

UC San Diego

Research Final Reports

Title

Development of a Recirculation System and Diet for the Culture of California Halibut
(Paralichthys californicus)

Permalink

<https://escholarship.org/uc/item/5mk942k6>

Authors

Piedrahita, Raul H.
Conklin, Douglas E.

Publication Date

2004-04-01

Final Report**Raul H. Piedrahita, Douglas E. Conklin, UC Davis****3/1/2001–2/29/2004****Project R/A-116: Development of a Recirculation System and Diet for the Culture of California Halibut (*Paralichthys californicus*)**

The major goal of the project was the development of recirculation systems and diets for the California halibut (*Paralichthys californicus*). Specific objectives included the determination of bioengineering design parameters (rates of oxygen consumption and ammonia and urea production in tank culture), the characterization of major nutrient requirements and the development of a suitable practical diet; and the design and testing of a prototype recirculation system for the commercial culture of California halibut.

Although not included as an original objective in the proposal, unforeseen circumstances resulted in the establishment of a small recirculation hatchery on the UC Davis campus to rear fish from the egg stage. This system has a total volume of approximately 3.5 m³ and consists of four raceways (2.4 m long, 22 cm wide with a water depth up to 22 cm), a reservoir, a moving bed biological water treatment unit, a constant head tank, a pump, and an alarm and backup system. Temperature can be regulated with a combination heater/chiller unit. Various other rearing units can be added to the system for carrying out specific experiments. A similar system for larger juveniles is located at the Bodega Marine Laboratory (BML). The primary differences between the BML and UC Davis campus systems are that circular tanks are used instead of raceways and that the BML system is operated in a semi-recirculation mode with a constant input of fresh seawater due to the availability of piped seawater at the laboratory. However, the BML

system can also be operated in a closed recirculation mode if the laboratory seawater supply is interrupted.

The hatchery has been used to rear larvae and weaned juveniles successfully and to carry out a number of experiments to determine metabolic rates of juveniles as affected by a number of cultural practices such as biomass density and water velocity, and the impact of a number of environmental conditions on the fish (e.g. salinity).

California halibut eggs are sensitive to handling stress immediately after fertilization (between 3 and 17 hours post fertilization). Consequently, the fertilized eggs should be harvested, rinsed, and transferred to an incubator as soon as possible after fertilization. Further manipulation or shipment of the eggs should be delayed until the eggs have reached an advanced stage of development, around 36-48 h after fertilization. Fertilized eggs and larvae have been shipped successfully from the Redondo Beach hatchery to the UC Davis facilities following these guidelines.

Early morphological development of the larvae has been characterized. It has been found that larval growth is retarded with any delay in first feeding but the point of no return does not occur until between 6 and 8 days post hatch (dph) at 18°C.

The development of a green-water technique during the larval rearing of the halibut allowed an increase in juvenile production. Larval survival from 3 to 28dph exhibited a ten-fold increase (from 5 to 50%) when the green water technique was compared to the original protocol. Additionally the post-metamorphic (35 dph) standard length was significantly higher when the algae were present in the rearing tanks.

In order to further improve the larval rearing techniques and develop a hatchery protocol, the weaning success at different dates has been evaluated. The results show that a significant growth and survival can be obtained when the post-metamorphic larvae are weaned after 36 dph using a commercially available microdiet. The characterization of the digestive enzyme production by the California halibut larvae is currently being evaluated to further understand the mechanisms responsible for the lack of success during early weaning.

Satiety feeding rates for fish 5 to 10 g in size have been found to be approximately 1.5 to 1.8 % of body mass per day, and drop to about 1.2 % for 300 g fish at a temperature of about 20 °C and a salinity of 31 ppt. Preliminary estimates of food conversion ratio (mass of food consumed per unit biomass gain) range as low as 0.6. This result is very promising and is in agreement with published data for other flatfish.

Weaned juveniles are quite tolerant of salinity changes. Survival and growth of 5 g fish were tested for salinities ranging from 5 to 30 ppt. The results indicate that growth, survival and food conversion ratio are not affected by salinity for this size fish and agree with recent findings. This tolerance makes it possible to use freshwater dips for the treatment of occasional external parasites and fungus spots.

The rates of oxygen consumption and ammonia and urea production were measured for fish ranging from about 5 to 200 g. Oxygen consumption was found to range between 0.6 and 0.8 g O₂/g feed, ammonia production was under 0.01 g total ammonia nitrogen (TAN)/g feed, and urea production under 0.001 g Urea-N/g feed. The rate of oxygen consumption is similar to that reported for other fish. However, the rate of

ammonia production is substantially lower than for other fish. The rate of urea production relative to ammonia production is slightly higher in comparison to other fish. All rates (O_2 consumption, ammonia and urea excretion) showed relatively small diurnal fluctuations with rates typically rising slightly during the late afternoon and early evening for fish fed continuously over the daylight hours.

The settling velocity distributions for solid waste produced by fish at different sizes and for different feeds also were characterized. Preliminary results show that about 80% of the particles (by mass) have a settling velocity greater than 1 cm/s independent of fish size (5 to 100 g fish). However, the type of feed used resulted in significant changes with respect to the settling properties of the waste produced.

To evaluate the effect of dietary lipid content on protein utilization, juvenile fish were fed diets with gross energy contents ranging from 13.7 to 16.6 kJ/g, with supplemental energy provided by lipid at a constant level of dietary protein. Fish were evaluated for growth, whole-body composition, and N excretion. Increased lipid energy content (decreased protein-energy ratio) significantly increased net protein retention from 37.4 to 54.3% of ingested N between the 13.7 and 16.6 kJ/g energy level treatments, respectively. Increased lipid energy content also significantly reduced excretory TAN loss from 20.4 to 14.0% of ingested N between the 13.7 and 16.6 kJ/g energy level treatments respectively. These results indicate that nonprotein energy can be effectively utilized by California halibut to improve protein efficiency within the tested range of dietary energy, and is significant to the development of an efficient and cost-effective formulated feed.

Any potential aquaculture endeavors in California will have to fit within the economic and regulatory climate of the state, which includes the relatively high cost of energy and the recent uncertainty associated with its availability, as well as stringent environmental regulations. It is for these reasons that our program to advance culture techniques appropriate for California halibut is focused on the development of a recirculation growout system. This would allow for the establishment of industrial-style culture facilities that could be located at a variety of sites within the state. Recirculation allows for the retention of heat energy used to elevate water temperatures needed to maximize growth rates while also minimizing any impact on the environment. In keeping with this overall goal, information gathered on optimum husbandry practices, including diet and engineering parameters related to feeding and waste removal, was used to design a prototype production system. This prototype system has been built at BML and is being used to refine the system configuration for the growout phase. The system consists of two rectangular tanks (3 m by 1.5 m) and two square tanks (1.5 m), plus a water treatment system (swirl separators, drum filter, moving bed biofilter, and oxygenation). This system is expected to have a carrying capacity of approximately one metric ton of 1 kg fish, and is currently being evaluated for growout phase performance.

Publications

Bush, D. E., Muguet, J. B., Gisbert, E., Rounds, J., Merino, G. E., Conklin, D. E., and Piedrahita, R. H.. 2002. Effect of Handling Stress on Egg Viability of California Halibut *Paralichthys californicus*. Abstract and Poster presented at Aquaculture America 2002. San Diego, California (January 27 - 30, 2002).

Gisbert, E., Merino, G. E., Muguet J.-B., Bush, D. E., Piedrahita, R. H., and Conklin, D. E. 2002. Morphological Development of Hatchery-Reared California Halibut *Paralichthys californicus* Larvae. Abstract and Poster presented at Aquaculture America 2002. San Diego, California (January 27 - 30, 2002).

Conklin, D. E., Piedrahita, R. H., Merino, G. E., Muguet, J. B., Bush, D. E., Gisbert, E., and Rounds, J. 2002. Development of California Halibut *Paralichthys californicus* Culture. Abstract and Presentation at Aquaculture America 2002. San Diego, California (January 27 - 30, 2002).

Piedrahita, R. H., Merino, G. E., Muguet, J. B., Conklin, D. E., and Bush, D. E.. Recirculation System for Hatching and Early Growth of California Halibut *Paralichthys californicus*. Abstract and Presentation at Aquaculture America 2002. San Diego, California (January 27 - 30, 2002).

Gisbert, E., Merino, G. E., Muguet, J. B., Bush, D., Piedrahita, R.H., and Conklin, D.E. 2002. Morphological development and allometric growth patterns in hatchery-reared California halibut *Paralichthys californicus* larvae. Journal of Fish Biology 61:1217-1229.

Bush, D. E., Piedrahita, R. H., and D. E. Conklin. 2002. Digestibility of DHA, EPA, and total lipid is not affected by lipid ration or lecithin supplementation in California halibut, *Paralichthys californicus* Abstract and paper presented at the 10th International Symposium on Nutrition and Feeding in Fish. Rhodes, Greece (June 1 - 2, 2002).

Cervantes-Trujano, M., Piedrahita, R. H., and D. E. Conklin. 2002. Feeding behavior of post-metamorphic juveniles of California halibut (*Paralichthys californicus*) related to prey density and food selectivity. Paper presented at the AQUAMAR Internacional (September 3 - 7, 2002).

Cervantes-Trujano, M., G. Merino, J. B. Muguet, Bush, D., Piedrahita, R. H. and Conklin, D. E.. 2002. Avances en el desarrollo de la tecnología de cultivo de larva del lenguado de California *Paralichthys californicus*. Paper presented at the XIII Congreso Nacional de Oceanografía. Puerto Vallarta, Mexico (October 7 - 11, 2002).

Conklin, D. E., Piedrahita, R. H., Bush, D., Muguet, J. B., Bush, D. E., Merino, G. E., and Cervantes-Trujano, M. 2002. The California Halibut as an Aquaculture Candidate – A Comparison to Other Flatfish. Abstract and Poster presented at the 8th Biennial Flatfish Biology Conference. Westbrook, Connecticut (December 10 - 11, 2002).

Merino, G. E., Muguet, J. B., Bush, D., Cervantes-Trujano, M., Conklin, D. E., and Piedrahita, R. H. 2003. Production of California Halibut *Paralichthys californicus* Larvae in a Recirculating System. Abstract and paper presented at Aquaculture America 2003. Louisville, Kentucky (February 19-21, 2003).

Merino, G. E., Piedrahita, R. H., and Conklin, D. E. 2003. Morphometrics of California Halibut *Paralichthys californicus* Determined by Image Analysis. Abstract and paper presented at Aquaculture America 2003. Louisville, Kentucky (February 19-21, 2003).

Merino, G. E., Muguet, J. B., Bush, D., Conklin, D. E., and Piedrahita, R. H. 2003. Batch and semicontinuous culture of marine rotifers *Brachionus plicatilis* in saltwater: an alternative to seawater culture. Abstract and paper presented at Aquaculture America 2003. Louisville, Kentucky (February 19-21, 2003).

Merino, G. E., Piedrahita, R. H., and Conklin, D. E. 2003. Settling velocity of solids from California halibut *Paralichthys californicus* raceways. Abstract and paper presented at Aquaculture America 2003. Louisville, Kentucky (February 19-21, 2003).

Cervantes-Trujano, M., Conklin, D. E., and Piedrahita, R. H. 2003. The effectiveness of seven protein sources as feed attractants for the California halibut *Paralichthys californicus*. Abstract and paper presented at Aquaculture America 2003. Louisville, Kentucky (February 19-21, 2003).

Conklin, D.E. 2003. The Potential for Flatfish Culture in California. Abstract and Presentation at the Western Regional Aquaculture Conference & Exposition. Reno, Nevada (March 12 - 15, 2003)

Gisbert, E., Merino, G. E., Piedrahita, R. H., and Conklin, D. E. 2003. Determination of the point of no return (pnr) and nutritional condition of California halibut (*Paralichthys californicus*) larvae. Abstract and paper to be presented at World Aquaculture Society Meeting 2003. Salvador, Brazil (May 19 - 13, 2003).

Herzka, S.Z., D.E. Conklin, R. Piedrahita and J.P. Lazo. 2003. US-Mexico cooperative efforts in California halibut research. Bight Bulletin 7: 4-7.

Conklin, D.E., R.H. Piedrahita, G.E. Merino, J.B. Muguet, D.E. Bush, E. Gisbert, J. Rounds and M. Cervantes-Trujano. 2003 Development of California halibut, *Paralichthys californicus*, culture. Journal of Applied Aquaculture 14: 143-154.

Bush, D. E. 2003. The effect of dietary lipid content on protein utilization in California Halibut *Paralichthys californicus*. Thesis submitted to Dept of Animal Science and University of California Davis in partial fulfillment of degree of Master of Science (December 2003).

Gisbert, E., R.H. Piedrahita and D.E. Conklin. 2004. Ontogenetic development of the digestive system in California halibut (*Paralichthys californicus*) with notes on feeding practices. Aquaculture 232: 455-470.

Gisbert E. Conklin DB. Piedrahita RH. 2004. Effects of delayed first feeding on the nutritional condition and mortality of California halibut larvae. Journal of Fish Biology. 64(1):116-132.

Muguet, J.B., Bush, D. E., Merino, G. E., Conklin, D. E. and Piedrahita, R. H., 2004. Green water culture of California halibut, *Paralichthys californicus*, larvae. Abstract and poster presented at the World Aquaculture Society meeting 2004, Honolulu, Hawaii (March 2-6, 2004).

Bush, D.E., Conklin, D.E., Merino, G.M., Muguet, J.B., Piedrahita, R.H., 2004. The effect of dietary lipid content on protein utilization in California halibut *Paralichthys californicus*. Abstract and paper presented at the World Aquaculture Society meeting 2004, Honolulu, Hawaii (March 2-6, 2004).