

A framework for the identification of research gaps on sea lice in the salmon industry in Chile

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Abstract

A novel procedure for the identification of research gaps integrated a two-fold step process including an expert consultation that was carried out within the salmon industry through Salmon research Institute (INTESAL), and a literature search followed by a systematic review. Expert consultation would envisioned to provide all aspect that were 'unknown' by the participants. Conversely, literature search were conducted to capture most that is known about both diseases that were explored in this first stage.

A cross-matching process was used to formulate questions from the gaps found by an expert. A literature search was conducted to find the correct answers to those questions. From the questionnaire, unanswered and those without a correct answer, were referred here as research gaps.

A total of 61 research questions or gaps were identified. Each research question was assigned to several topics (n=21) that ultimately were grouped into six core research areas as follows: Infectious Disease Ecology, Agent Response Studies, Salmon Immune Response, Health and pathogen control, Vaccine development and Human Dimension.

Sea lice and Research Gaps in Chile

Chile has decided to become a food producing country and today is the second main producer of salmon across the globe. One of the main problems associated with sustaining supply relates to diseases that affect the fishes. Sea lice is among the most important sanitary problems in the global salmon aquaculture industry.

The indirect and direct cost associate to Sea lice (*Caligus* spp) in Chile was estimated on k US \$ 319.000 (Table 1).

To control and reduce the effects of sea lice it is necessary to substantially increase the quality and quantity of fundamental and applied knowledge. However, since salmon farming takes place in changing marine environments, where several environmental factors affect the diseases' incidence and spread. It necessary o integrate knowledge from diverse biological disciplines to whole environment disciplines. In addition, productive and management decision such as pharmacological treatments, productive cycle schemes, fish densities and others, also changes the status of the diseases. Finally, the "human dimension" of fish diseases management, including human behavior, institutional frameworks, knowledge management, decision making, economics and policies also determines in part the current status of the diseases in the Chilean salmon farming industry. This complex and multifactorial problematic needs the integration of multiple disciplines in a comprehensive interdisciplinary research scheme.

Table 1 . Cost associated to *Caligus* infestation in Chile based on 650.000 tons annual.

ITEM	Cost	Cost unit	Value	Base anual	Base unit	kUSD
Treatment	40,000	Bath	1	1,400	site	56,000
Mortality	5.00	USD/kg	0.3%	650,000	ton	9,750
FCR (Food)	1.40	USD/kg	0.05	650,000	ton	45,500
Cost (Unproductive)	0.08	USD/kg	1	650,000	ton	54,600
Lower Quality	1.20	USD/kg	3%	650,000	ton	23,400
Lower Size	0.20	USD/kg	1	650,000	ton	130,000
						319,250

Source: INTESAL unpublished data.

Methods and Results

The procedure for the identification of research gaps integrated a two-fold step process including an expert consultation that was carried out within the salmon industry through the salmon and trout growers association (SalmonChile), and a literature search followed by a systematic review (Figure 1). Expert consultation would envisioned to provide all aspect that were 'unknown' by the participants. Conversely, literature search were conducted to capture most that is known about both diseases that were explored in this first stage.

Literature searches were conducted in English and Spanish to identify investigations related to the infection caused by *P. salmonis* and sea lice, in wild and farmed salmonids. Two familiar electronic databases for the authors, Web of Science and PubMed (MEDLINE). References cited in retrieved reports were reviewed to identify additional reports, which, if not available on line, were requested and scanned through a academic library. Titles and abstracts were imported into a reference manager system (EndNote, version X7, Thomson Reuters, Carlsbad, CA, USA). Subsequently, a double independent extraction of information, metrics and indicators from the publications was conducted by the authors. Extracted data were reviewed and in case of disagreement, a second revision of the manuscript was jointly conducted by the authors in order to reach consensus on the results interpretation.

A cross-matching process of identifying questions from the expert consultation that had found an answer from the literature search was carried out for sea lice. Questions without an answer, or any failure to identify an appropriated answer, were referred here as research gap. Each of the research gaps was assigned to a discipline and sub discipline as before. Subsequently, research gaps were grouped into major topics to end up with core research areas.

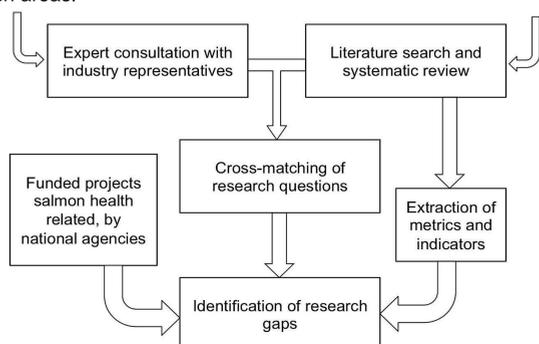


Fig 1. Graphical representation of steps and processes involved in the identification of research gaps.

Sea lice literature review included a number of 210 relevant papers (Figure 2). Sea lice research has been done by a wider number of research groups in the world. Much of the research since 90's was focused on the biology, life and development stages of the parasite. In Chile, Universidad Austral and Universidad de Los Lagos have been the most productive institutions, including now the LGIM/PUCV.

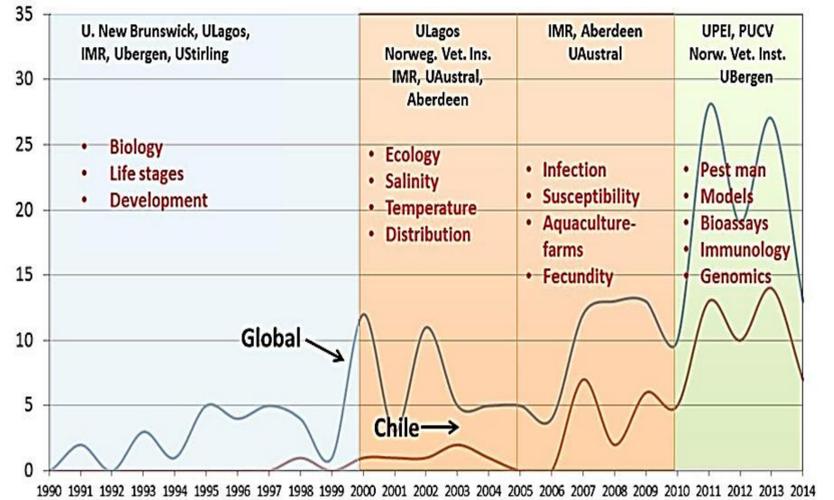


Fig 2. Timeline of retrieved publication for *Caligus* spp

A total of 61 research questions or gaps were identified. Each research question was assigned to several topics (n=21) that ultimately were grouped into six core research areas (Figure 3) as follows:



Fig 3 . Venn-Diagram to represent the six research areas (colored circles), and topics (numbers from 1 to 21, within circles) identified in the framework for the identification of research gaps on sea lice in the salmon industry in Chile

Conclusions

Sea lice is one of the diseases with the greatest impact in economic terms in the salmon industry in Chile.

To control and reduce the effects of Sea lice in Chile, it is necessary to substantially increase the quality and quantity of fundamental and applied knowledge.

Through a novel procedure for the identification of research gaps integrated a two-fold step process include an expert consultation and a literature search followed by a systematic review was possible identify a total of 61 research questions or gaps that ultimately were grouped into six core research areas as follows: Infectious Disease Ecology, Agent Response Studies, Salmon Immune Response, Health and pathogen control, Vaccine development and Human Dimension (management).

This work will contribute to improve technological transfer and funding policy recommendations and promote expertise and collaboration between the scientific community and the salmon industry.

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