$h_0/D_s < 1.25$	0.2 B_s

(a) Widt Additions Table (van Koningsveld et al., 2021)



(b) Wind Rose Puerto Madryn (Meteoblue, 2024)

Figure F.2: Channel width elements

To determine these various width factors ($\sum W_a$), one has to determine various environmental factors:

- Cross-wind:
  To assess the cross-wind, historical wind data from Meteoblue (1985 onwards) was used. The wind rose shows that winds above 33 knots (61.1 km/h) from the SSE occur 0 hours per year, while winds above 15 knots (27.8 km/h) occur for 56.3 hours annually. Without applying the width factor, the channel would be unusable for 56.3 hours per year, which is deemed acceptable.
- Cross-current:
  Due to a lack of data, a cross-current between 0.5 and 1.5 knots was assumed. This decision was

made after consulting with the other group MDP366 (a project-team working on a nautical study in the area).

- Long-current:
  Again, due to a lack of data, a long-current between 1.5 and 3.0 knots was assumed. This decision also was made after consulting with the other group MDP366.
- Wave height:
  MDP366 provided a significant wave height of 3.5 meters from the MP366 group, resulting in a wave height factor of $1B_S$.
- Seabed composition:
  For the access channel, particularly in phase two at the Restinga where harder material and large sediment are present, a conservative value of $0.2B_S$ was used.
- UKC:
  The under-keel clearance factor depends on the ratio between the guaranteed depth h_0 and the draught of the vessel D_S. This ratio is 1.19, 1.10, 1.07, for vessel types Poteros, Madrid Trader and Panamax respectfully. This means that for all vessels this ratio is smaller than 1.25.

To summarize the essential factors for determining channel width, the following table is presented:

Element	**Value**	**Element**	**Value**
W_{bm}	$1.5B_S$	$W_{a,longcurrent}$	$0.2B_S$
W_b	$0.3B_S$	$W_{a,waveheight}$	$1B_S$
W_p	$1.2B_S$	$W_{a,seabed}$	$0.2B_S$
$W_{a,wind}$	0	$W_{a,UKC}$	$0.2B_S$
$W_{a,crosscurrent}$	$1B_S$		

Table F.2: Overview width access channel

Substituting all the values of table F.2 into equations F.5, the following values for the various vessels are obtained:

Vessel	**Beam [m]**	**Single Lane [m]**	**Double Lane [m]**
Poteros	11.3	53.11	113
Madrid Trader	28.4	133.48	284
Panamax	32.2	151.34	322

Table F.3: Results width Access Channel

Depth

The depth of the access channel is determined using the following formula:

$$h_0 = D_S - T + s_{max} + r + m \tag{F.6}$$

With:

- h_0 = guaranteed depth of the access channel [m]
- D_S = draught of the vessel [m]
- T = tidal restriction, here T = 1.77 [m]
- s_{max} = squat, rule of thumb = 0.5 [m]
- r = response to waves = $0.5H_{S,1year}$ = 1.25 [m]
- m = UKC = 1 [m]

The length of the dredged area for the access channel depends on the required depth for the access channel. The bathymetry analysis, shown in Figure J.1 derived from (La Poutré et al., 2023), gives the distance of the coastline where these values are reached, and the ships will be at open seas. In Figure J.1 it is visible that none of these values will be reached at the end of the bathymetry analysis, which means the values obtained in subsection F.1.1 are normative.

Determining the previously stated values and summarizing them in a table one obtains:

Vessel	Draught [m]	h_0 [m MOP]
Poteros	5.1	-6.08
Madrid Trader	9.5	-10.48
Panamax	12.5	-13.48

Table F.4: Results depth AC

F.1.2. Internal Waterways

Second, the guidelines regarding the internal waterways are elaborated.

Width

The width of the waterways depends on the beam of the ship, the equation used in Equation F.7, which is a conservative estimate, is based on the rules of thumb of (Thoresen, 2014). The equation is twice the beam of the largest vessel that has to access that part of the port added by the bank clearance, which is 30 meters.

$$W = 2 * W_{bm} + 30 \tag{F.7}$$

For all the different vessels, the channel widths are shown in Table 5.6, the widths for the fishing vessels smaller than the squid (poteros) are not normative for the waterway, considering that the bank clearance is excessive relative to the size of the beam.

Depth

The depth of the waterway parts is divided into two depths, one depth for the berth pocket and one for the waterway. This division is needed due to the large tidal range, limiting the dredging operations. For the calculations of the depths, Equation F.6 is used, however, the influence of squat and waves are negligible due to the low speeds of the vessels and the fact that it is a sheltered area. The difference between the berth pocket depth and the waterway depth is the fact that the lowest astronomical tide (LAT: -1.84 m MOP) is used for the berth pocket depth and the average high tide quadrant (+1.77 m MOP) is used for the waterway. This ensures that the vessels will not go aground at the lowest tide (LAT) when berthing at the quay, and all vessels will be able to sail out at the high tide quadrant.

F.2. Terminal Areas

In this section, the PIANC guidelines are explained to determine the required areas for all terminal facilities.

F.2.1. Container Terminal Areas

To determine the areas needed for the container terminal in the port Equation F.8 is used, (Ligteringen, 2021).

$$A = \frac{N_c \cdot \overline{t_d} \cdot A_{TEU}}{r_{st} \cdot 365 \cdot m_c} \tag{F.8}$$

The calculation for the average dwell time has been given by Equation F.9, (Ligteringen, 2021).

$$\overline{t_d} = \frac{t_{dmax} + 2}{3} \tag{F.9}$$

For the calculation of the required terminal area a number of assumptions and design decisions have been made, shown in Table F.5. The required area per TEU (A_{TEU}) is related to the assumption that reach stackers are used as stacking equipment in the Terminal. The maximum dwell time ($t_{d,max}$) is determined to be 25 days, which has been confirmed by Argentine port expert Pablo Arecco. The nominal stacking height (r_{st}) and acceptable occupancy rate (m_c) are both conservative estimates, for the reason that this is a very small port, with only one terminal where efficiency can be low.

Considering the fact that the main goal of the container terminal is the export of frozen fish and goods, a Container Freight Station (CFS) has been omitted from the calculations. Another assumption that has been made as a consequence of this fact, is that there are only two types of stacks: export reefer and empty import reefer containers, both account for 100 percent of the containers that go through the port.

Parameter	**Value Phase 1**	**Value Phase 2**
A_{TEU}	25 [-]	25 [-]
$t_{d,max}$	25 [days]	25 [days]
N_c	20.000 [TEU]	60.000 [TEU]
m_c	0.65 [-]	0.65 [-]
$r_s t$	0.65 [-]	0.65 [-]

Table F.5: Assumptions for Terminal Area

Equation F.8 gives the area for the storage of containers, and the apron area is added to obtain the total area of the terminal. The apron area is the combination of the quay length and the width of the apron. The length of the quay is determined in subsection 5.1.1, and the width of the apron is an addition of a few widths, which are dependent on the type of container crane. The crane used in this port is a mobile crane which can be used for both the general cargo and the containers. Considering the fact that the port is small, the gantry crane would require more space and is more expensive, whilst the received efficiency does not outweigh these flaws. The widths are the setback of 3-5 meters, which is the spacing between the coping and the waterside crane limit, the crane spacing, which is the moving area for the crane, and the traffic lane for the reach stackers. The total apron width results in 35 meters, for both phases 1 and 2.

F.2.2. General Cargo Terminal Areas

To determine the required general cargo terminal area a combination was made with the Python model described in section D.1 and the same input variables used which can be seen in Table D.1. This was done with a calculation for the 50 wind turbines in accordance with the boundary conditions. It is assumed that the terminal will be utilized for handling all break bulk cargo in the upcoming area. The steps outlined in Table F.6 detail the process undertaken by the model to compute the total stacking area. The model estimates the required stacking area in the port and the arrival frequency of ships carrying different parts over time. The wind turbine components in question include blades, base segments, nacelles, and hubs, which are key to constructing 50 wind turbines per year.

Output	**Description**
Maximum Stock Observed	Calculated maximum stock at any point for each component type.
Stacking Area Calculation	Estimated minimum stacking area based on maximum stock levels.
Total Stacking Area	Combined stacking area including safety margins and separation between part types.
Shipping Frequency	Predicted ship arrivals are required to maintain stock levels over time.

Table F.6: Summary of necessary input/outputs

Stacking area calculations: Calculates the area required to store blades, considering overlap.

$$\text{Blade Area} = \left(\frac{\text{max stock blades}}{2}\right) \times \text{overlap factor} \times \left(\text{blade length} + 2 \times \text{safety margin}\right) \times \left(\text{blade width} + 2 \times \text{safety margin}\right) \quad \text{(F.10)}$$

To calculate the stacking area for segments without overlap aka the hubs, nacelle's and base segment Equation F.11 was used:

$$\text{Segment Area} = \text{max stock segments} \times \left(\text{segment length} + 2 \times \text{safety margin}\right) \times \left(\text{segment diameter} + 2 \times \text{safety margin}\right) \quad \text{(F.11)}$$

For calculating the additional area for part separation for safe handling and access the following calculation was made as can be seen in Equation F.12:

$$\text{Separation Area} = \left(\text{segment diameter(smallest side)} + \text{safety margin}\right) \times \text{max stock segments} \times \text{segment separation margin} \quad \text{(F.12)}$$

By adding the calculated stocking areas for the segments, safety and handling area and potential required turning area the total stacking area can be calculated:

$$\text{Total Stacking Area} = \text{Blade Area} + \text{Segment Area} + \text{Separation Area} + \text{Turning Area} \quad \text{(F.13)}$$

Calculating these values and combining them results in the Table 5.11 found in subsection 5.2.3.

G

Strategic Analysis

This appendix contains figures that visually display the elements discussed in section 3.2.

As mentioned in subsection 3.2.1, Figure G.1 provides a clear summary of the stakeholder roles and demands, ensuring that all parties' expectations are clearly identified.

Stakeholder	Industrias Bass	UNPSJB Universidad Nacional de la Patagonia San Juan Bosco	National Government	Ministry of Infrastructure, Energy, and Planning of Chubut (MIEP)	Municipality of Rawson	Ministerio de Ambiente (Ministry of Environment)	Port Authorities
Role	Constructor and investor in the port expansion. Owns the private (norhtern) side of the port.	Academic and research institution that contributes to the environmental, social, and economic research connected to regional development.	National governing body. Need to approve the project.	Decision-maker and financer.	Governing body of Rawson, Puerto Rawson, and Playa Unión.	Responsible for environmental regulations and oversight regarding projects that may impact natural resources.	Manage the day-to-day operations of the port, ensuring compliance with regulations and efficient functioning.
Interest	• They want to **expand port capacity** to handle more fishing, general carog and container vessels. • They want to **profit** from the construction and long-term operations of the port. • They want the expansion to proceed **without excessive regulatory delays.**	• They want their expertise in **marine biology** and **environmental sustainability** to be integrated into the project, with access to ongoing data for research. • They want the project to offer **collaborative educational and research opportunities** for their students and faculty. • They want the expansion to support **sustainable regional growth**, ensuring the protection of natural resources and ecological balance. • **Collaboration** between UNSJB students and International MDP students to **learn from eachothers experiences**	• They want the port expansion to **improve** Argentina's **export capacity**. • They want the project to be **economically viable** and beneficial for national growth. • They want to **attract foreign investment** and **enhance infrastructure** in line with national development goals.	• They want the port expansion to **stimulate economic growth** in Chubut. • They want the project to proceed **smoothly** to increase regional trade and exports. • They want to resolve coastal erosion issues alongside the expansion to **ensure long-term infrastructure sustainability.**	• They want the project to create jobs and **boost the local economy.** • They want the expansion to **address coastal erosion** that threatens residential and recreational areas. • They want to ensure that the expansion **does not harm tourism** or the quality of life for residents.	• They want the port expansion to adhere to **strict environmental guidelines** to minimize ecological impacts and ensure **sustainable practices.** • They aim to protect **biodiversity** and ensure the project does not harm local wildlife. • They seek compliance with laws related to **water protection** and **coastal erosion** management.	• They want the port expansion to **enhance operational efficiency.** • They seek to **maintain safety** and compliance with national and provincial regulations. • They aim to improve logistical capabilities to **reduce turnaround times** for vessels. • They want to ensure that the expansion **supports economic activity in the region**, benefiting local businesses.

Stakeholder	Direction of Port Infrastructure (DPI)	Public Fisheries (S.U.P.A)	Inhabitants	Touristic Companies	Environmental Organizations	Instituto Provincial del Agua (IPA) (Water Institute)	Provincial Government of Chubut
Role	Supervises and surveys port projects in Chubut.	Operate fishing activities around Puerto Rawson.	Residents of Playa Unión, Puerto Rawson and Trelew.	Provide tourism services around Playa Unión and Puerto Rawson.	Non-profits focused on environmental preservation, including Fundación Vida Silvestre and local groups like Estación de Fotobiología Playa Unión.	Regulates water bodies in Chubut, including areas like Puerto Rawson. IPA also works to ensure that projects adhere to environmental regulations concerning water.	Oversees public infrastructure projects, including the port expansion, and ensures alignment with regional development goals.
Interest	• They want to ensure that the port infrastructure is upgraded **without disrupting port operations**. • They want the expansion to **adhere to national port regulation**s and operational standards. • They want to **avoid excessive environmental impacts** that could **cause public or governmental backlash**.	• They want the port expansion to **increase handling capacity** for their catch. • They want more efficient logistical operations that will **reduce costs and time.** • They want **continued access to fishing ground**s with minimal disruption from port activities.	• They want the project to **prioritize protecting the beach and local environment**. • They want **assurance** that pollution from port activities and dredging will be minimized. • They want investment in coastal protection to **address ongoing erosion** issues.	• They want the port expansion to **avoid harming the appeal** of local tourist activities (e.g., beach use, dolphin watching). • They want **coastal erosion to be addressed** to protect the beach, which is critical for tourism. • They want any changes to **improve tourism infrastructure** indirectly (e.g., better roads, amenities).	• They want the port expansion to **avoid damaging the local marine ecosystem**, particularly concerning sea lions and dolphins. • They want dredging and other construction activities to **follow stringent environmental standards.** • They want more **focus on sustainable practices and environmental preservation** over economic growth.	• They want to ensure **sustainable water management** during the port expansion. • They want the expansion to **incorporate measures that protect local water bodies** and manage coastal erosion effectively	• They want the port expansion to **stimulate economic growth and job creation in the region.** • They aim to **enhance regional trade capacity** and **attract foreign investment**. • They seek to ensure that **environmental sustainability measures** are incorporated into the expansion. • They want to **improve infrastructure** in line with national development goals while **addressing community concerns**.

Figure G.1: Stakeholder overview

Below the summaries are displayed regarding the insights gained from the site visit. Figure G.2 contains obtained information through Rodrigo, Figure G.3 is the data received via Martin Castillo.

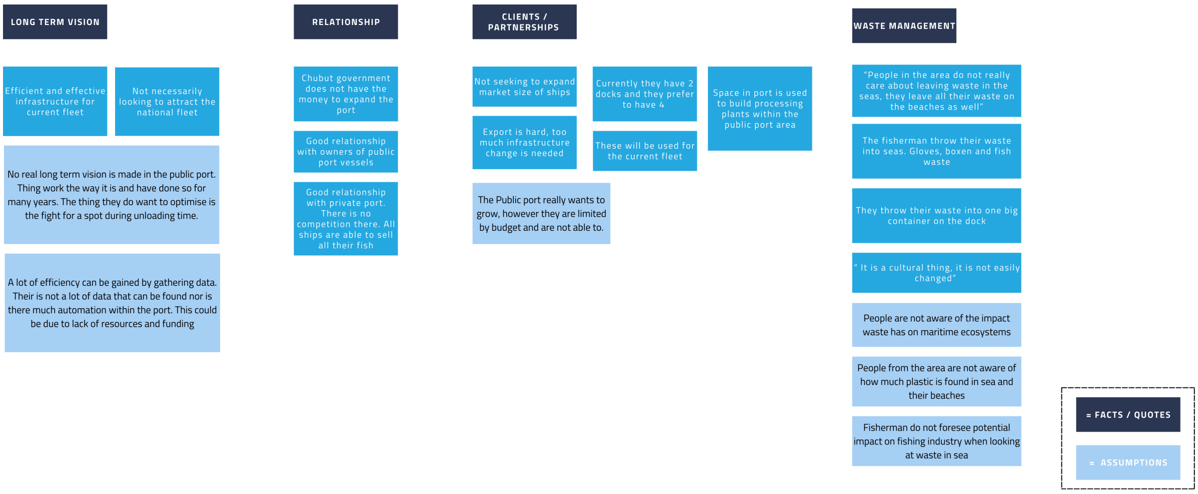


Figure G.2: Sight visit insights Rodrigo

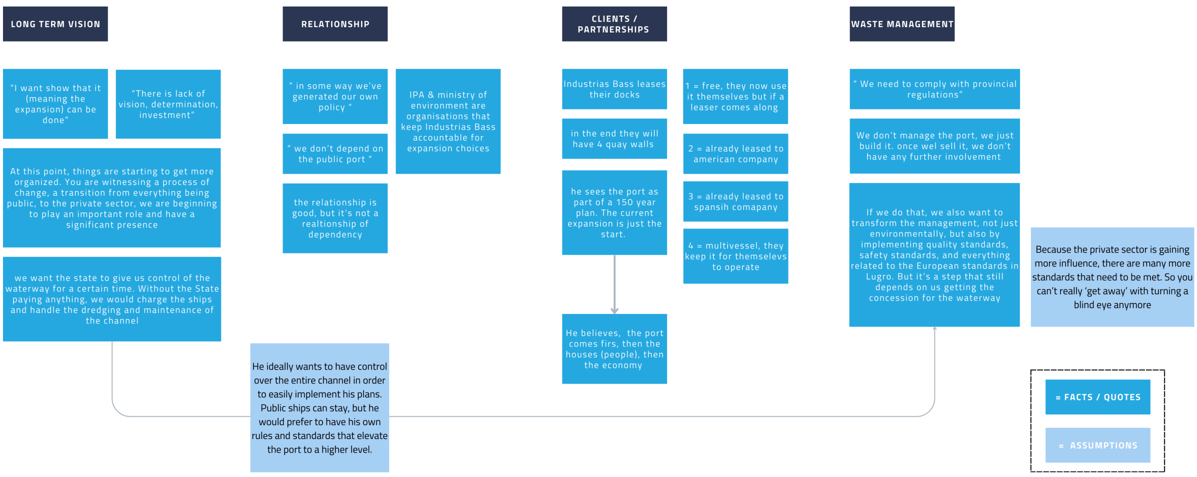


Figure G.3: Site visit insights Sr. Castillo

H

Concepts figures

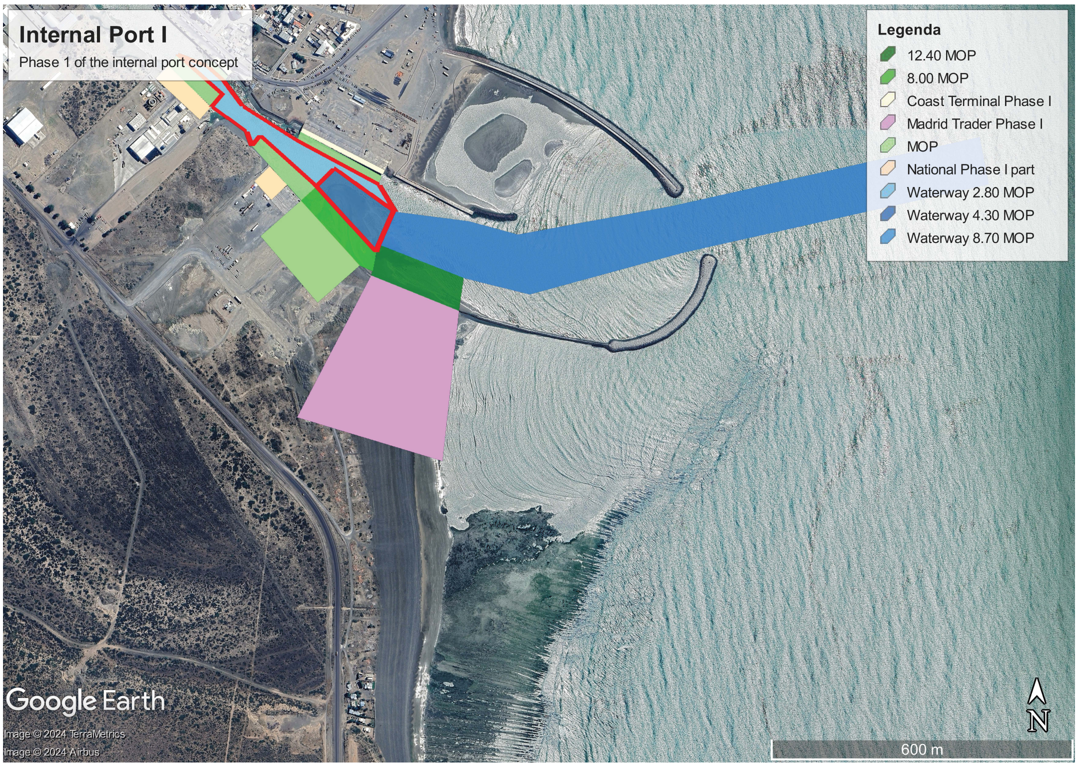


Figure H.1: Concept Internal port phase 1

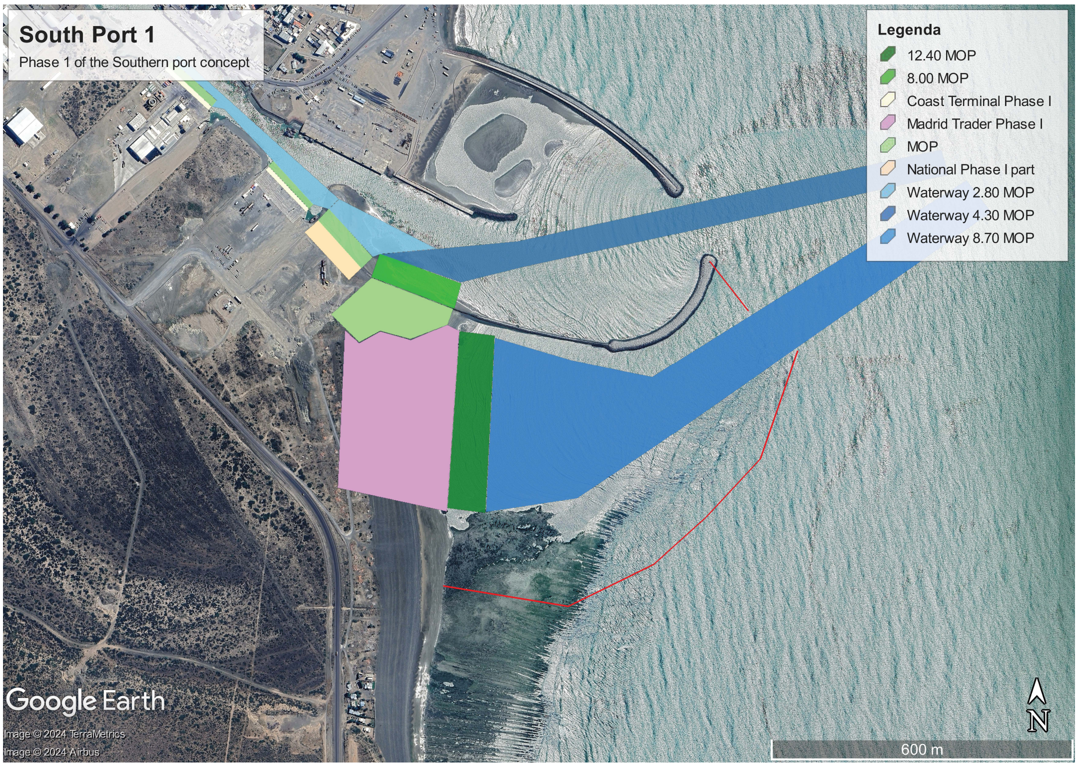


Figure H.2: Concept Southern port phase 1

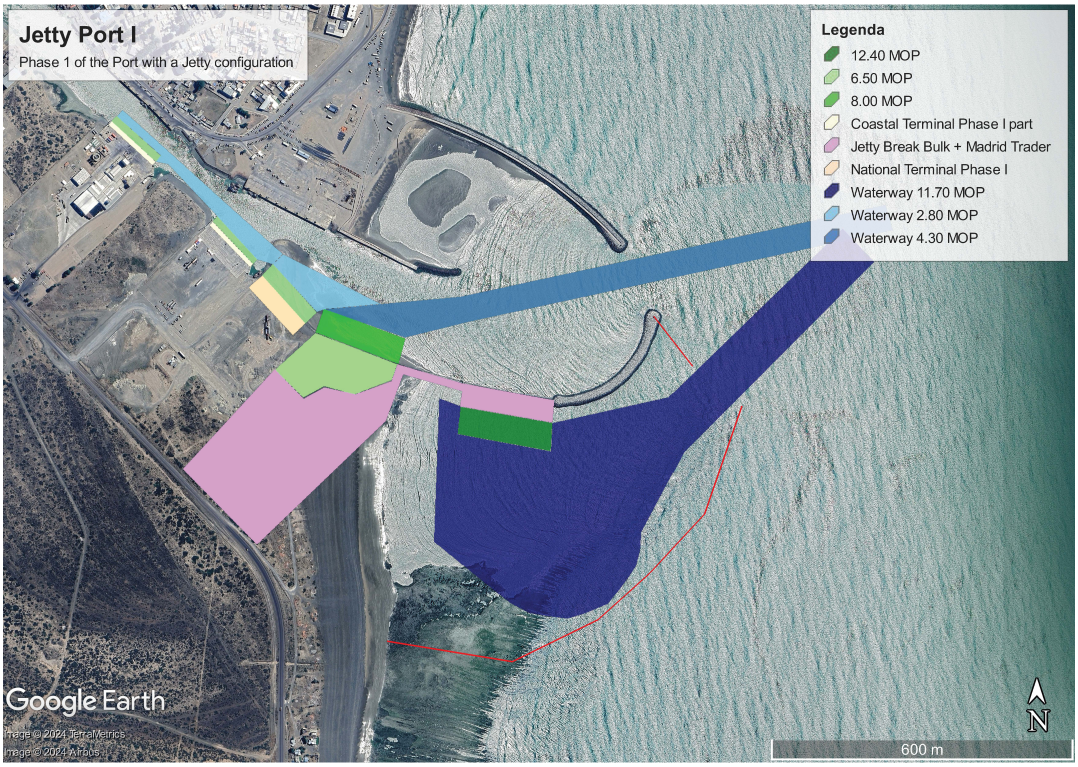


Figure H.3: Concept Jetty port phase 1

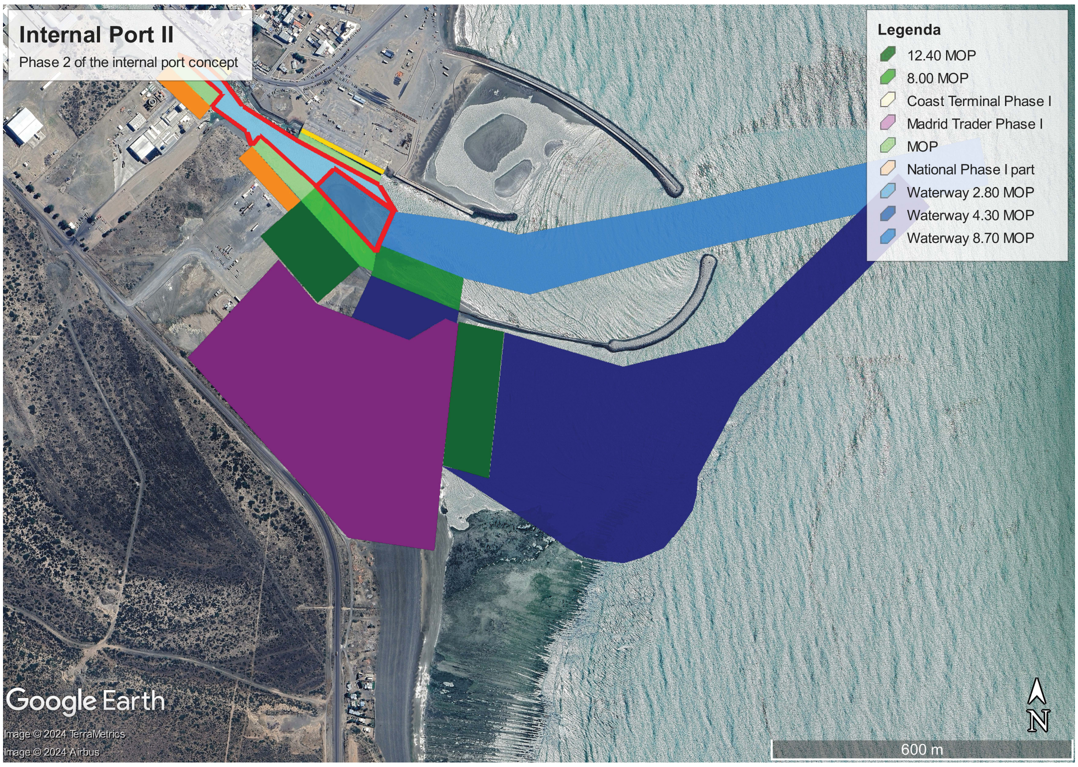


Figure H.4: Concept Internal port phase 2

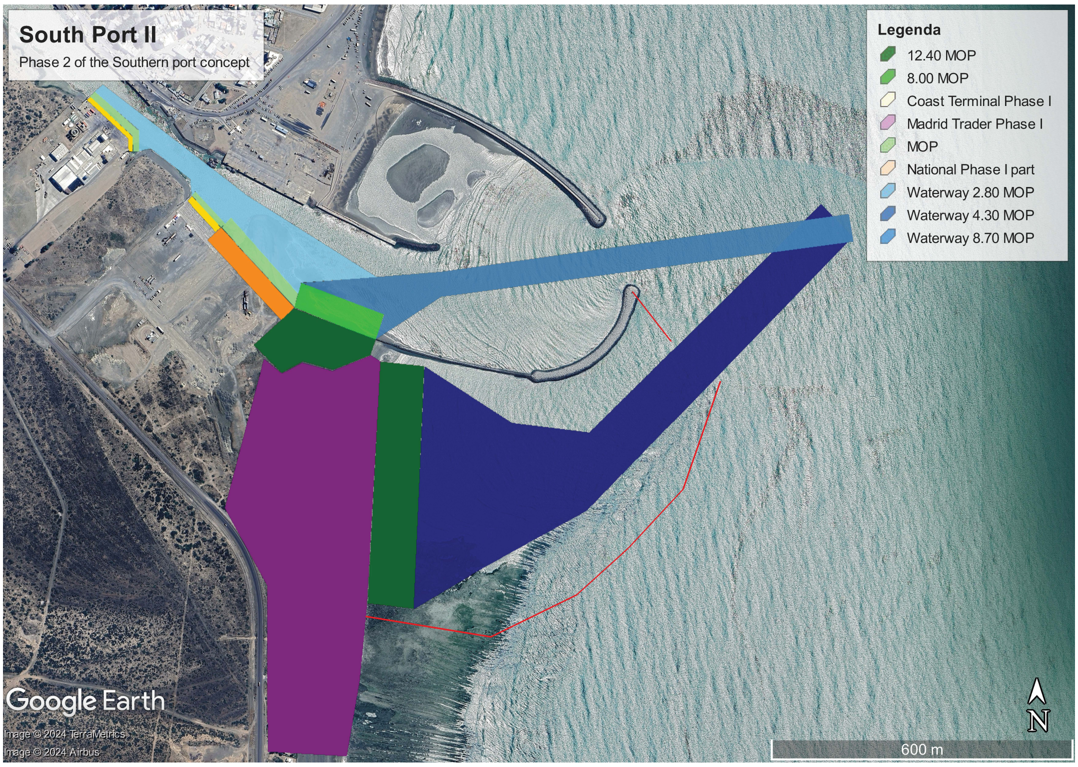


Figure H.5: Concept Southern port phase 2

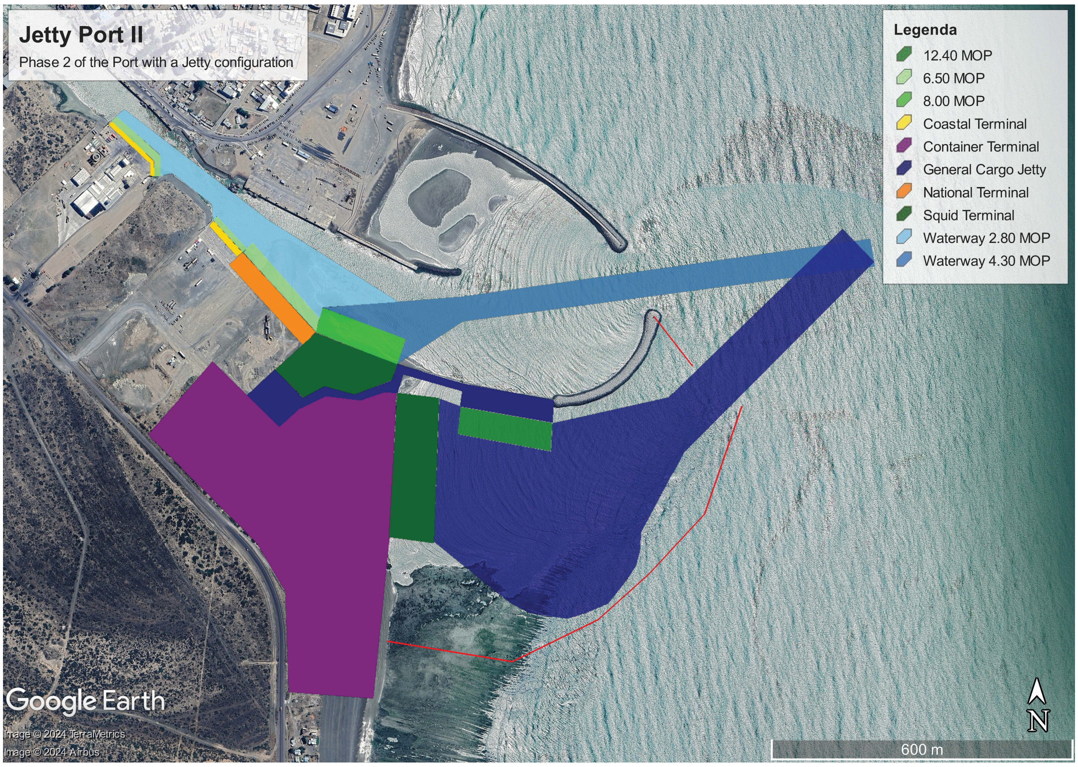


Figure H.6: Concept Jetty port phase 2

I

Multi-Criteria Analysis

I.1. Criteria

For the MCA, the most important criteria are evaluated to compare the different concepts. The criteria are as follows:

Costs

Typically, cost is the most important factor because it directly impacts the project's budget and feasibility. However, in this case, the client is looking for a high-ambition design and is willing to limit financial bounds. Therefore, the weight given to cost in this analysis is lower than usual, set at **14%**. Previously mentioned factors that fall within this criterion are Dredging Activities (seasonal and constructive), Sediment Mitigation, and complex construction elements, also known as CAPEX and OPEX.

Scalability

Scalability refers to the capacity of the harbour to effectively manage increased workload, volume, or complexity without significant degradation in performance or efficiency. It evaluates whether the system can grow or adapt to future demands. The client is interested in having the option for future expansion. Based on this requirement, it is clear that the design should be ambitious to accommodate potential growth. This is why the weight of this criterion is relatively large: **16%**.

Handling Capacity

Handling Capacity for harbour design refers to the harbour's ability to accommodate and manage the volume of ships, cargo, and other activities it is expected to handle. This criterion evaluates how well the harbour can meet current and future demands, including the capacity for docking, loading and unloading cargo, and managing traffic. Handling capacity summarizes the performance and efficiency of the harbour, which are critical for long-term success and functionality, hence its relatively high weight (**16%**).

Operational Disturbance

To ensure that during construction, business can continue as much as possible, the disturbance of the traditional fishing industry is taken into account. Additionally, the design must account for the safety of local communities by minimizing disruptions and potential hazards associated with harbour operations. This criterion is assigned a weight of **8%** in the analysis.

Environmental Protection

Environmental protection focuses on preserving the natural ecosystem surrounding the Port of Rawson throughout the expansion process. For a more detailed explanation of its corresponding design requirements, see section 6.3. This criterion is assigned a weight of **16%** in the MCA, underscoring the urgency of addressing the port's alignment with its environmental context.

CRITERION	WEIGHTS	ALTERNATIVES	
		SOUTHERN PORT	JETTY PORT
COSTS	14%	4	7
SCALABILITY	20%	9	7
HANDLING CAPACITY	20%	9	6
OPERATIONAL DISTURBANCE	8%	7	5
ENVIRONMENTAL PROTECTION	8%	4	8
HOLISTIC ECONOMIC GROWTH	14%	8	8
SAFETY & COMPLIANCE	16%	6	7
FINAL SCORE	100%	7.12	6.86

Figure I.1: Sensitivity analysis shows un-robust results

Holistic economic growth

Holistic economic growth refers to the opportunities that the port concept creates for economic diversification as well as sustainable workforce development. For a more detailed explanation of its corresponding design requirements, see section 6.3. This criterion is assigned a weight of **14%** in the MCA, reflecting its importance in ensuring the port expansion translates into opportunities for boosting the local economy.

Safety & Compliance

Safety for harbour design focuses on ensuring that the harbour's infrastructure, operations, and management practices protect people, property, and the environment from potential hazards. This includes considerations for both operational safety and emergency response. Safety measures should comply with both national and international safety standards and address specific regulations set forth by the Direction of Port Infrastructure (DPI). This criterion is assigned a weight of **16%** in the analysis.

I.1.1. Weights

During the project, a spreadsheet was shared with all clients, allowing them to assign weights to the specific criteria as they saw appropriate. Although the criteria were slightly adjusted during the design process, these changes were minimal. The weights provided by the clients remain valid and are the primary input for the MCA. They are displayed in the table below:

Criterion	Weight [%]
Costs	14
Scalibility	16
Handling Capacity	16
Operational Disturbance	8
Environmental Protection	16
Holistic Economic Growth	14
Safety & Compliance	16

Table I.1: Terminal area per species of fish

Sensitivity analysis figure

J

Bathymetry analysis

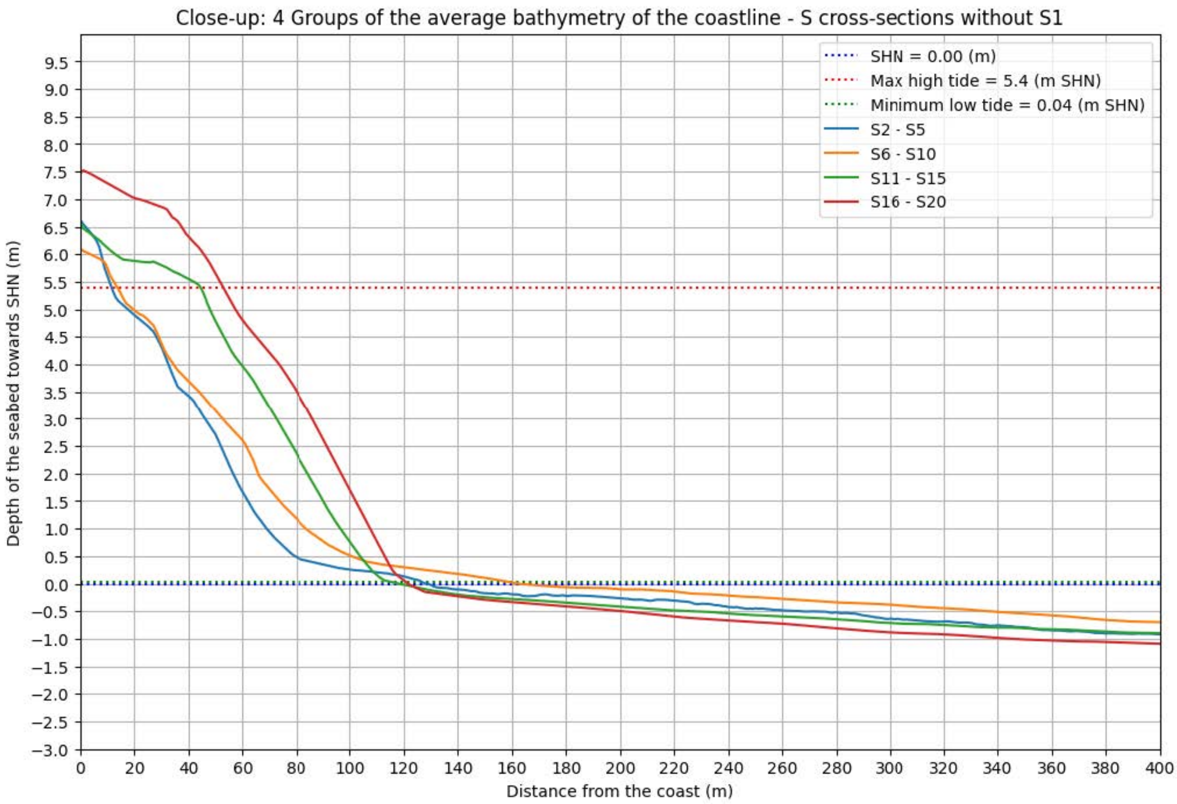
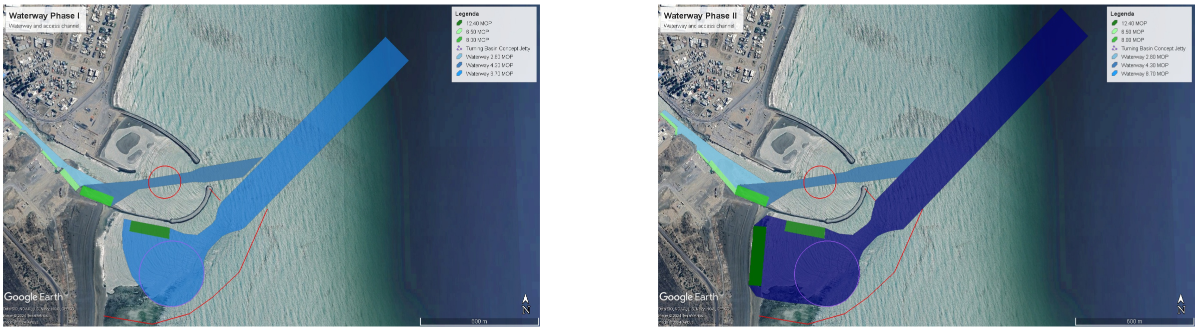


Figure J.1: Bathymetry analysis for access channel

K

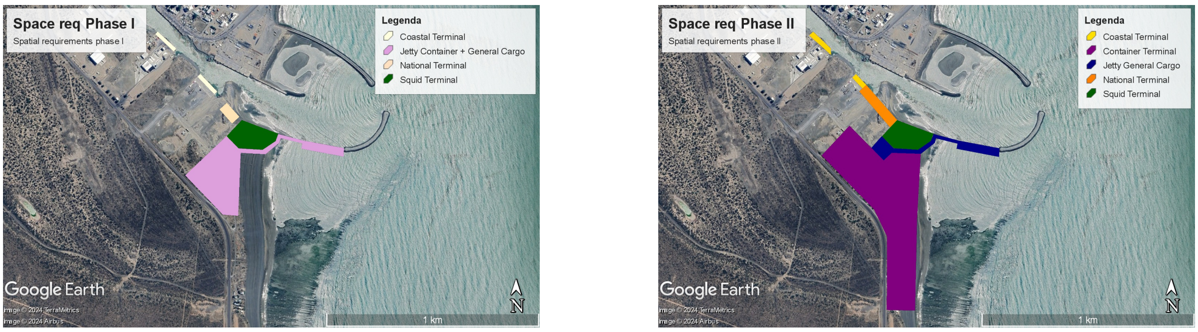
Nautical specifications summary



(a) Waterway and access channel phase I

(b) Waterway and access channel phase II

Figure K.1: Comparison of 'Nautical requirements' Port Concepts for Phases 1 and 2



(a) Spatial requirements phase 1

(b) Spatial requirements phase 2

Figure K.2: Comparison of 'spatial requirements' Port Concepts for Phases 1 and 2

Specification	Vessel	Phase I	Phase II
Access channel length [m]	North port	152	152
Access channel length [m]	South port	1223	1407
Access channel depth [m MOP]	North port	-6.50	-6.50
Access channel depth [m MOP]	South port	-10.5	-13.50
Access channel width seabed [m]	North port	54	54
Access channel width seabed [m]	South port	134	151
Access channel width sea level [m]	North port	78	78
Access channel width sea level [m]	South port	176	205
Turning basin diameter [m]	North port	166	166
Turning basin diameter [m]	North port	207	324
Turning basin depth [m]	North port	-4.50	-4.50
Turning basin depth [m]	North port	-9.00	-12.00
Berth pocket depth [m MOP]	Poteros	-8.0	-8.0
	Madrid Trader	-12.5	-12.5
	Panamax	-15.5	-15.5
	Red Fleet	-6.5	-6.5
	Yellow Fleet	-6.5	-6.5
	Heavy Lift	-12.5	-12.5
Waterway depth [m MOP]	Poteros	-4.5	-4.5
	Madrid Trader	-9.0	-9.0
	Panamax	-13.0	-13.0
	Red Fleet	-3.0	-3.0
	Yellow Fleet	-3.0	-3.0
	Heavy Lift	-9.0	-9.0
Berth pocket width [m]	Poteros	23	23
	Madrid Trader	57	57
	Panamax	65	65
	Heavy Lift	48	48
	Red Fleet	10	10
	Yellow Fleet	9	9
Number of berths	Poteros	2	2
	Heavy Lift	1	1
	Madrid Trader	1	1
	Panamax	1	1
	Red Fleet	2	5
	Yellow Fleet	9	9
Quay length required [m]	Poteros	85	128
	Heavy Lift	168	168
	Madrid Trader	202	202
	Panamax	300	300
	Red Fleet	88	220
	Yellow Fleet	198	198

Table K.1: Nautical Specifications for Port Expansion Design
(values are rounded up to either whole or half meters)

Specification	Phase I	Phase II
Length [m]	1225	1410
Width A.C. North Harbour [m]	55	55
Width A.C. South Harbour [m]	135	155
Depth A.C. North Harbour [m, MOP]	-6.50	-6.50
Depth A.C. South Harbour [m, MOP]	-10.50	-13.50

Table K.2: Master Plan Access Channel

Specification	Phase I	Phase II
T.B. N.H. Diameter [m]	170	170
T.B. S.H. Diameter [m]	210	325.00
T.B. N.H. Depth [m, MOP]	-4.50	-4.50
T.B. S.H. Depth [m, MOP]	-9.00	-12.00

Table K.3: Master Plan Turning Basin

Specification	Phase I	Phase II
N.H. Channel Width [m]	55.00	55.00
S.H. Channel Width [m]	90.00	95.00
N.H. Channel Depth [m, MOP] (beyond Poteros berth)	-3.00	-3.00
N.H. Channel Depth [m, MOP]	-4.50	-4.50
S.H. Channel Depth [m, MOP]	-9.00	-12.00

Table K.4: Waterway Dimensions Master Plan

Vessel	Depth [m, MOP]
Yellow fleet	-6.50
Red fleet	-6.50
Poteros	-8.00
Heavy Lift	-12.50
Madrid Trader	-12.50
Panamax	-15.50

Table K.5: Depths berth pocket per vessel Master Plan

L

Port strategies

The following findings were derived from combining knowledge from conversations with relevant stakeholders in the port with desk research.

L.1. Sustainable Workforce

Sustainable Workforces are fundamental to achieving long-term economic security in Puerto Rawson. This requires employment that not only provides stable incomes year-round but also aligns with environmental sustainability and social equity.

L.1.1. Findings

Puerto Rawson currently experiences a seasonal employment gap tied primarily to the fishing industry. During the high season, from December to March, fishermen can earn substantial incomes, with some making up to €1000 per day. The income structure is based on a minimum wage established by law, with additional earnings linked to the quantity of fish caught.

An important finding of Puerto Rawson's fishing sector is that in the public part of the port, most ships are family-owned. Employment is often passed down through generations, making it difficult for outsiders to enter the industry, despite the high desire from the region to work on fishing vessels.

Efforts are being made by port authorities to professionalize the labor market through training and certification programs. While this may open new opportunities for workers outside the traditional fishing families, the roll out of these programs has been slow, and the overall impact remains limited. Meanwhile, the private sector, mainly owned by Industrias Bass, is expanding, which may bring in more job opportunities. However, this alone may not fully resolve the issue of seasonal employment, highlighting the need for broader economic diversification.

L.1.2. Challenges

The main challenge in achieving Sustainable Workforces is the seasonal nature of employment. While fishermen can earn significant amounts during the high season, the lack of work or need for work during the low season creates income instability and makes it difficult to maintain a sustainable year-round workforce. This creates a two-tier labour market, those who are highly compensated for part of the year, and those who are unemployed or underemployed for the remainder.

There are also gaps in skills development. Although the port authorities have introduced new training and certification requirements to professionalize the workforce, the roll out of these programs has been slow. Additionally, there are still gaps in the availability and accessibility of these programs for local workers. This limits the ability of the existing labour force to adapt to new jobs created by port expansion and leaves outsiders without the skills necessary to participate in the new opportunities.

L.1.3. Opportunities

Diversification is key to creating sustainable workforces in Puerto Rawson. By promoting sectors like renewable energy and logistics, the local economy can become less reliant on fishing, providing year-round employment opportunities. The planned wind farm for hydrogen production offers significant potential for creating jobs in the energy sector.

Additionally, the ongoing expansion of the private sector of the port, driven by Industrias Bass, presents a strategic opportunity to introduce year-round employment. With plans for a 150-year vision involving the development of housing and economic infrastructure around the port, there is potential for long-term growth that can stabilize employment.

Skills development and training programs present another opportunity. Collaborating with local educational institutions could enhance the workforce's ability to adapt to new industries. This would diversify the skill sets available and prepare workers for emerging sectors like renewable energy and fisheries technology.

L.1.4. Limitations

Data on the overall employment situation, particularly regarding the local workforce, is difficult to find or collect, which adds to the challenge of assessing the long-term impacts of the port expansion on job creation. Additionally, the willingness to work remains uncertain.

L.2. Sustainable Economy

A sustainable economy in Puerto Rawson is vital for long-term growth. This section outlines the current economic dependencies, highlights emerging opportunities in renewable energy and logistics, and addresses the challenges of building a more resilient and diversified local economy.

L.2.1. Findings

Puerto Rawson's economy is heavily dependent on the fishing industry. Currently, almost no other export is being done from the port. However, new interesting opportunities are emerging. Industrias Bass's consideration of developing a massive wind farm, is particularly innovative. The proposal to export hydrogen from Argentina is part of a broader energy transition strategy that aligns with global trends toward cleaner fuels.

National economic participation is also significant in energy matters, as Argentina produces 84% of the country's oil and 80% of its gas from this region. Projects like the $30 billion Argentine LNG initiative, driven by YPF (Spaltro, 2024), aim at developing a large liquefied natural gas (LNG) plant in Sierra Grande, located in the province of Río Negro, and aim to position the country as a global LNG exporter by 2027(Mejor Energía, 2023.

Additionally, other sectors like livestock and agriculture play an important role in the region. The large sheep population and growing agricultural output in Patagonia increase the need for ports like Puerto Rawson to handle export products.

L.2.2. Challenges

The economic diversification needed to support a sustainable economy faces several obstacles. The port's current reliance on fishing makes it vulnerable to external risks.

Moreover, while new industries like renewable energy are promising, they require substantial investment and infrastructure development to become viable. The introduction of a container terminal to expand trade beyond fisheries requires collaboration between local industries and international partners to ensure enough volume of goods to sustain operations year-round.

Another significant challenge is the lack of infrastructure to support these new industries. For instance, establishing hydrogen production and an international export hub involves long-term planning, substantial capital, and public-private partnerships to share the financial risks. Without strategic planning and consistent investment, these new sectors may not mature quickly enough to offset the risks associated with dependence on fishing.

L.2.3. Opportunities

Puerto Rawson has significant opportunities to expand its export capabilities by developing a container terminal and improving its logistics infrastructure. The development of an international export hub through the creation of a container terminal will strengthen Puerto Rawson's role in global trade.This would position the port as a key player in international markets and create a more sustainable economy. By collaborating with other industries in Chubut, the aim is to maximize the volume of goods being exported, benefiting the region's economy.

While fishing remains the primary economic driver, there are growing opportunities in other sectors such as renewable energy, logistics, and agriculture. Specifically, the potential for hydrogen (H2) production and exports from the planned wind farm and LNG projects offers a promising avenue for diversification.

Public-private partnerships present another opportunity. Engaging private businesses in the port's development could share the financial risks while ensuring innovation and investment. This approach could unlock new business opportunities and strengthen Puerto Rawson's position in both national and international markets.

L.2.4. Limitations

Business opportunities within the port are very dependent on assumptions. Current markets and industries are difficult to map and hardly any data is available on the economic position and economic growth of Puerto Rawson. While a lot of assumptions and opportunities can be made and seen, they depend heavily on a great variety of internal and external port factors. This makes it difficult to explore new markets and market opportunities.

L.3. Sustainable Marine Ecosystems

The risk of ongoing pollution could lead to a loss of fertility in the seas, threatening the future of fishing and the entire ecosystem. Therefore it is important to protect wildlife from the harm caused by human waste and hazardous materials, knowing that these efforts are also vital for the entire ecosystem regardless of whether fishing remains possible in the years to come.

L.3.1. Findings

The port's waste management systems are currently inadequate, contributing to pollution in the waters and on nearby beaches like Playa Union. Fishermen often discard waste, including gloves and human waste, directly into the sea, adding to the environmental damage. The low awareness and efforts on waste management in combination with the lack of regulation, inefficient distribution of waste containers in the port and the lack of control and knowledge by the competent authorities, would be some of the factors that have a negative impact in achieving sustainable management of port waste.

In December 2005, the municipalities of Trelew, Puerto Madryn, and Rawson in Chubut, Argentina, signed a Framework Agreement to "regulate the joint management of waste generated in part municipalities" in order to promote sustainable development and environmental protection. The provincial state also agreed to support the project (del Vecchio, 2018). This framework is unfortunately not yet been introduced to the public.

In addition, Rawson is already participating in a program called RIL. The objective of the Program is to help cities in the design of strategies for waste management. They do not specifically focus on ports, however, Puerto Madryn is also joining this program.

L.3.2. Challenges

A major challenge in ensuring the sustainability of marine ecosystems is changing community behavior around waste management. Pollution is normalized in the community, especially among those involved in fishing. Educational efforts have been limited in their effectiveness, and there is a lack of enforcement of existing regulations around waste disposal. The main challenge here, according to port authorities, is to motivate, incentivize and change the behaviour of the community towards waste and pollution.

Port expansion activities, such as dredging, also pose a risk to marine biodiversity if not properly managed.

Ensuring that these activities do not disrupt local ecosystems will require stringent environmental monitoring and management. Additionally, there is a significant gap in the technological infrastructure necessary for cleaning up oil spills and other hazardous materials, which limits the ability to maintain healthy waters.

L.3.3. Opportunities

There is a clear opportunity to improve the port's waste management system through stronger regulation, better educational programs, and investments in modern facilities. There is an opportunity to improve waste management systems by investing in better infrastructure and stricter regulations. Collaborating with local authorities and the community through multiple sources could create a cultural shift toward more sustainable practices.

By focusing on these three areas; regulation, education, and facilities, Puerto Rawson can make meaningful progress toward protecting its marine ecosystems

In the following chapters these channels will be further elaborate on.

L.3.4. Limitations

This project does not explore waste management patterns and logistics in detail. Research shows the basic implementations within the port, however extensive research on logistic opportunities has not been done. This means that waste collection facilities and integrated facilities have not been designed within the port design. In addition, a shift in behavior should be considered first before implementing expensive facilities.

Furthermore, technologies for cleaning waters from oils and other hazardous materials coming from mines and agricultural industries have not been extensively researched. Further research is needed to discover how these processes can be implemented within the port to ensure healthy seas and animals.

M

PWMP & MARPOL Annexes

MARPOL Annex	Waste type
Annex I (Oil)	Oily bilge water Oily residues (sludge) Oily tank washings Dirty ballast water Scale and sludge from tank cleaning Other (specify)
Annex II (NLS) (*)	Category X substance Category Y substance Category Z substance Other
Annex IV (Sewage)	
Annex V (Garbage)	A) Plastics B) Food waste C) Domestic waste (e.g. paper/cardboard, rags, glass, metal, bottles, crockery, etc.) D) Cooking oil E) Incinerator ashes F) Operational waste G) Animal carcasses (*) H) Fishing gear (**) I) E-waste J) Cargo residues (Harmful to the Marine Environment, HME) (*) K) Cargo residues (non-HME) (*)
Annex VI (Air pollution related)	Ozone depleting substances and equipment containing such substances Exhaust gas cleaning residues

Table M.1: Waste types under MARPOL Annex I to VI

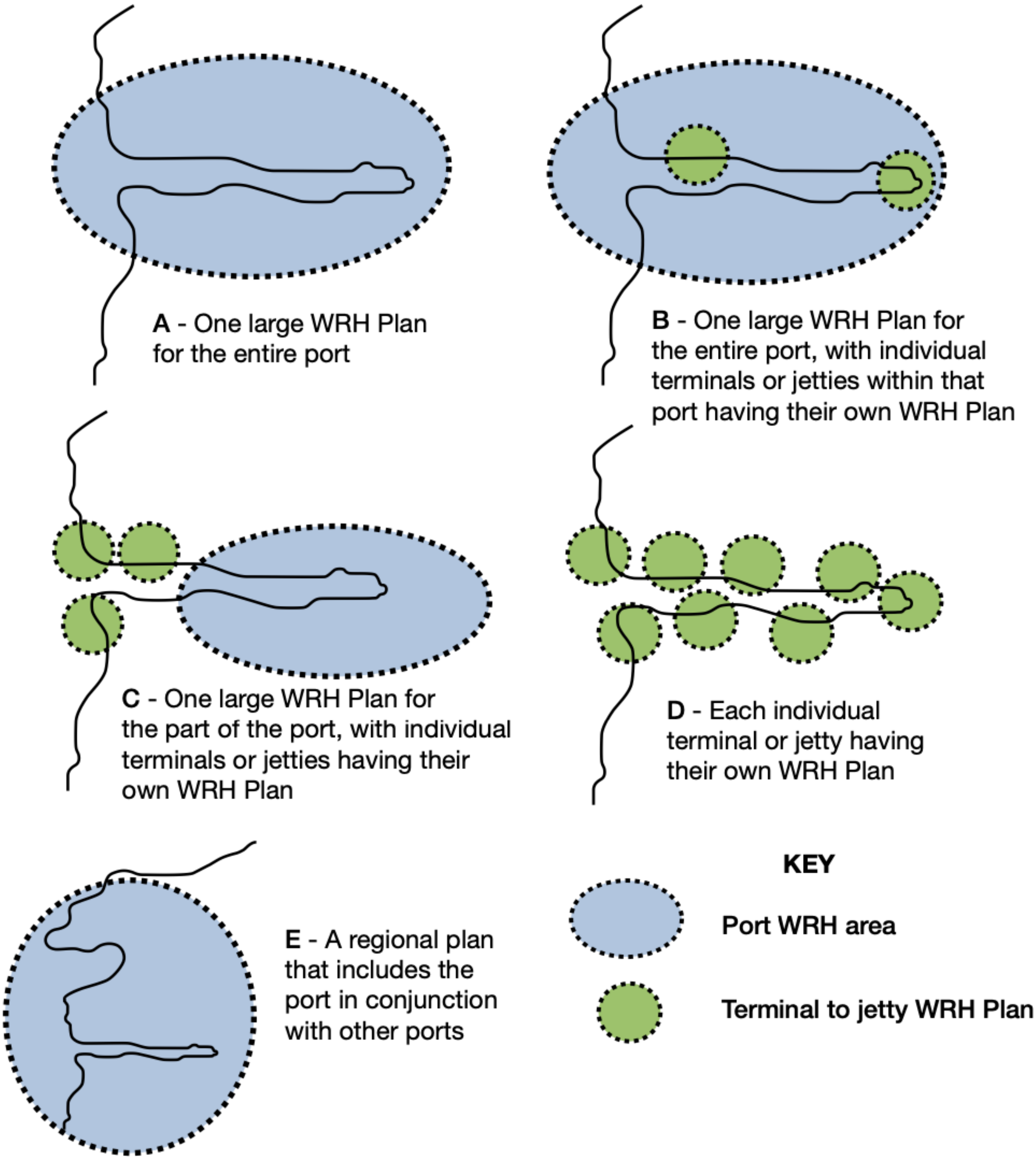


Figure M.1: Types of PWMPs with additional WRH plans (Van Den Dries, 2022)

MARPOL Annex	Fee system details
MARPOL Annex I	- For ship-generated oily waste (bilge water, sludge, waste oil): application of a system containing a fixed indirect fee supplemented with a refundable deposit/penalty (in case of no delivery). - For MARPOL Annex I cargo residues and washing waters: the delivery of cargo residues and washing waters is charged directly, linked to the amount of waste delivered.
MARPOL Annex II (*)	Application of a direct fee system linked to the amounts of waste delivered.
MARPOL Annex IV	Depending on the normal and expected traffic in the port (amounts of sewage), application of an indirect cost recovery system with reasonable amounts.
MARPOL Annex V	- For garbage: 100% indirect cost recovery system, including a full or partial right to deliver. - For cargo residues: application of a direct fee system linked to the amounts of waste delivered. - For cruise/passenger ports heavily affected by seasonal traffic, indirect systems can be applied.
MARPOL Annex VI	Application of a direct fee system linked to the amounts of waste delivered.

Table M.2: MARPOL Annex Cost recovery Systems

APPENDIX 3

STANDARD FORMAT FOR THE WASTE DELIVERY RECEIPT

The designated representative of the reception facility provider should provide the following form to the master of a ship that has just delivered wastes/residues.
This form shall be retained on board the ship along with the appropriate Oil Record Book, Cargo Record Book or Garbage Record Book.

1. RECEPTION FACILITY AND PORT PARTICULARS

1.1 Location/Terminal name:	
1.2 Reception facility provider(s)	
1.3 Treatment facility provider(s) – if different from above:	
1.4 Waste/residue Discharge Date and Time from:	to

2. SHIP PARTICULARS

2.1 Name of ship:	2.5 Owner or operator:
2.2 IMO number:	2.6 Distinctive number or letters:
2.3 Gross tonnage:	2.7 Flag State:

2.4 Type of ship: ☐ Oil tanker ☐ Chemical tanker ☐ Bulk carrier ☐ Container ☐ Other cargo ship ☐ Passenger ship ☐ Ro-ro ☐ Other (specify)

3. TYPE AND AMOUNT OF WASTES/RESIDUES RECEIVED

MARPOL Annex I – Oil	**Quantity (m^3)**
Oily bilge water	
Oily residues (sludge)	
Oily tank washings	
Dirty ballast water	
Scale and sludge from tank cleaning	
Other (please specify)	
MARPOL Annex II – NLS	**Quantity (m^3)/Name[1]**
Category X substance	
Category Y substance	
Category Z substance	
OS – other substance	
MARPOL Annex IV – Sewage	**Quantity (m^3)**

MARPOL Annex V – Garbage	**Quantity (m^3)**
A. Plastics	
B. Food wastes	
C. Domestic wastes	
D. Cooking oil	
E. Incinerator ashes	
F. Operational wastes	
G. Animal carcasses	
H. Fishing gear	
I. E-waste	
J. Cargo residues (non-HME)[2]	
K. Cargo residues (HME)[2]	
MARPOL Annex VI – related	**Quantity (m^3)**
Ozone-depleting substances and equipment containing such substances	
Exhaust gas-cleaning residues	

On behalf of the port facility I confirm that the above wastes/residues were delivered.

Signature: ……………………………… Full Name and Company Stamp: …………………………………………

[1] Indicate the proper shipping name of the NLS involved.

[2] Indicate the proper shipping name of the dry cargo.

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Figure M.2: Appendix 3 of the IMO Consolidated guidance for PRF providers and users (MEPC.1/Circ.834/Rev.1)

N

Sustainable ecomarine systems

N.1. Environmental implications

Results emerging from waste generated have significant implications for health and the environment. These implications can, in turn, greatly impact nature and the economy. The most pressing implications include:

A. **Lead and Phenols in Blood:** Lead and phenols (" a group of aromatic chemicals containing one phenyl ring with an attached hydroxyl group" (“Phenols/phenoxy acids | Chemical Classifications | Toxic Substance Portal | ATSDR”, n.d.)) have been found in the blood of people in the community. While the water distributed through the network is purified, it still contains certain minerals or metals at levels higher than those allowed for human consumption.

B. **Eutrophication Process:** This process causes the death of fish and biota. Eutrophication refers to the biogeophysical and biological effects in an aquatic ecosystem derived from an increase in the supply and availability of nutrients, mainly nitrogen and phosphorus, but sometimes other minerals such as silica, potassium, calcium, iron, or manganese. The development of algae leads to turbidity, preventing light penetration and making photosynthesis at the bottom of the water body impossible, thus reducing oxygen production. This, in turn, causes the mortality of fish and biota (Bensey and González, n.d.).

C. **Death of Whales and Other Species on Peninsula Valdés:** The Whale Conservation Institute reports that the Southern Right whales visiting the Valdés Peninsula may be exposed to metals and chemical pollutants from sources such as mining, oil transport and storage, and port activities. These port activities mainly take place in Puerto Madryn, however pollution streams are slowly moving towards Rawson. The organization indicates that the whale mortality observed at the Valdés Peninsula since 2007 could be connected to the presence of these contaminants (A. Donini et al., 2023).

D. **Red Tide Toxins:** These toxins have an impact on marine life and create human health risks. Red tide toxins have been found in whales that died in Peninsula Valdés and are a result of eutrophication. While not all red tides are toxic, some produce harmful toxins. These are influenced by nutrient pollution that can promote excessive algae growth. Harmful Algal Blooms (HABs) have significant impacts on marine life and human health (A. Donini et al., 2023).

   - **Impact on Marine Life:** Red tide toxins can lead to mass fish deaths, harm marine mammals like whales and orcas, and affect seabirds found on Peninsula Valdés. These toxins interfere with the nervous systems of animals, often causing paralysis or death.
   - **Human Health Risks:** People can be exposed to red tide toxins by consuming contaminated seafood (especially shellfish). Symptoms in humans can include nausea, vomiting, breathing issues, and in severe cases, neurological problems. Since the beginning of the Program in 2003, researchers have studied more than 900 whales.

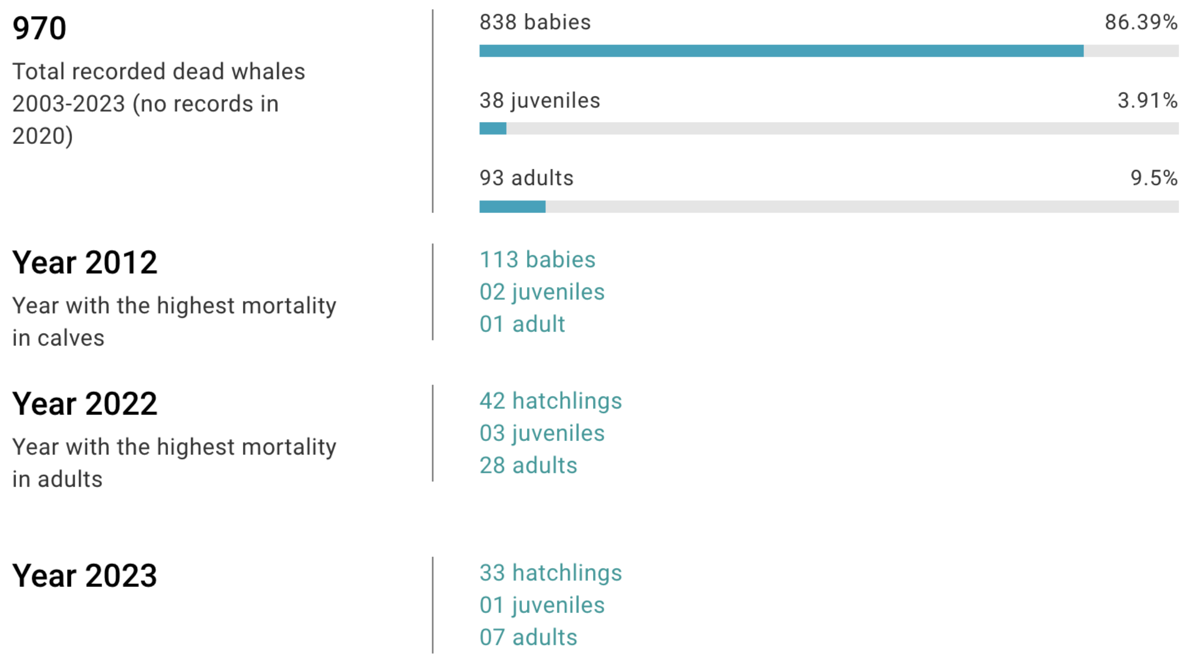


Figure N.1: Whale Mortality Statistics (de Conservación de Ballenas, 2024)

N.2. Design decisions for integration

Integrating the eco-friendly structures mentioned in subsection 8.3.2 into the expansion of Puerto Rawson requires considerations in several design decisions. These interventions should be integrated into both the material and shape selection phase of the breakwater and quay wall construction, as well as when choosing partners for the development of these elements.

Material selection

In terms of material selection, it is important to make use of eco-friendly concrete to biologically enhance the sustainability of the new port extension while promoting marine life. While constructing the breakwater and quay wall elements, bio-enhancing concrete compositions should be selected. These create a chemically balanced concrete that ensures that it does not leach harmful substances into the surrounding water while supporting the growth of marine organisms.

The texture of the material is equally important; it should contain a rough surface texture. This provides essential attachment points for various marine species and consequently promotes the growth of organisms like oysters, corals, or barnacles. This stimulates marine life and enhances the ecological value of the port infrastructure.

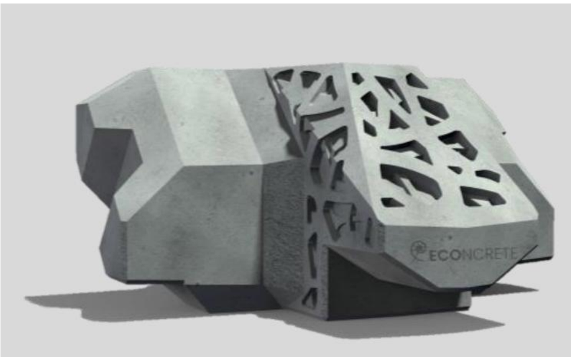


Figure N.2: Breakwater block design by XBlock, in collaboration with E-Concrete (Xbloc, 2022)

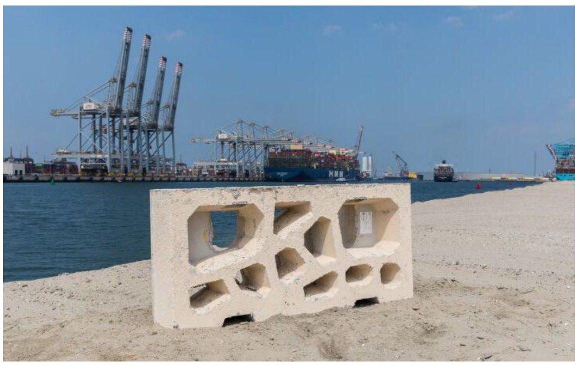


Figure N.3: Quay wall construction block from the expansion of Port of Rotterdam (ECOncrete, n.d.-b)

Shape selection

Not only does the material influence marine habitat formation, but the shape of the construction blocks for both the breakwater and quay wall can also positively impact marine life and, consequently, enhance water quality.

For the breakwater construction blocks, select shapes and textures that promote water retention and provide suitable conditions for marine organisms to thrive. Such a breakwater block can be seen in Figure N.2. The block is the result of a joint effort between Xblock and ECOncrete (Xbloc, 2022). The unique design of these blocks stimulates the formation of tide pools and leads to the habitation of marine life.

For the quay wall construction blocks, certain voids or recesses can be integrated into the design of the blocks to create room for marine organisms, like Figure N.3. These spaces mimic favourable habitat conditions of local native target species (ECOncrete, n.d.-a). Additionally, a less design-invasive alternative involves using seawall panels, an example of which is shown in Figure 8.4. These eco-engineered seawall panels provide ideal conditions for various organisms to settle and thrive (ECOncrete, 2024).

Possible partners

To successfully realise these design innovations for the expansion of Puerto Rawson, it is recommended to partner up with enterprises like ECOncrete and Xblock. Both of these companies have already successfully implemented nature-inclusive port infrastructure. By incorporating their solutions into the port expansion project, it can be ensured that the new infrastructure is both functional and environmentally sustainable. Additionally, local restaurants in Rawson could also be potential partners.

Partner	Role
ECOncrete	ECOncrete specializes in developing eco-friendly construction materials and designs for marine infrastructure. A notable example of their work is the Living Ports project in Puerto de Vigo, where they integrated ecological ECOncrete units into the port's breakwater (see Figure 8.6). This initiative has proven effective in promoting marine life, with numerous species, such as green and brown algae, barnacles, crabs, limpets, worms, sea cucumbers, snails, starfish, and tunicates thriving on ECOncrete infrastructure after six months of monitoring (ECOncrete, 2024).
XBlock	XBlock specializes in breakwater construction. Their recent partnership with ECOncrete has enabled them to develop breakwater elements that are not only nature-inclusive but also exhibit high hydraulic stability. The innovative design allows for quick placement and interlocking capabilities, ensuring robust protection against wave action while promoting marine life through increased porosity (Xbloc, 2022).
Local Restaurants	Another recommendation is to implement a shell recycling program where discarded oyster shells from local restaurants and seafood markets are collected and used as substrates for new oyster banks. By placing these materials in strategic locations, port management can actively promote the growth of oyster banks. Additionally, establishing partnerships with local restaurants can enhance community involvement in environmental initiatives.

Table N.1: Partnership Overview

O
Validation

This validation plan focuses on understanding the practical needs and considerations for implementing the Port Waste Management Plan and the eco-friendly design measures.

Type of validation that will be used is validation in the form of feedback review and a plan refinement. This will be constructed by providing public and private stakeholders with the concepts of Port waste management and eco-friendly design measures. This validation will only contain a risky assessment matrix, which is able to give insight into the feasibility of the concept in relation to the assumptions made.

O.1. Target users

In this concept validation the 2 most important stakeholders of the strategy have been involved. Linking back to the future vision: aligning the needs of both public and private.

1. **Rodrigo**, representing the public part of the port.
2. **Castillo**, representing the private part of the port.

the validation aims to identify potential adjustments to the project.

O.2. Feedback Review and Plan Refinement

Analysis of User Feedback
All feedback gathered from the users will be documented and categorized based on the main themes: operational feasibility, environmental impact, economic viability, and strategic alignment.

- **Positive Feedback** Areas where the PWMP and design measures received strong user interest and met the success criteria.
- **Negative Feedback** Areas of concern or where implementation may face challenges.

Plan Refinement
Based on the feedback, the plan will be revised to address concerns raised by the users and any potential implementation challenges identified during pilot testing.

O.2.1. Validation Questions - Public port

This validation plan focuses on understanding the practical needs and considerations for implementing eco-friendly design measures and the Port Waste Management Plan within Puerto Rawson. As a member of the Public port and port administration, a set of questions have been developed to give feedback and review our concept.

First, a brief summary of the concepts will be given. The Port Waste Management Plan (PWMP), aims to reduce and manage port waste, focusing on Puerto Rawson. The PWMP addresses different waste types defined by MARPOL Annexes (e.g., oil, sewage, garbage, air pollution), emphasizing the need for specific facilities, cost-recovery systems, and compliance measures. This means that the Puerto Rawson Port Waste Management Plan (PWMP) is designed to implement tailored waste reception and handling (WRH) plans for both public and private docks. Partnering with Girsu, the local waste processor. In terms of the Public dock, containing family owned vessels, this means the implementation of mobile waste containers covering categories from MARPOL Annex V. This includes Plastics and cans, Paper/cardboard, Glass, Residual waste, Fishing gear and Hazardous waste.

The WRH plan of the Public dock includes implementing six main waste containers, with additional containers for special waste (e.g., E-waste) placed in a shared area between docks. This results in some actions needed to ensure success:

- Fishing vessels and their personnel need to separate waste either on their vessels or later on the dock
- They will need to place their waste in the correct waste containers
- They will need to start paying for disposing their waste
- They will actively need to contribute to not disposing waste into sea

A joint WRH plan across both public and private docks centralizes management, enabling the PWMP to cover the broader operational area, which includes nearby businesses, the port administration, and restaurants. To support sustainable compliance, the PWMP recommends separate cost recovery systems for the public and private docks. The public dock would use an indirect fee system, encouraging compliance by charging all vessels equally, which helps discourage ocean dumping.

Additionally, a waste delivery receipt (WDR) will be required for all ships, documenting the types and amounts of MARPOL-regulated waste collected, fostering transparency and ensuring compliance with waste management practices.

Eco-Friendly Design Measures for Puerto Rawson Port Expansion:
To enhance water quality, the Puerto Rawson port expansion incorporates eco-friendly design features in its quay walls and breakwater, such as oyster banks, tide pools, and quay wall habitats. These elements promote biodiversity and water filtration, benefiting the marine ecosystem. Key measures include using bio-enhancing concrete with rough textures for marine life attachment, and integrating specialized block shapes that support tide pools. Partnerships with ECOncrete and Xblock are recommended, along with oyster shell recycling from local restaurants for new oyster banks. This approach improves water quality, durability, biodiversity, reduces CO_2 emissions, and lowers material costs.

General Questions:

1. Implementation Considerations:
    - What do you believe are the key factors necessary for successfully implementing both the PWMP and the eco-friendly design measures?
2. Stakeholder Engagement:
    - How do you envision engaging different stakeholders in the implementation process? What roles should they play?
3. Measurement of Success:
    - What metrics or indicators would you suggest using to measure the success of the implementation of both the waste management plan and the eco-friendly design measures?

Specific Questions for the PWMP:

1. Cost Recovery Structure:
    - What type of cost recovery system do you believe would be most effective for funding the PWMP ?
2. Challenges and Barriers:

- What specific challenges do you anticipate in the implementation of the PWMP looking at the family owned vessels and their way of working?
- What specific challenges do you anticipate in the implementation of the PWMP looking at the provided facilities and logistics?

3. Community Awareness:
    - How important do you think community awareness and education are for the success of the PWMP?
    - What initiatives would you recommend to enhance public engagement?

Specific Questions for Eco-Friendly Design Measures:

1. Feasibility and Willingness:
    - What are your thoughts on the feasibility of implementing the proposed eco-friendly design measures?
    - Do you believe there is a willingness to implement eco-friendly design measures within the port expansion from a provincial standpoint, while they will be paying for it?
    - What is the measurability of the success of the implementation? When can the project, once applied, be considered successful?
    - When would this project be successful in your view as a private port stakeholder? What added values do you see in this addition to your specific port expansion?

Thank you for your participation. We hope to see your elaborated feedback and review of our concept. For further information and a more detailed look at the concepts we have added an extensive PDF in the attachment of this e-mail.

O.2.2. Validation Questions - Private port

This validation plan focuses on understanding the practical needs and considerations for implementing eco-friendly design measures and the Port Waste Management Plan within Puerto Rawson. As the owner of the Private port, a set of questions have been developed to give feedback and review our concept.

First, a brief summary of the concepts will be given. The Port Waste Management Plan (PWMP), aims to reduce and manage port waste, focusing on Puerto Rawson. The PWMP addresses different waste types defined by MARPOL Annexes (e.g., oil, sewage, garbage, air pollution), emphasizing the need for specific facilities, cost-recovery systems, and compliance measures. This means that the Puerto Rawson Port Waste Management Plan (PWMP) is designed to implement tailored waste reception and handling (WRH) plans for both public and private docks. Partnering with Girsu, the local waste processor. In terms of the Private dock, containing privately owned vessels, this means the implementation of mobile waste containers covering categories from MARPOL Annex V and privately organized waste collection of Annex I, II, IV and VI. Annex V includes Plastics and cans, Paper/cardboard, Glass, Residual waste, Fishing gear and Hazardous waste.

The WRH plan of the Private dock includes implementing six main waste containers, with additional containers for special waste (e.g., E-waste) placed in a shared area between docks. The private owned companies should also facilitate reception and collection of the other waste collected. This can be facilitated by partnership between Industrias Bass and Girsu or between Girsu and the private companies. This results in some actions needed to ensure success:

- Fishing vessels and their personnel need to separate waste either on their vessels or later on the dock
- They will need to place their waste in the correct waste containers
- They will need to start paying for disposing their waste
- They will actively need to contribute to not disposing waste into sea

A joint WRH plan across both public and private docks centralizes management, enabling the PWMP to cover the broader operational area, which includes nearby businesses, the port administration, and restaurants. To support sustainable compliance, the PWMP recommends separate cost recovery systems for the public and private docks. The Private dock, which caters to larger, commercial operators, a direct usage-based fee system is recommended, aligning with consumption-based service models common for commercial vessels.

Additionally, a waste delivery receipt (WDR) will be required for all ships, documenting the types and amounts of MARPOL-regulated waste collected, fostering transparency and ensuring compliance with waste management practices.

Eco-Friendly Design Measures for Puerto Rawson Port Expansion:
To enhance water quality, the Puerto Rawson port expansion incorporates eco-friendly design features in its quay walls and breakwater, such as oyster banks, tide pools, and quay wall habitats. These elements promote biodiversity and water filtration, benefiting the marine ecosystem. Key measures include using bio-enhancing concrete with rough textures for marine life attachment, and integrating specialized block shapes that support tide pools. Partnerships with ECOncrete and Xblock are recommended, along with oyster shell recycling from local restaurants for new oyster banks. This approach improves water quality, durability, biodiversity, reduces CO_2 emissions, and lowers material costs.

General Questions:

1. Implementation Considerations:
    - What do you believe are the key factors necessary for successfully implementing both the PWMP and the eco-friendly design measures?
2. Stakeholder Engagement:
    - How do you envision engaging different stakeholders in the implementation process? What roles should they play?
3. Measurement of Success:
    - What metrics or indicators would you suggest using to measure the success of the implementation of both the waste management plan and the eco-friendly design measures?

Specific Questions for the PWMP:

1. Cost Recovery Structure:
    - What type of cost recovery system do you believe would be most effective for funding the PWMP ?
2. Challenges and Barriers:
    - What specific challenges do you anticipate in the implementation of the PWMP looking at the privately owned vessels and their way of working?
    - What specific challenges do you anticipate in the implementation of the PWMP looking at the provided facilities and logistics?
    - Do you anticipate that private companies will implement waste management systems by themselves? Or do you think they need to be enforced to do so?
    - Do you see a potential partnership between the private port and Girsu? (Or possible other waste handlers)
3. Community Awareness:
    - How important do you think community awareness and education are for the success of the PWMP?
    - What initiatives would you recommend to enhance public engagement?

Specific Questions for Eco-Friendly Design Measures:

1. Feasibility and Willingness:
    - What are your thoughts on the feasibility of implementing the proposed eco-friendly design measures?
    - Is there a willingness to implement eco-friendly design measures within the port expansion from a private owned standpoint?
    - What is the measurability of the success of the implementation? When can the project, once applied, be considered successful?
    - When would this project be successful in your view as a private port stakeholder? What added values do you see in this addition to your specific port expansion?

Thank you for your participation. We hope to see your elaborated feedback and review of our concept. For further information and a more detailed look at the concepts we have added an extensive PDF in the attachment of this e-mail.

P

Interview transcript Sr. Castillo

Is there a (long term) vision or mission towards which the port is working? Who/which parties is/are contributing to this mission?

For the strategic aspect, there is a vision or mission for the expansion of the port. What countries like ours lack is innovation and infrastructure. That is, we shouldn't think that it can't be done. I've traveled through Holland, or the Netherlands, many times, and honestly, it seems incredible to me how in the middle of nowhere there's a canal and a ship passes through. I'm like that, passing by, huge ships. We have land, land, land, and more land, and not a single canal. The concept is fantastic to me—understanding that with work, with investment, you can build a country like the one you have. Clearly, when you see Holland, or the Netherlands, and then you look at Patagonia where there are thousands of square kilometers with nothing. What we lack is vision, investment, determination, and the will to make our country more like the Netherlands. So, that's our mission, to generate development where before it was thought nothing could be done, and we are doing our best. This is a project I've been thinking about for 15 years. I spent 5 years negotiating to buy the land. All this time, I've been navigating the ups and downs of our country to make things possible. It's not easy, but I think by applying a little of the Dutch mentality, or Netherlands' mentality—I don't know how to put it—I believe all this is possible, and we're going to have a country that can generate more and more added value, instead of just producing raw materials, which is our great challenge. We have the problem, or what we call the curse, of raw materials. That is, we can't get away from just exporting crude oil.

What are the main personal objectives of expansion?

Show that it is possible.

What is your relationship with the port authorities?

No good, we have a good relationship. Eh... In some way, we've generated our own policy, our own development, our own activity, and we don't depend on the public port. We depend on the environmental authorities, or the ones with restrictions, which is called the Provincial Water Institute, which is Equipal, and they are the ones who own the river. It's not the port, but rather an entity that manages all the water in the province. It's called IPA. Yes, perfect, yes. Provincial Water Institute. They are the ones who have to approve our projects. Also the environmental authorities. But once it's approved by those two, we don't depend on the third one. So, we have a good relationship, but it's not a relationship of dependency. They do their things, and we have ours. Who has to approve the projects? IPA, which is the Provincial Water Institute. And the environmental authorities. The Ministry of the Environment. The one that handles the environmental matters for the whole province. Ministry of the Environment. Environment.

Who are your biggest clients?

Our clients are today the most important fishing companies. We don't have many clients. These three, well, actually, the first dock, the big one that you saw, ah, you weren't there, the big dock you didn't see.

This is the first one. This is the second one that they also built. And this is the one we are working on now. We sell it through leasing. Do you know what leasing is? Well, this dock was returned to us. It's back with us. And this year we are going to operate it ourselves. And it's for sale. When someone comes along, it will be sold. This one has been sold to an American company. And this one was sold to a Spanish company. This one will be sold at some point. Whoever wins the bid. And this one, which is Ricardo del Valle, the multipurpose one, our idea is to keep it and operate it. Not sell it. Because it has a port crane, it's a much more expensive dock, and it's the one that will give the place its dynamic. So, we are thinking of not selling it. To keep it for ourselves. But also, because of the vision—going back to the vision. For us, cities first develop the port, then the houses, and then the economy. I don't know if you understand, but I hope so. Today we are developing a new port, we are going to develop the industry, and we are going to build housing. Oh, with a Dutch construction system, as well. Which we have here. So, we have all this to develop. I have a video in Spanish, which I can show you if you want, but we have a development plan for the next 150 years. So, I don't know if I'll live long enough to see it through. This is the beginning—the port is the starting point of the development process we're envisioning.

Do you see new business opportunities within the port? Do you see yourself exporting anything other than fish?

Argentina has very large wind generation processes for hydrogen. Our idea is for the electrolysis plants to be located here. They will be situated here. There will be very large power lines, electroducts, that will come here. Very large electric lines. And from there, the idea is that it will be processed and exported via a monobuoy. The hydrogen will go on ships and be exported through a monobuoy. But that depends a lot. The projects involve German capital, Polish capital. And there's also a very large company from Norway. Norway. Norway. Norway, what is Norway? Norway. Yes, we are... in contact. A lot... A lot... All along this Argentine coast, basically this entire region, you have some of the best, most consistent winds on the continent. You have good winds in the north and at sea. So, it's very expensive to put a turbine at sea, almost three times more than putting one on land. Here, if there's something in abundance, it's land and wind—consistent wind. The wind farm you saw in Rawson, and the same one in Madryn, I don't know if you're familiar with it, the one on the road to Madryn, they have between 53% and 58% of the time producing energy. This is a record. On land, they are among the highest-producing wind farms. Only those in the North Sea produce more, but they are far away. But there isn't much electricity consumption in the region, right? No, because for it to be considered green... It's a big challenge to export electricity, right? No, it's an advantage. Because for hydrogen to be considered green, 100% green... You understand? The energy has to be generated, transported, processed—in other words, the hydrogen is produced... Yes. And it's not connected to the normal electric grid. It's isolated. Yes, isolated. It's not connected to the grid, so it doesn't matter what the country's consumption is, because it has to be 100% separate from the local grid to certify it as green. 100% green. So, it's an opportunity because it's going to be generated... The project is for it to be generated in the center of the province, in this area, where there's the most wind, even more than on the coast. It's transported to the port... No, with the power line.

What does the port have in place regarding waste management?

We comply with the provincial regulations. We don't manage the environmental aspect; that's handled by the provincial authority. Although we are thinking of transforming into the "Blue Port," following European standards like those in Lugro, it's a project we have planned based on the dredging process. We are offering the State to grant us the concession for the waterway, to give us control of the waterway for a certain time. The waterway goes from the last dock, which is here, to the outside, covering this whole area. We're asking them to give it to us without the State paying anything, and we would charge the ships and handle the dredging and maintenance of the channel. If we do that, we also want to transform the management, not just environmentally, but also by implementing quality standards, safety standards, and everything related to the European standards in Lugro. But it's a step that still depends on us getting the concession for the waterway. Does that make sense?

What strategies does the port employ to reduce the amount of waste generated by vessels docking at the facility?

As I mentioned, here we're given the concession for the entire waterway by the State. This is public—the waterway is public. We are taking on the concession for each of these for 30 years. We operate and maintain them. And we charge the ships for entering and exiting. Just like in the Netherlands. So, in this case, yes, we will implement policies to improve waste management, continuous improvement, and several other matters related to traffic control and many things that today are done as they are. So, at this point, things are starting to get more organized. You are witnessing a process of change, a transition from everything being public to the private sector beginning to play an important role and have a significant presence.

In fact, there are now more private docks than public ones. Today, there are more private docks than public ones. Whereas before, everything was public, and there was no private sector. Five years ago, there were no private docks. It was all public. And that's why there were fewer rules, and things were a bit looser. But there's concern that this could also affect the public sector. They don't operate the same way we do. They worry a lot about this. That's why there's a bit of caution. Yes, I understand. And it's a big part of the concern. Yes, indeed. It's a big part of the concern, but it's something to be mindful of.

There is awareness of the damage that is happening, and I believe that in the near future, best practices will improve. Again, I think the active participation of the private sector will help improve these issues. Today, we're really in a bad situation, very bad. There isn't much... people have started to become aware of what's being caused, and practices are beginning to be implemented to reduce pollution, especially plastic pollution, which is horrible. Again, I think this public-private management approach is improving, and it's going to create significant momentum because the companies that buy in, which are the largest ones, have environmental responsibilities to uphold and can't continue doing the reckless things they've been doing. So, I think in the short term, things will continue to change quickly. But it will likely take some time.

Q

Risk Matrix

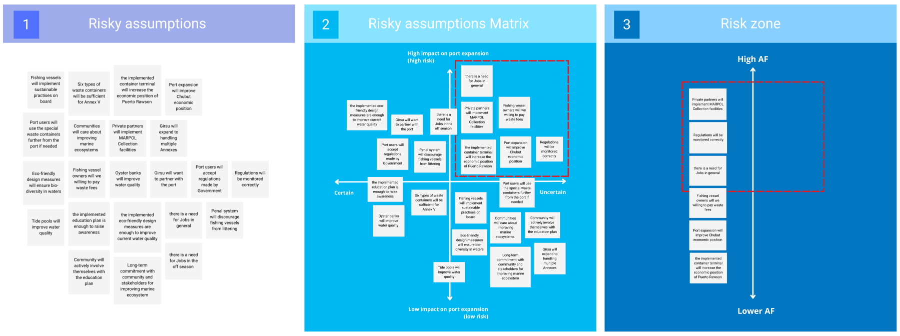


Figure Q.1: Risk full Assumptions

Risk		Affect (Focus on TECOP)	Key Impact People Assets Schedule Cost Reputation	Risk Impact	Likelihood (1 - very unlikely to 5 - very likely)	Severity (1 - low severity to 5 - High severity)	RAM (S/M/S/C)	Mitigation	Likelihood	Severity	Treated RAM	Future Actions
Non Technical Project Risks												
P.01	Sudden policy shifts chubut province, that could block the dredging permits	Political - A sudden withdrawal of government support could lead to temporary or even permanent work stoppage	Schedule	Threa d	2	5	Critical	In early negotiations, seek support from both ruling and opposition parties. Secure project support through contractual agreements with compensation clauses for breaches.	1	5	Severe	Frequent meetings with local government. If needed, make an agreement for providing services in return. (Like maintenance dredging of a part of the northern bank)
P.02	Stakeholder Management Failure	Economics - Potential project halt due to withdrawal or denial of agreement by shareholders	Assets	Thread	4	5	Critical	Implement early stakeholder engagement through comprehensive outreach programs. Set clear contractual agreements with fines for non-compliance. Develop buyout strategies.	2	4	Severe	Frequent stakeholder meetings, and make strong contractual agreements.
P.03	Permits Rejection	Political - May result in delays, scope changes, or project halting, or even having to choose another concept	Schedule	Thread	3	5	Critical	Keep close contact witht the chubut province about the place. It might be possible to provide the province something in return in order to obtain security about permit to build on the old breakwater	2	5	Critical	Keep these organizations informed throughout construction to prevent potential work pauses.
P.04	Lack of Communication	Organizational - In a project of this scale and complexity, where numerous stakeholders are involved, inefficient cooperation can result in schedule delays and cost overruns	Schedule /C ost	Thread	2	2	Medium	Prior to construction initiation, establish clear hierarchical roles and communication channels. Conduct regular inter-departmental meetings to ensure alignment. Before crucial activities, supervisors must hold meetings to ensure the well-informed communication of tasks to the involved crew.	3	2	Small	Maintain strong communication throughout all the project, with all future projects.
P.05	Financial Risks (Cost Overruns)	Economical - Port expansion projects often face cost overruns due to unexpected expenses, inaccurate budget forecasts, inflation, or currency fluctuations, putting the project's financial viability at risk.	Cost	Thread	3	4	Severe	Implement strict financial management practices, including regular financial reviews and budget monitoring. Build a contingency fund to cover unforeseen costs without compromising the overall budget.	2	3	Medium	Develop a long-term financial strategy that includes securing additional funding sources if necessary, such as from public-private partnerships or external investors, to ensure financial stability during both construction and operation.
P.06	Unrealistic and Miscalculated Planning	Organizational - Poor-quality planning can result in chaos on the construction site, such as late ordering of crucial supplies or incorrect sequencing of tasks	Schedule	Thread	4	4	Critical	Those responsible for planning must possess relevant experience and understanding of the project scope. Foster collaboration between departments to consider all aspects before finalizing the plan.	2	2	Medium	Hire external consultants to oversee implementation and identify potential malfunctions. Prohibit change orders during construction and incorporate buffer zones in the schedule.
P.07	Labor Shortages or Strikes	Organizational - A shortage of skilled labor or labor disputes, such as strikes or union conflicts, can cause significant delays in construction, increase costs, or slow down operations.	Schedule	Thread	3	3	Severe	Develop strong labor agreements and maintain regular dialogue with unions and worker representatives to prevent disputes. Provide fair wages and good working conditions to minimize the risk of strikes.	2	2	Small	Invest in training programs to build a skilled workforce and continuously improve working conditions. Foster long-term relationships with labor unions to ensure sustained cooperation and workforce stability.
P.08	Changes in Trade Policies	Economics - Shifts in international trade policies, such as tariffs, trade restrictions, or changes in import/export regulations, could negatively impact the flow of goods through the expanded port, reducing its projected economic viability.	Cost	Thread	1	5	Severe	Stay informed on global trade developments and engage with trade experts to anticipate changes that might affect the port's operations. Develop flexible business models that can adapt to different trade conditions.	1	3	Medium	Establish relationships with multiple international markets to diversify trade flows. Regularly review and adapt the port's operational strategy to account for changes in global trade policies, ensuring resilience to shifts in the global economy.
P.09	Environmental Protests or Legal Challenges	Organizational - Environmental concerns about the port's impact on ecosystems, water quality, and wildlife can lead to protests, legal challenges, or injunctions, halting construction or requiring expensive redesigns to meet environmental standards.	Cost	Threa d	2	4	Severe	Conduct thorough environmental impact assessments (EIA) and develop mitigation strategies that reduce the port's ecological footprint. Engage environmental groups early to demonstrate that environmental concerns are being addressed.	2	2	Small	Implement continuous environmental monitoring during both construction and operation, ensuring compliance with environmental standards. Transparently report results to reduce the risk of future legal challenges or protests..
P.10	Sudden downfall in shrimp catch in the are	Economical - In case there will be less shrimp caught, it could have very negative consequences for the business in the port. As fishing vessels might look to other ports.	Reputatio n	Thread	2	4	Severe	Play a role in making sure that there is no overfishery. Also make an effort to reduce waste in the port.	1	2	Small	Invest in parallel sustainable initiatives in the local community, such as a waste reduction program. Besides ensure regulation against over-fishery.
Technical Project Risks												
P11	Geotechnical issues	Technical -Unforeseen soil or foundation conditions can lead to instability during construction, such as improper foundation settlement, slope failures, or unexpected ground conditions (e.g., soft soils, high water tables), leading to costly delays and design revisions.	Cost & schedule	Threa d	2	3	Medium	Do sufficient soil investigation beforehand. So that the proper excavation material can be used	1	3	Medium	Map out soil data in regional or national databases.
P.12	Dredging and Sediment Management	Technical - Problems related to sediment transport, erosion, or deposition can occur, affecting both the dredging operations and the long-term stability of the access channels and berths. Improper sediment disposal or unforeseen environmental impacts can also be an issue.	Assets	Thread	3	5	Critical	Use advanced hydrodynamic modeling to predict sediment behavior and optimize dredging plans. Regularly monitor sediment movement and adjust dredging operations to prevent excessive deposition or erosion.	2	3	Medium	Explore potential synergies with nearby countries for H2 exports.
P.13	Design Flaws in Breakwaters or Quay Walls	Technical - Structural failures or design miscalculations in key infrastructures like breakwaters, quay walls, and jetties can occur. These flaws could result from incorrect load assessments, wave impact estimations, or inadequate materials, leading to failures that compromise the port's safety and operability.	Schedule /C ost	Thread	2	5	Severe	Perform detailed structural analysis using industry-standard models and conduct peer reviews of the designs to avoid miscalculations. Utilize high-quality materials and construction methods to withstand environmental stresses like waves and tides.	1	3	Small	Maintain constant observation and awareness of these phenomena.
P.14	Weather-Related Construction Delays:	Technical - Adverse weather conditions, such as high winds, storms, or unexpected flooding, can significantly slow construction progress, leading to delays and cost overruns. Construction in marine environments is particularly susceptible to such conditions.c	Schedule	Thread	3	3	Medium	Incorporate weather forecasting tools and seasonal analysis to plan construction during favorable conditions. Prepare contingency plans that allow for schedule flexibility and consider building temporary protections against adverse weather.	2	2	Small	Similar to mitigation strategy
P.15	Supply Chain Disruptions for Materials or Equipment	Economical - The global supply chain can affect the timely delivery of critical construction materials (e.g., concrete, steel) or specialized equipment (e.g., cranes, dredging equipment). Delays in procurement could stall or disrupt construction timelines.	Schedule	Thread	3	3	Medium	Ensure proper stock and planning	2	2	Small	Have good talks with suppliers and ensure good relations with trustworthy suppliers
P.16	Contractors not following safety rules	Technical - Non-compliance could result in work accidents, causing project delays due to safety investigations and procedures.	People	Thread	4	3	Severe	Enforce stringent contract obligations for contractors. Choose contractors with a strong safety track record. Establish a secure work site with proper safety equipment and accident response plans.	2	3	Medium	Implement fines for contractors who repeatedly fail to comply with safety regulations.

R

Roadmap

1 Navigating towards progress | 2 Foundations of Sustainability | 3 Growth & Green Innovation

Now ··· **2030** *(expansion phase 1)* ··· **2040** *(expansion phase 2)*

CONCEPT

Construction activites

- Now: Current port operations
- 2030:
  - Construct container terminal
  - Construct heavy lift terminal
  - Expand fishing terminal
- 2040:
  - Expansion of the container terminal
  - Further expansion of fishing terminal

Type of vessels to berth

- Fish cargo: Yellow fleet (*shrimp*; from 2040 *sardines*); Red fleet (*shrimp, hake*); Poteros barcos (*squid*)
- General cargo: Heavy lift vessels
- Container: Madrid trader; Panamax (from 2040)

GOALS

Strategic goals

In the first phase, the focus will be on preparing the ground. This means creating awareness and providing education to ensure that all stakeholders are aligned and working towards our strategic goals:

Goal	Phase 2	Target	Phase 3	Target
BALANCING JOB DISTRIBUTION	Short term job creation	*achieve 250 FTE*	Long term job creation	*achieve 400 FTE*
STRENGHTENING COMPETITIVE POSITION OF THE PORT	Attracting new kinds of traffic	*attract 20 new vessels*	Attracting large vessels	*270 x 32,2 x 12,5 [m]*
EXPANDING EXPORT OPPORTUNITIES	Creating export opportunities through enabling storage by container terminal	*increase throughput by x%*	Diversify export into new markets beyond fishery	*at least 2 new markets*
ADAPTING THE PORT TO FUTURE ENERGY TRENDS	Creating wind energy throuygh heavy lift vessels and a general cargo terminal	*receive 50 WTGly*	Integration of wind energy to power port operations	*integrate 25% wind energy*
CONSERVING LOCAL ECOSYSTEMS IN AND ROUND THE PORT'S WATERS	Separation waste stream collection; Investment in nature-inclusive design elements	*PRF in place for Annex I & V*; *5% of total expansion costs*	Upgrading treatment facilities; Implementation of marine monitoring program	*PRF in place for Annex I to VI*; *10% improvement of water quality*

Future Vision:

Puerto Rawson thrives to become a valuable player among ports in Argentina by transforming communities through progressive mindsets and innovation while preserving Patagonian nature and safeguarding seas.

TRENDS & DEV

Internal (in port)

- Phase 1: Negative attitude of habitants of Rawson towards port expansion; Movement towards more certified and transparent port operations; Negative environmental impact from port pollution (as seen from Playa Unión observations); Increased pressure on port-city relationship
- Phase 2: Desire of increasing fish throughput; Greater demand for refrigerated cargo facilities for exports.; Desire of expanding export market beyond fishing
- Phase 3: Introduction of green hydrogen (H2) exports through Industrias Bass projects; Growing demand for employees in port for expanded port operations

External

- Phase 1: Increasing global demand for seafood; Nature-inclusive port designs; Use of eco friendly concrete in port design; Centralisation of port operations worldwide through international port regulations; Increasing concern for health of waterways; More strict governmental control on port operations
- Phase 2: Development of Argentina's hydrogen economy; Increased investment in renewable energy infrastructure in Chubut Province; Export of LNG in Rio Negro
- Phase 3: Increasing pressure from global climate agreements to lower carbon footprints in port operations.; Development of eolic windfarm near Rawson; Rise of global ocean cleanup initiatives; Rise of green shipping practices

DEVELOPMENT

Relevant stakeholders

- Phase 1: INDUSTRIAS BASS; Port administration Rawson; Municipality of Rawson; S.U.P.A.; IPA; Ministerio de Seguridad y Justicia (Gobierno del Chubut); Ministerio de Producción; Secretaría de Ambiente y Control del Desarrollo Sustentable (Gobierno del Chubut)
- \+ Phase 2: Consorcio GIRSU Virch - Valdes; Ministerio de Educación (Gobierno del Chubut); Universidad Nacional de la Patagonia San Juan Bosco; Local Community; Local schools
- \+ Phase 3: (Potential) additional waste handling partner; Provincial community; Provincial schools

Regulation

- Research MARPOL regulations and use guidelines to create implementation plan
- Ensure that all ports and vessels are fully operational with the MARPOL regulations
- Provide guidelines to port authorities and vessel owners on managing ship-generated waste
- Conduct in depth reviews of port activities to align waste management practices
- Expansion of Educational Outreach
- Establish a dedicated school for port and vessel personnel training, focusing on advanced waste management techniques
- Create educational exchange programs for port managers globally
- Develop regional penal system
- Launch a penal system for non-compliance with waste and water management regulations in the port
- Create a reporting mechanism for violations, accessible to port users and authorities
- ncrease the severity of penalties and broaden the penal system's reach to cover more waste-related offences
- mplement stricter fines for non-compliance, escalating penalties for repeat offenders
- Use collected fines to fund waste management and water protection programs
- Develop monitoring plan and build monitoring department
- Strengthen monitoring of port waste management practices
- Implement routine inspections of waste container distribution
- Invest in digital tools for tracking of waste disposal and collection. Estimating the daily average oil usage and waste generated by each fishing vessel
- Move from manual oversight to an automated monitoring system that ensures transparency and compliance
- Implement technology to log waste management data
- Require real-time reporting from ships before leaving port regarding waste disposal activities

Education

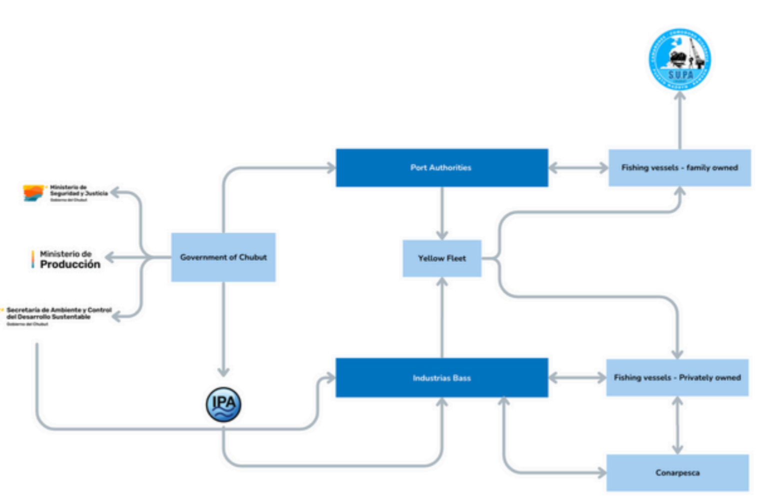
- Developing educational programs for Port operation teams
- Educate Port management and vessel personel
- Organise workshops and training for proper waste disposal, port sanitation, and MARPOL compliance
- Collaborate with organisations like RIL and MaRes to host training sessions
- Expansion of Educational Outreach
- Establish a dedicated school for port and vessel personnel training, focusing on advanced waste management techniques
- Create educational exchange programs for port managers globally
- Development of community awareness campaigns and school programs
- Launch community awareness campaigns
- Use webinars and digital platforms to reach wider community groups
- Transferring knowledge to local schools for the development and promotion of sustainability
- Connect port authorities with universities, offering opportunities for case studies
- Ongoing Community Engagement
- Create local task forces to monitor water quality and waste management practices within communities
- Organise yearly workshops and webinars to keep communities informed and engaged

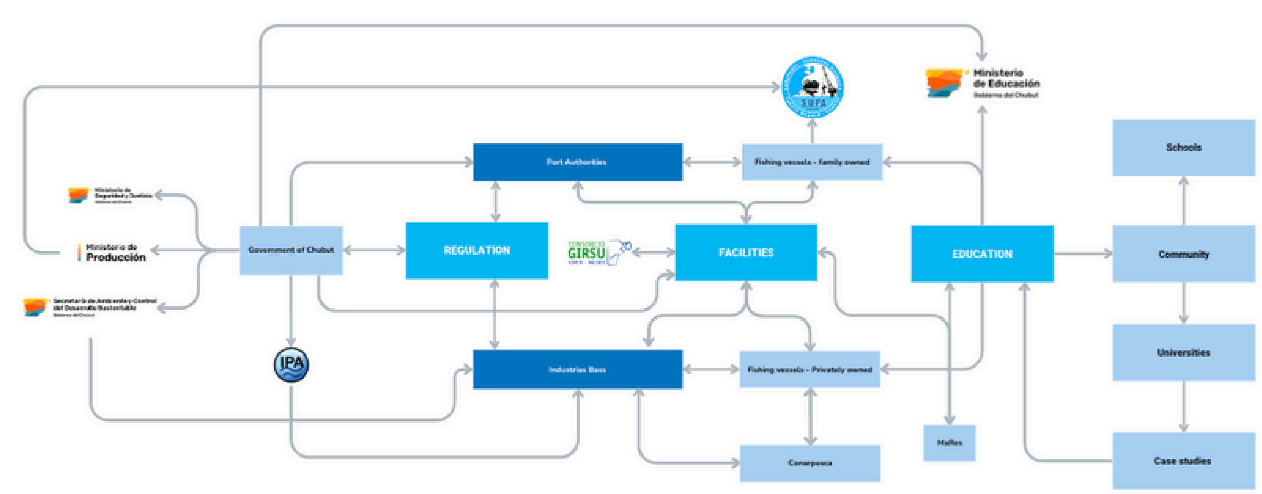
Facilities

- PWMP Development
- Apply for (partial) government funding of PWMP
- Establish partnership with GIRSU
- Create WRH Public dock; PRF Installation Public dock; PRF Annex V; PRF Annex V; PRF Annex I
- Create WRH Private dock; PRF Installation Private dock; PRF Annex V; PRF Annex I; PRF Annex II, IV, VI
- Expand GIRSU partnership for Annex II, IV, VI / create waste processing facilities
- Implementation of Cost Recovery System
- Place E-waste facility on common port ground
- Revise PWMP & start re-development
- Implement improved PWMP
- Operational Annex II, IV, VI waste processing facilities in place
- Integration of eco-friendly design measures in port design plans to improve water quality
- Shape & material selection of quay wall and breakwater elements
- Implement design interventions like gutters that stop contaminated water bodies from entering the water
- Installation of ecological ECOncrete units into the port's new quay walls
- Development & installation of new breakwater elements using XBlock
- Attach seawall panels to existing quay walls
- Implement oyster shell recycling program to promote growth of oyster banks
- Implement a marine monitoring program to assess and enhance ecosystem health,

BUSINESS

Value exhange





Potential partners

INIDEP · CONICET · RIL · 20 Foro para la Conservación del Mar Patagónico y Áreas de Influencia · EMSA · IMO International Maritime Organization · xbloc® · ECONCRETE · YPF · Linde · THE OCEAN CLEANUP