

Third International Scientific Workshop for the Argentine Shortfin Squid 19th - 21st Nov 2024, Bangkok, Thailand



Hosted by CAPES-UC, Center of Applied Ecology and Sustainability, Pontificia Universidad Católica de Chile

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Report of work in sessions and way forward

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Chairman and co-chairman of the workshops



1. Executive summary

The third workshop on the stock assessment and management of the *Illex argentinus* stock in the South West Atlantic was held between the 19th and 21st of November, 2024, in Hotel Berkeley Pratunam, Bangkok, Thailand.

Hosted by the Center for Applied Ecology & Sustainability of the Pontificia Universidad Católica de Chile, the workshop was chaired by independent scientists Dr. Rubén H. Roa-Ureta and Dr. Rodrigo Wiff, and attended by scientists representing government research centers and/or universities from China, South Korea, Brazil, and the Falkland Islands (Islas Malvinas), as well as Alexander Arkhipkin from Fisheries New Zealand, Ministry for Primary Industries, as an expert in the assessment and management of cephalopod fisheries, and Chia-Ying Jessie Ko, from National Taiwan University, Chinese Taipei¹, as an expert in aquatic ecosystems and fisheries science with experience in research focused on *Illex argentinus*.

The main purpose of the workshop was to make progress in the goal of building a regional database for stock assessment of *I. argentinus* in the South West Atlantic, including all countries' fleets, namely Brazil, Uruguay, Argentina, China, Chinese Taipei, South Korea and other fleets having licenses to fish in waters of the Falkland Islands (Islas Malvinas).

The main fleets according to landings volume are Argentinian operating in national waters and Chinese, Chinese Taipei and Republic of Korean fleets mostly operating in international waters. Total landings (and those of the main fleets) have entered a period of wide fluctuations after growing to over 1 million tonnes in 2000.

A subsidiary purpose was to present and discuss scientific advances and previous knowledge of the biology and population dynamics of *I. argentinus* in the South West Atlantic and options for stock assessment models.

The workshop started with a recapitulation of progress in the 1st (Chile) and 2nd (Panama) workshops. This progress is highly relevant to the major goal of the workshops, which is to conduct a regional stock assessment and then derive management actions for sustainability, and can be summarized as follows:

1. The stock is a unique genetic population unit from southern Brazil to Patagonia and international waters with a large north-south life history cycle and many smaller inshore-offshore cycles in Argentina and Brazil. Therefore it is valid to conduct a regional-level stock assessment.
2. Data needed to complete a regional stock assessment are monthly totals of catch and fishing effort and monthly samples of mean weight of squids in the catch for as many years as possible for each of the participating fleets. Detailed spatial data are not needed.
3. Stock assessment methods that could be implemented are of two types:
 - (a) depletion-based surplus production models,
 - (b) CPUE-based surplus production models.
4. Migrations between major regions (Brazil, Uruguay-Northern Argentina, Central and Southern Argentina, High Seas) could be included in the stock assessment though it may stretch the limits of capacity of the model conditional on the data.

The workshop continued with presentations of relevant data available to each of institutions represented in the workshop:

1. Brazil had sizable catches of *I. argentinus* from 2002 to 2013 by trawlers.
 - (a) Brazil has fishery-independent survey data from 2001 and 2002, including biological composition data.
 - (b) Brazil has fishing commercial data at the individual haul level from 2000 to 2006 and aggregated by month or week thereafter.
 - (c) Brazilian landings are negligible after 2008.
 - (d) Brazilian trawlers captured two phenotypes: large mature squid and smaller mature coastal squid.
 - (e) Brazilian data are very useful for representing the northern extreme of the spatial distribution of the stock.
 - (f) Brazilian data are already available to the working group.
2. Uruguay have significant landings of *I. argentinus* from 1975 to the present by trawlers.
 - (a) Uruguay does not have fishery-independent data.

- (b) Uruguay has fishing commercial data at the individual haul level from 1996 to the present.
 - (c) Uruguay does not have biological composition data but such missing data can be replaced with Argentinian data since both countries fleets operate in a common fisheries zone.
 - (d) Uruguayan fishing commercial data already are available to the working group.
3. Argentina has the largest landings of all countries' fleets targeting *I. argentinus* from 1950 to the present by jiggers, with further landings as by-catch of trawlers.
 - (a) Argentina has fishery-independent data in the form of pre-recruit surveys conducted annually at the start of the year.
 - (b) Argentina has fishing commercial data from jiggers at the individual haul level from 1990 to the present.
 - (c) Argentina has biological composition data from the pre-recruit survey and from commercial catches by jiggers.
 - (d) Argentinian trawlers targeting fish also capture *I. argentinus* (approximately 15% of total in weight).
 - (e) Argentinian biological composition and fisheries data from jiggers already are available to the working group.
 - (f) Argentinian commercial fishing data from the by-catch by trawlers need to be acquired.
 4. South Korea has large landings of *I. argentinus* from 1985 to the present by jiggers.
 - (a) South Korea does not have fishery-independent data.
 - (b) South Korea has fishing commercial data from jiggers at the individual haul level from 2017 to the present.
 - (c) South Korea has biological composition data from commercial catches by jiggers.
 - (d) South Korean biological composition and fisheries data from jiggers are not yet available to the working group.
 5. The Falkland Islands (Islas Malvinas) has a fleet of trawlers from joint ventures and a fleet of jiggers by providing licenses to Chinese Taipei and South Korean jiggers to fish in jurisdictional waters of the Islands.
 - (a) The Falkland Islands (Islas Malvinas) does not have fishery-independent data.
 - (b) The Falkland Islands (Islas Malvinas) has fishing commercial data from trawlers and jiggers aggregated by vessel per day of fishing from 1987 to the present.
 - (c) The Falkland Islands (Islas Malvinas) has biological composition data from commercial catches by trawlers from 2017 and by jiggers from 2024.
 - (d) The Falkland Islands (Islas Malvinas) biological composition and fisheries data are not yet available to the working group.
 6. Chinese Taipei has large landings of *I. argentinus* from 1985 to the present by jiggers.
 - (a) Chinese Taipei does not have fishery-independent data.
 - (b) Chinese Taipei did not present any characterization of their data
 7. China currently has the second large landings of *I. argentinus* starting in 1998 to the present by a fleet of jiggers.
 - (a) China does not have fishery-independent data.
 - (b) China has fishing commercial data from jiggers at the individual haul level from 1998 to the present, divided in two periods, 1998 to 2020, and 2020 to the present.
 - (c) China has biological composition data from commercial catches by jiggers from 2007.
 - (d) Chinese biological composition and fisheries data from jiggers are not yet available to the working group.

Although Chinese Taipei is one of the three four major fleets and they did not provide any information about their data, it is safe to assume that they collect data with the same standards as the other major fleets. Therefore, from (a) the presentations of data collected and stored by participants excepting Chinese Taipei, and (b) the examination of the characteristics of these data with respect to data templates for a regional stock assessment circulated in previous editions of the workshop, it was concluded that it is feasible to conduct a regional-level stock assessment once all sources of data are available to the working group. This conclusion is a major incentive to continue together for the common aim of scientifically assessing *I. argentinus*'s abundance, productivity, and sustainable harvest rates.

¹We are using the terminology of the South Pacific Regional Fisheries Management Organization, where Taiwan is a member and has accepted this format to refer to Taiwan

2. Introduction

The fishery for the Argentinian shortfin squid (*Illex argentinus*) is one of the largest invertebrate fisheries of the world. It has produced over a million tonnes of landings in some years (Fig. 1). In the last eight years of FAO's FishStat database, ships from 12 countries appear as participating in the fishery in both, coastal states and international waters. Ships flagged by China, Argentina, Taiwan, and South Korea take the larger fraction of the annual total, although ships with flags of Spain, Falklands Islands (Islas Malvinas) and Vanuatu, also take large catches (Figure 1). The *I. argentinus* fishery in the South West Atlantic and the jumbo squid fishery in the South East Pacific comprise between one third and almost one half of global cephalopod catches [2]. Clearly the *I. argentinus* fishery in the South West Atlantic is an important fishery for the food security, the health of ocean ecosystems and for the integrity of supply chains to several markets.

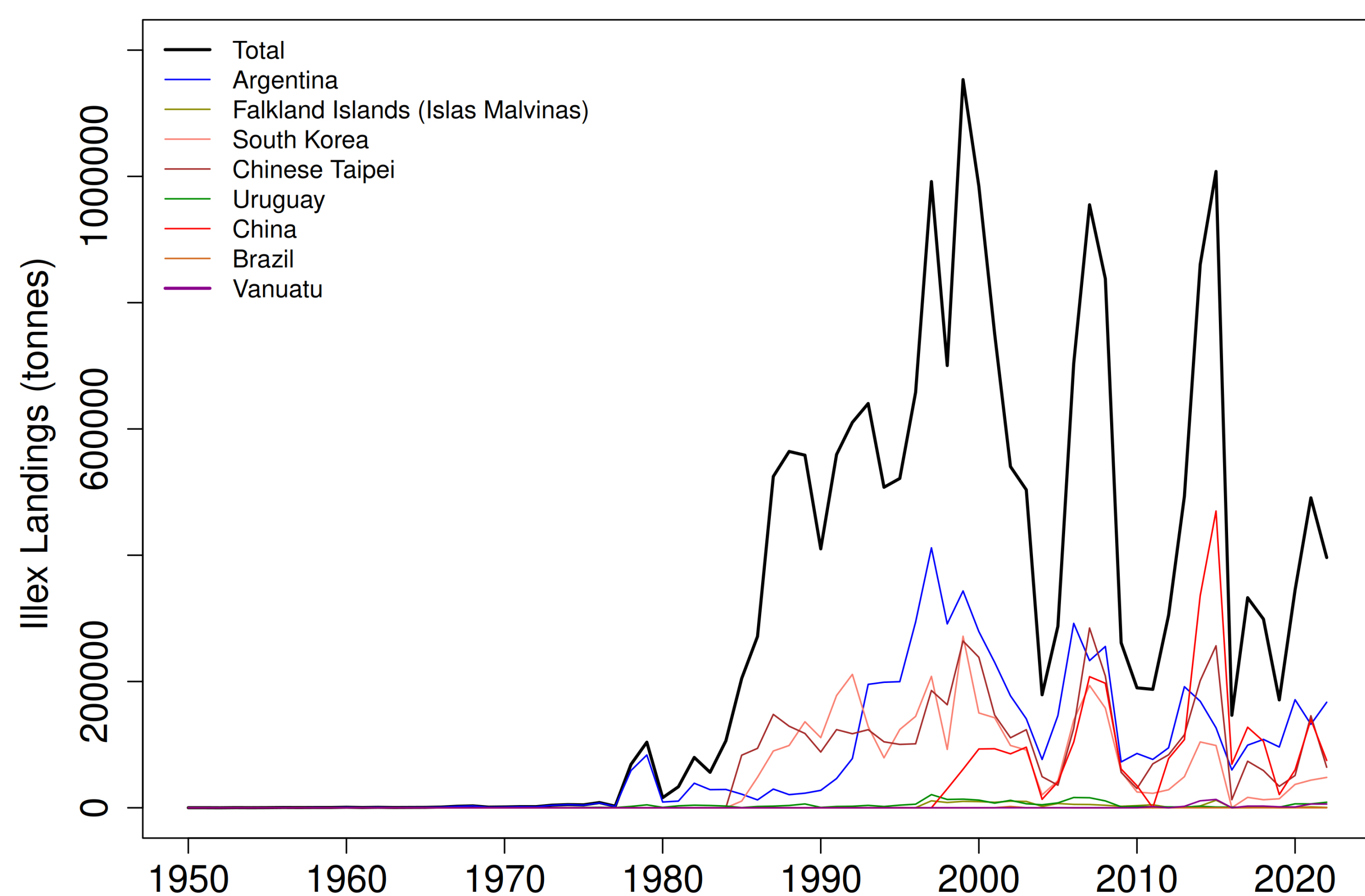


Figure 1: Landings of *I. argentinus* in the SW Atlantic as recorded by FAO up to 2022.

Arkhipkin et al. [2] have recently raised the issue of lack of integrated management and stock assessment across the region, both in the jumbo squid fishery and the *I. argentinus* fishery. Winter [13] presented stock assessment results for *I. argentinus* using Argentinian and Falkland/Malvinas Islands data with survey estimates and depletion models for 2019. This assessment did not include catches of the three large Asian fleets. Other scientists have presented partial assessments with Chinese Taipei data [3] and data from China flagged fleets [11]. Although these results provide a benchmark of biomass and other parameters of interest, they are only partial in nature and ignore the major issue of the functioning of the stock across the whole region. Knowledge of the stock's spatial dynamics across the whole region is essential for scientific management and requires the use of data from all fleets to produce a region-wide assessment.

The jumbo squid fishery in the South-East Pacific is overseen by a regional body with scientific mandate and capacity while the *I. argentinus* fishery lacks any form of coordinated and comprehensive monitoring and management. As a result, Arkhipkin et al. [2] fear that uncontrolled catches mostly in the high seas will make the *I. argentinus* stock susceptible to overfishing. They propose the creation of a multi-national advisory forum that would collect data, conduct regional-level stock assessment, and offer management advice based on scientific results. Within this context, the workshop in its three editions has naturally evolved into discussing innovative solutions to achieve the ultimate purpose of conducting region-wide stock assessment of the *I. argentinus* stock in the South West Atlantic.

In the time series of landings recorded by FAO (Fig. 1), a pattern emerges whereby landings increase steadily to over a million tonnes during the first 25 years (1975 to 2000) of the fishery and then they start to experience wide fluctuations over the remaining 22 years. This happens to total landings and the landings of the four largest fleets (China, Argentina, South Korea and Chinese Taipei). This is consistent with previous research showing that cephalopod stocks have a tendency to instability that is built-in their population dynamics though it is triggered by fishery removals [9, 7]. Fluctuations such as those observed in the *I. argentinus* fishery landings indicate that fishery removals have reached a magnitude that alters the population dynamics of the stock, adding urgency to the need to assess the status of the stock.

The first two workshops of this series (2022 in Chile, 2023 in Panama) achieved progress in conditioning a spatially-explicit population dynamics model that has been built and supported by all scientists participating in the workshop. They also helped define a database template conducive to regional stock assessment using innovative modeling approaches. The third edition of the workshop was aimed at characterizing the data available by all major countries participating in the fishery in order to build the database and conduct the stock assessment during 2025.

3. Location and Agenda

The workshop took place between the 19th and 21st of November, 2024, in Hotel Berkeley Pratunam, Bangkok, Thailand.

Workshop participants included the workshop conveners, scientists invited as country representatives and experts participating on a strictly scientific collaborative status. Country representatives came from Brazil, China, South Korea, Chinese Taipei, and the Falkland Islands (Islas Malvinas) (Table 3).

Table 1: List of contributors

Name	Institution
Conveners	
Rubén Roa-Ureta	Chairman, Independent consultant, Spain
Rodrigo Wiff	Co-Chairman, Pontificia Universidad Católica de Chile, Chile
Observers	
Manuel Martinez	Sustainable Fisheries Partnership, Chile
Country representatives	
Gang Li	Shanghai Ocean University, China
Jintao Wang	Shanghai Ocean University, China
Wei Yu	Shanghai Ocean University, China
Eunjung Kim	National Institute of Fisheries Science, South Korea
Hyejin Song	National Institute of Fisheries Science, South Korea
Frane Skeljo	Falkland Islands Fisheries Dpt., Falkland Islands (Islas Malvinas)
Rodrigo Silvestre	Universidade Federale de Sao Paulo, Brazil
Invited experts	
Chia-Ying Jessie Ko	National Taiwan University, Chinese Taipei
Alexander Arkhipkin	Ministry for Primary Industries, New Zealand

The agenda of the workshop was established prior to the meeting and consisted of 21 presentations in six work sessions (Figure 2). Six of the presentations described databases by the co-chairman (Argentina and Uruguay) or country representatives (Brazil, China, Chinese Taipei, Falkland Islands (Islas Malvinas), South Korea), another six presentations described relevant scientific research (Jintao Wang, Wei Yu, Hyejing Song, Alexander Arkhipkin, and Co-chairman), and the remaining presentations were re-capitulations of previous work, database structure, and daily summaries of work done the previous day (chairman).

Each participant started giving his or her background and this served as personal presentation and first step into getting to know each other. The main goal for this workshop was established as to achieve a regional stock assessment of the *I. argentinus* stock in the South West Atlantic to provide scientific advice that can serve as the basis for sustainable exploitation of the stock.

The format of presentations was informal, with presenters describing their slides and participants asking questions and starting discussions, while the co-chairman took notes for the daily summary.

The agenda was completed and in the final session participants agreed on the continuation of work with two formats.

1. The chairman and co-chairman will prepare a letter of request for data to each of the participant's countries using the charter and results of the workshop as background information, including a non-disclosure signed agreement, then upon favorable reception of the request for data, they will proceed to build the regional database and made it available to all participants in secure fashion. All of this should be completed by September 2025.
2. Participants agreed to re-convene in the last quarter of 2025 to conduct stock assessment during the Fourth International Workshop, to be held in Okinawa, Japan,

as a side event of the Cephalopod International Advisory Council (CEAC) meeting, on October 25th to November 1st, 2025. The chairman and co-chairman will contact the CEAC meeting organizers in order to make the workshop an official side event to the CEAC meeting.

DAY 1

Time	Activity
9:00 - 10:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Welcome. Participants presentation Agenda Workshop motivation and topics to cover
10:00 - 11:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Recap from First two Workshops
11:00 - 11:30	Coffee Break
11:30 - 13:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Review of available data and published research
13:00 - 14:30	Lunch Break
14:30 - 15:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Data format requirements
15:00 - 15:30	Rodrigo Silvestre (Brazil) <ul style="list-style-type: none"> Data from Brazil
15:30 - 16:00	Coffee Break
16:00 - 16:30	Rodrigo Wiff (Co-Chairman) <ul style="list-style-type: none"> Data from Uruguay
16:30 - 17:00	Rodrigo Wiff (Co-Chairman) <ul style="list-style-type: none"> Data from Argentina

DAY 2

Time	Activity
9:00 - 9:30	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Summary (day 1) Agenda day 2
9:30 - 10:30	Frane Skeljo (Representative from Falkland Island (Islas Malvinas)) <ul style="list-style-type: none"> Data From Falkland Islands (Islas Malvinas)
10:30 - 11:00	Gang Li (Representative of China) <ul style="list-style-type: none"> Data From China
11:00 - 11:30	Coffee break
11:30 - 12:00	Eunjung Kim & Hyejin Song Representatives of South Korea <ul style="list-style-type: none"> Data From South Korea
12:00 - 13:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Summary of database building
13:00 - 14:30	Lunch Break
14:30 - 17:00	Scientific presentations session 1.
14:30 - 15:30	Alexander Arkhipkin. "High seas fisheries: the Achilles' heel of major straddling squid resources".
15:30 - 16:00	Coffee Break
16:00 - 17:00	Rodrigo Wiff (Co-chairman). "Fisheries Phase Diagram to Fluctuating Stocks"

DAY 3

Time	Activity
9:00 - 9:30	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Summary (Days 1 and 2) Agenda day 3
9:30 - 12:15	Scientific presentations session 2.
9:30 - 10:30	Jintao Wang. "Illex argentinus stock assessment in the Southwest Atlantic Ocean based on Chinese jigging fishery data"
10:30-11:00	Wei Yu. "Eddy impacts on Illex argentinus in the Southwest Atlantic Ocean"
11:00 - 11:30	Coffee Break
11:30 - 12:15	Jessie Ko. "Influences of environmental changes on squid diet and abundance over Southwest Atlantic: thinking about future squid resources"
12:15 - 13:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> General discussion of proposals for methods of stock assessment and their conditioning. The latter includes spatial dynamics, number of separate fleets, extension of time series, and data to be included.
13:00 - 14:30	Lunch Break
14:30 - 15:30	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Data sharing protocols. This is a discussion and decision-making for details of sharing the database, including disclosure and confidentiality issues and mechanisms for updating as new years of fishing are added. Working groups. This is a discussion and decision-making of how to organize the stock assessment work, including whether groups work independently with the data, using different code and methods, or whether the group in the workshop prefers to keep working together.
15:30 - 16:00	Coffee Break
16:00 - 17:00	R. Roa-Ureta (Chairman) <ul style="list-style-type: none"> Way Forward Agreements Workshop Closure

Figure 2: Agenda of the Third International Scientific Workshop for *I. argentinus*

4. Sessions

4.1 Day 1

4.1.1 Preliminaries

The session started with presentations of participants and the main goal of the workshops, which is to establish a working group of scientists that would build a stock assessment database and conduct a stock assessment of the *I. argentinus* stock in the South-West Atlantic at the regional level and then publish those results in a peer-reviewed scientific journal. Further steps to this main goal would cover issues of implementation of management measure leading to sustainable harvest rates calculated from results of the stock assessment.

The chairman gave two presentations, one with a recapitulation of work in the previous two workshops and another with a proposal for a template for the stock assessment database that needs to be completed by the workshop participants.

The fishery's main characterization since the late 90s and the present is one of very wide fluctuations in landings (Figure 1). Work done in 2022 and 2023 resulted in an agreement on a fundamental hypothesis about the spatial functioning of the stock, with a large north-south life history cycle and many smaller inshore-offshore cycles in Argentina and Brazil (Figure 3). In addition, work by Falkland Islands (Islas Malvinas) scientists show that the stock is a single genetic unit [4]. These two previous results provide scientific support the main goal of the workshops: to conduct a regional-level stock assessment.



Figure 3: Agreed hypothesis of the spatial functioning of the *I. argentinus* stock in the South-West Atlantic.

The chairman described further progress towards a regional stock assessment in previous workshops. In particular, it has been agreed that wide fluctuations in landings reveal relevant aspects of the population dynamics and productivity of the stock, rather than market forces. These agreements mean that in the context of the total biomass dynamics of the stock, as represented by generalized mathematical models

of fishery science,

$$B_y = B_{y-1} + f(\theta, B_{y-1}) - C_{y-1}$$

$$f(\theta, B_{y-1}) = rB_{y-1} \left(1 - \frac{B_{y-1}}{K}\right)^{p-1}$$

- B is stock biomass
- y is year
- f is the biomass production function
- $\theta = \{K, p, r\}$ is a set of parameters that are unique to the *I. argentinus* stock and determine its productivity
- C is the annual total catch by all fleets operating in the fishery
- r is the intrinsic rate of population growth
- K is the carrying capacity of the environment
- p is the symmetry of the production function

the intrinsic rate of population growth (r in the equation above) will be large (> 2) thus triggering instability and fluctuating dynamics in the biomass of the stock after being fished for a sufficient number of years. A further consequence of fluctuating dynamics would be the need to use biological reference points of a generalized nature, based on the generalized surplus production concept of the latent productivity [9].

The chairman described database templates to conduct regional stock assessment, following two feasible methodological approaches: (a) indices of relative abundance from catch per unit of effort (CPUE) standardization fitted to the biomass dynamics [12] (CPUE approach), and (b) absolute biomass from multi-annual depletion models fitted to the biomass dynamics [10] (catch dynamics approach) (Figure 4).

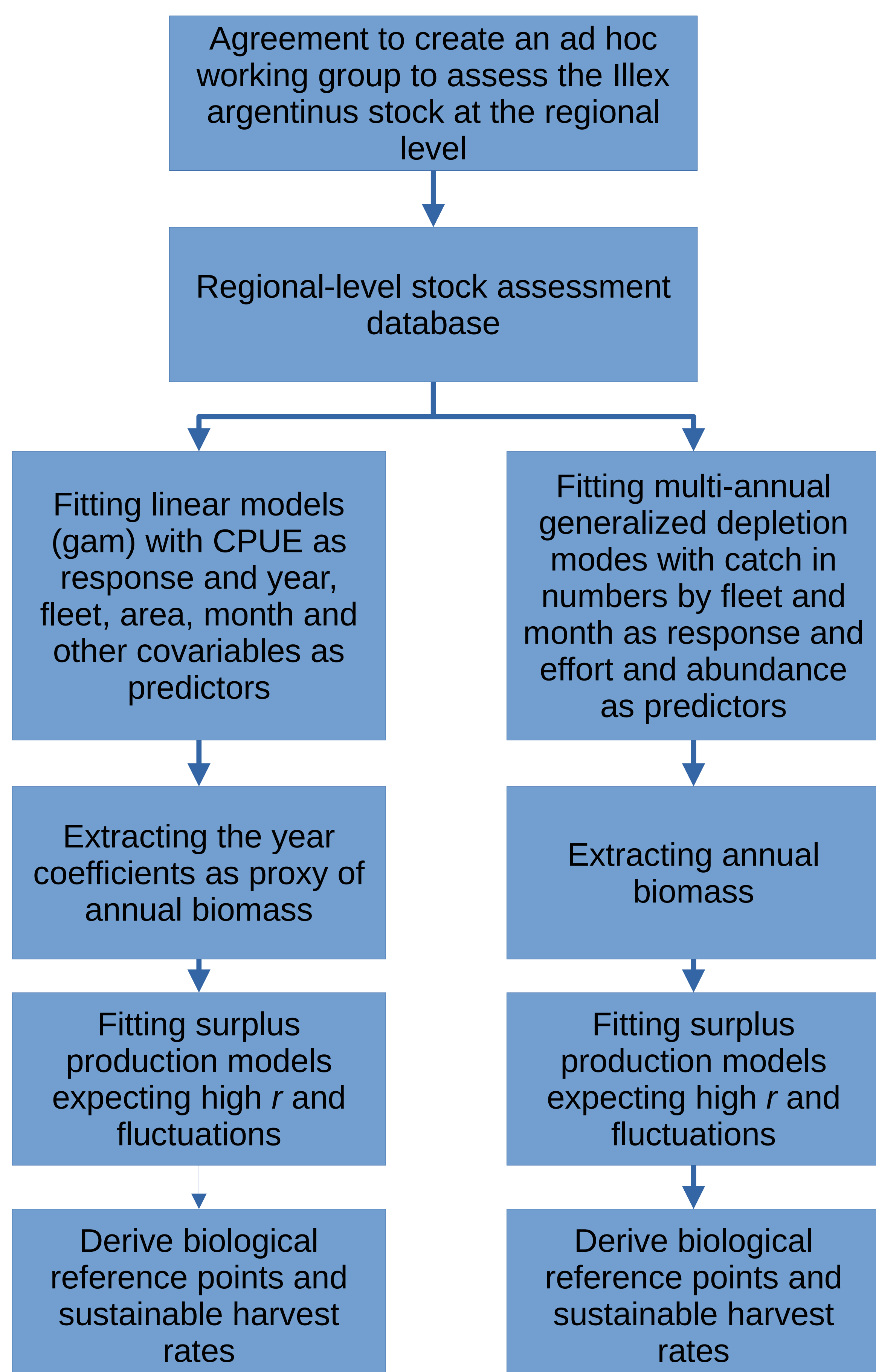


Figure 4: Feasible methodological approaches to the regional stock assessment of *I. argentinus* in the South-West Atlantic.

Data template for building a database for regional stock assessment of the Illex stock in the SW Atlantic.

This format is useful for two data-intermediate stock assessment methods: (1) CPUE-based indices of relative abundance fitted to surplus production models and (2) depletion-based biomass estimates fitted to surplus production models.

The range of months is only referential. Times series might be longer or shorter.

The number of co-variables is only referential. These can be any number of covariables.

If the country only has jiggers, leave trawlers columns empty.

If the country has trawler only in a range of years fill the trawlers columns for those years and leave

Needed in both approaches

Needed in the depletion-based approach

Useful in the CPUE-based approach

Argentina									
	Catch Jiggers	Effort Jiggers	M. wgt Jiggers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers	CoVar1	CoVar2	
Jan 2001									
Feb 2001									
Mar 2001									
...									
...									
...									
Dec 2012									
Jan 2013									
Feb 2013									
...									
...									
...									
Sep 2024									
Oct 2024									
Nov 2024									
Dec 2024									

Falkland I.									
	Catch Jiggers	Effort Jiggers	M. wgt Jiggers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers	CoVar1	CoVar2	
Jan 2001									
Feb 2001									
Mar 2001									
...									
...									
...									
Dec 2012									
Jan 2013									
Feb 2013									
...									
...									
...									
Sep 2024									
Oct 2024									
Nov 2024									
Dec 2024									

Uruguay						
	Catch Trawlers	Effort Trawlers	M. wgt Trawlers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers
Jan 2001						
Feb 2001						
Mar 2001						
...						
...						
...						
Dec 2012						
Jan 2013						
Feb 2013						
...						
...						
...						
Sep 2024						
Oct 2024						
Nov 2024						
Dec 2024						

Brazil					
	Catch Trawlers	Effort Trawlers	M. wgt Trawlers	CoVar1	CoVar2
Jan 2001					
Feb 2001					
Mar 2001					
...					
...					
...					
Dec 2012					
Jan 2013					
Feb 2013					
...					
...					
...					
Sep 2024					
Oct 2024					
Nov 2024					
Dec 2024					

China (International waters)						
	Catch Jiggers	Effort Jiggers	M. wgt Jiggers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers
Jan 2001						
Feb 2001						
Mar 2001						
...						
...						
...						
Dec 2012						
Jan 2013						
Feb 2013						
...						
...						
...						
Sep 2024						
Oct 2024						
Nov 2024						
Dec 2024						

Chinese Taipei (International waters)						
	Catch Jiggers	Effort Jiggers	M. wgt Jiggers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers
Jan 2001						
Feb 2001						
Mar 2001						
...						
...						
...						
Dec 2012						
Jan 2013						
Feb 2013						
...						
...						
...						
Sep 2024						
Oct 2024						
Nov 2024						
Dec 2024						

Rep. Of Korea (International waters)						
	Catch Jiggers	Effort Jiggers	M. wgt Jiggers	Catch Trawlers	Effort Trawlers	M. wgt Trawlers
Jan 2001						
Feb 2001						
Mar 2001						
...						
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Dec 2012						
Jan 2013						
Feb 2013						
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...						
Sep 2024						
Oct 2024						
Nov 2024						
Dec 2024						

Figure 5: Monthly time step database template to fill with data by each country in order to conduct regional stock assessment of *I. argentinus* in the South-West Atlantic under two feasible methodological approaches.

The chairman remarked that:

- Under the CPUE approach to stock assessment, Var1, Var2, etc., could be any number of co-variables to help fit the linear models to standardize CPUE. Examples of co-variables are mean depth, seawater temperature, location, and vessel characteristics reflecting fishing power.
- It is not imperative that data from all fleets overlap the same time period. They can start at different year/month combination, have gaps because of no fishing, and end at different year/month combination.
- The longer the time series the better for the stock assessment.
- Monthly catch and effort data must be complete, although a few months of either catch and/or effort data missing are tolerable and can be managed.
- The mean weight data may have more missing data but it is necessary that these data extend over nearly all months even if doing that in different years.
- Several members of the working group do not believe that biological composition data such as length and age composition are very useful for the assessment of

cephalopods in general, based on Arkhipkin et al. [1], although these data are useful for other purposes.

- Fisheries-independent data such as scientific survey data are useful for both, the CPUE- and the catch-dynamics approaches to regional stock assessment.

4.1.2 Brazilian, Uruguayan and Argentinian data

Dr. Rodrigo Silvestre presented a characterization of data from Brazil and Dr. Rodrigo Wiff did the same for the data from Uruguay and Argentina.

- Official Brazilian fishing commercial data from trawlers (catch and effort) covers from 2001 to 2006 and is presented in very high resolution (haul-by-haul).
- Brazilian fishing virtually ended in 2006 because of lack of resource, possibly fishing-led depletion.
- Brazilian catches included two squid phenotypes, large mature squid and smaller mature coastal squid.
- Brazil has fishery-independent survey data from 2001 and 2002, including biological composition data.
- Brazilian data already are available.
- Uruguay has official data from 1996 to the present at high resolution (catch and effort, haul-by-haul data, vessel characteristics, and geographical positions).
- Uruguay fishes *I. argentinus* in a zone that a common management regime with Argentina.
- Uruguay does not collect biological composition data from commercial catches but these missing data can be replaced with Argentinian data from the common fishing zone.
- Uruguayan data already are available.
- Argentinian data from jiggers are collected since 2013 at high resolution (trip-by-trip catch and effort). Previous data of a similar nature spanning 1990 to 2012 could be obtained.
- Argentina has large samples of biological composition data from observers on-board jiggers.
- Argentina conducts an annual pre-recruit pre-season survey since the late 90s.
- Argentinian trawlers also capture *I. argentinus* as by-catch (nearly 15% of total catches).
- Argentinian jiggers data already are available but trawlers and survey data are not yet available.

4.2 Day 2

The chairman summarized the main points of presentations and discussions held on the first day of the workshop. Dr. Skeljo presented a characterization of data from the Falkland Islands (Islas Malvinas), while Dr. Li did the same for Chinese data and Drs. Kim and Song presented Republic of Korea data. Dr. Arkhipkin gave a presentation of his article on straddling squids in various fisheries, including *I. argentinus*, and Dr. Wiff presented recent research on how to calculate biological reference points for stocks that are undergoing biomass fluctuations.

- The Falkland Islands (Islas Malvinas) provide fishing licenses to Chinese Taipei and Korean fleets to catch *I. argentinus* inside its Conservation Zone (Figure 6).
- The Falkland Islands (Islas Malvinas) data stored locally include detailed information regarding catch, effort (since 1987), and biological composition (since 1988).
- The Falkland Islands (Islas Malvinas) catch and effort data are reported daily per vessel through logbooks, including geographical positions aggregated in quadrants of 0.5° longitude x 0.25° latitude.
- The Falkland Islands (Islas Malvinas) data available from outside the Falklands Conservation Zone need not be provided to the working group as these data shall come from Argentina and Asian countries.
- The South Korean general approach to fishing for *I. argentinus* and the data that they collect was presented by Drs. Kim and Song, each covering different aspects.
- South Korean flagged fishing vessels operating in the region are jiggers (30) and trawlers (10) and they operate year round (though the season starts in October in one year and ends in September next year).
- The South Korea Overseas Fisheries Association (KOFA) managed the total catch data prior to 2015 while the National Institute of Fisheries Science (NIFS) received detailed catch and effort data from logbooks.

- All South Korean high-seas fishing vessels have been required to report data through the Electronic Reporting System (ERS) to the Fisheries Monitoring Center (FMC) since 2015.
- South Korean jigging and trawling operations in the region are monitored by on-board observers, whom collect fishing as well as biological composition data.
- The Chinese fleet fishing for *I. argentinus* has gone through three phases of development (1998-2012, 2013-2020, 2020-the present).
- Chinese fleets phases are characterized by their number of vessels and by their technological development, with much more advanced techniques in the latest phase.
- Chinese catch and effort data prior to 2020 included weekly aggregated reports containing information such as company name, vessel name, date, latitude, longitude, and catch.
- Chinese catch and effort data since 2020 follows the same format as data submitted to the South Pacific Regional Fisheries Management Organization for the jumbo squid fishery.
- Chinese catch and effort data from 1998 to the present are detailed in nature (aggregated by week or haul-by-haul logbooks), with sufficient resolution for both stock assessment methodological approaches.
- Chinese biological composition data are collected by observers and stored at the Shanghai Ocean University

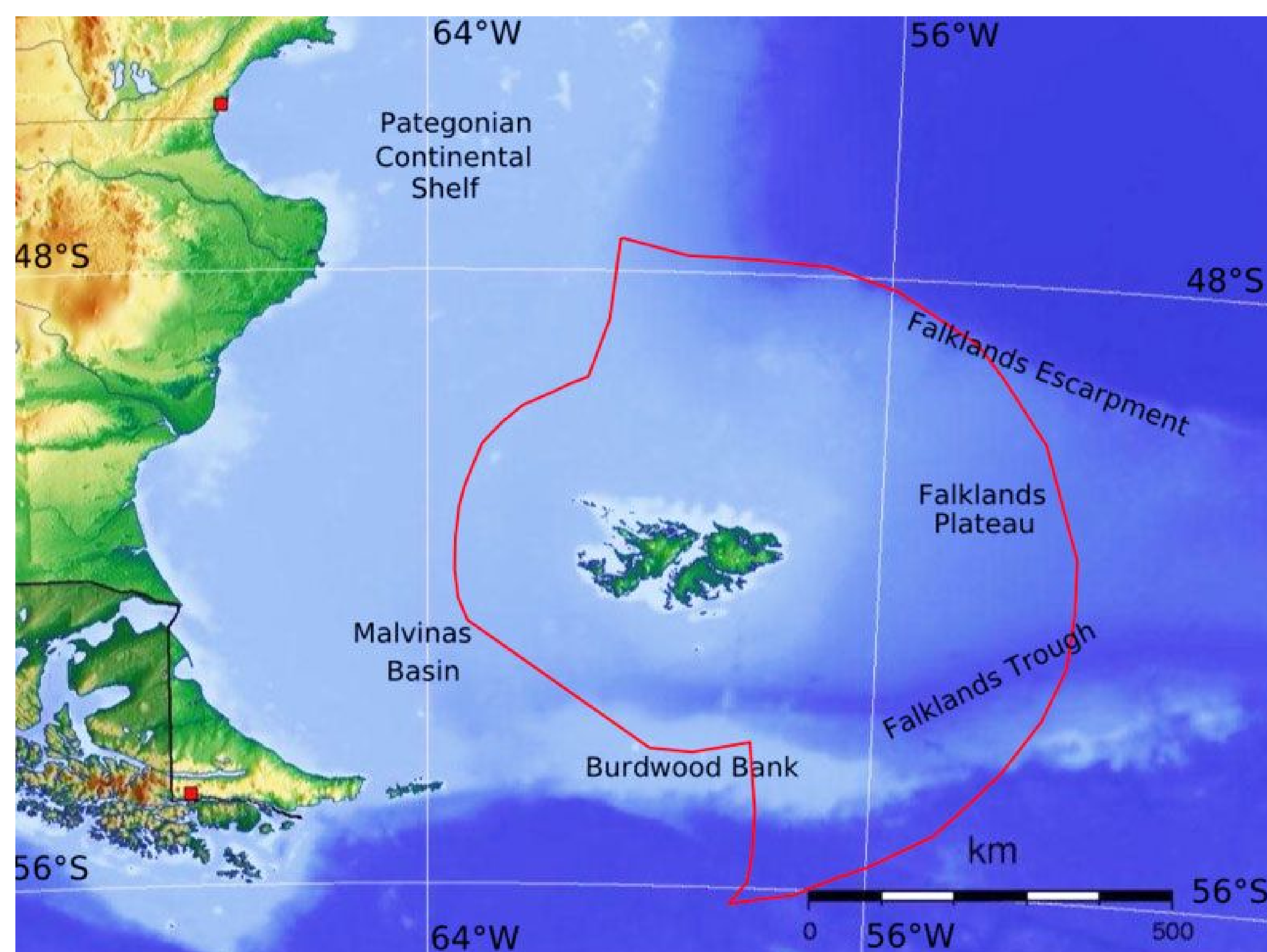


Figure 6: Falkland Islands (Islas Malvinas) conservation zone

Dr. Arkhipkin presented his work based on the recent publication regarding the risks of overfishing faced by straddling squid stocks. Essentially this work covers both the *I. argentinus* in the South-West Atlantic and the jumbo squid fishery in the South-East Pacific, and argues that these stocks have critical phases (Achilles heels) in their life history that make them more vulnerable to fishing. This happening in the context of not having controls over the harvest rates coming from accepted stock assessments, biological reference points, and sustainable harvest rates at the regional level. Dr. Arkhipkin also presented fleet movements from the South-West Atlantic to the South-East Pacific by Asian fleets, as obtained from available positioning data. Currently only the Chinese fleet performs such movements while the South Korean and Chinese Taipei fleets operate on the *I. argentinus* stock in the South-West Atlantic exclusively.

A conceptual model of the spatial functioning of the *I. argentinus* stock presented by Dr. Arkhipkin mostly confirms the model developed during the 1st Workshop in Chile (Figure 3).

Dr. Wiff presented ongoing modeling and methodological work to derive biological reference points for the management of stocks with high intrinsic rate of population growth and regular or irregular fluctuations in biomass. This is relevant to the charter of the working group because cephalopods have high intrinsic rate of population growth on account of their life history, so it is expected that if the *I. argentinus* workshop achieve its goals it will have to resort to those new developments.

So Dr. Wiff presented a new method to build phase diagrams (Kobe plot) for these stocks and its application to some cephalopod stocks, small pelagic fish stocks, and long-lived fish. This methodology was presented as a generalization of the fisheries

phase diagram for the management of stocks with fluctuating dynamic, and it essentially consisted in replacing the biomass that yields the maximum sustainable yield and the fishing mortality rate that when applied yields the maximum sustainable yield for similar concepts but derived from the average latent productivity.

4.3 Day 3

Day 3 was devoted to presentations of scientific topics, to write down conclusions, and to develop plans to conduct a fourth workshop with the aim to conduct stock assessments under both methodological approaches using the newly built regional database.

- Dr. Wang presented results of a stock assessment with Chinese data and the JABBA system for fitting surplus production models. The model was of the Schaefer type and used total annual landings and the raw CPUE of Chinese jiggers as data. This is one of the available two approaches to assess the *I. argentinus* stock and therefore a valuable first try.
- It was recommended that the model be generalized to the Pella-Tomlinson form (shown in the equation above), re-fit with data from all fleets (regional level), standardize the CPUEs, and fit the data with less informative prior distribution in the catchability parameter.
- Dr. Yu presented research into the connection of oceanographic eddies and fishing results related to *I. argentinus* abundance (catch ratio, occurrence probability and occurrence frequency of $CPUE \geq 5$).
- Fishing results connected to *I. argentinus* abundance were further related to three environmental variables to develop a habitat suitability index and provide insights into the results concerning eddies.
- Fishing results were higher in cyclonic eddies, as opposed to anti-cyclonic eddies, as expected from the physics of transport of deeper waters in these eddies. This result was considered very interesting and having potential applicability in environmentally-driven time-varying parameters stock assessment models.
- Fishing results were also higher for colder waters and waters with higher concentration of Chl-a.
- The overall conclusion was that cyclonic eddies, cold waters, and high Chl-a enhance variables that lead to higher fishing results related to *I. argentinus* abundance. The implication was that most of these fishing results reflected actual squid abundance.
- Dr. Ko presented recently published research on environmental correlates of squid fishing results by the Taiwanese fleet connected to abundance (catch) and the diet of squid from stomach content analysis.
- The environmental data involved the application of species distribution models in order to predict potential impacts of climate change on squid catches.
- Predictions included slightly increasing squid annual abundance but fewer high-abundance opportunities by the year 2100 due to changes in the Atlantic Symmetric Pattern.
- Nevertheless expected trends in sea surface temperature may offset the modeled gains due to the Atlantic Symmetric Pattern.
- The most important item in the diet of *I. argentinus* was crustaceans but with proportion of occurrence of fish and cephalopods increasing in larger squid.

After scientific presentations, the working group debated two main issues: (a) how to proceed with the building of the database and (b) where to meet for a continuation of work until achievement of the main goal.

In connection with the first issue, there were two positions. The first one dates back to the first workshop and proposed that the database would be kept in safe custody by independent experts, namely the chairman and the co-chairman. The second position proposed that the database be shared by all parties of the workshops after signing of a carefully prepared non-disclosure agreement. The predominant view of the working group was that the database shall be assembled by the chairmanship and once assembled it shall be shared with all parties, bound by a non-disclosure agreement.

In connection with the second issue, the working group agreed to seek funding and meet again after one year of separate work to conduct stock assessments with the newly built database. In the interim, the working group also agreed to meet online if necessary. It was brought to the attention of all participants that there is new meeting of the Cephalopod International Advisory Council (CEAC) in Okinawa, Japan, between October 25th and November 1st, 2025, and it would be a good idea to have the fourth workshop as a side event of the CEAC meeting, in order to bring visibility and exposure to the work that has been completed. The working group agreed with this

proposal and committed to procure the funding and re-convene at the chosen time and location. The chairman and co-chairman would initiate contacts with CEAC's organizers, Ryuta Nakajima and Dan Rokhsar, to formally attach our workshops to the CEAC meeting, to be hosted by the Okinawa Institute of Science and Technology.

5. Conclusions

1. After characterization of the data collected from all major fleets and countries participating in the *I. argentinus*, the most important conclusion was that it is feasible to conduct a data-intermediate regional stock assessment (for a definition of data-poor, data-intermediate, and data-rich, see Roa-Ureta et al. [8].).
2. This data-intermediate regional stock assessment could take any of two approaches that have been widely used in fishery science and would include the following data along a time series that may extend for many years:
 - (a) Monthly total catch by fleet and/or country.
 - (b) Monthly total fishing effort by fleet and/or country.
 - (c) Monthly mean weight or mean length of squids in the catch by fleet and/or country.
 - (d) Annual surveys inside the Argentinian jurisdictional waters.
 - (e) A few early surveys conducted in Argentinian jurisdictional waters.
 - (f) Co-variables connected to environmental conditions, with special consideration of eddies.
3. The most important fleet/gear is jiggers in all countries fleets but trawlers have substantial activity in several countries fleets. Therefore the database format will be expanded to include this second fleet in some countries fleets.
4. Chairman and co-chairman will prepare a report of the 3rd workshop and include a formal request of data to the authorities of each country. Work will continue through electronic communication means.
5. The formal request will include provisions for securing the data including the signing of a non-disclosure agreement by all members of the working group.
6. The working group agreed that in the case of successful building of the regional database, the fourth workshop will be carried out in Okinawa, Japan, as a side event to the Cephalopod International Advisory Council 2025 conference.

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