Supplementary material

A TOOL TO ANTICIPATE THE POTENTIAL IMPACTS OF EXPANDING MARINE SALMON FARMING

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Supplementary figures

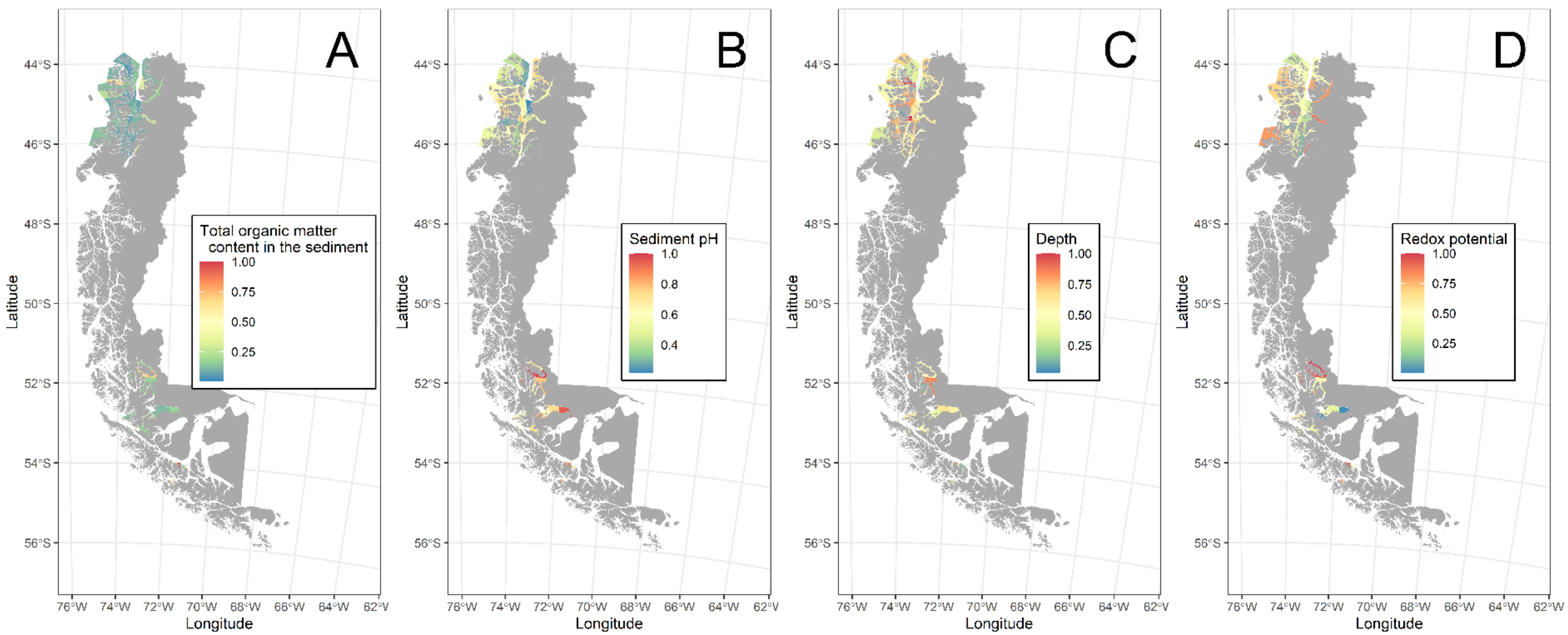

Figure S1. Spatial distribution of indicators Total organic matter in sediment (%) (A), pH in sediment (B), site depth (m) (C), and Redox potential (mV) (D)

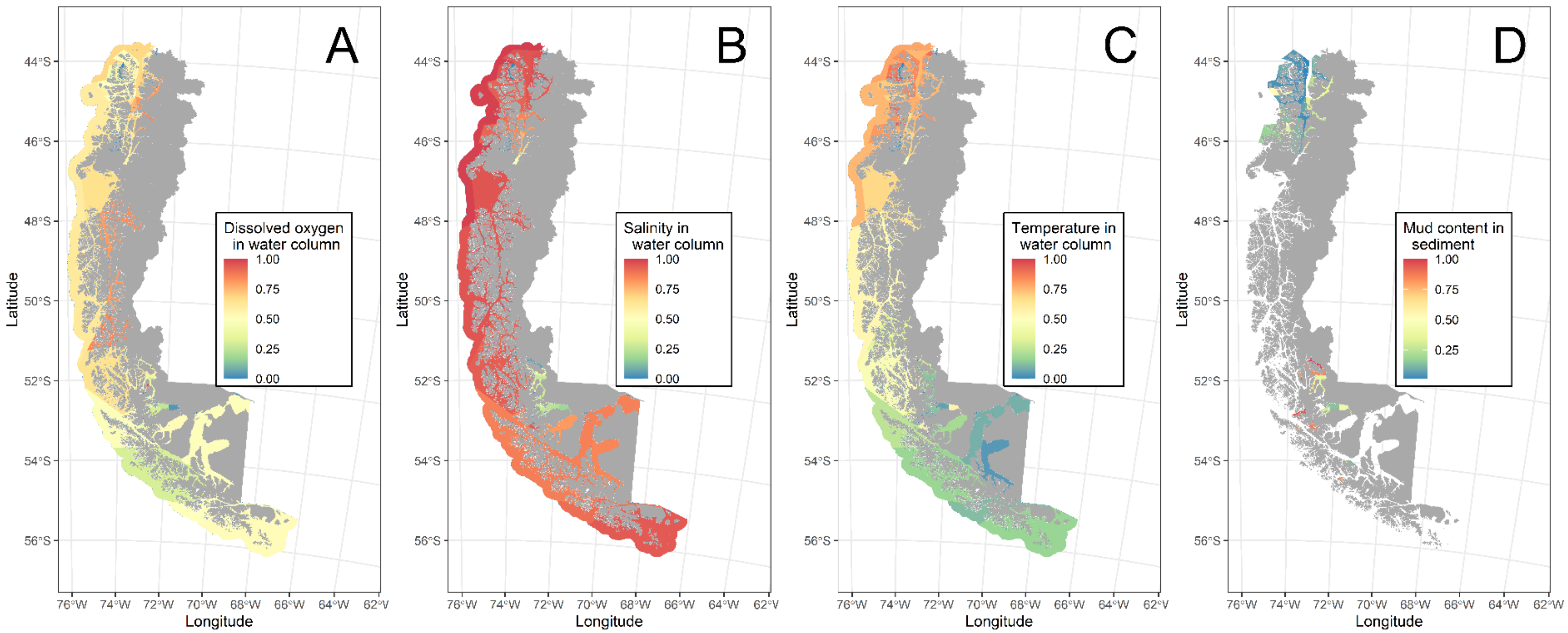

Figure S2. Spatial distribution of indicators Dissolved oxygen (mgL^{-1}) (A), salinity (psu) (B), water temperature (°C) (C), and sediment mud content (%) (D)

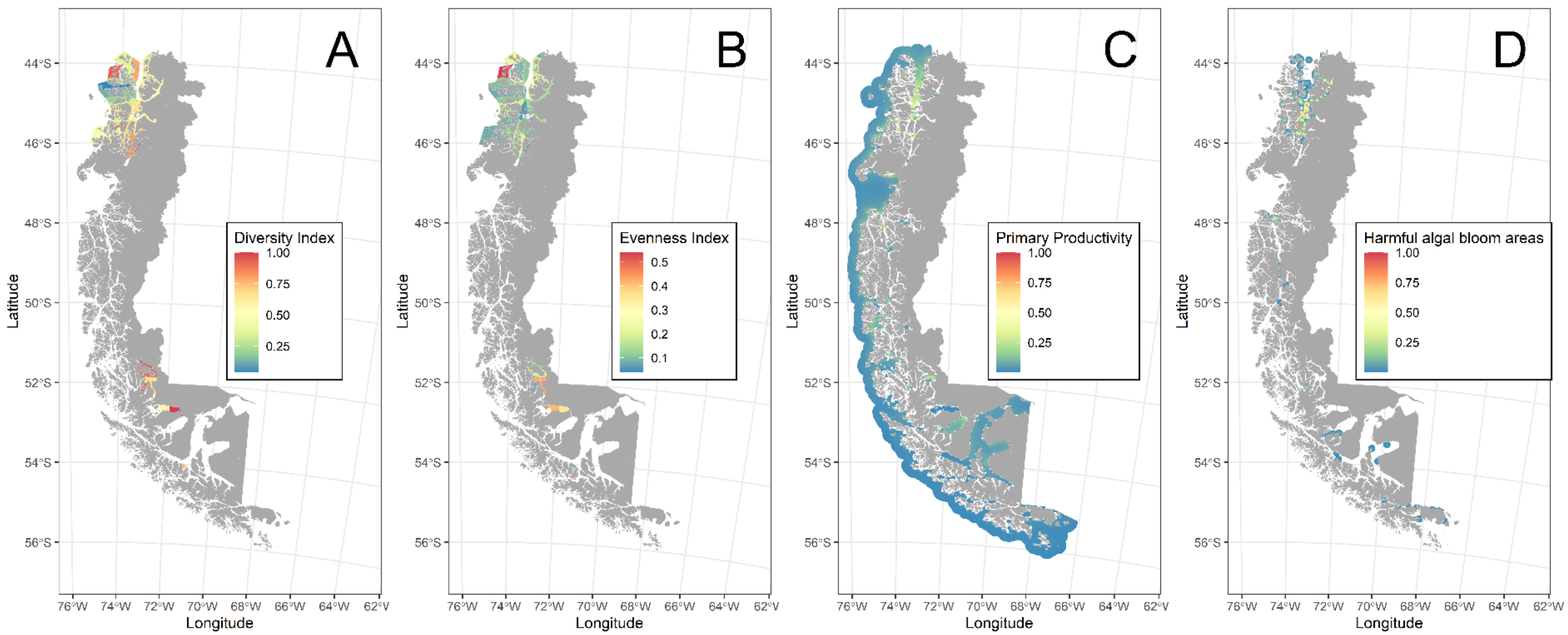

Figure S3. Spatial distribution of indicators of macrofauna diversity (A), evenness in macrofauna community (B), primary productivity (mgChl-a m^{-3}) (C), and Harmful algae bloom Frequency of HAB (number of events in a given monitoring area) (D)

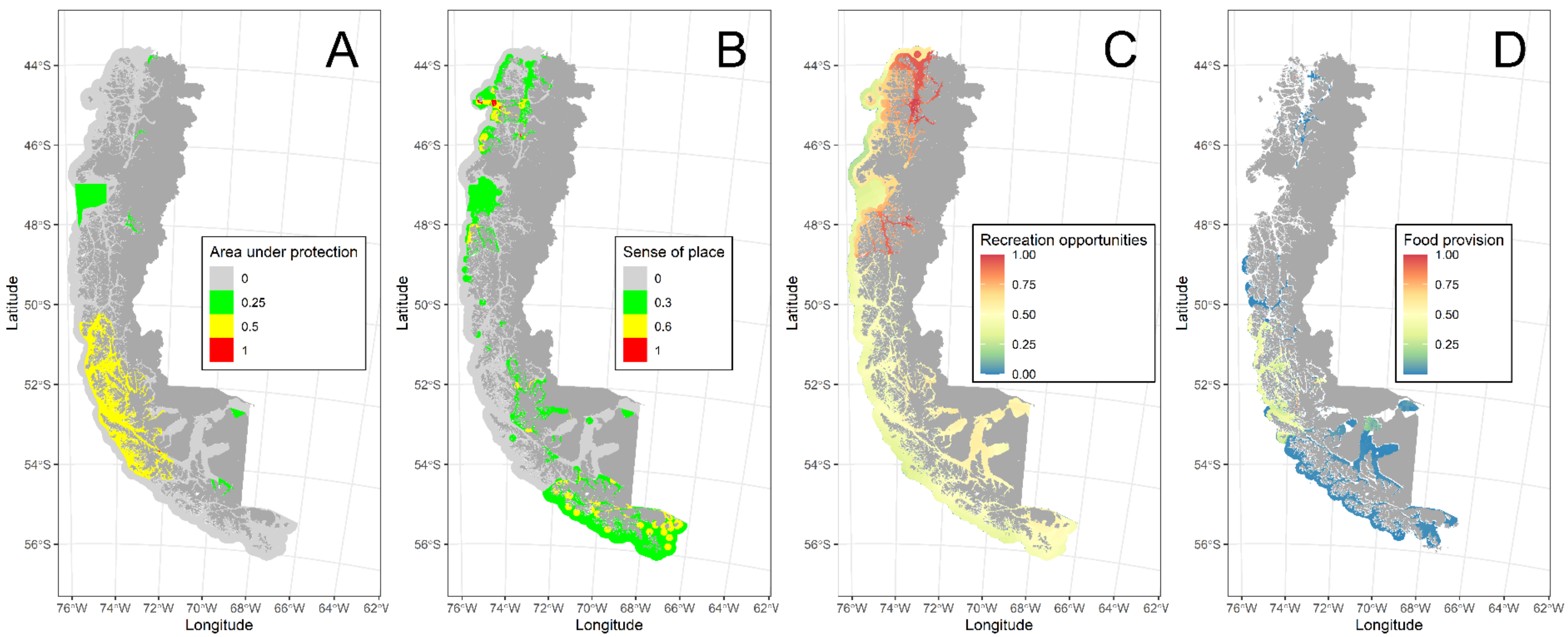

Figure S4. Spatial distribution of indicators Marine Protected Area (km^2) (A), Sense of Place (km^2) (B), Recreation Opportunities (km^2) (C), and Food provision (km^2) (D)

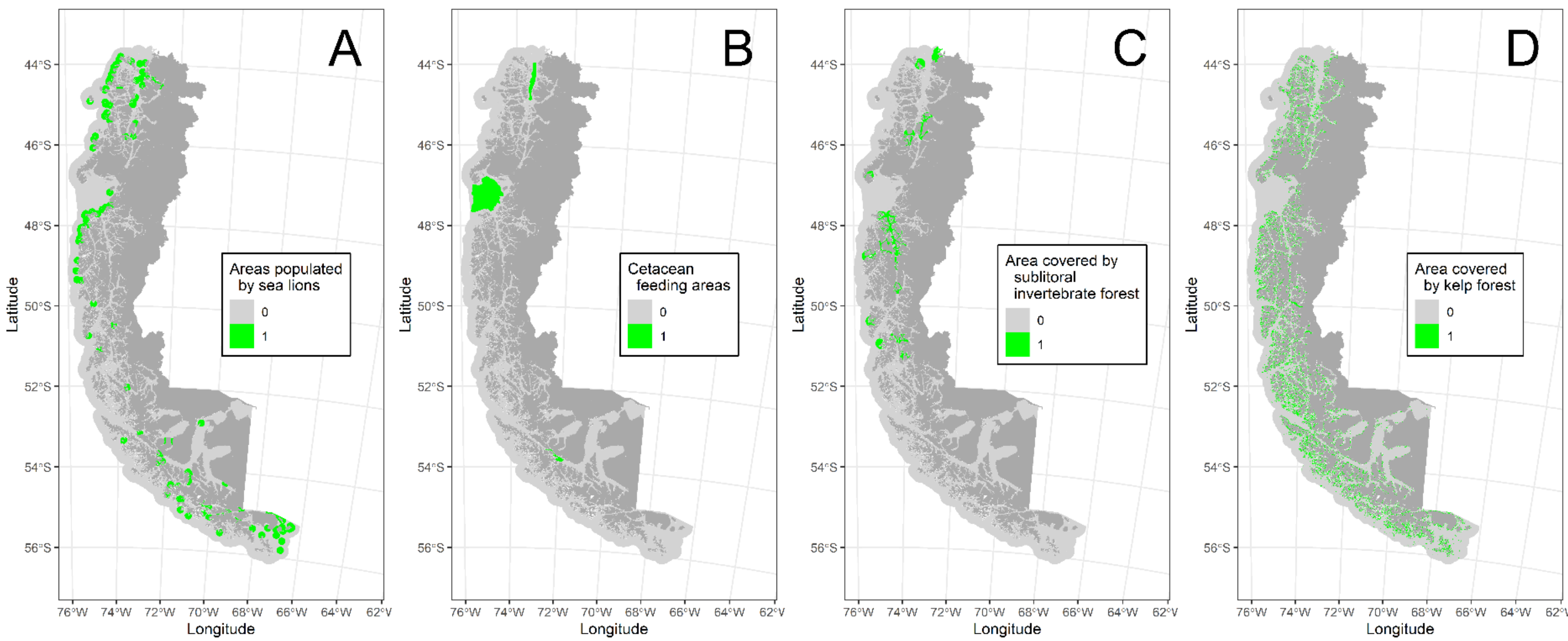

Figure S5. Spatial distribution of indicators of the Areas populated by sea lions (km^2) (A), Cetacean feeding areas (km^2) (B), Areas covered by sublittoral invertebrate forest (km^2) (C), and Areas covered by kelp forest (km^2) (D).

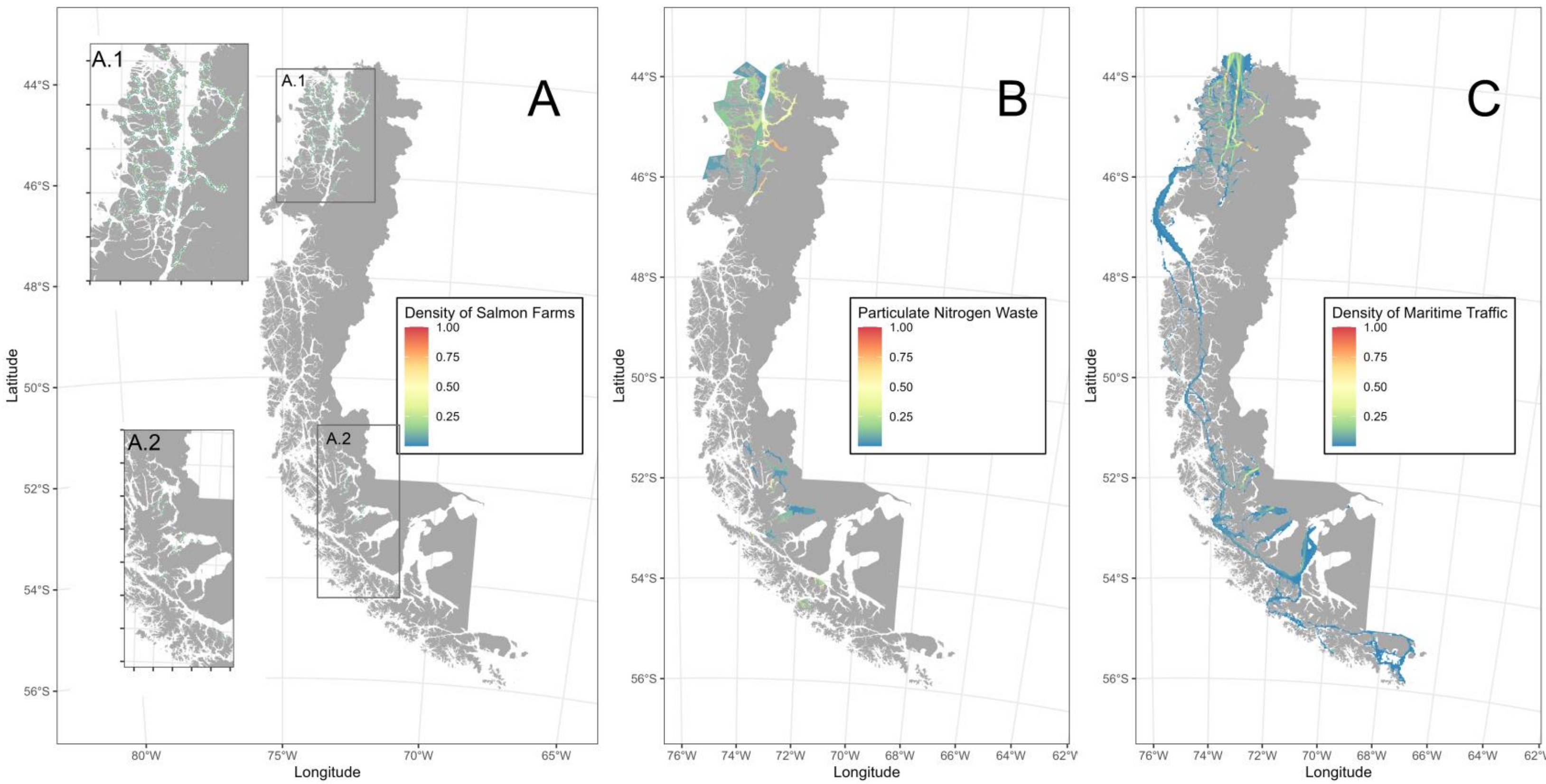

Figure 5SM. Spatial distribution of indicators of salmon farming pressure, salmon farm density (number of farms per km^2) (A), Dissolved nitrogen (ton per Group of Salmon Farms*[3]) (B), and Maritime traffic (number of ships per day per km^2) (C).

[3] Group of Salmon Farms: All salmon farms operating in a spatial administrative unit

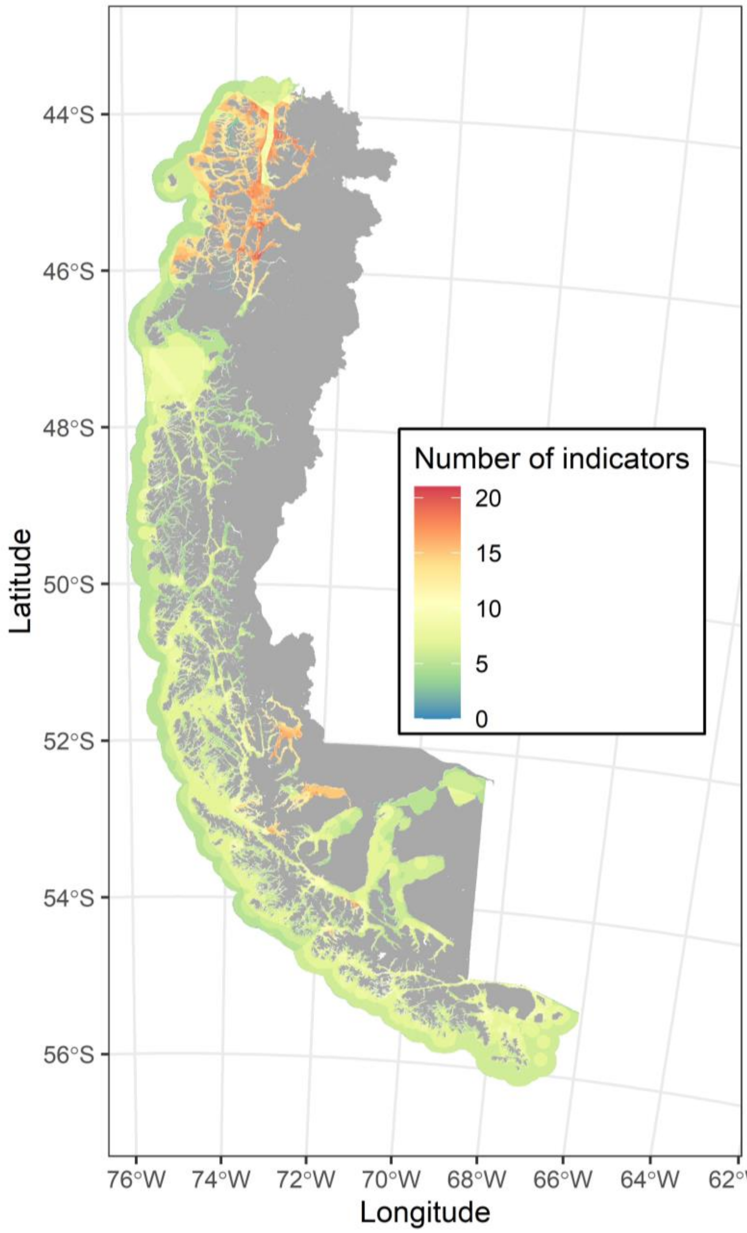

Figure S6. Number of indicators (sensitivity + pressure) for a given pixel at the study region.

Supplementary Tables

Table S1. Ecogeographic Units (EGUs) defined to divide the Ecoregion Channels and Fjords of Southern Chile. EGUs represent areas that can be grouped because of their similar hydrographic characteristics and benthic communities. EGUs are labeled with a number but also by the name that the Chilean administration has associated with these areas. In addition, we related each EGUs to a given type of ecosystem to search for distribution patterns of sensitivity, pressure, and the Salmon Farming Potential Impact across the different ecosystems (see Method section).

EGUs	Name	Ecosystem Type
1	Almirantazgo sound	Sound
2	Strait of Magellan	Channel
3	Northern fjords	Fjord
4	Northern channels	Island-channel system
5	Northern oceanic coast	Oceanic coast
6	Penas gulf	Oceanic Gulf
7	Central oceanic coast	Oceanic coast
8	Central channels	Island-channel system
9	Beagle channel	Channel
10	Southern oceanic coast	Oceanic coast
11	Otway sound	Sound
12	Skyring sound	Sound
13	Central fjords	Fjord
14	Southern oceanic coast	Oceanic coast
15	Southern fjords	Fjord
16	Moraleda channel	Channel
17	Almirante Montt fjord	Fjord

Table S2. Sensitivity factors, Pressure factor and the indicators composing each factor. A description of the relationships used between the sensitivity of each indicator and the pressure (salmon farming) is also given via a brief explanation of the bases for the assumed relationships. The method of normalization of the indicator before estimating the Salmon Farming Potential Impact Index is also provided. The sources of data and information to support the relationship between sensitivity indicators and pressure are reported in Table S9.

Sensitivity / Pressure Factor	Indicator	Assumption of the relationship	Description of the interaction	Normalized method
Sensitive Habitats (SH)	I1. Area populated by sea lions (km^2).	Areas populated with sea lions are more sensitive to salmon farming than non-populated areas.	Sea lions are attracted by the food that salmon represent. They move to the farms and stay there affecting artisanal fisheries as well as the bird community of the area.	Presence (1) / Absence (0)
	I2. Cetacean feeding areas (km^2).	Cetacean feeding areas are more sensitive to salmon farming than areas where there is no presence of cetaceans	Maritime traffic increases the possibility of cetacean mortality due to the collision of cetaceans and ships. In addition, the traffic noise may affect behavior of these mammals.	Presence (1) / Absence (0)
	I3. Area covered by kelp forests (km^2)	Areas covered by kelp forests are more sensitive to salmon farms than areas not covered by kelp forests.	Organic enrichment could cause changes in habitats and community composition and structure of these habitats.	Presence (1) / Absence (0)
	I4. Area covered by sublittoral invertebrate forest (km^2).	Sublittoral areas covered by invertebrate forests are more sensitive to salmon farms than areas where no invertebrate forests.	Eutrophication and deposition of particulate matter (organic and inorganic), as well as the use of chemical compounds, may affect diversity of unique and fragile habitat formed invertebrate species	Presence (1) / Absence (0)
Biotic Attributes (BA)	I5. Diversity of soft bottom macrofauna species (Shannon Wiener Index)	Areas with high macrofauna diversity are less sensitive to salmon farming than areas with less diversity.	Areas with less soft bottom macrofauna diversity could change more rapidly to azoic stages under a continuous input of organic waste.	1- (Normalized value)
	I6. Evenness Index (Soft bottom macrofauna community).	Areas with high macrofauna evenness are less sensitive to salmon farming than areas with less evenness.	Areas with less soft bottom macrofauna evenness could change more rapidly to azoic stages due to the dominance of a few opportunistic species under a continuous input of organic waste.	1- (Normalized value)

	I7. Harmful algal bloom areas (Frequency of HAB events in a given monitoring area).	Areas with larger occurrence of harmful algal bloom are more sensitive to salmon farming than areas with no reported occurrence of harmful algae blooms.	Nitrogen and phosphorous inputs from salmon farming may increase the probability of eutrophication, which (together with other factors) may trigger a harmful algae bloom.	Normalized value
	I8. Primary productivity (mgChl-a m^{-3})	Areas associated with higher values of chlorophyll-a are more sensitive to salmon farming than areas less productive.	Nitrogen and phosphorous inputs from salmon farming may increase primary productivity, but also the risk changes in algae community composition affecting the trophic web	Normalized value
Abiotic Attributes (AA)	I9. Depth (m)	Shallower areas are more sensitive to salmon farm operations than deeper areas.	Salmon farm operations in shallower areas may accumulate organics waste faster and in larger quantities than farms operating in deeper areas.	1- (Normalized value)
	I10. Dissolved oxygen in water column close to the bottom (1m) (mgL^{-1}).	Areas in which the concentration of dissolved oxygen is naturally lower are more sensitive to salmon farming than areas in which dissolved oxygen is naturally higher.	Lower dissolved oxygen concentration close to the bottom may increase the possibility for the dominance of anaerobic conditions via metabolism of organic waste that is produced by salmon farming.	1- (Normalized value)
	I11. Temperature in water column (ºC)	Areas in which water column temperature is higher are more sensitive to salmon farming than areas in which temperature is lower.	Locations with higher temperature may be exposed more frequently to harmful algal bloom events, outbreaks of the Chilean sea lice species, and water column oxygen depletion	Normalized value
	I12. Salinity in water column (psu).	Areas in which water salinity is higher are more sensitive to salmon farming than areas in which water salinity is lower.	Salmon farms operating in higher salinity locations have larger sea lice burdens causing fish stress and skin damage allowing fish infection with bacteria and viruses that may cause fish mortality on the farms and collocated native fish communities	Normalized value
	I13. Mud content in sediment (%).	Areas of higher concentrations of mud in the sediment are more sensitive to salmon farming than areas with lower concentration of mud.	Soft bottom sediments with high content of mud are associated to poor oxygenation which may affect organic matter metabolism and soft-bottom community diversity and composition promoting the presence of opportunist species.	Normalized value

	I14. Total Organic Matter (TOM) content in the sediment (%)	Areas of higher concentrations of TOM are more sensitive to salmon farming than areas with lower TOM	Organic matter is deposited on the sea bed and processed by the fauna, however, when the organic matter bottom deposition rate is greater than what can be processed important changes in the habitat and community composition occur, due the increasing oxygen demand.	Normalized value
	I15. Oxygen availability in the sediment (Redox potential) (mV).	Areas with sediment containing lower availability of dissolved oxygen are more sensitive to salmon farming than areas with higher availability of dissolved oxygen in the sediment.	Poor availability of oxygen in the sediment restricts the capacity of organic waste processing. Therefore, sustained input of organic matter in these areas may cause hypoxic or/and anoxic sediments, affecting community composition and in extreme cases azoic stages may occur.	1- (Normalized value)
	I16. Sediment pH.	Areas with sediment containing lower pH are more sensitive to salmon farming than areas with higher pH sediment.	Areas in which the sediment pH is low are considered more sensitive to salmon farming because the degradation of organic debris that accumulates on the bottom can cause further reductions in pH when degradation occurs under anaerobic conditions.	1- (Normalized value)
Ecosystem Services and Marine Protected Areas (ES-MPA)	I17. Area under protection (MPA) (km^2).	Marine protected areas are more sensitive to salmon farming than areas non-protected.	MPA are defined to protect conservation objects, extraction of marine resources by the artisanal fisheries and to preserve ancestral culture. Because of this salmon farming is less accepted by the society, as it may affect (in various ways), the protection objective in these areas.	Normalized value
	I18. Sense of place (SP) (km^2)	Areas that have being characterized as of high sense of place are more sensitive to salmon farming than areas that have not been defined as having sense of place.	The presence of salmon farms in not desirable in those areas for which communities have established relationship because of the cultural heritage.	Normalized value

	I19. Recreation opportunities (RO) (km^2)	Areas that sustain larger opportunities for recreation activities are more sensitive to salmon farming than areas having less opportunities for recreation activities.	The presence of salmon farms is not a desirable attribute for the landscape of those areas highly attractive for tourism in the study area, due to the infrastructure and the changes that may occur on the surrounding areas.	Normalized value
	I20. Food Provision (FP) (km^2)	Areas that provide a larger quantity of food from marine sources are more sensitive to salmon farming than areas that are not providers of food.	Different aspects of salmon farming (infrastructure, impacts on the seabed, as well as the potential for eutrophication) have a negative impact on the potential to produce food in areas where resources are extracted.	Normalized value
Salmon farming (SF)	I21. Density of Salmon Farms (number of farms per km^2)	Higher densities of salmon farms put more pressure on the sensitivity attributes of the area	Areas with high concentration of salmon farms are expected to produce larger effects than areas with lower farm densities because of the concentration of infrastructure, larger quantities of organic and inorganic waste.	Normalized value
	I22. Particulate Nitrogen Waste (ton per km^2).	A larger input of particulate nitrogen waste puts more pressure on the sensitivity attributes of the area.	The input of nitrogen waste is a *proxy* of the input of dissolved nitrogen, one of the nutrients that cause eutrophication. Because of this, areas receiving this nitrogen may be more susceptible to eutrophication and consequently to harmful algae blooms.	Normalized value
	I23. Density of Maritime Traffic (number of ships per day per km^2) (estimated from data for a two-year period)	Higher densities of maritime traffic put more pressure on the sensitivity attributes of the area.	Areas concentrating the maritime traffic associated with salmon farm operations are expected to affect sensitive habitats.	Normalized value

Table S3. Sensitivity categories per Ecogeographic unit (EGU): Total area of each EGU, the area and percentage (%) of the area with no data, and the area and percentage of that area under each sensitivity value category for that EGU (Low <0.22, Medium 0.22-0.35, High 0.35-0.51, and Extremely High 0.51-1).

				Value category: low		Value category: medium		Value category: high		Value category: extremely high	
EGU	Total Area (km^2)	Area with no data (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
1	4,648	2	0.04	4,107	88.35	401	8.63	139	2.98	0	0.00
2	12,775	7	0.06	8,580	67.16	3,288	25.74	861	6.74	39	0.31
3	1,269	5	0.35	287	22.57	157	12.33	530	41.78	292	22.97
4	10,762	9	0.08	505	4.69	1,964	18.25	4,823	44.81	3,462	32.17
5	13,818	0	0.00	11,023	79.77	1,426	10.32	1,363	9.86	7	0.05
6	10,627	3	0.02	3,652	34.36	1,736	16.34	5,235	49.26	2	0.02
7	19,763	4	0.02	11,011	55.71	5,889	29.80	2,652	13.42	208	1.05
8	13,284	29	0.22	2,139	16.10	7,065	53.19	3,853	29.00	199	1.50
9	2,604	12	0.45	1,116	42.87	1,206	46.32	270	10.36	0	0.00
10	8,319	2	0.02	4,703	56.53	3,378	40.61	237	2.85	0	0.00
11	2,403	2	0.07	1,976	82.24	403	16.77	22	0.91	0	0.01
12	1,982	2	0.08	241	12.15	492	24.80	1,095	55.24	153	7.73
13	4,186	24	0.56	1,549	37.00	1,912	45.68	625	14.93	77	1.83
14	22,585	3	0.01	19,056	84.38	3,084	13.66	442	1.95	0	0.00
15	4,889	14	0.29	2,534	51.83	2,023	41.37	302	6.17	17	0.35
16	3,800	2	0.05	74	1.95	161	4.22	1,213	31.91	2,350	61.86
17	1,589	4	0.22	173	10.85	124	7.77	582	36.64	708	44.52

Table S4. Contribution (%) of each sensitivity factor to the sensitivity sub-index.

EGU	Abiotic Attributes	Biotic Attributes	Sensitive Habitats	Ecosystem Services and Marine Protected Areas	Total
1	57.51	3.80	9.62	29.07	100.0
2	49.99	2.82	10.96	36.23	100.0
3	54.10	24.47	11.27	10.15	100.0
4	47.62	18.06	19.25	15.07	100.0
5	66.99	2.42	9.78	20.81	100.0
6	46.98	1.47	27.40	24.14	100.0
7	54.40	2.06	16.75	26.79	100.0
8	43.82	0.99	23.43	31.76	100.0
9	36.28	0.69	31.04	32.00	100.0
10	42.41	0.87	21.63	35.09	100.0
11	57.80	5.83	13.07	23.30	100.0
12	40.51	20.19	9.70	29.60	100.0
13	53.59	0.74	22.03	23.64	100.0
14	51.62	0.99	10.19	37.20	100.0
15	34.42	0.34	30.36	34.89	100.0
16	42.61	26.84	17.32	13.23	100.0
17	45.48	28.49	6.00	20.03	100.0

Table S5. Pressure categories per Ecogeographic unit (EGU): Total area of each EGU, the area and percentage (%) of the area with no data, and the area and the percentage of that area under each pressure value category for each EGU (Low <0.06, Medium 0.06-0.2, High 0.2-0.4, and Extremely High 0.4-1).

				Value category: low		Value category: medium		Value category: high		Value category: extremely high	
EGU	Total Area (km^2)	Area with no data (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
1	4,648	4,648	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	12,775	8,314	65.08	4,214	32.98	129	1.01	91	0.71	28	0.22
3	1,269	224	17.65	130	10.26	12	0.91	515	40.54	389	30.65
4	10,762	379	3.52	4,407	40.95	4,833	44.90	1,077	10.01	67	0.62
5	13,818	10,295	74.51	3,234	23.40	289	2.09	0	0.00	0	0.00
6	10,627	8,519	80.17	2,108	19.83	0	0.00	0	0.00	0	0.00
7	19,763	19,113	96.71	650	3.29	0	0.00	0	0.00	0	0.00
8	13,284	9,643	72.59	3,641	27.41	0	0.00	0	0.00	0	0.00
9	2,604	1,542	59.24	1,061	40.76	0	0.00	0	0.00	0	0.00
10	8,319	6,212	74.67	2,108	25.33	0	0.00	0	0.00	0	0.00
11	2,403	1,612	67.09	791	32.91	0	0.00	0	0.00	0	0.00
12	1,982	264	13.32	1,206	60.84	470	23.72	42	2.12	0	0.00
13	4,186	3,487	83.31	682	16.29	14	0.33	3	0.08	0	0.00
14	22,585	22,541	99.80	44	0.20	0	0.00	0	0.00	0	0.00
15	4,889	3,505	71.69	1,196	24.46	184	3.77	4	0.08	0	0.00
16	3,800	46	1.22	1,023	26.92	1,678	44.15	943	24.81	110	2.90
17	1,589	227	14.25	903	56.80	295	18.53	145	9.11	21	1.31

Table S6. Salmon Farming Potential Impact Index (SFPII) categories per Ecogeographic unit (EGU): Total area of each EGU, the area and percentage (%) of the area with no data, and EGUs' area and the percentage of that area under each of the four value categories of SFPII (Low>$6x10^{-7}$-0.05, Medium >0.05-0.14, High>0.14-0.3, and Extremely High >0.3-1).

				Value category: low		Value category: medium		Value category: high		Value category: extremely high	
EGU	Total Area (km^2)	Area with no data (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
1	4,648	4,648	100.00	0	0.00	0	0.00	0	0.00	0	0.00
2	12,775	8,315	65.08	4,220	33.03	188	1.47	39	0.31	14	0.11
3	1,269	227	17.86	132	10.40	30	2.32	531	41.82	350	27.60
4	10,762	384	3.57	5,126	47.63	4,208	39.10	964	8.96	80	0.74
5	13,818	10,295	74.51	3,519	25.47	4	0.03	0	0.00	0	0.00
6	10,627	8,519	80.17	2,108	19.83	0	0.00	0	0.00	0	0.00
7	19,763	19,113	96.71	650	3.29	0	0.00	0	0.00	0	0.00
8	13,284	9,645	72.61	3,639	27.39	0	0.00	0	0.00	0	0.00
9	2,604	1,548	59.45	1,056	40.55	0	0.00	0	0.00	0	0.00
10	8,319	6,212	74.67	2,107	25.33	0	0.00	0	0.00	0	0.00
11	2,403	1,612	67.09	791	32.91	0	0.00	0	0.00	0	0.00
12	1,982	265	13.38	1,559	78.64	148	7.47	10	0.50	0	0.00
13	4,186	3,489	83.35	690	16.49	7	0.17	0	0.00	0	0.00
14	22,585	22,541	99.80	44	0.20	0	0.00	0	0.00	0	0.00
15	4,889	3,508	71.74	1,238	25.32	143	2.92	1	0.02	0	0.00
16	3,800	48	1.26	822	21.63	1,716	45.17	1,087	28.61	127	3.34
17	1,589	229	14.41	744	46.80	443	27.89	141	8.89	32	2.01

Table S7. Contribution (%) of the interaction between each of the sensitivity factors and pressure to the Salmon Farming Potential Index (SFPII) for each Ecogeographic Unit (EGU). The contribution is estimated by adding the values of sensitivity factor*pressure per pixel for each EGU and then calculating the total value for the interaction in the EGU. EGU1 is excluded since no pressure was estimated. ES &MPA: Ecosystem Services and Marine Protected Areas.

EGU	Interaction of each sensitivity factor and Pressure factor	Summation of interaction values at the EGU	Total value of the interaction for the EGU	Contribution (%)
2	Sensitive habitats	33.14	164.70	20.12
	Abiotic attributes	80.10		48.63
	Biotic attributes	19.13		11.61
	ES & MPA	32.33		19.63
3	Sensitive habitats	95.14	1108.78	8.58
	Abiotic attributes	624.16		56.29
	Biotic attributes	289.37		26.10
	ES & MPA	100.11		9.03
4	Sensitive habitats	501.60	2877.63	17.43
	Abiotic attributes	1425.65		49.54
	Biotic attributes	535.17		18.60
	ES & MPA	415.21		14.43
5	Sensitive habitats	3.02	81.14	3.73
	Abiotic attributes	60.85		74.99
	Biotic attributes	2.71		3.34
	ES & MPA	14.55		17.94
6	Sensitive habitats	2.63	10.01	26.23
	Abiotic attributes	4.64		46.32
	Biotic attributes	0.13		1.29
	ES & MPA	2.62		26.16
7	Sensitive habitats	1.44	5.87	24.56
	Abiotic attributes	2.41		41.09
	Biotic attributes	0.19		3.31
	ES & MPA	1.82		31.04
8	Sensitive habitats	10.12	49.64	20.39
	Abiotic attributes	21.68		43.67
	Biotic attributes	0.59		1.18
	ES & MPA	17.25		34.76
9	Sensitive habitats	1.15	3.48	33.05
	Abiotic attributes	1.17		33.60
	Biotic attributes	0.03		1.00
	ES & MPA	1.13		32.36
10	Sensitive habitats	1.08	3.99	27.08
	Abiotic attributes	1.52		38.21
	Biotic attributes	0.03		0.84
	ES & MPA	1.35		33.86

11	Sensitive habitats	0.33	4.59	7.09
	Abiotic attributes	2.71		59.07
	Biotic attributes	0.32		6.92
	ES & MPA	1.24		26.92
12	Sensitive habitats	15.88	192.22	8.26
	Abiotic attributes	87.09		45.31
	Biotic attributes	33.87		17.62
	ES & MPA	55.38		28.81
13	Sensitive habitats	3.06	27.64	11.05
	Abiotic attributes	11.52		41.67
	Biotic attributes	0.20		0.73
	ES & MPA	12.87		46.55
14	Sensitive habitats	0.03	0.09	27.38
	Abiotic attributes	0.04		38.12
	Biotic attributes	7.E-04		0.77
	ES & MPA	0.03		33.73
15	Sensitive habitats	15.30	45.48	33.64
	Abiotic attributes	17.04		37.47
	Biotic attributes	0.09		0.20
	ES & MPA	13.05		28.69
16	Sensitive habitats	303.32	1825.80	16.61
	Abiotic attributes	793.79		43.48
	Biotic attributes	478.08		26.18
	ES & MPA	250.61		13.73
17	Sensitive habitats	19.89	359.38	5.54
	Abiotic attributes	155.63		43.31
	Biotic attributes	106.65		29.67
	ES & MPA	77.21		21.48

Table S8. Data source for each indicator of sensitivity indicator and the pressure (Salmon farming).

Sensitivity / Pressure Factor	Indicator	Data source
Sensitive Habitats (SH)	I1. Area populated by sea lions (km^2).	IFOP monitoring, revisado en Pizarro 2016 (TESIS MAGISTER)
	I2. Cetacean feeding áreas (km^2).	Government data and scientific articles
	I3. Area covered by kelp forests (km^2)	MORA-SOTO ET AL. (2020) (Pers. Comm.)
	I4. Area covered by sublittoral invertebrate forest (km^2).	HAUSSERMANN ET AL. (2021)
Biotic Attributes (BA)	I5. Diversity of soft bottom macrofauna species (Shannon Wiener Index)	Environmental Report (Requested to SERNAPESCA)
	I6. Evenness Index (Soft bottom macrofauna community).	Environmental Report (Requested to SERNAPESCA)
	I7. Harmful algal bloom areas (Frequency of HAB events in a given monitoring area).	IFOP monitoring (Personal communication, IFOP)
	I8. Primary productivity (mgChl-a m^{-3})	Satellite Images, sensor MODIS AQUA, NASA
Abiotic Attributes (AA)	I9. Depth (m)	Salmon farm preliminary site characterization (https://www.sea.gob.cl/), (https://sernapesca.cl)
	I10. Dissolved oxygen in water column close to the bottom (1 m) (mgL^{-1}).	Salmon farm preliminary site characterization (https://www.sea.gob.cl/); CIMAR cruise (SHOA); (https://sernapesca.cl)
	I11. Temperature in water column (ºC)	Salmon farm preliminary site characterization (https://www.sea.gob.cl/); CIMAR cruise (SHOA); (https://sernapesca.cl)
	I12. Salinity in water column (psu).	Salmon farm preliminary site characterization (https://www.sea.gob.cl/); CIMAR cruise (SHOA); (https://sernapesca.cl)
	I13. Mud content in sediment (%).	Salmon farm preliminary site characterization (https://www.sea.gob.cl/) (https://sernapesca.cl)
	I14. Total Organic Matter (TOM) content in the sediment (%)	Salmon farm preliminary site characterization (https://www.sea.gob.cl/) (https://sernapesca.cl)
	I15. Oxygen availability in the sediment (Redox potential) (mV).	Salmon farm preliminary site characterization (https://www.sea.gob.cl/) (https://sernapesca.cl)
	I16. Sediment pH.	Salmon farm preliminary site characterization (https://www.sea.gob.cl/) (https://sernapesca.cl)
Ecosystem Services and Marine Protected Areas (ES-MPA)	I17. Area under protection (km^2) (MPA).	Government Data
	I18. Sense of place (SP) (km^2).	Government data and scientific articles
	I19. Recreation opportunities (RO) (km^2)	Government Data
	I20. Food Provision (FP) (km^2)	

Salmon farming	I21. Density of Salmon Farms (number of farms per km^2)	Localization Report (Requested to SERNAPESCA)
	I22. Particulate Nitrogen Waste (ton per km^2).	Salmon Harvest Report (Requested to SERNAPESCA)
	I23. Density of Maritime Traffic (number of ships per day per km^2) (estimated from data for a two-year period)	Geographical Positioning of Vessels Report (Requested to SERNAPESCA).

Table S9. Relative weight given by the experts to indicators of a given factor.

Sensitivity / Pressure Factor	Indicator	Relative weight
Sensitive Habitats (SH)	I1. Area populated by sea lions (km^2).	0.223
	I2. Cetacean feeding areas (km^2).	0.243
	I3. Area covered by kelp forests (km^2)	0.242
	I4. Area covered by sublittoral invertebrate forest (km^2).	0.292
Biotic Attributes (BA)	I5. Diversity of soft bottom macrofauna species (Shannon Wiener Index)	0.369
	I6. Evenness Index (Soft bottom macrofauna community).	0.136
	I7. Harmful algal bloom areas (mgChl-a m^{-3}).	0.272
	I8. Primary productivity (Frequency of HAB events in a given monitoring area).	0.223
Abiotic Attributes (AA)	I9. Depth (m)	0.105
	I10. Dissolved oxygen in water column close to the bottom (1 m) (mgL^{-1}).	0.250
	I11. Temperature in water column (ºC)	0.082
	I12. Salinity in water column (psu).	0.073
	I13. Mud content in sediment (%).	0.100
	I14. Total Organic Matter (TOM) content in the sediment (%)	0.144
	I15. Oxygen availability in the sediment (Redox potential) (mV).	0.132
	I16. Sediment pH.	0.116
Ecosystem Services and Marine Protected Areas (ES-MPA)	I17. Area under protection (MPA) (km^2).	0.348
	I18. Sense of place (SP) (km^2).	0.314
	I19. Recreation opportunities (RO) (km^2).	0.096
	I20. Food Provision (FP) (km^2).	0.243
Salmon farming	I21. Density of Salmon Farms (number of farms per km^2)	0.403
	I22. Particulate Nitrogen Waste (ton per km^2).	0.392
	I23. Density of Maritime Traffic (number of ships per day per km^2) (estimated from data for a two-year period).	0.206

Table S10. Experts participating in the processes of indicator validation and weighting of the indicators.

Expert	Research area	Affiliation	Activity
1	Benthic ecology, Biological Oceanography	Universidad de Magallanes (UMAG)	Indicator validation
2	Fishery Ecology	Instituto de Fomento Pesquero (IFOP)	Indicator validation
3	Biological Oceanography	Universidad Austral de Chile (UACh)	Validation and weighting of indicators
4	Physiology, ecology and conservation of subantarctic macroalgae	Universidad Austral de Chile (UACh)	Indicator validation
5	Analytic methods for detecting marine biotoxins	Laboratorio de Toxinas Marinas, Facultad de Medicina-Universidad de Chile	Indicator validation
6	Benthic ecosystems of Chilean Patagonia	Universidad San Sebastian (USS)	Validation and weighting of indicators
7	Littoral ecology	Universidad Austral de Chile (UACh)	Validation and weighting of indicators
8	Biological Oceanography	Centro de Investigación en Ecosistemas de la Patagonia (CIEP)	Validation and weighting of indicators
9	Physical oceanography, mathematical modeling of biophysical processes	Universidad Austral de Chile (UACh)	Indicator validation
10	Harmful algae blooms	Centro de estudios algas nocivas (CREAN) Instituto de Fomento Pesquero (IFOP)	Weighting of indicators
11	Biological Oceanography	Universidad Austral de Chile (UACh)	Weighting of indicators
12	Macroalgae forests	School of Geography and the environment, University Oxford	Indicator validation
13	Oceanography, harmful algae bloom, assessment of environmental effects of anthropogenic activities and natural events at local and global scales	Instituto de Fomento Pesquero (IFOP)	Weighting of indicators
14	Clime change and aquaculture. Implementation of ecosystem approach to aquaculture	Interdisciplinary Center for Aquaculture Research (INCAR)	Weighting of indicators
15	Nutrition and feeding of reproductive fish, echinoderm and crustaceans	Departamento de Ciencias Agropecuarias y Acuícolas, Universidad de Magallanes	Weighting of indicators
16	Environmental education and management for conservation of marine and terrestrial ecosystems	Wildlife Conservation Society (WCS)	Weighting of indicators
17	Biological Oceanography	Ocean Scientist Application	Weighting of indicators
18	Salmon farming company	Salmon farming company	Weighting of indicators
19	Salmon farming company	Salmon farming company	Weighting of indicators
20	Environmental Sciences: Marine and continental aquatic systems	Instituto Tecnológico del Salmon (INTESAL)	Weighting of indicators
21	Sustainable aquaculture	Monterey bay aquarium seafood watch	Weighting of indicators

Table S11. Average number of indicators (effort) used to estimate SFPII, Sensitivity and Pressure for each EGU.

EGUs	Average number of indicators		
	SFPII	Sensitivity	Pressure
1	6.25	6.25	0.00
2	6.72	6.35	0.37
3	11.35	9.47	1.88
4	13.51	11.85	1.66
5	5.68	5.42	0.25
6	6.90	6.71	0.20
7	6.01	5.98	0.03
8	6.29	6.01	0.27
9	7.16	6.75	0.41
10	7.01	6.76	0.25
11	6.25	5.92	0.33
12	12.48	10.81	1.67
13	5.57	5.36	0.21
14	6.17	6.17	0.00
15	6.58	6.26	0.31
16	15.18	13.13	2.05
17	12.49	10.99	1.50

Supplementary Information

SI1. Sensitivity, Pressure and Salmon Farming Potential Impact Index (SFPII)

The spatial pattern of sensitivity values at the pixel scale followed a decreasing gradient from east to west in the northern part of the study region (43 to 46 degrees) (Fig. SI1A). From the continent to the ocean, sensitivity values between 0.52 and 1 were observed in the fjords, decreasing smoothly to the channels and island areas next to the fjords in the oceanic direction (with sensitivity values between 0.23 to 0.51), and dropping to low sensitivity values in the oceanic zones of the study region (<0.23). In the south (51-53 degrees), larger sensitivity values were also estimated in the continental area (>0.51) than in the oceanic areas, but the distribution pattern is patchy compared to the sensitivity gradient observed in the north.

The spatial pattern of pressure at the pixel scale showed one large area located at the north of the study region where values reached 1.0, and two small areas located in the southern fjords and sounds, where values were in the extremely high category, though closer to the lower limit (0.4) (Fig. SI1B). The largest area of pressure was in the north of the study region, and it showed a decreasing gradient from the fjords and the Moraleda channel towards the islands-channel systems and the ocean areas. In the south, the high values were concentrated in the core areas of the Almirante Montt fjord and Skyring sound. These north and south areas were connected by low score areas showing the maritime traffic routes (Fig. SI1B).

As in the pressure sub-index, the SFPII spatial distribution pattern at the pixel scale (Fig SI1C) showed a large area of values above 0.3 in the northern part of the study region, and two smaller areas in the south, occupying most of the area within the Almirante Montt fjord and Skyring sound. The channel-islands systems (which connect the north with the southern part of the study region through maritime traffic associated with salmon farming) exhibited low scores for the SFPII (<0.05) (Fig. SI1C).

All EGUs showed a notable scattering of SFPII scores in the low range (>0 and 0.25) (Fig. SI1D, Table SI1). The highest mean SFPII (0.25) was estimated in the Northern fjords (EGU3), followed by Moraleda channel (EGU16), the northern channels (EGU4), Almirante Montt fjord (EGU17), and Skyring sound (EGU12). The rest of the EGUs exhibited mean SFPII values below 0.03. Despite all the EGUs displaying a notable scattering of their values, the EGUs with higher mean values showed less dispersion compared to the EGUs with low mean values (mean <0.03).

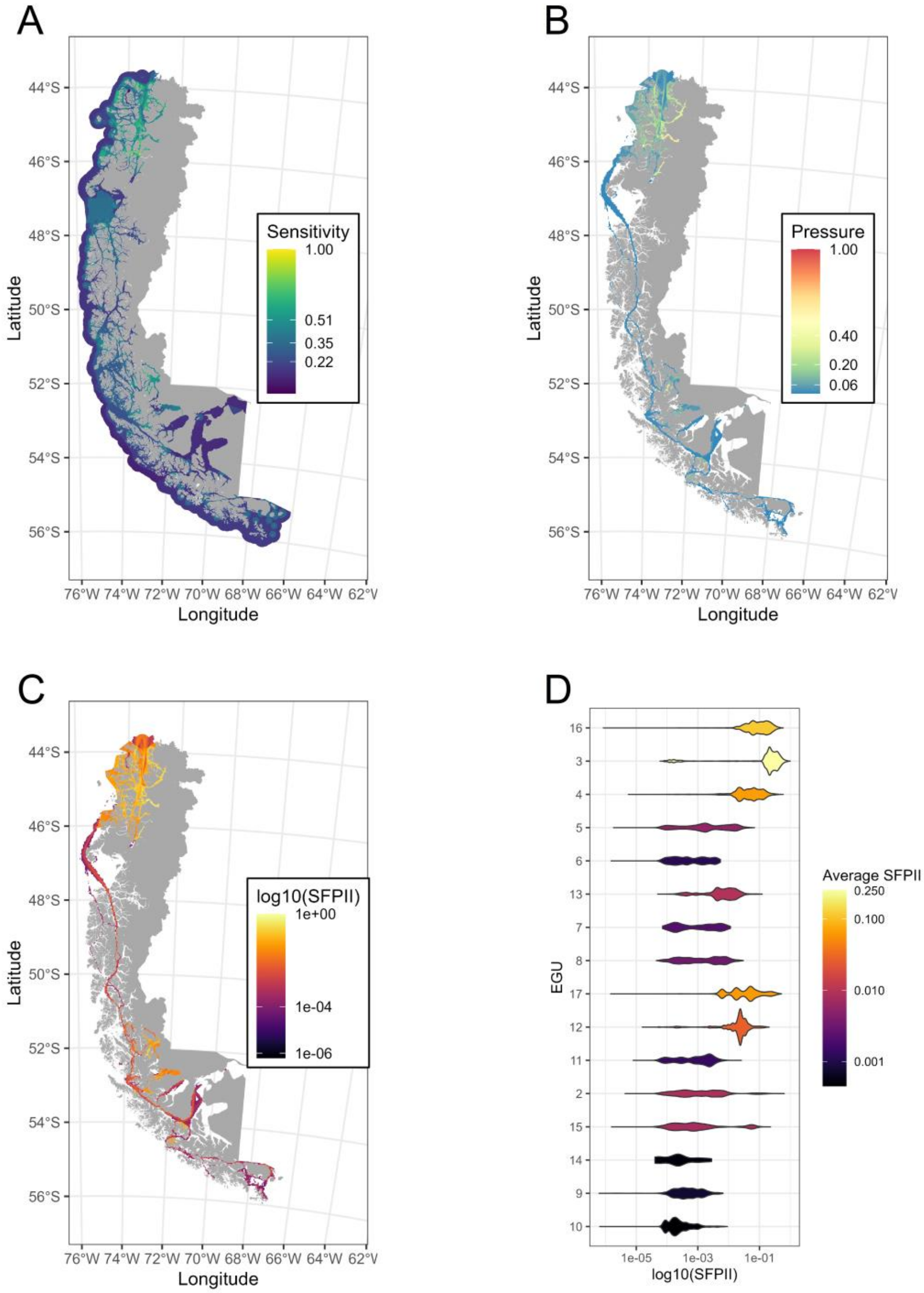

Figure SI1.1. (A) Spatial distribution of sensitivity at the pixel scale. (B) Spatial distribution of pressure at the pixel scale. (C) Spatial distribution of Salmon Farming Potential Impact Index (SFPII) ($\log_{10}$(SFPII)) at the pixel level. (D) Violin plot showing the distribution of SFPII ($\log_{10}$(SFPII)) at the pixel level and the average SFPII scores per EGU, where the shape of the violin represents the scattering of the SFPII scores within the range and the color the average value of the pixel within each EGU

Table SI1.1. Minimum, Maximum and Mean values for the Salmon Farming Potential Impact Index (SFPII) (sd: standard deviation) estimated for areas exhibiting salmon farming pressure. Zeros were removed when estimating the means.

EGU	SFPII			
	Minimum	Maximum	Mean	sd
1	0.00	0.00	0.00	0.00
2	4.E-06	0.64	0.01	0.04
3	6.E-05	1.00	0.25	0.15
4	6.E-06	0.59	0.07	0.06
5	2.E-06	0.07	0.01	0.01
6	2.E-06	0.01	1.E-03	1.E-03
7	7.E-05	0.01	2.E-03	3.E-03
8	4.E-05	0.03	3.E-03	4.E-03
9	6.E-07	0.01	8.E-04	9.E-04
10	7.E-07	0.01	5.E-04	8.E-04
11	8.E-06	0.03	1.E-03	1.E-03
12	2.E-05	0.21	0.03	0.02
13	5.E-05	0.12	0.01	0.01
14	4.E-05	3.E-03	5.E-04	7.E-04
15	2.E-06	0.23	0.01	0.02
16	9.E-07	0.59	0.12	0.09
17	1.E-06	0.52	0.06	0.08

SI2. Contribution of indicators to sensitivity factors and indicators to pressure factor.

Among the indicators included in the factor abiotic attributes, the indicator "dissolved oxygen" was the most influential in almost all EGUs, but especially in the Northern oceanic coast (EGU5), the Central oceanic coast (EGU7), Almirantazgo sound (EGU1), Otway sound (EGU11) and Central fjords (EGU13). In Skyring sound (EGU12) all the abiotic factors contributed similarly (Table SI2.1).

The biotic attribute factor contributes between the 18.1 and 28.5% to the sensitivity sub-index in the EGU3, 4, 16. In these EGUs, the indicator "macrofauna diversity" provided the largest contribution to the sensitivity sub-index (Table SI2.1)).

The indicators having the main contribution to the sensitive habitats factor were "area of cetacean feeding" in the EGU6, while the "presence of marine sea lions" and "presence of kelp forest" were the most important in the EGU9 and EGU13 (Table SI2.1).

Regarding the ecosystem services and marine protected areas factor the relevance of the indicators was different across the EGUs. In the southern area of the study region, where this factor was relevant, the most important indicator was "sense of place", except for EGU2 where the indicators of "marine protected areas" and "recreation opportunities" were the most important. In EGU14, in addition to "sense of place" the indicator "recreation opportunities" was also important, while in EGU15 "marine protected areas" joined "sense of place" as the key contributing indicators (Table SI2.1). In EGU8 only "marine protected areas" was relevant to the sensitivity of the study region.

Salmon farming is represented by the pressure factor, which is composed of three indicators. The indicator "maritime traffic" was present in all the EGUs, except in Almirantazgo sound (EGU1). Its contribution to the pressure sub-index varied between 14.5 and 100% (Table SI2.2). The Penas Gulf (EGU6), Central oceanic coast (EGU7), Southern oceanic coast (EGU10 and EGU14), and Beagle channel (EGU9) exhibited only "maritime traffic" as pressure. In those EGUs in which salmon farms were present, the major contribution to pressure scores is associated with the indicator "particulate nitrogen waste", which varied from 0.35% to 82.7%. The EGUs where this indicator contributed the most (>60%) were Northern fjords, Northern channels, Skyring sound, Moraleda channel, and Almirante Montt fjord (UEG3, 4, 12, 15, 16, and 17, respectively) (Fig. 2D, Table S5).

Table SI2.1. Contribution (%) of each of the indicators selected to the sensitivity sub-index. *Redox potential

EGU	Percentage of contribution of the indicators																			
	Abiotic attributes								Biotic attributes				Sensitive habitats				Ecosystem services and Marine Protected Areas			
	Oxygen availability in the water column	Salinity in water column	Temperature in the sediment	Mud content in sediment	Total organic matter in the sediment	Sediment pH	Oxygen availability in the sediment*	Depth	Diversity of soft bottom macrofauna species	Harmful algal bloom areas	Primary productivity	Evenness Index	Cetacean feeding areas	Area covered by kelp forests	Area covered by sub-littoral invertebrate forest	Area populated by sea lion	Sense of place	Food provision	Recreation opportunities	Area under protection
1	37.4	19.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	3.6	0.0	0.0	7.1	0.0	2.5	8.8	0.6	15.5	4.1
2	29.6	15.8	3.0	0.2	0.3	0.4	0.4	0.2	0.6	0.0	2.1	0.0	1.4	6.3	0.0	3.3	3.6	5.4	13.0	14.2
3	19.2	6.1	6.1	2.6	2.5	4.5	8.4	4.6	19.8	2.2	0.9	1.5	0.0	7.7	2.0	1.6	0.7	0.2	9.3	0.0
4	14.2	7.0	6.7	1.0	1.7	5.3	6.8	5.0	14.1	0.6	1.4	1.9	2.5	5.9	2.7	8.2	6.9	0.0	8.0	0.2
5	36.1	16.6	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	1.1	2.0	6.6	9.5	0.0	11.3	0.0

6	26.3	11.4	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	21.8	2.2	0.9	2.5	9.2	0.0	7.4	7.5
7	31.6	14.1	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.5	5.5	3.9	6.9	3.6	4.9	9.1	9.3
8	26.3	10.6	6.1	0.2	0.1	0.2	0.2	0.2	0.0	0.1	0.9	0.0	0.0	14.1	8.0	1.3	3.4	4.7	7.9	15.7
9	22.2	12.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	16.4	0.0	14.6	23.1	0.5	8.4	0.0
10	26.0	13.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	6.1	0.0	15.6	25.0	0.3	9.7	0.0
11	36.7	16.6	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	5.3	0.0	0.0	9.1	0.0	3.9	1.7	1.3	14.3	5.9
12	8.8	3.7	2.9	3.7	2.3	9.7	3.7	5.8	16.7	0.0	0.3	3.1	0.0	7.3	0.0	2.4	13.7	0.3	7.2	8.4
13	33.1	11.8	7.4	0.3	0.1	0.2	0.4	0.2	0.0	0.2	0.5	0.0	0.0	13.1	7.1	1.9	4.2	1.5	10.9	7.1
14	29.6	18.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	7.1	0.0	3.1	15.1	1.5	10.7	9.9
15	17.3	13.0	2.9	0.2	0.2	0.3	0.3	0.1	0.0	0.0	0.3	0.0	0.0	20.0	0.0	10.3	14.3	0.6	9.0	10.9
16	14.7	5.6	5.2	1.1	1.4	5.2	4.3	5.1	19.4	4.0	1.7	1.7	0.2	5.9	5.2	6.0	5.8	0.1	7.1	0.3
17	11.8	2.5	1.6	5.1	3.9	7.7	7.4	5.5	24.5	0.0	1.0	3.0	0.0	6.0	0.0	0.0	6.1	3.6	5.4	5.0

Table SI2.2. Contribution (%) of each of the selected indicators to the pressure sub-index.

EGUs	Percentage of contribution of the indicators		
	Salmon farming		
	Particulate Nitrogen Waste	Density of Salmon Farms	Density of Marine Traffic
1	0.0	0.0	0.0
2	53.7	7.5	38.8
3	72.9	11.5	15.6
4	66.6	13.2	20.2
5	0.4	0.0	99.6
6	0.0	0.0	100.0
7	0.0	0.0	100.0
8	0.4	0.0	99.6
9	0.0	0.0	100.0
10	0.0	0.0	100.0
11	1.0	0.0	99.0
12	61.6	17.2	21.2
13	18.3	9.6	72.1
14	0.0	0.0	100.0
15	82.7	2.8	14.5
16	67.5	11.1	21.4
17	62.7	12.0	25.3

SI3. Limitations of the tool and future improvements

In calculating the SFPII it is recognized that the sensitivity indicators used are probably subject to the shifting baseline syndrome (Soga & Gaston, 2018). This would obscure the absolute natural sensitivity of the systems, which have already been subjected to decades of intense development. This may be reinforced by using expert knowledge to provide indicator weights and establish potential relationships between indicators of sensitivity and sensitivity of the ecosystems, because these judgements are based on incomplete knowledge of the ecological status of these ecosystems prior to salmon farming being established. In addition, the lack of interactive cumulative effects between the indicators used to construct the sensitivity sub-index may be obscuring the real dimension of the index. This is important as the simple assumption of additive effects used here has been found to not always be the case in natural systems (Brown et al., 2013; Piggott et al., 2015; Côté et al., 2016).

The data used to construct the index can be limited due to the absence of spatial resolution and concerns over the selection of indicators with sufficient spatial coverage to be informative might not correspond to the indicators most relevant to the system attributes of interest. The lack of a homogeneous spatial coverage of data through the study region might be a limitation on construction of the indices. This issue will likely persist, as the multiple potential information providers often do not use commonly held spatial extents, resolution, or types of observation systems. Unfortunately, many of the broader coverage arrays that present a high spatial coverage, might have a low accuracy. This is especially true for places like Patagonia due to the complexity of the coastline and prevailing weather (cloud) conditions. In contrast those data sets with high resolution and accuracy (e.g., from sediment sampling) have low spatial coverage.

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