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YELLOWTAIL KINGFISH

– A QUEST FOR NEW AQUACULTURE SPECIES IN CHILE

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ACUINOR hatchery.

Yellowtail kingfish (*Seriola lalandi*) are found in temperate waters of the Pacific and Indian oceans, off South Africa, Japan, Australia, Chile and the USA. This is one of several Seriola species currently cultured in different development stages around the world.

*By Sagiv Kolkovski and Juan Lacámara**

In Japan, there are three species cultured: *S. lalandi* (called *hiramasa* in Japanese), *S. quinqueradiata* (*hamachi* and *buri* for the young and adult stages, respectively) and *S. dumerili* (*kanpachi*).

The species cultured in Australia and New Zealand is known as *Seriola lalandi lalandi* and it's similar to the one found in Chilean waters. Another notable species of interest as an aquaculture candidate is the warm water species *Seriola rivoliana* that is currently grown in Mexico, Canary Islands and Hawaii.

Japan is the largest producer of *Seriola*, with a total annual production of around 160,000 tons, mainly of *S. quinqueradiata*, followed by *S. dumerili*. *S. lalandi* comprises of only a small percentage of the total production. However, market value is higher for *S. dumerili* and *S. lalandi* than *S. quinqueradiata*.

In recent years, *S. dumerili* has gained significant interest in the Mediterranean. Spain, Greece, Italy, Croatia and Turkey currently have R&D programs to develop this species culture. Malta already has a small commercial production (estimated at 500 tons). Saudi Arabia's National Prawn Company is currently developing the commercial production of this species and plans to produce about 30,000 tons a year.


Adult yellowtail kingfish.

ACUINOR

Seriola lalandi can be found in waters of North Chile. This species is similar to the one found in Australia, as well as the Californian yellowtail. However, although the aquaculture industry in Chile is developed and is considered to be one of the largest in the world, not many attempts were made to culture this species.

In 2008, a new initiative was developed by a private company – Acuícola del Norte (*ACUINOR*). The company's vision is very innovative since the Chilean marine fish aquaculture is solely concentrated on salmon and trout.

The hatchery location was chosen in one of the driest and harshest environments in the world, the Atacama Desert, where the ocean water temperatures allow the rearing of *Seriola*. The hatchery is located near Caldera (900 km north of Santiago). While it's quite isolated, this ensures complete biosecurity coupled with access to airports and major facilities.

The company's goal is to establish the yellowtail kingfish aquaculture in Chile through a vertical development, which includes hatchery, nursery, and growout in land-based recirculating systems.

Initially, the hatchery including the larvae and juveniles tanks, live feed systems and the recirculating systems were built according to marine hatchery specifications. However, developers found that this standard design wasn't optimal for yellowtail. Therefore, during the past four years, most of the systems have been modified in order to be as effective and efficient as possible for this demanding species. This was done with the help of the Corporation for the Development of Production (CORFO) and in collaboration with Dr Sagiv Kolkovski from *Nutrakol*, Australia.

Currently, *ACUINOR* is the only company in the world that can supply *S. lalandi* eggs, larvae, juveniles and market size fish year round, exporting most of these to Europe, Asia and USA.

Broodstock

Seriola lalandi spawns naturally in tanks after conditioning under controlled photoperiod and/or temperature. Unlike many of the *Seriola* species (i.e. *dumerili*), broodstock are relatively easy to manipulate and don't require any hormonal induction. Spawning may be triggered or inhibited by temperature change. Spawning can be triggered by increasing the water temperature after a period of 'winterizing' (16-18°C). Fish can reach maturation after 13 months but will reach full maturation after 2-3 years, and they need another two years to reach their maximum fecundity with good quality eggs.

Like most *Seriola* species, for optimal spawning conditions, *S. lalandi* requires large volume tanks (60-150/m^3) with low biomass (<5 kg/m^3). The need for large tanks and facilities prevents many companies and R&D centers from having more than one broodstock tank.

Currently, *ACUINOR* is the only company in the world that can supply yellowtail kingfish eggs and larvae year round. The company has four independent broodstock rooms, each contains one 85/m^3 tank and an independent recirculating system that hosts both wild and F1 fish. The room's water temperature and photoperiod are designed to cover year round, so spawning season differs from room to room by 3 months.

The egg and larvae quality in each room, regardless if it is the natural spawning season or the 'off-season', is similar, with average fertilization rates of 98% and 95% hatching.

To achieve these results, a specific nutritional program was developed

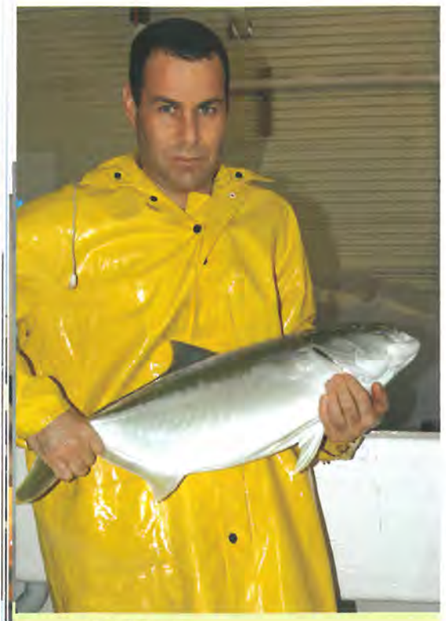

Yellowtail kingfish juvenile.

by Dr Kolkovski, combining fresh diets (pilchards and mackerels) and semi-moist diets that include premium fishmeal and oil. Nutritional additives developed specifically for *S. lalandi* (Nutrabrood, *Nutrakol*) are added to the feed at different levels according to the fish spawning program and include essential nutrients such as Highly unsaturated fatty acids (HUFA's) at specific levels and ratios, vitamins, immunostimulants, carotenoids, etc. Herbal extracts*, which act as hormonal boosters and modulators, are also added before and during the spawning season to support and improve the gonadal development and quality.

Eggs are collected and transferred to independent hatching rooms; they are incubated in specially designed hatching tanks with up-welling water current to ensure no eggs will sink to the bottom (*Seriola sp.* eggs tend to do so just before hatching).

The hatched larvae are counted and transferred to the larvae tanks or packed and shipped to customers around the world. Newly hatched larvae can be safely transferred over a period of 48 hours without any mortality.

Adult yellowtail kingfish.



Sagiv Kolkovski.

Larvae rearing

Seriola spp. larvae exhibit fast growth compared to other marine species grown in aquaculture. Hence the need for specific rearing protocols as well as different nutritional additives for live feeds in order to support their fast growth rate requirements. Eggs and first feeding larvae are relatively large at 1.1 mm diameter and 4.5 mm, respectively. The rearing protocol includes enriched rotifers *Brachionus plicatilis* (large strain) for first feeding (10-20 rotifers/ml^{-1}) and enriched *Artemia* for days 12-25 after hatching (DAH). Weaning on to a microdiet can commence at 20 DAH and can be administered as early as 15 DAH.

Assisted by CORFO, optimizing the larvae rearing protocols and the environment was the main focus of *ACUINOR* for the past four years. More recently, through a specific innovative support line entitled PROTOTIPOS DE INNOVACIÓN EMPRESARIAL (prototypes for business innovation) and with the collaboration of several research centers and universities in Chile (Universidad de Chile) and overseas (*Nutrakol*, Australia), major efforts were conducted to optimize the nutrition and pathogen resistance of larvae.

Larvae nutrition

It's been demonstrated that *Seriola sp.* larvae has higher requirements and different ratios for n-3 HUFA including DHA and EPA in the diet. DHA is accumulated into the central nervous system of the larvae, and it is essential not only for fish activity and quality but also for the development of schooling behavior in the juvenile stage. These fatty acids are added to live feeds such as rotifers and *Artemia*.

As part of the CORFO project, 'tailor-made' live feed enrichments specifically made for *S. lalandi* were tested*. These enrichments support not only the nutritional requirements of the larvae, but also boost the immune system through supplementing immune stimulants, promoting a better growth and survival of larvae during the live feed stages. Using these 'tailor-made' enrichments also increased the live feed cleanliness compared to other powdered commercial products.

Juan Lacámara.

Yellowtail kingfish juveniles.

Researchers reported high mortalities during and after metamorphosis with Pacific yellowtail (*S. lalandi* formally known as *S. mazatlana*). It was found that yellowtail kingfish larvae are susceptible to bacterial infections, which, in many cases, are transferred through the live feed organisms. A new additive, based solely on herbal extracts and aimed at reducing the bacteria in live feeds while boosting and supporting the larvae immune system was also tested*; it's now incorporated as a standard additive during the live feed phase. Aside from its bactericidal effect, the additive increases larval stress resistance; this is extremely important during the transition periods between feeds i.e. rotifers to *Artemia* and then weaning stages.

Environmental conditions

Stabilized larvae tank environmental conditions received particular attention. At early stages *Seriola* larvae are phototaxis-positive and required relatively high light intensity (1,000-10,000 Lux). However at ~20 DAH, larvae preference changed to a lower intensity (100 Lux). *ACUINOR*'s light and photoperiod protocols follow these patterns: during the morning, green algae are pumped to the tank to create a 'green water' environment. Following that, lights are dimmed up, imitating sunrise and preventing light shock by sudden light. This is an essential procedure since *Seriola* larvae and juveniles are extremely sensitive to sudden bright light. Similar patterns are used during the evening, when light is turned off gradually.

Fresh green algae (*Tetraselmis and Nannochloropsis* ssp) are grown in the hatchery and continuously pumped to the larvae tank during the day. Low rate continuous pumping was chosen over manually supplying to prevent any 'chain-saw' changes (ups and downs in algae concentration). The algae are pumped by using peristaltic pumps into the water inlet to the tank bottom, thus creating an optimal mixing in the tank.

System development

In order to optimize the rearing environment, new larvae tanks and filtration systems were installed. The standard tanks (ranging between 3-20m^3) generally used at *ACUINOR* and in any other hatchery around the world required a significant amount of time and manpower for maintenance. When using a brush siphon, it takes 30-45 minutes to vacuum 20m^3. Moreover, siphoning the tank bottom also resulted in siphoning larvae which usually caused high mortalities due to stress.

Therefore, Dr Kolkovski and Oceans Design (USA) developed a new tank design with automatic self-cleaning arms that rotate at low speed (1 round/hour). The larval tank design includes a flat bottom with a gutter from the tank wall to the center (radius). The cleaning arm is made of stainless-steel with a soft brush that moves around the tank collecting the debris and organic matter from the bottom. When crossing the gutter the waste is dropped into it, leaving the brush clean. A valve at the end of the gutter allows partial removal of the waste. Complete waste removal is done daily by siphoning the gutter, which takes 2-3 minutes. The self-cleaning tanks (*NutraKol / Oceans Design*) reduced the accumulation of

Self cleaning tank with arm and outlet filters.

organic matter in the tank to almost nothing, which resulted in a significant reduction in bacterial counts. This in turn increases the larvae survival due to the yellowtail behavior (during the night, larvae sink to the bottom of the tank where they can find organic accumulations and bacteria. Having the bottom continuously cleaned significantly reduced the bottom bacteria infection. The cleaning arm motor is placed over the center of the tank on heavy-duty aluminum beams and is splash proof, thus eliminating any risk of electrocution.

ACUINOR is the first hatchery in the world that uses these tanks. This reduced the labor requirements during the larvae culture. Currently, the company is running a full trial with self-cleaning tanks and regular tanks, comparing larvae survival and growth as well as environmental parameters.

Outlet filters

One of the main issues with larvae tanks is the need to keep the water surface completely clean of debris and oil. This is extremely important during the early stages when larvae inflate their swim bladder. Oil increases the water surface tension, which prevents the larvae from 'breaking' the surface to gulp air. Debris on the surface also increases the bacterial infection when larvae are trying to inflate their swim bladder.

Outlet filter.

Yellowtail kingfish are susceptible to these issues and in many cases swim bladder inflation rates can be low, resulting in high deformities (sometimes up to 40% of larvae batches). To prevent and/or reduce this issue, protein skimmers are usually installed to concentrate oils and debris. These devices require daily cleaning by soaking the oils with paper towels; besides, skimmers only remove oils partially and, in fact, they could create an area with high bacteria loads.

To solve this problem, an outlet box filter was developed by Dr Kolkovski that eliminates the use of skimmer, keeping the water surface pristine at any time while making filter screens replacement a few-seconds job (compared to traditional outlet filters). The filter is made of ultra-light plastic sheets and is shaped as an inverted trapezoid. An airline at the bottom of the filter box creates fine air bubbles. Since the screens are angled out, bubbles are forced to 'brush' the screen surface, cleaning it from debris and preventing any blockage. The screen is located in a specific slot and can be changed simply by inserting a new screen in the second slot and pulling the dirty screen out, thus preventing larvae from escaping. Due to the large surface area and the double-side screens, the filter box acts as a skimmer, removing the oil from the surface.

Larvae tanks have an up-welling water inlet, which pumps the algae with the incoming water that enters the tank at the center already containing microalgae for green water.

Future R&D

The survival rates of *Seriola* larvae are usually low at 10-15%. However, with the on-going improvements and optimization *ACUINOR* applied to the larvae rearing protocols and systems, the company is aiming at reaching a survival of 20% in the near future. Survival is only one of the factors the company looks at. Deformities are a major issue with all the *Seriola*

Screen changing in outlet filter.

sp. With the recent improvements in nutrition and systems, *ACUINOR* is aiming at reducing the deformities occurrence, which is already low, to less than 1%.

Fully automated micro-diet feeders will be installed in the near future, which will optimize the feeding regime and the tank hygiene.

There is a need to dedicate further research time to weaning diets and improvements in growout diets. Although there are several feed mills in Chile supplying feeds to the salmon aquaculture industry, no company is producing yellowtail kingfish growout diets (which are different than salmon diets). Therefore, collaboration between the company *NutraKol* (Australia), the University of Temuco and *ACUINOR* is currently discussed in order to develop and produce these diets.

ACUINOR long term research includes genetic improvements to their broodstock. The first stage, done by the University of Chile, which looked at the current genetic health of the broodstock groups, concluded that the genetic pool is extremely wide. A genetic program is now being developed to further improve the future broodstock to keep optimal progeny.

Sagiv Kolkovski, PhD, has collaborated with several marine finfish projects all over the world. Currently he's the R&D Manager of NutraKol, Australia.
Juan Lacámara, MBA, is an entrepreneur and the Director of ACUINOR.
* All products mentioned have been developed by Nutrakol. For more information, contact Dr. Kolkovski: nutrakol@iinet.net.au