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Australian Southern bluefin tuna farming and research activity – National report

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SUMMARY – An overview is provided showing how Australian research on the biology and culture of tuna has grown in scope and intensity in step with the successful development of the farming of Southern Bluefin Tuna in South Australia. The nature, progress and future directions are summarised for research on tuna feeds, product quality, environmental management, health and hatchery propagation. Some of the practical problems are discussed, and the approach to coordination of research and industry development is briefly outlined.

Key words: Tuna, aquaculture, research, industry development.

RESUME – *"Activités en matière de recherche et d'élevage du thon rouge dans le sud de l'Australie - Rapport national". Une critique est fournie qui montre comment les recherches australiennes sur la biologie et la culture du thon ont augmenté en portée et en intensité à la mesure du succès du développement de l'aquaculture du thon "Southern Bluefin" en Australie du Sud. La nature, le progrès et les futures directions sont résumés au sujet de la nourriture du thon, de la qualité du produit, de la gestion écologique, de la santé et de la propagation d'éclosion. Quelques-uns des problèmes pratiques sont discutés, et l'approche à la coordination brièvement esquissée.*

Mots-clés : *Thon, aquaculture, recherche, développement industriel.*

Research and development relating to the aquaculture of Southern Bluefin Tuna (SBT), *Thunnus maccoyii,* has naturally evolved in parallel with the emergence of the industry through several phases.

Feasibility phase

The Australian tuna fishermen and their Japanese colleagues initiated feasibility studies (1989-90), in the face of the challenge of quota limits on the wild fishery. The Tuna Boat Owners Association of Australia (TBOAA) and experts from the Japan Tuna Federation and Japan Sea Farming Association considered possible sites and concluded that wild tuna could in principle be caught and transported to potential farming sites in South and Western Australia.

A three-year project (1991-93) was then undertaken by the TBOAA, the Japanese Overseas Fisheries Cooperation Foundation and the South Australian Government, with seed funding from the Fisheries Research and Development Corporation. This project comprised mainly empirical trials of capture, transport and growth in sea-cages, but even at this stage some large fish were set aside for possible future spawning studies, and preliminary environmental models were set up and baseline data collected.

Industry development

A critical breakthrough came in 1993, when a leading tuna fishing company successfully demonstrated that large numbers of tuna could be encircled by a purse seine net, swum into a hexagonal towing cage, slowly towed back to Port Lincoln, and then swum into grow-out cages. Methods of delivering the feed (baitfish, mainly pilchards) and harvesting fish developed progressively from 1991-93, and the weight gain as a proportion of feed used rapidly increased. Commercial development of the tuna farming industry advanced steadily from 1993 to 1997, with some 18 companies actively involved on their own account, and also beginning to commission and contribute as an industry to research on key issues, and state and national research agencies also accordingly started to take up projects on health, environment and nutrition.

Environmental research identified marked impacts on benthic communities, below and near cages. Very limited baseline data was available on the relevant waterways, but nevertheless rough estimates of carrying capacity were made.

The industry established a program of monitoring, sampling and diagnosis to detect health issues and identify possible pathogens. Little is known about tuna pathogens generally, and so far the incidence of disease problems has been low and has been managed by progressively improved husbandry (particularly water quality, management of nets, and methods of handling and transferring fish). The major health incident so far (in 1996) related to unusual environmental conditions, and the risk of a recurrence has been reduced by moving the cages to deeper water.

Strategic R&D

The most pressing research goal of the industry was to develop manufactured feeds to replace the use of baitfish. The Cooperative Research Centre for Aquaculture (CRC-A) was set up in early 1994, and its program included a small-scale project on this topic as well as studies on the quality of product from the tuna farms. In 1997, the evident economic potential of tuna farming and the range of research activities prompted the Fisheries Research and Development Corporation to establish its Subprogram on SBT Aquaculture, with strong CRC-A involvement, providing a focus for developing research strategy and greatly increasing the resources available, particularly for nutrition and feed development and product quality.

Improved feeds, more specifically the use of manufactured pelleted feeds rather than baitfish, are expected to offer many advantages: higher production efficiency, consistent high product quality, minimal nutrient loss to environment and reduced quarantine risks. There is an ongoing progression in feed research from the quality and efficient use of baitfish, through the use of mashes and moist pellets towards fully manufactured drier feeds. Useful feeds obviously must be attractive to the fish, easily ingested and fully retained by the fish, and efficiently assimilated. They must yield fast growth and the desired characteristics in the final flesh product.

Research methods used have included analysis of tuna flesh and baitfish composition, study of the behavioural and physiological characteristics of tuna and of the anatomy, ultrastructure, and enzymology of the tuna gut, and measurement of ingredient digestibilities. A range of methods have been used to assess the suitability of experimental feeds, including surrogate species (such as salmon), comparative growth trials on a small-scale "research farm", and biochemical correlates of growth. Archival tags have been used to study the feeding performance of individual fish and to modify feeding strategies accordingly.

The work to date shows that pelleted feeds are capable under research conditions of providing as good growth and condition as do baitfish, but also that rapid weaning onto pellets is crucial to achieve a high survival rate, and to avoid an uneconomic growth lag. By 2000, the feasibility of manufactured feeds was clearly apparent, and Pivot Aquaculture (now Skretting Australia) and the Stehr Group have undertaken commercial-scale trials.

Research on product quality has followed three strands: (i) modification of husbandry and harvest practices to ensure and improve flesh quality; (ii) work in parallel with feed development to ensure effects of new diets on quality are satisfactory; and (iii) the development of new tools and methods for measurement of quality. Work on tools for quality assessment has addressed the measurement of rigor as predictor of shelf life, the establishment of non-destructive measurements (e.g. of carcase fat) and minimally destructive sampling techniques, objective colour measurement systems and the use of trained sensory panels.

Amongst the findings of this work are: (i) the demonstration that pelleted feeds can yield good colour and fat content, but there are many factors involved here; (ii) the fat composition of tuna not surprisingly reflects the diet composition; and (iii) inclusion of vitamins in diets may enhance product shelf-life. The study of harvest stress has proved technically very complex in tuna: harvest stress certainly influences the energy status of fish flesh but has not yet been correlated with quality and shelf-life. Methods of achieving rested harvest have been explored but are yet to show an advantage for product quality in tuna.

This period of research highlights some major issues in dealing with SBT, as a consequence of its size, value and behaviour. Much use has been made of a "research farm", using small replicated sea-cages managed by research staff. This system has great value in testing innovative ideas, but is expensive and yields inferior fish performance compared to commercial operations, and this creates a barrier to acceptance of its results by industry. Trials on farms are essential to provide confidence in results, but they present major challenges in implementing scientific methodology, owing to the difficulty in handling the fish without incurring stress-related mortalities, and to the heavy commercial risks. *In vitro* models and surrogate species have also been exploited, but testing their validity as models of SBT is in itself a major challenge, and the models used so far are found to be suitable only for quite specific experimental purposes.

Current and future research

In 2000, a Strategic Research and Development Plan for SBT Aquaculture for 2001-07 was published and a new Cooperative Research Centre for Sustainable Aquaculture of Finfish (Aquafin CRC) was funded by the Australian Government (2001-08). The Aquafin CRC is the main focus for Australian SBT research and the CRC model has proved a useful mechanism for achieving multi-disciplinary research and industry collaborations, both industry-wide and company-specific. Its program largely implements the Strategic Research and Development Plan, with projects on further diet development, product quality, health and environmental management, and propagation.

Regarding future work on improved manufactured feeds, while much will be achieved by the ongoing efforts of the feed companies, the research agencies also have continuing challenges. A research plant is available locally for small-scale for experimental diet development to enable a wide range of diet modifications to be made, and much effort is being made to develop methods for comparative growth trials which better mirror commercial performance, and because measuring further improvement in feeds (especially feed conversion ratios) is technically difficult in tuna.

Future directions in product quality research will include tracing of fish from cage to market, correlation of price with objective quality parameters, examination of fat accretion and muscle development through grow-out cycle, and further efforts to assess and modify husbandry stresses to achieve the highest quality and price.

Environmental management in aquaculture is a rapidly evolving subject, not least for tuna farming, with increasing community expectations and regulatory standards, which affect access by industry to farming sites. Industry also well understands the dependence of economic performance on good environmental conditions, and our scientists aware of an extending horizon of environmental impacts, with a concern for nutrients, phytoplankton, and water quality effects over whole water systems. Environmental management is also moving from a past phase of assessment and restriction towards adaptive management and mitigation. This progress, of benefit to industry and the general community, requires and is receiving close collaboration between industry, researchers and government regulators. Present and future research includes the development of tools for fast, cost-effective acquisition of ecosystem data, characterisation of waste flows, and evaluation of methods of impact mitigation. The new focus on regional sustainability assessment involves development of stakeholder teams, new methodologies and models, and rapid acquisition of vast bodies of data.

Tuna health research is becoming more urgent with our expectation of greater health threats as industry intensifies, and perhaps particularly if and when tuna hatcheries are established. The recently initiated health research includes a risk assessment program, strategic development of our ability to characterise and study viruses (through tuna cell line development), and the design and implementation of early-warning surveillance and response procedures.

The domestication of SBT, in the sense of developing hatchery technologies for this species, is a major goal of Aquafin CRC and at least one company. The Aquafin CRC is looking for international collaborators to specifically complement its existing strengths, and preparing a business framework to attract the essential industry collaborations.