Chapter 10

Knowledge and Research on Chilean Fisheries Resources

Diagnosis and Recommendations for Sustainable Development

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Abstract

As part of their efforts to improve the national fisheries management system, Chilean fisheries authorities have identified the need to develop a fisheries research program based on state-of-the-art fisheries knowledge and information systems. To meet this challenge, a structural matrix analysis of the existing cognitive system and a literature review was conducted. Knowledge gaps were identified through a comparison of the literature review and a conceptual model. The analysis suggests that research has largely been focused on fisheries biology studies, with little emphasis given to oceanographic factors, while almost no research on economic, social, or governability factors has been conducted. The analysis points to those elements that are needed to establish a research program that addresses priority elements towards the goal of sustainable fisheries in Chile. In spite of the analysis conducted on governance aspects of the existing fisheries management system, the analysis presented here is mainly focused on oceanographic, biological, technological, and economic aspects of the Chilean fisheries system. Thus, there is a need for further analysis of both social and governance aspects of fisheries.

Keywords: Fisheries management, sustainable development, knowledge base, governance, Chilean fisheries

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Introduction

Chilean fisheries are in urgent need of a way to systematize both information and knowledge in order to design and implement a fisheries research program in support of fisheries management. The objectives of the project reported in this chapter are:

1. to develop a knowledge matrix of the main fishing resources of Chile;
2. to conduct a comprehensive literature review upon which to build an analysis of the current state of knowledge of its main fishing resources; and
3. to propose a research program in support of fisheries management, based on past experiences and a prospective vision of the fisheries (Yáñez *et al*., 2007).

This research was conducted under two conditions: first, fisheries management and related research must contribute to the sustainable development of Chilean fisheries; and second, effective fisheries management and research must develop a common language and framework in order to facilitate cooperation between the government, the private sector, and the public in general, with the goal of building sustainable fisheries.

In this context the design, implementation, and assessment of fisheries management policy, strategies, and measures, require an integrated set of information and knowledge about the environmental, biological-ecological, technical, economic, social, legal, institutional, political, and cultural factors determining the performance of fishing activities and fisheries. In addition, the sustainable development approach requires that the fisheries system and its management be understood in the context of a specific geographic space in which it takes place and interacts with other human activities.

Accordingly, a systems and holistic interpretation of the fisheries sector was adopted to gain the understanding needed in order to answer four questions related to the objectives of the study:

1. What system elements, structure and interactions need to be considered under the paradigm of sustainable development?
2. What set of knowledge and indicators is required to determine the system's current status with respect to sustainable development goals?
3. What is the system's current state of knowledge with respect to sustainable development goals?
4. What are the necessary future research paths for fisheries management?

Framework

This approach led to the development of a framework representing fisheries activities; the consideration of five Clusters of Minimum Knowledge (CMK) (oceanography, biology, technology, socio-economy, and governance) was used to understand the structure and function of the fisheries system. The fifth cluster refers to the system´s governance: it influences all other clusters and includes the knowledge required to understand the approaches, methods, and instruments to be used in fisheries management (Fig. 10.1).

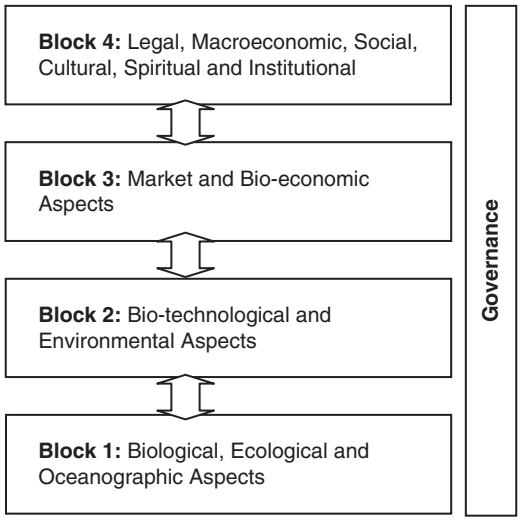

Fig. 10.1 Cluster of minimum knowledge used to understand the fisheries system.

The study was conducted following a seven step process. First, based on the first four clusters, and visualizing this interpretation of the fisheries system as a cognitive system, a team of specialists from different disciplines[1] identified and defined a set of knowledge elements as the minimum knowledge required for fisheries management under sustainable development (Table 10.1). The fifth cluster was defined by a group of decision-makers as a system of problems. The cognitive system may be represented as a network of relationships among different knowledge elements, the point of the analysis being the identification of those elements that are key for the system function.

Second, using the knowledge elements shown in Table 10.1, a structural matrix analysis, based on Godet (1994), of these knowledge elements as related to fisheries was conducted to estimate their influence and dependency on the system and to identify the key driving forces in the Chilean fisheries system. A direct causality analysis of the symmetric, structural, and binary matrix built with the elements shown in Table 10.1, allowed the calculation of the level of influence and dependence of each element (Fig. 10.2).

Third, based on this matrix analysis an influence-2 dependency diagram (Fig. 10.3) was constructed to facilitate the analysis of the knowledge elements in terms of their role and relative importance or specific weight in the system's functioning.

The diagram in Fig. 10.4 is a Cartesian plane, with axes indicating the level of influence or dependence of elements or variables considered. They are the basis for determining the shape and strength of the relations existing between the elements constituting the cognitive system. Notice that Fig. 10.4 is divided into four zones or sectors.[2] that are defined, moving in a clockwise direction and starting from the northwest quadrant as: forcing elements (F) (quadrant I); forcing-but-forced elements (F-F) (quadrant II); exit or consequence elements (E-NF) (quadrant III); and autonomous or non-forcing elements (A-NF) (quadrant IV). The forcing elements (F) refer to those that have great influence on the rest of the elements of the system, but are little influenced by them, or not at all (e.g., the influence of the energy from the sun on the marine ecosystems). Forcing-but-forced (F-F) elements have a significant

Table 10.1 The 61 knowledge elements identified as necessary for the fisheries system of Chile.

	Environmental-Oceanographic		
Code	**Description**	**Code**	**Description**
1	Tide	15	Productivity planckton
2	Swell	20	Rossby waves
3	Sediments	21	ENSO
4	Coast currents	22	Regimen shieff
5	Circulation of great scale	23	Nutrients and oxygen
6	Coastal circulation	A	Storm
9	Turbulence	B	Geomorphology
11	Vertical and horizontal gradients	E	Wind
14	Mesoscale structure		
	Biological-Ecological		
Code	**Description**	**Code**	**Description**
25	Stock	35	Natural mortality
27	Distribution, abundance, and population structure	36	Interspecific relations
30	Reproduction	39	Migrations
33	Recruitment	40	Life cycle
34	Growth		
	Technological		
Code	**Description**	**Code**	**Description**
41	Fishing mortality	57	Yield, processing
44	Catchability coefficient	60	Product life span
46	Exploitation pattern	64	Type of product
47	Fishing effort	68	Innoquity
49	Catch	77	Emissions
51	CPUE	81	Effluent
53	Installed processing capacity		
	Market and Bioeconomic		
Code	**Description**	**Code**	**Description**
85	Average cost of the unit of production	122	Consumer surplus
91	Marginal cost of the unit of production	123	Producer surplus
97	Social marginal cost from externalities	124	Species existence value
102	Final product price	125	Ecosystem existence value
103	Final product demand	AH	Marginal user cost from resource
119	Use level	AI	Marginal user cost from ecosystem
121	Used capacity		
	Macroeconomic		
Code	**Description**	**Code**	**Description**
109	Interest rate	126	Discount rate
110	Exchange rate	AF	Depreciation system
111	Tariff	AG	Subsidies
112	Duty		

level of influence in the system and receive a similar amount of influence from the system (e.g., the predator-prey relationship) – these are also labeled as conflict elements. Exit elements (E-NF) are those receiving great influence from the system while being unable to influence it (e.g., when considering the negative impact on the intertidal zone from effluents originated by a fish processing plant, which is an essential part of a coastal fishing community living on highly migratory species). Autonomous elements (A-NF) are those that, even though they are able to show some level of forcing or dependency with the system, they

i \ j	E1	E2	E3	E4	E5	E6	E7	E8	Inf	Influence
E1		0	0	1	0	0	1	1	3	$\Sigma_j e_{ij}$
E2										
E3		0		e_{ij}						
E4		1								
E5		0								
E6		1								
E7		1								
E8		1								
Dep		4								

Dependency $\Sigma_j e_{ij}$

Fig. 10.2 Representation of the analysis of the knowledge matrix.

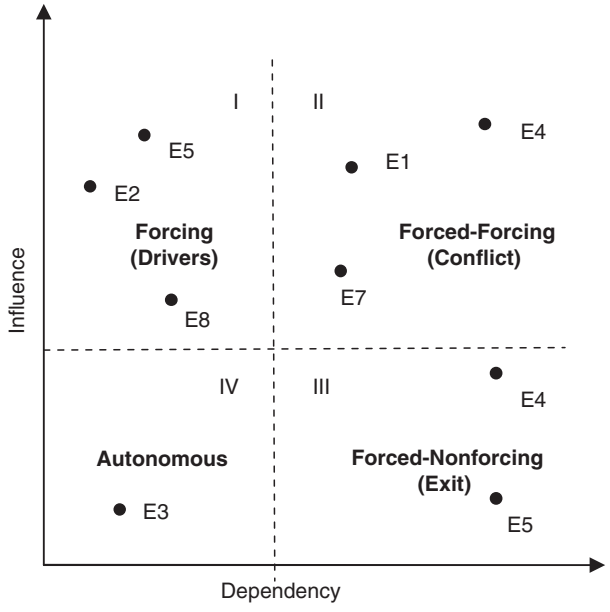

Fig. 10.3 Influence – dependency diagram (adapted from Godet 1994).

seem to be relatively independent of the system (e.g., the interrelationship between the members of the local "ladies literature and gin-rummy club" and those of their husbands in the fishing fleet and processing plant for the same coastal fishing community).

Fourth, keeping in mind the knowledge elements that were identified, a bibliographical analysis was conducted to characterize the present status of knowledge of Chilean fisheries, focusing on 31 main species, representing approximately 80% of total national landings and grouped as fish, crustaceans, mollusks, echinoderms, and algae (Table 10.2). The bibliographical

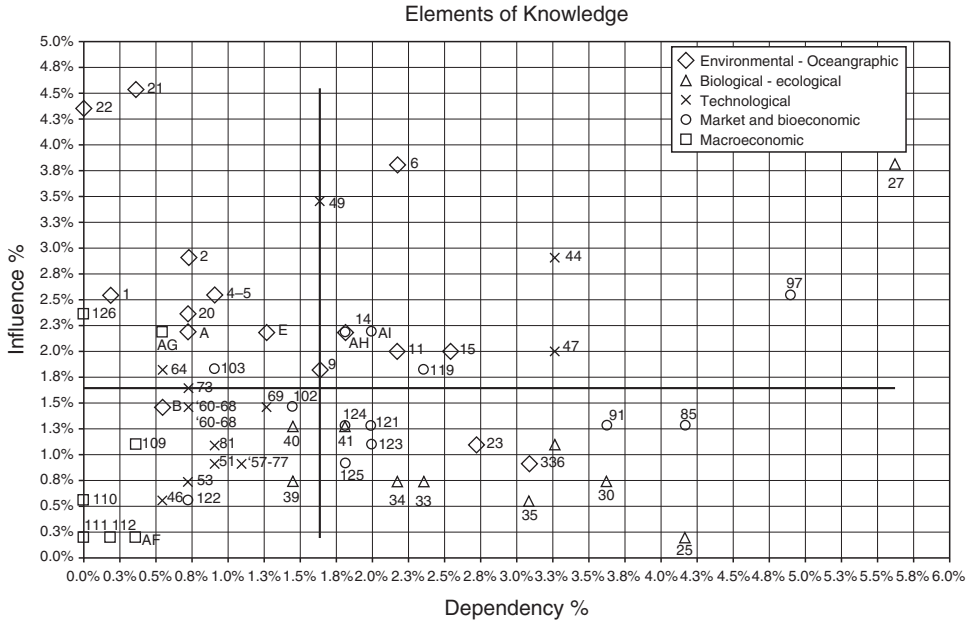

Fig. 10.4 Influence – dependency diagram presenting the knowledge elements according to their relative importance in the fisheries system of Chile.

Table 10.2 Main species of Chilean fisheries used in this analysis.

	Fishes		Crustacean
1	*Trachurus murphyi*	1	*Cervimunda johni*
2	*Merluccius gayi gayi*	2	*Pleucorondes monodon*
3	*Engraulis ringens*	3	*Hetrocarpus reedi*
4	*Sardinops sagax*	4	*Jasus frontalis*
5	*Clupea bentincki*	5	*Lithodes santolla*
6	*Xiphias gladius*		
7	*Macruronus magellanicus*		
8	*Merluccius australis*		
9	*Genypterus blacodes*		
10	*Dissostichus eleginoides*		
11	*Micromesistius australis*		
12	*Epigonus crassicaudus*		
13	*Hoplosthetus atlanticus*		
14	*Beryx splendens*		
15	*Raja chilensis*		
16	*Isurus oxyrinchus*		
17	*Prionace glauca*		
	Molluscs (others)		**Algae**
1	*Concholepas*	1	*Macrocystis spp*
2	*Loxechinus albus*	2	*Durvilea antarctica*
3	*Mesodesma donacium*		
4	*Gari solida*		
5	*Fissurella latimarginata*		
6	*Fissurella cumingi*		
7	*Thais chocolata*		

analysis had a database of more than one thousand references, including books, scientific papers, technical reports, theses, conference proceedings, and others (www.fip.cl).

Fifth, keeping in mind the knowledge elements identified, the characteristics of the 31 species considered for the bibliographical analysis, and the context in which their fishing activity takes place, a comparative analysis – aimed at identifying the presence of information about elements presented in Table 10.1 and the outputs from the bibliographical analysis – was conducted to identify those key knowledge elements deemed to be necessary for management of each of the species. Sixth, based on results obtained from steps four and five, a simple gap analysis was conducted. This analysis was based on whether or not there was research information about the key knowledge elements deemed necessary for the 31 species considered in this study. Finally, a scientific research priority program for the main fisheries resources of Chile, showing which aspects are in need of continuous research and where gaps exist that need to be filled, was designed, based on the results and complemented by expert judgment.

System structure, elements, interactions, and knowledge to be considered

Sixty-one knowledge elements were identified as relevant for the Chilean fisheries system through analysis of the four Clusters of Minimum Knowledge identified by the research. Table 10.1 presents these elements grouped according to the cluster to which they pertain: 28% of the 61 elements pertain to the Oceanography cluster; 13% to the Biology cluster; 25% to the Technology cluster; and 33% to the Socio-economic cluster (comprising market, bio-economic, and macro-economic information). Results from the matrix analysis synthesized by means of the influence-dependency diagram (Fig. 10.5) show that there are a total of 26 key knowledge elements to be considered for fisheries management purposes, which are part of both the forcing zone (quadrant I) and the forced-forcing zone (quadrant II). Those elements, which are part of the forcing zone, are said to be driving the system: that is, they have a strong influence on the system's performance and behavior. Those elements, which are part of the conflict zone, are also important to the system: they influence it but also are influenced by it, and are said to be the linkage variables in the system. Figure 10.4 also shows that 13 key knowledge elements (forcing elements) (Table 10.3) are fundamental if Chile is to move towards sustainable development of its fisheries. As Fig. 10.4 shows, several of the driving elements pertain to the Oceanographic-Environmental (in blue), the Market & Bioeconomic (in red), and the Macroeconomic (in orange) clusters, respectively, and some to the technological cluster (in purple). There are an additional 13 key knowledge elements that were considered to be Forcing-but-Forced elements, through the matrix analysis. Again, several among them pertain to the Oceanographic-Environmental cluster, some to the Market & Bioeconomic and Technological clusters and, only one to the Biological-Ecological cluster (in green). A total of 35 additional elements were considered to be Non-Forcing (15 of them are E-NF and 20 A-NF), through the matrix analysis.

Figure 10.5 shows the results of the comparative analysis that was conducted in order to know which of these 26 key knowledge elements were deemed necessary as research topics

Elements	Xiphias gladius	Trachurus murphyi	Sardinops sagax	Clupea bentincki	Engraulis ringens (north)	Engraulis ringens (south)	Merluccius gayi gayi	Merluccius australis	Macruronus magellanicus	Micromesistus australis	Genypterus blacodes	Dissostichus blacodes	Epigonus crassicaudus	Hoplosthetus atlanticus	Beryx splendens	Raja chilensis	Isurus oxyrinchus	Priorace glauca	Lithodes santolla	Jasus frontalis	Heterocarpus reedi	Cervimunda johni	Pleurocondes monodon	Concholepas concholepas	Loxechinus albus	Mesodesma donacium	Gari solida	Fissurella cumingi	Thais chocolata	Macrosystis sp.	Durvillea antarctica
Tide								x	x		x													x	x	x	x	x	x	x	x
Swell																								x	x	x	x	x	x	x	x
Coast current							x				x					x			x		x	x	x	x	x	x	x	x	x	x	x
Large scale circulation	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x		x											
Coastal circulation	x	x	x	x	x	x	x	x	x	x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Turbulence			x	x	x	x	x	x	x	x	x			x	x															x	x
Mesoscale structure	x	x	x	x	x	x								x	x		x	x		x											
Rossby waves	x	x	x	x	x	x	x				x						x	x													
ENSO	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Regime shift	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
Storm		x																													
Wind			x	x	x	x	x	x	x	x									x	x	x	x	x			x	x				
Planktonic productivity			x	x	x	x	x	x	x	x	x		x				x							x	x	x	x	x			
Vertical and horizontal gradients	x	x	x	x	x	x											x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Distribution, abundance and population	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Catchability coefficient	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fishing effort	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Catch	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Type of product	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Social marginal cost from externalities	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Final product demand	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Use level	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Marginal user cost from resource	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Marginal user cost from ecosystem	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Subsidies	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Discount rates	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cell with colored cross and background indicates that knowledge element is deemed necessary																															

Fig. 10.5 Key knowledge elements deemed to be necessary for research on the main fishery species of Chile.

Table 10.3 The 13 key knowledge elements.

Environmental-Oceanographic
Tide
Swell
Coast current
Large-scale circulation
Rossby waves
ENSO
Regime shift
Storm
Wind
Technological
Type of product
Market and Bioeconomic
Final product demand
Macroeconomic
Subsidies
Discount rates

for the 31 main fishery species under consideration. As shown in Fig. 10.5, all key knowledge elements from the Biological-Ecological, Technological, Market & Bioeconomic, and Macroeconomic clusters were considered to be necessary for research on all the main fishery species of Chile. However, differences arise with respect to the key knowledge elements pertaining to the Oceanographic-Environmental cluster. Figure 10.5 shows that only 3 out of 14 (21%) of the key knowledge elements in this cluster were deemed necessary research topics for 70–100% of the 31 species considered: these elements were Coastal Circulation, Rossby waves, and Regime shift. Out of 14 (43%) elements, 6 were deemed necessary research topics for a range of 40–70% of the 31 species studied, 4 out of 14 (29%) for a range of 10–40% of the 31 species, and the element Storms was deemed necessary for only 1 of the 31 species.

Current status of knowledge

The analysis of the system's current status of knowledge with respect to sustainable development goals was based upon the results of three analyses: the matrix analysis; the bibliographical analysis; and the comparative analysis of the results from the first two analyses. The bibliographical analysis showed that the most relevant set of existing fisheries research documents were Technical Reports (40%) and Theses (34%). It also showed a small number of articles published in scientific journals (Fig. 10.6).

The comparative analysis between results from the matrix analysis (i.e., key knowledge elements identified) and from the bibliographical analysis, showed current status (relative importance) of these key knowledge elements within the cognitive system for each of the 31 most important fishery species in Chile (Fig. 10.7). Figure 10.7 shows a set of Arabic numbers indicating the frequency with which information for this key element (rows) was found in the Chilean fisheries literature in relation to the corresponding species (columns).

Biological factors (distribution, abundance, and population structure) and technological factors (catchability coefficient, effort, catch, and type of product) have been the most

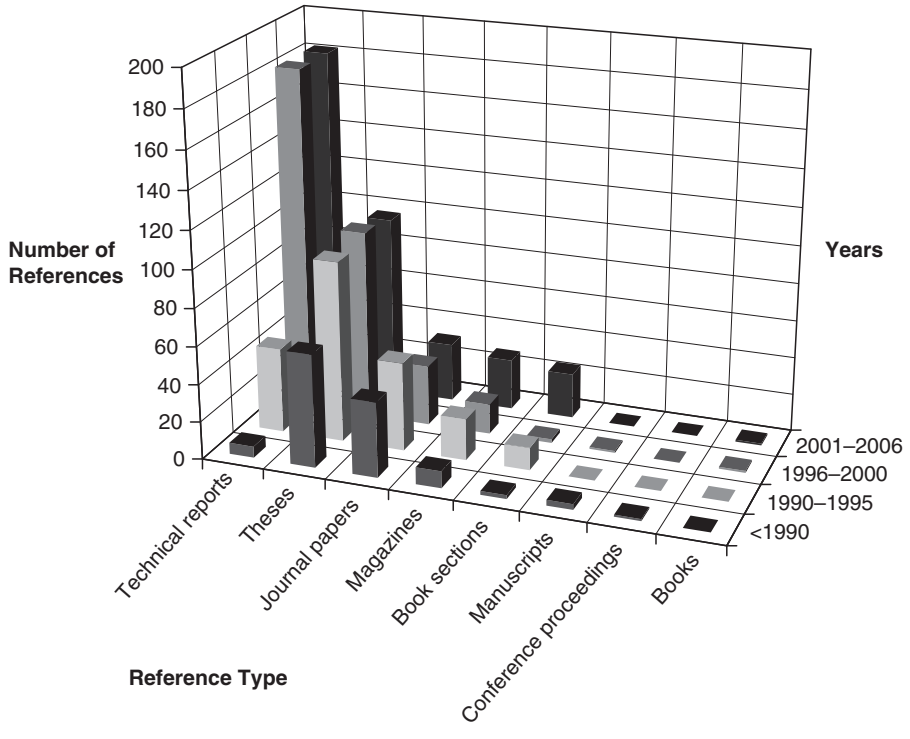

Fig. 10.6 Distribution of reference material on fisheries research, with respect to the main fishery species in Chile.

studied elements for all species during the last 15 years, whereas oceanographic and economic factors were less studied, with mostly zero frequency of occurrence (shown by empty cells in the figure). Based on information presented in Fig. 10.5, it is possible to say that the key knowledge elements are deemed necessary for management purposes in 73% of the cases across the 31 fish species considered.

Considering the numbers in Fig. 10.7 in a binary manner (i.e., a number indicates presence of information and no number indicates absence of information), a gap analysis was conducted to gain understanding of the level of information available for management purposes. Results show that on average 65% of the key knowledge elements requiring research for management purposes are missing. An analysis by knowledge clusters indicates that on average 88% of the elements pertaining to the Market & Bioeconomic cluster are missing, and that information on 87% of the key knowledge elements pertaining to the Macroeconomic clusters was also missing. In addition, information on the Oceanographic-Environmental cluster is missing in 73% of the cases on average. The Technological cluster had only 10% of the required information missing and the Biological- Ecological cluster showed information missing in only 6% of the cases. Finally, Figs 10.5 and 10.7 also shows that some key knowledge elements in the Oceanographic-Environmental cluster have been studied for species for which information is considered to be unnecessary (i.e., cells with Arabic number but no colored background).

Elements	Xiphias gladius	Trachurus murphyi	Sardinops sagax	Clupea benticki	Engraulis ringens (north)	Engraulis ringens (south)	Merluccius gayi gayi	Merluccius australis	Macruronus magellanicus	Micromesistus australis	Genypterus blacodes	Dissostichus blacodes	Epigonus crassicaudus	Hoplosthetus atlanticus	Beryx splendens	Raja chilensis	Isurus oxyrinchus	Priorace glauca	Lithodes santolla	Jasus frontalis	Heterocarpus reedi	Cervimunda johni	Pleucorondes monodon	Concholepas concholepas	Loxechinus albus	Mesodesma donacium	Gari solida	Fissurella cumingi	Thais chocolata	Macrosystis sp.	Durvillea antarctica
Tide						1																								2	1
Swell																														2	1
Coast current		2	2	2		2	4																2	1	1						
Large scale circulation		5			2																										
Coastal circulation		10	12	12	16	10	4		1														2	3						2	
Turbulence	1	3	2	2	3	1	1																1	1							
Mesoscale structure		2			2		1																								
Rossby waves																															
ENSO	2	8	7	7	9	3	5	1													1	1	1	3	2			1		3	
Regime shift		1	2	2	4	1																		2							
Storm																															
Wind	1	4	2	2	7	3																		1							
Planktonic productivity	1	3	3	3	2	3		1															1	1							
Vertical and horizontal gradients	10	39	22	22	36	17	10	3	1												1	2	6	7	2	1		1		1	
Distribution, abundance and population structure	20	95	42	42	57	31	48	23	17	8	9	20	2	9		3	1	1	9	5	18	19	28	35	19	9	1	8		20	7
Catchability coefficient	12	30	12	8	12	8	19	9	8	8	9	12		6		4	2	1	11	3	10	8	6	12	5	4	1	2		3	1
Fishing effort	20	53	17	23	18	18	24	27	24	15	19	26		6		7	4	3	9	3	15	15	16	18	11	3	6	8	1	1	1
Catch	34	94	27	40	43	32	42	44	30	20	27	32	2	9		9	4	3	12	10	29	31	29	25	20	10	7	14	2	6	2
Type of product	1	39	8	3		2	10	6	3	1	2	5	2	2		3			2		4	1	2	3	1	3	1		1	1	1
Social marginal cost from externalities					1																										
Final product demand	1						2	31		1	1	1		2		2							1							1	1
Use level							2		2	1														2	2	1					
Marginal user cost from resource																															
Marginal user cost from ecosystem																															
Subsidies																															
Discount rates	1		1		1						1					1								1		1		1			

Number: number of references including this element

Empty: no references dealt with this knowledge element

Fig. 10.7 Current status of the relative importance of the key knowledge elements in research, for the most important fishery species in Chile.

Table 10.4 Set of problems identified by the Group of Decision-Makers.

Number	Problem
1	Reactive fisheries authorities
2	Great number of fishermen and low resource availability
3	Inappropriate legal framework
4	Inadequate management process
5	Insufficient technical rules
6	Need for improved procedures for strategy, tactics, and public policy-making
7	Need to improve specific knowledge on cultural and social aspects of fisheries sector stakeholders
8	*Discarded by experts*
9	Lack of diagnosis relating to different types of institutions and actors
10	Need for better inclusion of precautionary principle
11	Need for improved coordination between national and international regulations
12	Need for better definition of management procedures
13	Need to improve joint efforts among fisheries institutions
14	*Discarded by experts*
15	Excessive pressure upon authorities
16	Need to increase personnel in Fisheries State Institutions
17	Incomplete Institutional Structure
18	Need for impact evaluation of management regulations
19	Management methods and measure of highly complex and uncertain nature
20	Negative synergic effects between industrial and artisanal fisheries
21	Need for improved specific fisheries policies (national and international)
22	Need to improve trust among different actors
23	Regulations tailored to private interest and unflexible tools
24	Need for improved relationship among fisheries authorities and artisanal fishery basis
25	*Discarded by experts*
26	Need to improve the use of regulatory instruments
27	Need for improvement of the sanction system
28	Need to improve the decision processes
29	Need for stronger differentiation of artisanal sector
30	Need to improve the political will and/or management capacity to enforce existing artisanal policies
31	Need to improve efficient programs on artisanal fisheries
32	Excess of paternalism with respect to artisanal fisheries
33	Need for long-term stability of the legal framework regarding industrial sector

Governance of the fisheries system (a system of problems)

The Group of Decision Makers identified a total of 30 problems (Table 10.4) and 12 of them were considered to be important for the structural analysis of the system (quadrants I and II) (Fig. 10.8). An affinity analysis of these 12 problems showed that they may be grouped as specific problems of governance and as problems of government capacity.

Discussion

Future research path for fisheries management

These results show that research for key knowledge elements pertaining to the Biological-Ecological and Technological clusters have been extensively researched for the main fishery species of Chile. This is positive, as these elements are considered to be necessary

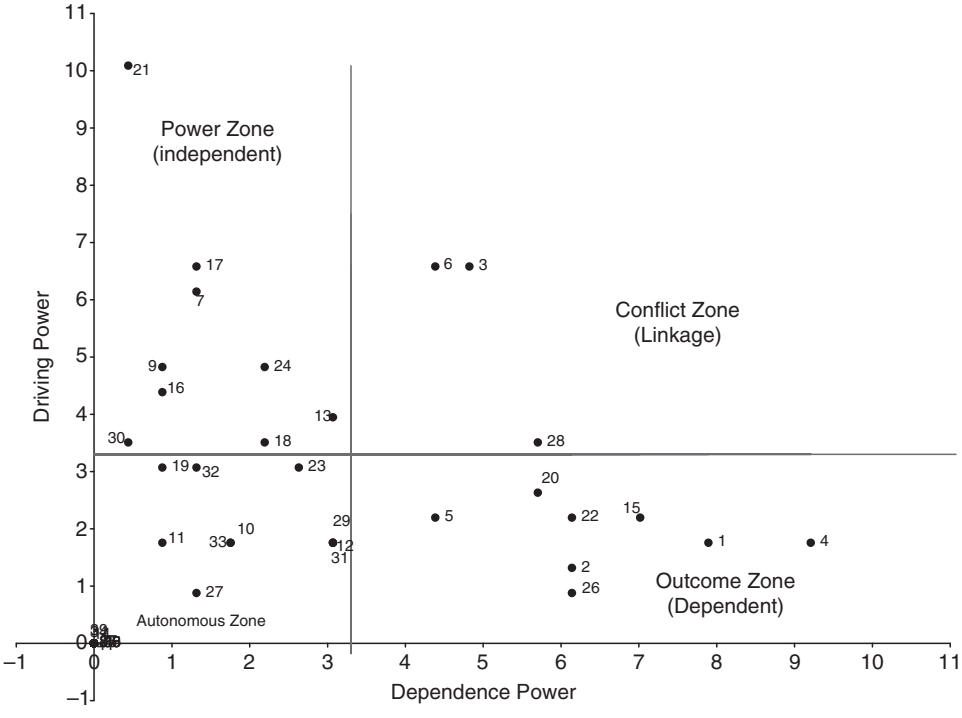

Fig. 10.8 System of problems: driving vs. dependence power of different problems.

research topics for all these species: the trend should be maintained. Results for the Oceanographic-Environmental cluster showed that, even though an important number of key knowledge elements are considered necessary research topics, they have not been researched during the period of analysis. The results also show that a significant number of additional elements have been researched over time. Thus, efforts should be maintained with respect to those deemed necessary and which are currently being studied, but should be significantly increased for those that have not yet been studied. With respect to the Market & Bioeconomic cluster, the results show a critical situation with a high percentage of missing information on key knowledge elements. A similar situation is observed for the Macroeconomic cluster. Research efforts should be increased with respect to these knowledge elements that were deemed necessary to all the main fishery species of Chile. The problems analysis of the governance system showed that a number of aspects related to governance and government capacity need to be researched in the future. These have been described in part of a second research program. If sustainable development of fisheries is to be attained, in addition to the previous knowledge clusters, relevant consideration should be given to research related to the improvement of the governance system, particularly those related to organizational and institutional structure, inter-institutional coordination, and human resources capacities and availability.

In summary, even though research efforts need to be maintained for those key knowledge elements for which evidence of past and current information was found (i.e., Biological-Ecological, Technological, and Oceanographic-Environmental clusters), research should be increased significantly for those knowledge elements for which key information is

missing, specifically the Market & Bioeconomic, Macroeconomic, and Oceanographic-Environmental clusters. The study also showed the relevance of governance aspects and the need for research in support of the strengthening of the Chilean fisheries governance system. Finally, it is important to highlight several research aspects for the key knowledge elements identified, such as timing, periodicity, geographical scope, and the level of inclusion with respect to the value chain, from the fishing ground to the consumer plate. It is also important to consider future research on social aspects of fisheries and their influence in the overall performance of the system and of its management structure: these were only marginally analysed in this study.

Endnotes

1. The team of specialists was comprised of two groups. First, by a permanent core group of nine professionals and scientists representing disciplines such as: oceanography, ecology, fisheries biology and oceanography, fisheries technology, fisheries and environmental economics, and business management. Second, by an extended group of 42 specialists from these disciplines plus others such as sociology, anthropology, and law, which represented the small- and large-scale private sector, the public sector, the academic sector, and ONGs. This second group participated in three validation workshops.
2. The level at which each axis is divided is determined by averaging the specific weight of all the elements considered, both in the dependency and influence axis.

References

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www.fip.cl. The 1038 references used in the diagnostic analysis can be found on the Project FIP No. 2005–25 bibliographic database.