Development Culture Technology of *Seriola lalandi* (VALENCIENNES, 1833) in Argentina.

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INIDEP ARGENTINA

THIS HIGHLY QUALIFIED PRODUCT VALIDATED BY THE CHEFS !!!!

¿Why Yellowtail kingfish, *Seriola lalandi*?

- Because it is a highly validated product by international chefs, for its flavor, texture, firmness of its flesh and culinary versatility.
- It is a trackable quality product it allows to follow, from the finished products and the processes up to the origins.
- It can be cultivated on land with recirculating aquaculture systems (RAS) at densities of 40 to 80 kg/m3.
- Producing is sustainable with 100% renewable energy.
- friendly to the environment, free of antibiotics and hormones.
- The RAS farming allows to be located near the consumer's centers.
- Its environmental footprint is reduced,
- Guarantees the availability of fresh fish daily, 365 days a year.

This is presented in a **" backward-looking" simulating tracking the product,** the report of development of *S. lalandi* culture technology.

Materials and methods used:

- Planning, organization and logistics for the capture of live specimens.
- Breeding stock formation.
- Adjustment of photoperiod to induce natural spawning. .
- Larviculture, following specific protocols.
- Large-scale feed formulation and production.
- Grow-out in RAS systems.

Figure 2 .Large-scale feed production

***FRESH FISH** ALL YEAR ROUND, WE GROW IT NEARBY*

SEA FARMING STATION

The INIDEP Sea Farming Station Program successfully completed the biological cycle of the *Seriola lalandi* for the first time in Argentina.

- Culture in land-based, with RAS system, which resulted in 3 kg specimens and final average conversion factor of 1.4. (Table and Figure 1).
- The qualified staff has over 10 years specialized experience in the field, having been trained by Japanese, Chinese and Korean experts in several aquaculture centers and universities in those countries.
- The Sea Farming Station has an estimated surface of 1,500 m^2 and is equipped with several 25 m^3 RAS tanks for marine fish culture, environmentally friendly and sustainable technology.

GROWING FISH

- We have grown 1100 specimens that were supervised, selected and fattened to 3 kg in a little more than 2 years, (Table and Figure 1).
- Under feeding protocols, in optimal culture conditions.
- This feed was formulated by the research team and CENADAC and produced by PACÚ TEKO specially for this target species. Spinedi & Menguez, 2017 (Figure 2).

Table 1 Growth parameters during fattening of Seriola lalandi. SD: standard deviation. N: number of individuals. SGR: standard growth rate. CF: conversion factor.

Date	Days	Average weight (g)	Average length (cm)	N	SGR (%/day)	CF	Survival (%)
27/1/2017	0	7,15±1,6	8,4±0,7	1100	-	0,7	100
14/2/2017	18	13,25±2,7	10,8±0,7	1100	3,4	0,9	100
14/3/2017	46	42,51±8,5	15,8±0,9	1100	4,2	1,1	100
26/4/2017	58	58,54±13,7	17,8±1,5	1100	2,7	1	100
8/5/2017	101	125,64±29,2	23,7±1,5	1100	1,8	1,4	100
7/8/2017	192	354,27±68,3	32,3±2,2	519	1,1	1,5	47,2
6/9/2017	222	469,3±55,6	35,4±1,2	390	0,9	1,8	100
21/12/2017	328	1282,5±176,7	49,8±2,6	135	0,9	1,7	100
7/3/2018	405	1915,15±216,8	57,6±2,2	44	0,7	1,9	100
2/4/2019	795	3081,30±628,6	68,7±4,2	44	0,4	1,9	100
Average					1,8	1,4	

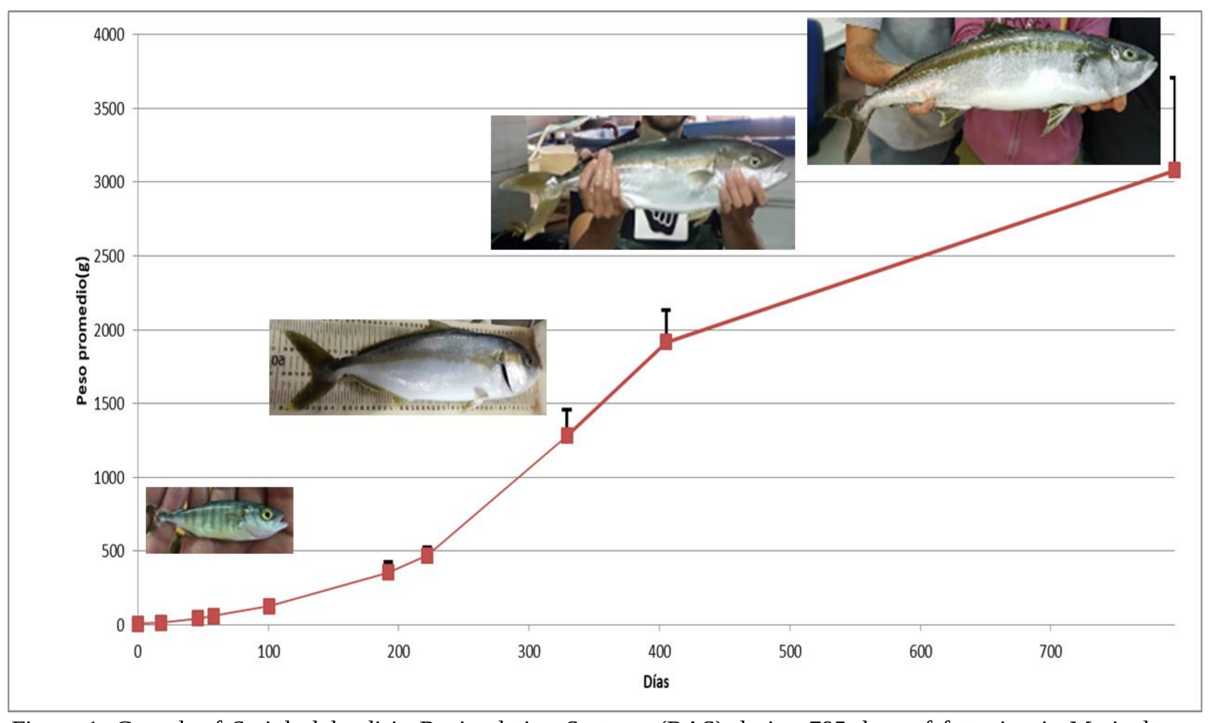

Figure 1. Growth of Seriola lalandi in Recirculation Systems (RAS) during 795 days of fattening in Mariculture Station, INIDEP.

***HEALTHY FISH** (without antibiotics or hormones).*

FINGERLING PRODUCTION

Out of 50,000 eggs produced during the spawning season (Table 2), we selected one spawning to produce yellowtail. Following marine fish farming guidelines (Avilés & Castelló, 2004).

- The staff of this project monitored:
  - Stages of fish development, management of photoperiod and lighting intensity.
  - Feeding with microalgae, artemia rotifers and copepods until "weaning", continuing with stater feed.
  - Embryology and larval development was closely observed and documented (TablaSymonds *et al*., 2014 (Figure 3 and 4).
- 50 days in the rearing tanks, 1561 juveniles were produced, with a survival rate of 7%.

THE NURSERY, taking care of your development!!!

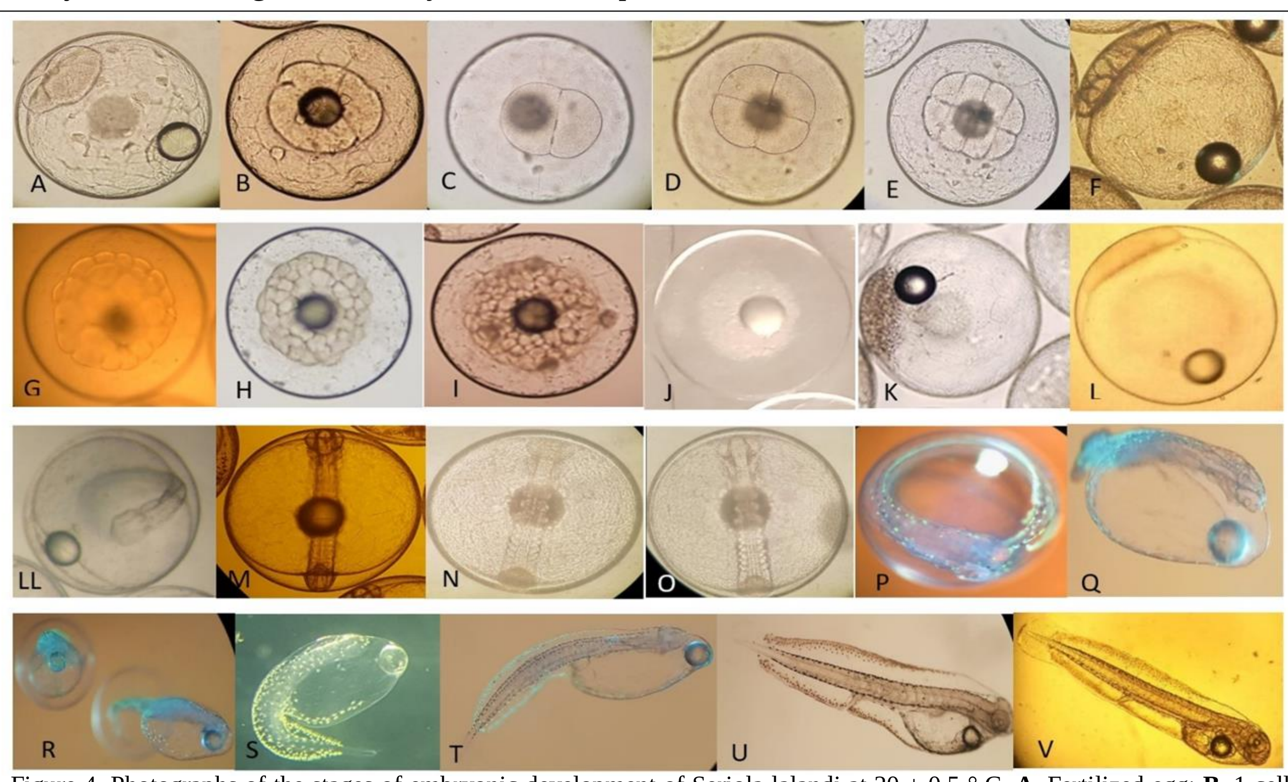

Figure 4. Photographs of the stages of embryonic development of Seriola lalandi at 20 ± 0.5 ° C. **A**, Fertilized egg; **B**, 1 cell (40 min); **C**, 2 cells (1 h 12 min); **D**, 4 cells (1 h 46 min); **E**, 8 cells (2 h. 25 min); **F**, 8 cell view animal pole (2 h. 52 min); **G**, 16 cells (3 h. 48 min); **H**, 32 cells (4 h. 04 min); **I**, 64 cells (4 h. 04 min); **J** Mórula (6 h. 46 min); **K**, Blastula (11 h. 25 min); L, Early Gauge (22 h. 20 min); **LL**, embryo in formation (24 h. 02 min); **M**, Appearance of Kupffer's vesicle and sooths, 10-11 (27 h. 02 min); **N** formation of auditory vesicles and ocular lens, somitos 13-14 (33 h. 53 min); **O**, Melanophores on the body of the embryo, sototths 18-21; **P**, Heartbeat, sooths 28-30 (63 h. 06 min); **Q**, Larva about to hatch (67 h. 53 min); **R-S-T**, Hatching of the pre-larva, marked development of pigmentation (71 h. 22 min); **U-V**, pre-larva.

Figure 3. Morphological development of *Seriola lalandi* larvae and juveniles at 20 ± 0.5 ° C. **A**, just hatched pre larva, 4.22 ± 0.03 mm total length (LT); **B**, 1 day after hatching (dpe), 4.75 ± 0.19 mm LT; **C**, 2 dpe, 4.98 ± 0.09 mm LT; **D**, 3 dpe, 5.28 ± 0.21 mm LT; **E**, Post larvae 10 dpe, 5.76 ± 0.19 mm LT; **F**, 15 dpe, at 7.06 ± 0.39 mm LT; **G**, 17 dpe, 7.74 ± 0.8 mm LT; H, 24 DPE, 9.79 ± 0.66 mm LT; **I**, 35 DPE, 23,. 38 ± 1.43 mm LT; **J**, 39 dpe, 48.67 ± 7.58 mm LT; **K**, 43 dpe, 256.42.44 mm LT; **L**, Juvenile 47 dpe, at 38.67 ± 5.65 mm LT; **LL**, 87 dpe, 236.11 mm LT.

*THOSE RESPONSIBLE FOR ITS **QUALITY***

BROODSTOCK

- Quarantine and acclimatization for 40 days, following disease control protocols.
- Stock management and sampling for sexing, morphometric data and electronic tagging for identification and tracking(Table 3).
- Constitution of stock with 29 wild breeders.
- Controlling of thermo-photoperiod to stimulate natural spawning (Figure 5).
- Feeding protocols with fish, previously frozen and wet pellet 3 months before to spawning season.

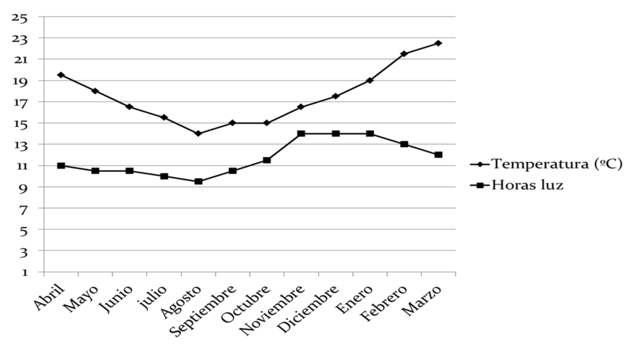

Figure 5. Management of thermo-photoperiod

Table 2. Number of total eggs (ET), number of viable eggs (EV), percentage of viable eggs (EV), fertilization rate (TF), average diameter of eggs (DE + ds) and average diameter of oil drop (DO + ds), corresponding to the first reproduction of Seriola lalandi in the Mariculture Station, INIDEP.

Nº	DATE	ET	EV	EV	TF (%)	DE (mm)		DO (mm)	
1	15/11/2016	55.800	53.300	96	98	1,403	± 0,01	0,324	± 0,05
2	20/11/2016	44.841	43.900	98	99	1,402	±0,01	0,320	± 0,07
3	23/11/2016	386.100	350.400	91	100	1,392	± 0,1	0.331	± 0,04
4	25/11/2016	490.200	460.200	94	99	1,405	± 0,01	0,331	± 0,06
5	29/11/2016	302.700	285.600	94	98	1,420	± 0,01	0,340	± 0,04
6	04/12/2016	600.300	560.400	93	100	1,380	± 0,01	0,329	± 0,05
7	11/12/2016	380.400	310.500	82	99	1,388	± 0,01	0,336	± 0,05
8	15/12/2016	305.000	285.800	94	100	1,389	± 0,01	0,329	± 0,06
9	17/12/2016	434.000	82.200	19	98	1,394	± 0,01	0,333	± 0,03
10	18/12/2016	360.600	320.900	89	99	1,414	± 0,02	0,329	± 0,02
11	21/12/2016	240.900	230.800	96	99	1,390	± 0,01	0,333	± 0,03
12	26/12/2016	390.700	365.800	94	99	1,401	± 0,07	0,341	± 0,01
13	29/12/2016	603.900	542.400	90	100	1,393	± 0,01	0,328	± 0,04
14	31/12/2016	700.100	670.600	96	99	1,369	± 0,02	0,326	± 0,07
15	06/01/2017	610,200	556.900	91	99	1,322	± 0,03	0,321	± 0,08
	TOTAL	5.905.700	5.120.000						
	AVERAGE	393.713	341.333	88	99,07	1,391	± 0,16	0,330	± 0,047

NATIVE SPECIES OF ARGENTINA

WILD-CAUGHT YELLOW TAIL KINGFISH BROODSTOCK

The catches of *Seriola lalandi* were made on shallow rocky banks off the coast of the city of Mar del Plata (Figure 6 and Table 7).

Two fishing methods were used to catch the specimens, as follows:

- "**trolling**": a fishing modality that was carried out with the yacht at a speed of 6-7 knots constant, employing three rods with Rapala x-rap Magnun 30 lures, cast at 30, 60 and 100 m distance allowing them to reach different depths.
- "**jigging**": Fishing modality that started with the detection of a characteristic mark of *S. lalandi* on the echo sounder, and proceeded to fish with front reels, 30 lb rods and lures called "jigs" that were held vertically with the boat drifting.

Table 3. Morphometric data and sex of the Seriola lalandi breeding staff formed in April 2016. ID: Identification by electronic chip; LT: total length; LF: long furca; LS: standard length. F: female. M: male. ND: not determined. DE— Standard offset.

Nº de Specimens	ID Number	weight (kg)	LT (cm)	LF (cm)	LS (cm)	Sex
1	3966	3,5	76,5	65,0	62,0	M
2	1643	6,5	94,5	83,0	78,0	F
3	1147	6,2	93,5	84,0	80,0	N/D
4	7723	4,3	82,5	72,5	69,0	M
5	577A	2,4	65,5	58,0	45,0	M
6	5170	5,4	91,0	81,0	77,0	M
7	2F32	4,6	80,5	71,0	64,0	M
8	3855	3,9	76,0	67,0	63,0	F
9	1B4F	11,8	116,0	105,0	95,0	N/D
10	19GE	3,6	77,0	68,0	63,0	F
11	0502	3,6	77,0	69,0	62,0	N/D
12	6E07	4,3	78,0	70,0	63,0	F
13	1B7C	5,3	91,0	80,0	75,5	M
14	1E40	3,7	76,5	68,0	61,0	F
15	3724	3,6	77,5	67,0	60,0	M
16	3643	4,5	77,0	69,0	62,0	M
17	7D79	4,1	78,0	70,0	63,0	M
18	2805	4,1	79,5	71,0	64,0	M
19	7550	6,8	99,0	89,0	80,0	M
20	5418	3,8	77,5	69,0	62,5	N/D
21	1237	5,1	87,5	77,0	70,0	N/D
22	7224	4,5	81,0	72,0	65,0	N/D
23	6852	3,1	62,5	55,0	49,5	F
24	7430	2,9	69,5	61,0	54,0	M
25	793F	4,1	75,0	67,0	60,0	N/D
26	5272	4,0	80,0	71,0	64,0	F
27	6F51	3,5	74,0	65,0	58,0	M
28	4B21	4,8	84,0	74,5	67,0	N/D
29	2C02	4,1	80,0	71,0	64,0	M
	Average	**4,6**	**81,3**	**72,1**	**65,5**	
	DE	1,7	10,5	9,8	9,9	

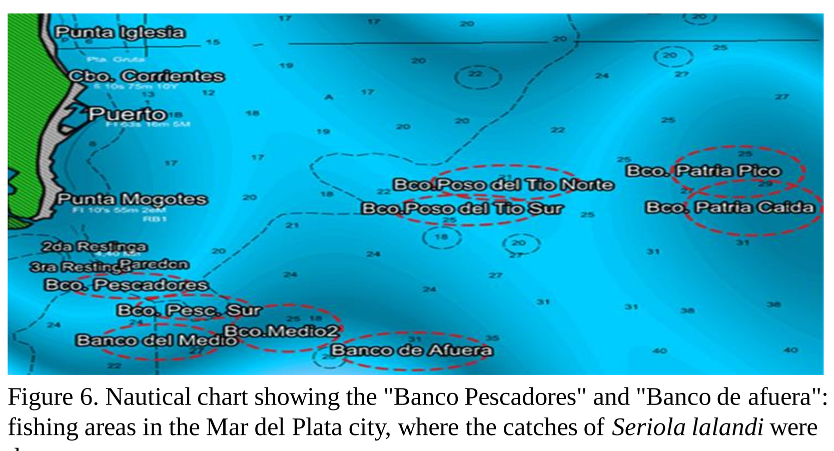

Figure 6. Nautical chart showing the "Banco Pescadores" and "Banco de afuera": fishing areas in the Mar del Plata city, where the catches of *Seriola lalandi* were done.

Table 7: Capture of *Seriola lalandi* breeders.

FISHING SPOTS	SPECIMENS CAPTURED
Banco Afuera	6
Banco El Levante	16
Banco Patria	2
Banco Pescadores	6

CONCLUSIONS

Demand for "premium" seafood in developed countries is increasing significantly every year. The farmed yellowtail is the most valued product in the world behind wild tuna. In Argentina, 10,000 tons/year of salmon is imported from Chile with wholesale prices of 6.5/8 U$D HOG (head on gutted, with head, eviscerated). *S. lalandi* show market prices in Europe of 14/17 U$D HOG (head on gutted). The juvenile price for fattening purposes of 1 g is 2.95 U$D (Cobo, 2019). Theses species experience a demand in the international market, with counter prices of 34 U$D in the "whole fish" presentation and 60 euros in the "fillet" presentation. *S. lalandi* shows an excellent adaptation to RAS production systems and can be grown at high densities of 40-80kg/m3. Its growth is 0-3 kg in one year with a feed conversion factor (FCR) of 1.6 (Blanco et al., 2011; Kamstra and Kloet, 2013; Stuart and Drawbridge, 2013) and is considered as "best choice" according to "Seafood Watch program Reports 2020" of The Monterey Bay committee.

Farming technology transference to the private sector of seafood products at commercial scale is an outstanding issue in Argentina.

Among the species that INIDEP has closed the aquaculture rearing cycle, the yellowtail kingfish *Seriola lalandi* is the one with the best biological, commercial and culture features for its production on a commercial scale in Argentina.

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MONTEREY BAY AQUARIUM SEAFOOD WATCH PROGRAM, 2020. Our recommendations help you choose seafood that's fished or farmed in ways that have less impact on the environment.https://www.seafoodwatch.org/seafoodrecommendations/groups/amberjack?q=seriola%20lalandi&t=seriola%20lalandi&type=farmed&method=farmed

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