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Aquaculture Collaborative Research and Development Program (ACRDP) Fact Sheet

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The Development of Cost-effective Diets and Husbandry Protocols for the Sustainable Aquaculture of Rockfish in British Columbia

Summary

Rockfish belong to the family Scorpaenidae (*Sebastes spp.*), and as a group have been identified as potential candidates for aquaculture. Sebastes species of the western Pacific are being cultured in both Korea and Japan. Considered a delicacy of Asian cuisine, rockfish have been the target of commercial and recreational fisheries. However, wild rockfish fisheries in the eastern Pacific have been in decline for years possibly due to the lucrative retail sale of live fish driving overfishing of these species. Populations of inshore rockfish are rapidly declining throughout coastal British Columbia. Conservation initiatives and fishery bans have been established to help restore depleted stocks of rockfish but this approach will require many years to be successful. However, a vibrant and active market for rockfish remains and alternative strategies are needed to fill these niches using an environmentally sustainable approach. This research project looks at the development of effective culture technology and husbandry protocols for sustainable rockfish aquaculture production in British Columbia to meet the high market demand for these fish without further depleting the natural stocks.

Introduction

The 2007 commercial landings of rockfish species in British Columbia (BC) were 19,000 metric tons (MT) with a landed value of $21 million CDN and wholesale value of $37.6 million CDN. However, overfishing is considered to be the cause of sharp declines in the rockfish populations in the Pacific Northwest, which has been occurring over the past several years. Conservation issues associated with the wild harvesting of rockfish are now driving interest in establishing a sustainable aquaculture industry that can provide an alternate source of rockfish to the consumer market.

Copper Rockfish (*Sebastes caurinus*, Figure 1), a nearshore rockfish species, has been identified as having good potential as a viable aquaculture species. Copper Rockfish mature relatively early (3-8 years) and have a high level of fecundity (producing many eggs). These are favourable characteristics for broodstock development purposes. They are a temperate species, preferring temperatures in the range of 7-13°C, which is similar to temperatures used

Figure 1.
Copper Rockfish (*Sebastes caurinus*).

for commercial rearing of salmonids. Copper Rockfish are also extremely palatable, and are considered to be a high value gourmet seafood product, especially in the live-fish trade. They are relatively easy to transport live to market. Copper Rockfish adapt readily to culture conditions, but many aspects of their growth, feeding and reproduction remain to be characterized before they can become a viable commercial aquaculture species.

This research project, carried out in three consecutive studies, was designed to provide information on rockfish culture that could lead toward the development of a sustainable rockfish aquaculture industry in BC. Initial studies addressed the need to develop a pelleted diet with optimal physical attributes that would support excellent growth and health of rockfish (Study 1). Next, a feeding study (Study 2) was conducted to optimize the dietary concentrations of the most expensive energy-yielding nutrients for rockfish, namely, protein and lipid (fat). Finally, a growth study on three size classes of juvenile rockfish was conducted to evaluate growth rates of the size classes and to examine the influence of seasonal seawater temperature and photoperiod on growth performance (Study 3). In a previous study conducted at the Fisheries and Oceans Canada's Centre for Aquaculture and Environmental Research (CAER) in West Vancouver, BC, the growth rate of rockfish was observed to increase with increasing water temperatures and it was suspected that there was an effect of fish size on this response. Size dependent growth rates have been demonstrated in other marine fish, for example Sablefish (*Anoplopoma fimbria*) held under ambient temperature and photoperiod conditions, such that when these fish approach the 1 kg size, growth rate rapidly declines without a concurrent decline in appetite/feed intake (Erin Friesen, pers. comm.). There are significant economic repercussions to this observation. Hence, there was a need to examine if this phenomenon also occurred in temperate rockfish.

Methods

Juvenile rockfish (approximately 3 g each) were collected by divers from the Sechelt area of BC (north of Vancouver in the Georgia Strait), and transported to the CAER. The fish were acclimated in 150-L fibreglass tanks supplied with flow-through, filtered and oxygenated, ambient temperature sea water and simulated natural photoperiod for several months. At the start of the first feeding study the fish weighed approximately 7.5 g and appeared to be a uniform group of juvenile Copper Rockfish (*S. caurinus*). However, when the fish were about 20 g, it was discovered that approximately 25% of the population were actually Quillback Rockfish (*S. maliger*), and a few large Yellowtail Rockfish (*S. flavidus*) were also mixed in with this population.

Study 1: Diet Formulation

Juvenile rockfish (the group of all three previously mentioned species) showed a preference for pellets that sink slowly so feed production studies were undertaken to produce a diet with a density (buoyancy) that allowed the pellets to sink at an optimal velocity. The experimental pellets were created by using a laboratory scale California Pellet Mill (low temperature, without steam injection) and vacuum microwave drying at a constant field strength. This study involved the testing of fifteen different diet formulations with various levels of un-gelatinized and gelatinized starch while keeping constant the total dietary concentrations of starch and moisture. The physical attributes of length, width, air-dry weight, surface floatation time, and sinking rate of each starch-diet type and starch-blend category, were measured.

Study 2: Feeding Study

This study was undertaken to determine the influence of dietary protein and lipid levels on the rockfish species' growth performance, body composition and health. Triplicate groups of 25 juvenile rockfish (approximately 7.5 g mean initial body weight), were held in 150-L partially covered tanks provided with flow-through seawater. Fish were hand fed (Figure 2) to satiation, three times daily, with one of six experimental diets containing one of three concentrations of protein and one of two levels of lipid for a total of 15 weeks. Daily food consumption was monitored by weighing feed containers at the end of the day. Growth was assessed monthly.

Fish performance during the study was assessed by determining the effect of diet treatment on: weight gain [WG (g) = final body weight, FBW initial body weight, IBW]; specific growth rate [SGR (%body weight / day) = (ln FBW – ln IBW) / 105 days x 100]; dry feed intake [DFI (g/fish) = total dry feed intake consumed over 105 days (g) / number of fish]; feed efficiency ratio

Figure 2.
Feeding of experimental diets to juvenile rockfish.

[FER (g/g) = WG / DFI]; protein efficiency ratio [PER (g/g) = WG / protein intake (g)]; percent fish mortality; final whole body concentrations (% of wet weight) of proximate constituents (moisture, ash, protein and lipid).

Fish health was assessed using standard haematological analyses (i.e., blood cell counts, hemoglobin) and histological analyses of major organs such as gills and liver, to determine if there were any adverse health effects of diet treatment.

Study 3: Seasonal Growth Performance

This study examined the effect of seasonal variations in water temperature and photoperiod on the growth performance and health of rockfish in different size categories. The remaining rockfish from Study 2 were used in this growth study. Fish were graded into 3 size classes: small (27.7 g mean weight), medium (51.1 g mean weight), and large (95.2 g mean weight). A uniquely coded Visual Implant Tag (Northwest Marine Technologies) was implanted in each fish (Figure 3). This allowed the tracking of individual fish performance throughout the study period. Triplicate groups of each size class were reared separately in 1100-L oval fiberglass tanks, supplied with flow-through ambient temperature, filtered and oxygenated seawater, under a simulated natural photoperiod. The rockfish were hand fed to satiation twice daily, using the optimal diet formulation as determined from Study 2. Daily records of sea water temperature as well as dry feed intake and mortality in each group were maintained for a period of 35 weeks (February to October). The fish were removed from their respective tanks at 4-week intervals to monitor their individual gains in weight and length, and their overall condition.

At the end of the 35-week study, the fish were weighed, measured and samples were taken for health assessments. Growth performance and health performance were determined as described in the previous study (with the exception of protein efficiency ratio and whole body proximate composition analyses).

Figure 3.
Implanting of rockfish with visual implant tags (Northwest Marine Technologies) for the individual identification of fish.

Results

Study 1 was successful in producing a diet with the optimal physical feed properties for a rockfish diet in terms of a pellet size and buoyancy. Ensuring that the feed had the optimal physical properties was necessary before studying the nutritional requirements in Study 2.

Study 2 indicated that variations in protein and lipid concentrations in the pelleted food, on fish weighing between 7.5 and 13.5 g, had no significant effect on the overall growth (final body weight, weight gain, specific growth rate), feed usage (feed efficiency ratio), and health parameters of those fish. There were also no diet-related effects found in percent cumulative mortality or final

whole body proximate composition. Intake of dry feed was significantly higher in fish ingesting the diets with low protein content when compared to those consuming the diets with medium and high protein content. At all protein levels, the inclusion of the higher lipid concentration resulted in consistent growth improvement.

For Study 3, although previous observations in the growth of rockfish at the Centre for Aquaculture and Environmental Research appeared to reveal a trend whereby the growth rates of the fish increased with rising sea water temperatures and increased photoperiod, the study did not reveal an effect of temperature on fish growth performance. All fish growth rates increased with the seasonal increases in day length and temperatures of spring and summer. By late summer, growth rates decreased as day length declined, even though sea water temperatures were still rising indicating a positive correlation between fish growth rates and photoperiod.

Study 3 also demonstrated that rockfish growth performance is significantly influenced by fish size. The SGR values followed the sequence: small sized rockfish > medium sized fish > large sized fish. This information is critical since rockfish are a very long-lived genus of fish and information on their early growth rates, vital for successful culture, is largely unknown. However, the groups of larger sized fish were more severely infected with a blood-feeding gill fluke which likely contributed to the signs of anaemia, more prevalent in these fish. In contrast the smallest fish had reduced parasite loads. This health issue may have contributed to some of the observed growth differences.

Conclusions

The results of this research project provide new information that will facilitate further developments in the quest to determine the most cost-effective diet formulations and rearing conditions for the sustainable culture of rockfish in BC. This will help in reducing the need for the capture of wild juvenile rockfish for culture and will enable culture experiments to be conducted on individual rockfish species rather than mixed wild rockfish species. Knowledge was obtained on how to produce a feed with optimal physical and nutritional requirements. Narrow variations in the dietary concentrations of protein and lipid can affect rockfish growth performance and basic health parameters. This work should be broadened to examine the effect of wider variations in dietary protein:energy ratios and to also examine dietary concentrations of digestible carbohydrates on the growth performance, body compositions and health of different rockfish species throughout their life history. It will also be important to determine how to incorporate terrestrial lipid sources (plant and animal origin) without compromising fish growth, health, and the quality of the market size product for human consumption. In addition, the importance of optimizing photoperiod and, to a lesser extent, water temperature on rockfish growth was revealed in these studies. This should be investigated in more detail using factorial designs so that the single and interactive effects of temperature and photoperiod can be singled out for the different life history stages. Moreover, the health assessments in this research, while providing baseline health information for BC rockfish, could be expanded in future studies to enable the development of comprehensive health management programs for the improved welfare of cultured rockfish.

The described ACRDP projects (P-05-04-007, P-07-08-017) were collaborative efforts among Fisheries and Oceans Canada (DFO), the University of British Columbia and Ko-Un Fish Company Ltd. The lead scientist on this project, Dr. Shannon Balfry, can be contacted at **shannon.balfry@vanaqua.org**.

For further information on this and other ACRDP projects, visit: **www.dfo-mpo.gc.ca/science/aquaculture/acrdp-pcrda/main_e.htm.**

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