

Aquatic Veterinary Medicine – Specific to cultured, display and wild aquatic life.



Dr Richmond Loh

2012 George Alexander Foundation International Fellowship
Fellowship funded by the George Alexander Foundation





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i. Executive Summary

The importance of aquatic animals for farming, in research and as environmental sentinels, has grown dramatically in the recent years. With the increasing use of aquatic animals, the demand for veterinary input has followed suit. As such, the practice of aquatic veterinary medicine with aquatic livestock, public aquaria and pets requires strengthening. All aquatic animal industries are now challenged with a growing number of significant diseases and the need for trained aquatic veterinarians is rapidly increasing. However, in Australia, there is a critical shortage of highly trained aquatic veterinarians and there are insufficient training opportunities for specialised aquatic animal health diagnostic professionals. This ISS Institute Fellowship will enable Dr Richmond Loh to continue making a high-level contribution to the field of aquatic veterinary medicine in Australia on an ongoing basis.

The report summarises the teachings and new knowledge gained by the Fellow during the overseas research program. He attended the Seavet course that covered veterinary medical aspects of marine megafauna such as sharks, stingrays, fish, pinnipeds, cetaceans, manatees, turtles and penguins. Along the journey, the Fellow also visited other establishments to learn about the roles veterinarians play in the various industries. He visited the Department of Agriculture in Hawaii, the University of Hawaii at Hilo, attended an aquaponics conference, and visited several aquaculture farms, ornamental fish farms and the University of Florida's Tropical Aquaculture Laboratory in Ruskin, Florida, USA.

The Fellow compiled a questionnaire of relevant questions as requested by stakeholders for investigation. During his visits and international experience, the Fellow found an allegedly reef-safe product for marine white spot disease in fish. Other highlights of the trip included discovering that aquaponics can play a vital role in engaging the community, finding that five Australian cities occupied the top six positions in keyword searches for 'aquaponics', following only Honolulu. These cities have a keen interest in leading the way towards creating sustainable food production with minimum carbon footprint. There is also keen interest by Hawaiian aquaculturists to acquire Australian barramundi. The report concludes with a number of practical recommendations for government, industry, associations and the education and training sector that will help grow and consolidate a vibrant and sustainable sector for the aquatic veterinary industry in Australia.

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ii. Abbreviations/Acronyms

AAH	Aquatic Animal Health
ABIN	Australian Biosecurity Intelligence Network
AQWA	Aquarium of Western Australia
ANZCVS	Australian & New Zealand College of Veterinary Scientists
CTAHR	College of Tropical Agriculture and Human Resources
DAFF	Department of Agriculture, Fisheries and Forestry
DEC	Department of Environment and Conservation
ELISA	Enzyme-linked immunosorbent assay
FRDC	Fisheries Research and Development Corporation
IAAAM	International Association for Aquatic Animal Medicine
IBC	Intermediate Bulk Container
ISS Institute	International Specialised Skills institute
MRI	Magnetic Resonance Imaging
NELHA	Natural Energy Laboratory of Hawaii Authority
NOVICE	Network Of Veterinary Information & Communications technology in Education
NRM	Natural Resource Management
OIE	Office International des Epizooties (World Organisation for Animal Health)
OPEC	Organisation of the Petroleum Exporting Countries
PPE	Personal Protective Equipment
RAS	Recirculating Aquaculture System (see definition below)
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SPF	Specific Pathogen Free
WAVMA	World Aquatic Veterinary Medical Association
WWOOF	Willing Workers on Organic Farms

iii. Definitions

RAS

An aquaculture water supply approach whereby water is continuously recirculating through the system without requiring new water.

Google trends

An online search tool that allows users to see how often specific keywords, subjects and phrases have been queried over a specific period of time.

1. Acknowledgements

Dr Richmond Loh would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the ISS Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 200 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.

International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.

In this context, the ISS Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the ISS Institute's work.

For further information on our Fellows and our work see <http://www.issinstitute.org.au>.

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Fellowship Sponsor: The George Alexander Foundation

The George Alexander Foundation supports activities in the following two areas:

Education

- to help talented young people achieve their full potential in any endeavour
- to support programs designed to improve educational, employment and leadership opportunities for disadvantaged young people

Environment and Conservation

- to develop partnerships with communities, government and the private sector to prevent irreversible damage to the environment and to encourage the maintenance of biodiversity

The Fellow would like to thank the George Alexander Foundation for providing funding support for this Fellowship.

Supporters

The Fellow received support from various representatives/end users that he represents through his work:

- Dr Alan Lymbery, Associate Professor, Murdoch University.
- Dr Arthur Blewitt, CEO, Agrifood Skills Australia.
- Dr Megan Parker, CEO, Australian and New Zealand College of Veterinary Scientists.

Organisations Impacted by the Fellowship

Government

- Fisheries Research and Development Corporation (FRDC).
- Department of Fisheries in the respective states.
- Department of Agriculture, Forestry and Fisheries (DAFF).
- Department of Environment and Conservation (WA).
 - » Marine Science Program.
 - » Marine Mammal.
 - » Sea Turtle Conservation.
- Department of Primary Industries NSW.
 - » Wild Fisheries Unit.
- Department of Primary Industries, Parks, Water and Environment (Tasmania).
- Department of Agriculture and Food WA.
- Department of Environment and Resource Management (Queensland).
- Connecting Spaces (formerly Australian Biosecurity Intelligence Network [ABIN]).
 - » Project Neptune.

1. Acknowledgements

Industry

- Various aquaculture industry bodies
 - » Australian Finfish Farmers Association.
 - » Australian Abalone Growers Association.
 - » Australian Barramundi Farmers Association.
- Public aquaria.
- Ornamental fish industry.

Professional Associations

- Australian & New Zealand College of Veterinary Scientists (ANZCVS).
- Zoo and Aquarium Association.
- Australian Wildlife Health Network.
- Wildlife Disease Association - Australasian Section.
- World Aquatic Veterinary Medical Association (WAVMA).

Education and Training

- Murdoch University
 - » Wildlife Epidemiology and Conservation Medicine.
 - » Veterinary Pathology.
- University of Western Australia.
- University of Tasmania.
- Griffith University.
- University of Queensland
 - » Moreton Bay Research Station.
- University of Sydney
 - » Centre for Veterinary Education.
- James Cook University.
- South Australia Museum.
- Perth Zoo.
- Zoos South Australia.
- Aquarium of Western Australia (AQWA).
- Seahorse World, Tasmania.
- Australian Registry of Wildlife Health.
- Sea Life - Merlin Entertainments Group.
- Dolphin Marine Magic.
- Australian Institute of Marine Sciences (AIMS)
 - » Arafura Timor Research Facility.
- Veterinary Classrooms (formerly Webinar Vet).

1. Acknowledgements

Community

- Wildlife conservation societies.
- Western Australian Wildlife Rehabilitation Council.
- Koi Society of Western Australia.
- Australian Marine Wildlife Research & Rescue Organisation (AMWRRO).
- Australian Freshwater Turtles.
- Friends of the Western Swamp Tortoise.
- Turtle Oblonga Rescue and Rehabilitation Network.

2. About the Fellow

Dr Richmond Loh - The Fish Vet

DipProjMgt, BSc, BVMS, MANZCVS (Aqua), MPhil (Vet Pathol), MANZCVS (Pathobiol), CertAqV.

University-based qualifications:

- Bachelor of Science, Murdoch University (2001).
- Bachelor of Veterinary Medicine & Surgery, Murdoch University (2001).
- Master of Philosophy – Veterinary Pathology, Murdoch University (2006).

Other qualifications and appointments:

- Member Australian & New Zealand College of Veterinary Scientists (Aquatic Animal Health) (2006) – by examination.
- Chartered Member of the Australian Veterinary Association (2006).
- Founding Member of the World Aquatic Veterinary Medical Association (2006).
- Diploma in Project Management – TAFE, Tasmania (2007).
- Certificate in Companion Animal Services – Aquatics, Level 3 Nelson Marlborough Institute of Technology (2009).
- Member Australian & New Zealand College of Veterinary Scientists (Veterinary Pathobiology) (2009) – by examination.
- Adjunct Lecturer for Murdoch University, School of Veterinary Science (2009).
- Secretary/Treasurer of the Aquatic Animal Health Chapter. Australian & New Zealand College of Veterinary Scientists (2011-2014).
- Communications Committee Member World Aquatic Veterinary Medical Association (2012).
- Awarded the George Alexander International Fellowship by the ISS Institute (2012).
- World Aquatic Veterinary Medical Association, Certified Aquatic Veterinarian (2013).
- President of the World Aquatic Veterinary Medical Association (2014).

Biography

Dr Loh has always been interested in animals, nature and medicine, so it was natural that he studied to become a veterinarian at Murdoch University. His first job was as a veterinary fish pathologist for the Tasmanian state animal health laboratory, providing diagnostic services for the large aquaculture farms including species such as salmon, trout, ornamental fishes, abalone and oysters.

He has been admitted as a Member of the Australian & New Zealand College of Veterinary Scientists (ANZCVS) by examination in the subjects of 'Aquatic Animal Health' and in 'Pathobiology'. He was awarded a Master of Philosophy degree for research into Tasmanian Devil Facial Tumour Disease and published seminal papers in Veterinary Pathology on the case definition. He is the first in Australia to be granted the title of WAVMA Certified Aquatic Veterinarian. He has published two books on veterinary fish medicine ('Fish Vetting Essentials' and 'Fish Vetting Medicines – Formulary of Fish Treatments') that have gained popularity and is being sold world-wide. He is now working on an instructional video entitled Fish Vetting Practical Tips.

2. About The Fellow

Dr Loh primarily offers veterinary services to owners of ornamental fishes as 'The Fish Vet' in the states of Western Australia and in Victoria. He is the consultant veterinarian to the AQWA; is an adjunct lecturer at Murdoch University; is a founding member of the World Aquatic Veterinary Medical Association (WAVMA) and will serve as its 2014 President. He is also the Secretary and Treasurer for the Aquatic Animal Health Chapter of the ANZCVS and provides advice on fish health and welfare to several universities and the RSPCA. His clients are diverse and he employs the full range of activities assumed of a veterinarian – from individual pet fish medicine, through to large operations involving food fish, clinical practice through to laboratory diagnostics and education. He is also a prolific publisher on the internet and social media platforms to help advance the field of aquatic veterinary medicine.

3. Aims of the Fellowship Program

This Fellowship will lead to the advancement of aquatic veterinary medicine, facilitation of professional dialogue between disciplines and across continents, whilst promoting better productivity through better health and welfare of the animals under our care. More specifically, the aims were to:

1. Expand the skill-set of the Fellow, effectively increasing the versatility, in the provision of high quality aquatic animal health veterinary services to stakeholders/end users - encompassing fish and aquatic invertebrates, under their various forms of existence - home aquaria, public aquaria, aquaculture and wild.
2. Learn alternative techniques and acquire new skills to be more effective at teaching aquatic animal health units and delivering lectures to students at university and to impart and share knowledge via participation at conferences and in publications.
3. Foster stronger relationships with the international network of fish veterinarians for future collaborations nationally and internationally.
4. Provide the Fellow with an opportunity for accelerated learning and to fill the gaps in knowledge, in particular in the area of advanced aquatic veterinary medicine.

Upon completion of the Fellowship research trip, the Fellow will be better equipped to assist the end users and other aquatic animal health providers in Australia.

4. The Australian Context

Fish are the single biggest pet “species” by far even when limited to those species with which owners tend to form emotional ties and therefore are more likely to seek veterinary treatment. It should also be noted that more than 50% of the animals used for experimental purposes last year in the UK were fish, again this statistic is repeated globally. Moreover, non-mammalian aquatic species are presenting as valuable sentinels, reflecting environmental risks relevant to human health, to detect mutagens, carcinogens and endocrine disruptions.

For several years salmon production in Scotland has been more valuable at farm gate prices than either beef or lamb and similar statistics are seen in several countries around the world. Overall, fish farming has expanded at 10% per annum for more than 20 years and now provides more than 50% of all seafood eaten. Aquaculture is playing a growing role in providing food for humans and to assist in the restoration of depleted stocks or threatened and endangered aquatic species. All aquatic animal industries are now challenged with a growing number of serious diseases and the need for trained aquatic veterinarians is rapidly increasing.

There are now strong demands for veterinarians in:

- Commercial aquaculture, which has become a dominant agriculture industry for the production of safe and wholesome seafood
- Pet fish medicine and other aquatic pet species
- Public aquaria, now demanding veterinarians oversee their animal health and welfare programs
- The development of government legislation and regulations and the implementation of international standards aimed at preventing, controlling and eradicating disease in all aquatic species.

All of these stakeholders are now seeking help from veterinarians who can deal with a diverse range of species from marine mammals to fin fish, amphibians and invertebrates such as molluscs, crustaceans.

The executive summary of the Fisheries Research and Development Corporation report titled, *‘Final Report - 2005/641 - Aquatic Animal Health Subprogram: current and future needs for aquatic animal health training and for systems for merit-based accreditation and competency assessments’* concludes:

“There is a shortfall in both total capacity and more prominently, in the availability of high skill level individuals within both laboratory and field service provision areas. It was widely recognised that many of the traditional pathways for training groups of such skilled individuals was through mentorship and self-education within State and Commonwealth Governments. These are now severely restricted due to a changing role of Government and ongoing tightening of resources. A significant proportion of all stakeholders felt that current Australian training opportunities were either completely absent or of insufficient depth. Seventy-three percent (73%) of survey respondents felt that the demands for aquatic animal health services were likely to increase over the next 5-10 years, which will only exacerbate the currently recognised shortages.”

Through discussions with an array of industry stakeholders across Australia there appeared to be sufficient training available for farmer level individuals but not for specialised aquatic animal health professionals. The DAFF and the FRDC are jointly funding an Aquatic Animal Health Training Scheme for 2013-2015, with the aim to improve knowledge and skills in aquatic animal health management to support Australia’s fishing and aquaculture industry, including the aquarium sector.

The recent biosecurity risk assessment of the ornamental fish industry suggests current practices are inadequate and that ornamental fish poses a biological threat to native fish, commercially cultured fish and recreational fisheries. It puts local and global biodiversity at risk through potential pest threats. There is negligible disease surveillance on ornamental fish after they leave the quarantine premises.

4. The Australian Context

Across the country, there is a large pool of veterinarians whom we can draw upon to conduct passive disease surveillance, mirroring the practices of the livestock industry. It will promote better management practices of ornamental fish, thereby preventing disease incursion to native fish, commercially cultured fish and recreational fisheries.

The Fellowship will enable the Fellow to continue making an ongoing high-level contribution to the field of aquatic veterinary medicine in Australia. Dr Loh aims to serve veterinarians around Australia, by enhancing aquatic animal health and welfare, public health, and providing services to aquatic animal owners, industries, and other stakeholders.

SWOT Analysis

Strengths

- There are currently 15 members of the Aquatic Animal Health Chapter of the ANZCVS, which is currently the highest level of specialised examinations for fish in the world.
- Australia is free from many diseases due to its stringent quarantine laws.
- There are funds available through organisations such as ISS Institute, FRDC and NRM's Caring for our Country.

Weaknesses

- Of the members of the AAH Chapter of the ANZCVS, three have retired, several are approaching retirement and one is overseas.
- Advanced training on aquatic veterinary medicine is not consistently available in Australia.
- Australia does not permit the culture of some species that are commonly cultured overseas.
- Many aquaculturists do not yet see the benefit of involving veterinarians in their operations.
- Australia does not have the population and resources to support a large base of aquatic veterinarians.
- Tightening of government expenditure leads to erosion of resources available to the aquatic animal industries.

Opportunities

- There is significant knowledge and information available overseas that we can tap into. There is no need to reinvent the wheel or make mistakes.
- Bring back the knowledge and conduct similar courses in Australia.
- Develop research and development capacity beyond current levels.
- Australia has vast coastlines spanning several climatic types ranging from tropical to temperate that can be utilised for appropriate fish culture.
- Be able to play a larger role in rehabilitation of sick or injured, native aquatic animals.

Threats

- Australia cannot compete with Asia in terms of costs of labour and materials.
- The geographical isolation of Australia escalates transport costs.
- Risk of disease incursion.

5. Identifying the Skills and Knowledge Enhancements Required

There are examples of areas in Australian industries where there are weaknesses in innovation, skills, knowledge, experience, policies and/or formal organisational structures to support the ongoing successful development and recognition of individuals and the particular sector.

The focus of all ISS Institute Fellowships is on applied research and investigation overseas by Australians. The main objective is to enable enhancement and improvement in skills and practice not currently available or implemented in Australia, and the subsequent dissemination and sharing of those skills and recommendations throughout the relevant Australian industry, education, government bodies and the community.

The areas of applied research for this Fellowship are therefore identified in the following paragraphs.

Veterinarians are uniquely qualified and legally charged to examine, diagnose and treat diseases in animals, due to their training in multiple species of animals and disciplines of medicine. However, many academic veterinary curricula around the world do not place sufficient focus on aquatic veterinary medicine to fully prepare graduates for practicing in this area.

There is a shortfall in both the total capacity and in the availability of high skill level individuals to service the aquatic animal health industry. Veterinary support is integral to the success of the aquatic sector. The demand for professional aquatic animal health services is likely to increase over the next five to ten years, which will only exacerbate the current acute shortages. It is widely recognised that many of the traditional pathways for training groups of such skilled individuals was through mentorship and self-education within State and Commonwealth Governments. These are now severely restricted due to the changing role of Government and ongoing tightening of resources.

The courses on aquatic animal health that are available in Australia are provided on an ad hoc basis and are of insufficient depth for specialised aquatic animal health professionals. Numerous opportunities do exist for veterinarians to obtain the education, knowledge, skills and experience necessary to competently practice aquatic veterinary medicine but these are overseas. The courses available overseas are dedicated to aquatic animal health, are intensive and they run for longer periods of two to four weeks or more. Some courses are flexible enough to be tailored to suit the skill and knowledge level of participants. In the field of adult learning it has been shown that one-off or short conferences are usually not successful in achieving meaningful knowledge transfer unless this is followed up by continual practice.

The recent biosecurity risk assessment of the ornamental fish industry suggests current practices are inadequate and that ornamental fish poses a biological threat to native fish, commercially cultured fish and recreational fisheries. There is negligible disease surveillance on ornamental fish after they leave quarantine facilities. There is a large pool of veterinarians across the country who can conduct disease surveillance, mirroring the practices of the livestock industry. The Fellow has generated interest among veterinarians through his publications entitled *Fish Vetting Essentials* and *Fish Vetting Medicines* and through his presence on the internet and social media platforms.

6. Planned Outcomes And Benefits

There are only two veterinarians in Western Australia with post-graduate, membership level qualifications in Aquatic Animal Health. This is currently the highest level of qualification available in the world for fish veterinarians. This training opportunity ensures continuity of quality aquatic veterinary services to the end users principally in Western Australia, but also in other states. In the Fellow's role as an educator, the course will enhance the quality of his teaching, ensuring a growing number of trained veterinarians in this discipline; covering aquaponics, foodfish and ornamental fish culture and veterinary medical aspects of marine megafauna such as sharks, stingrays, fish, pinnipeds, cetaceans, manatees, turtles and penguins.

7. The International Experience

The following section is an overview of the Fellowship destinations and it is presented in chronological order and under various subject headings.

7.1 Kailua Animal Clinic

Contact - Jill Yoshicedo, Veterinarian, Hawaii, USA

Objectives

1. Compare notes on the common fish health issues seen in practice, the common medications used and fee structure.

Outcomes

The meeting was held at the client's location, Disney's Aulani Resort in Hawaii, USA.

7.1.1 Koi health

Koi are currently the only freshwater species reared at Disney's Aulani Resort and there are generally no health issues. However, one recent issue is the increasing frequency of squamous cell carcinoma with the Sanke varieties being over-represented (particularly those with a dominance of red and black markings). It is suspected that the shallow pools without access to shade may be contributing to the condition. The most common treatments used for Koi ailments include a saltwater bath and ceftizidime as the antibiotic of choice. MS-222 is used for anaesthesia. A typical house call for one hour would attract a fee of US\$350, or in-clinic fee of US\$65 per 15 minute consult.

7.1.2 Marine display aquarium

There is a large outdoor marine aquarium in the resort. Each day, up to 20 people are able to snorkel in the tank and feed the fishes with lettuce and seaweed attached to a holder. Swimmers take a freshwater shower prior to entering the tank as measures for biosecurity as well as for tank hygiene. The diet for the marine fish is designed by Disney's own nutritionists and they receive as their staple, a combination of Mazuri gel diet and mysid shrimp.

There generally have been no fish health issues since its inception some three years ago. But recently, it was discovered that gill flukes were present in the fish population despite a period of quarantine during the establishment of the tank, health screening of ten per cent of the population and prophylactic treatment with praziquantel and chloroquine at the start up phase. There were no plans at attempting to eradicate the parasite because they do not seem to be causing disease. The fish health team are currently monitoring the situation.

Previously, Disney Aulani also held rayfish. These had a twice yearly health assessment including blood work. The issues they had with these rays were copepods and treatment involved removal by hand.

7. The International Experience

7.2 Hawaii Department of Agriculture, Animal Disease Control Branch

Contacts - Lei Yamasaki, Veterinarian, Aiea, Hawaii, USA and Liz Xu, Economist, Economic Development Unit

Objectives

1. To investigate the role of government veterinarians in aquatic animals.
2. To understand the range of services they provide to the aquatic sector.

Outcomes

It was interesting to meet with the Department of Agriculture veterinarian who was charged to service the aquatic sector. A significant part of the work conducted by the Department of Agriculture is on prawn health. Although the USA is no longer able to compete with Thailand, Vietnam and South American countries on prawn production, the prawn industry is still strong. The prawn industry in Hawaii now revolves around the supply of broodstock prawns that are free of OIE listed diseases (i.e. produce Specific Pathogen Free (SPF) animals).

For USA farms to obtain SPF status, 60 animals of every life stage present on the farm need to be tested at zero, three, six, 12, 18 and 24 months. Maintenance of the SPF status requires six-monthly testing of 30 animals thereafter. The initial outlay for this program is approximately US\$16,000 and then US\$2,500 to maintain the status. This is a small price to pay when each prawn can fetch between US\$25-35 per head. The value of each shipment averages US\$50,000. Annual exports to China can be in excess of 120,000 prawns and to Hong Kong, Indonesia and Vietnam were 50,000 per country.

The Department of Agriculture also services ornamental fish farms and other aquaculture type ventures like aquaponics. However, there are currently a limited number of veterinarians employed in government and the shortfall is met by contracting USDA-accredited veterinarians for some of the work. This is similar to what is presently in place in Australia with the Accreditation Program for Australian Veterinarians (APAV) and Australian Veterinary Reserve (AVR).

The Australian barramundi was flagged as a potential new species for culture in Hawaii because of its eating qualities, fast growth rate and its exotic name. However, the progress is being hampered by bureaucracy. It was discovered that there was a bottle-neck in the process of renewing and approving import permits (including existing and new aquaculture permits). It is possible that an imbalance in resources created inefficiencies and frustration to the extent that momentum for the development of new aquaculture ventures were hindered.

On another note, an innovative way that the department works is by embedding an economist from the Economic Development Unit into the fish health laboratories. The economist works closely with the extension officers to help find avenues to increase incentives and to help make aquaculture a success. Examples of things already in place include agricultural loans and tax breaks.

7. The International Experience

7.3 Kodama Koi Farm

Contact - Taro & Shannon, Kodama Koi Farm, Mililani, HI, USA

Objectives

1. To learn about the practices at USA's largest koi farm.

Outcomes

This is the largest koi farm in the USA and the farm sources fish directly from a single, parent source in Japan (Miyoshiike Company, Ltd). The fish are imported at four to five inch in length and they are grown out in a value-adding process which may take up to five years. Once fish arrive, they are quarantined for a month and are tested principally for koi herpesvirus (KHV) and spring viraemia of carp (SVC). A good quality koi may grow to 70 to 80 centimeters in length in that time and can fetch anywhere between US\$25,000-50,000. Fish to be sold are measured and then photographed to be advertised on their website (Fig. 7.3.A).



Fig. 7.3.A A large kohaku is being measured to be sold.

Once the order has been placed, fish are held in quarantine for one week (Fig. 7.3.B). The fish are then inspected by the government veterinarian to ensure that there are no signs of disease prior to shipping. Sale fish are delivered to their clients within 24 hours of packing without the use of anaesthetics. Typically they are packed with one-third water and two-thirds oxygen. Fish are fasted during the week prior to packing.

7. The International Experience



Fig. 7.3.B The fish are held in quarantine and fasted for the week prior to export.

In terms of medications used on the farm, it was explained that when koi are stressed, salt is added at a rate of three to six grams per litre and Melafix may be used. No other medications are used routinely.

7.4 Mari's Gardens

Contact - Fred Lau, Mililani, HI, USA

Objectives

1. To learn about aquaponics in practice.

Outcomes

Formed initially as a landscaping business, Mari's Gardens has expanded to hydroponics and more recently aquaponics. This is now the largest aquaponics farm in the USA, with 1.5 acres of the 18-acre nursery dedicated to aquaponics. On Mr Lau's farm, there are 14 raceways that contain 30,000 fish, used to produce a variety of vegetables including Manoa lettuce, oak leaf lettuce, green onions, Japanese cucumbers, tomatoes and beets.

Mari's Gardens is expanding and Mr Lau is still investing heavily in research and development. He is investigating the use of different fish species (and breeds), plant species (and breeds) and system designs. He pointed out what worked and what did not work and with ideas stemming from his strength and experience in hydroponics. Out of the different hydroponic methods, he favours the Nutrient Film

7. The International Experience

Technique (NFT). He pointed out that there is a need to automate the processes to create efficiencies. One of the biggest hindrances to a straight modification of hydroponics to aquaponics is the problem with pipe blockage due to the amount of suspended solids generated through fish culture.

The Fellow shared some ideas with Mr Lau in terms of using large pipes, ways of 'polishing' the water using settling tanks and the different types of water filtration and on the use of air lift method to move water to the plants (Fig. 7.4.A).

Plants in his NFT hydroponics system are grown using oasis sponge medium because it is marginally cheaper than rock wool. The ebb and flow trays for his aquaponics systems consists of lamellated layers starting with cinder rock at the base, then coral, cinder rock, coconut cord and finally, topped with sunshine mix. The advantage of using cinder rock is that it may allow for direct planting of seeds to save time. The disadvantage is that it can breakdown over time and cause blockages in the system.

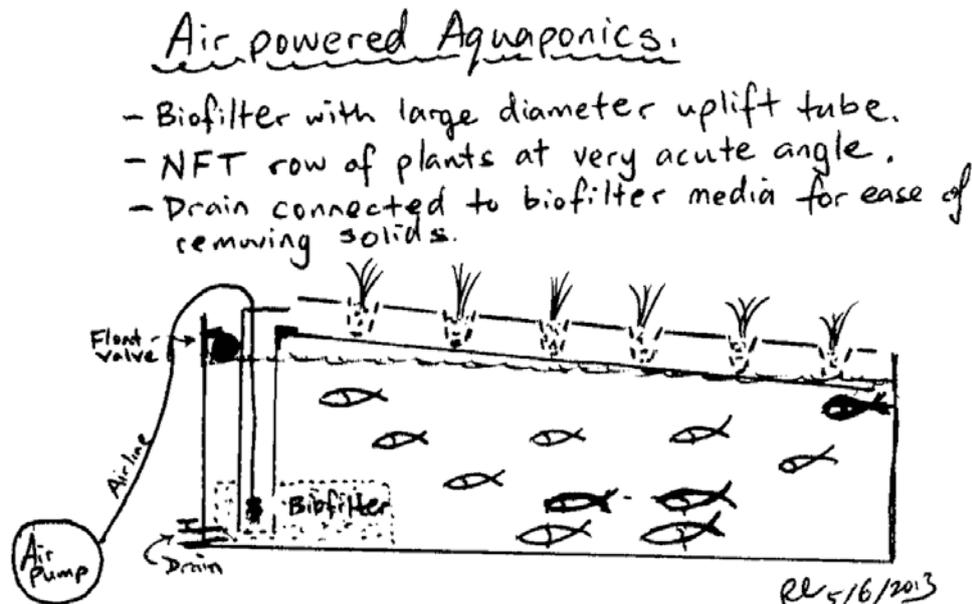


Fig. 7.4.A Simple, low-cost aquaponics design by the Fellow. This design will ensure no line blockage, continuous aerated water flow for plants and fish and biofiltration and solids removal for the fish. There will be a tap that drains the tank through the biofilter so that the filter can be cleaned while making a water change. There will be a float valve to maintain water level so that fish and plants will never dry out.

Mr Lau uses well water and it comes out at pH 5.5-6.0 and at 18.8-20°C. Iron levels are maintained at 1600 mg/L for optimal plant health. During his experimentation, Mr Lau discovered that he could extend the fruiting season of blueberry if he could deliver cooler water to the roots. This was achieved by having the water reservoir buried in the ground, away from the sun.

The biggest issue the farm faces is with caterpillar damage. *Bacillus thuringiensis* is used as a biological control agent. The bacteria is sprayed on the foliage and the crystal proteins of the bacteria, called δ -endotoxins, have insecticidal action. Other issues include it being labour intensive, low degree of mechanisation, high capital cost and high electricity cost.

Mr Lau pointed out that so far, aquaponics producers are only selling the vegetable crop. He stressed that for aquaponics to reach its full potential, income needs to be derived from both the plants and the fish.

Mr Lau showed the Fellow the setting of a unique dining experience where the long table is actually a

7. The International Experience

shallow aquarium covered with Perspex sheets. Diners will enjoy seeing guppies, freshwater prawns and other aquatic creatures swim beneath their plates (Fig. 7.4.B).



Fig. 7.4.B A unique dining experience (left) can be had at Mari's Gardens with an aquarium table. The vertical aquaponics system (right) for the 'high-end' market is still 'under wraps'.

Mr Lau then shared with the Fellow his latest project that involves creating a vertical aquaponics system (see Fig. 7.4.A) for the high-end market. The target client would be money-rich, oil-rich, water-poor countries where it is difficult to get fresh fruit/vegetables and fish. Each unit may be marketed at a price of US\$20,000. He is working with the Horimasa Company in Japan.

7.5 University of Hawaii, Hilo

Contacts - Dr. Kevin Hopkins, Director, Hawaii, USA, Maria Haws, Pearl Research & Training Program Director and Adam Daw, Researcher, Octopus culture

Objectives

1. To learn about the research being conducted at the university.
2. Learn about the courses available.

Outcomes

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Dr Hopkins explains that the University of Hawaii's aquaculture course has strong foundations based on the fundamentals of biology, ecosystem, farming and water quality. There is room for strengthening the subjects relating to pathology and is interested in having veterinary input which is only limited due to funding issues. The course concentrates on better management practices in order to avoid diseases. The strength of the course relies on drawing on the expert staff from other faculties such as engineering, biology, chemistry and others.

Dr Hopkins has a philosophy that there is a diminishing supply of arable land for agriculture and therefore there is need for more aquaculture. Also, the aquaculture sector is starting to use more and more terrestrially sourced foods such as soy, competing with human and terrestrial farmed animal foods. Some of the terrestrially grown grain is also being diverted towards energy production. With greater competition, the prices for terrestrially produced food ingredients will not remain economical. Dr Hopkins emphasised that we should instead be farming the sea. He believes that eventually sea-sourced foods could be a more nutritionally balanced diet for marine cultured fish.

Following on from this discussion, the politics between wild fisheries and aquaculture became the topic of importance. At the moment, there is awareness that non-tariff barriers can impede the progress of aquaculture. It is predicted that just as had occurred with terrestrial animals, there would come a time when wild fisheries will no longer be able to meet consumer demand and that aquaculture is the way of the future.

The topic of integrated fish farming was also raised. In relation to research into octopus culture, several countries have been investigating the methods. The only researchers who have been successful in raising newly hatched octopus larvae were those who fed them crab larvae. Researchers who fed other foods such as plankton and newly hatched Artemia have been unsuccessful. It may be possible that the octopus culturists may need to create a partnership with the crab culturists so that the crab producers could spawn enough crab larvae to raise the octopus young.

Dr Hopkins' group is also investing in research into aquaponics. He realises that although different aquaponics designs are more suitable to certain types of plants, he wants to design a single system that is versatile enough to be used for all plant types. For this reason, he favours the flood and drain technique and is investigating ways to make it work for all plants. The issue with NFT is that the plants need to be handled in a certain way to avoid wilting. He is in disfavor with the floating raft method because the roots are soaking in deoxygenated waters, creating unhealthy plants.

Dr. Hopkins expressed that one major issue aquaculturists face is that when fish get sick, there are only a limited range of registered drugs. These are very expensive and so most cannot afford it. Of course all effort is put into preventive management practices, but there needs to be a more economic solution to disease outbreaks.

7.6 Natural Energy Laboratory of Hawaii Authority (NELHA)

Contact - Jane Keller, Presenter, Friends of NELHA, USA

Objectives

1. To investigate what was the incentive for sustainability production of energy and food.
2. To visit some of the aquaculture farms at the site.

Outcomes

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Hawaii was formed from a volcano and is only seven million years old and as such has no fossil fuels and no terrestrial animals or edible vegetation. Eighty five per cent of food in Hawaii is brought in from the mainland. Hawaiians pay as much as 43c/kW of electricity (compared to rates as low as 3.5c/kW in states like Washington). Hawaii Natural Energy Institute was established in 1974, a few months after an oil embargo by Organization of the Petroleum Exporting Countries (OPEC) oil cartel triggered economic and political chaos in the United States and the rest of the industrialised world. In an attempt to wean itself from imported oil, NELHA was born. Wind, solar, wave and algal bio-oils are all part of the work that is being conducted. When the embargo on oil was lifted, the priorities changed, but work still continues on a smaller scale. Now it leases land and sells water to tenants that require these resources (e.g. aquaculturists (shrimp, algae, fish and abalone)) and bottled drinking water, or those who require work in the proximity to the sea. The government's promise to tenants is that should there be an interruption in water supply, it will be fixed within two hours. The setup is similar to the Broome Tropical Aquaculture Park in the north-west of Western Australia.

7.7 Kampachi Farms

Contact - Gavin Key, Researcher, Kampachi Farms, Kailua-Kona, Hawaii, USA

Objective

1. To investigate the latest in aquaculture research being conducted at this facility.

Outcomes

It was estimated that by 2048, all wild fisheries will collapse because only less than ten per cent of the original biomass will remain. This combined with increasing numbers of people with more disposable income and more health conscious population means they will want to eat more fish. We need to learn to farm the sea like we do on land.

The principle areas of research are: new feedstuffs, new species (greater than 22,000 to choose from) and farming technology (cage, automation, parasitic control, remote). Trialing unanchored, open-ocean boxes (Fig. 7.7.A left). Preliminary findings showed better feed conversion ratio(FCR) from 1.8 to 1.3, higher survival at 98 per cent and greatly reduced skin parasitism (with less than one fluke per fish) despite no treatment. They are now conducting research on whether the increased water velocity may be the reason for the improved performance (Fig. 7.7.A right).



Fig. 7.7.A The Aquapod net pen that floats in the ocean (left). Round tanks are used to create different water velocities for raising the fish to test the hypothesis of higher water current creating healthier fish.

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There is a tendency that consumers prefer eating carnivorous fish and therefore it would be difficult to expand the industry. There is research on creating commercial fish diets utilising soy bean and byproducts from algal culture (for biofuel or astaxanthin). It was discovered that fish texture and flavor can be altered by dietary changes in the few weeks prior to slaughter. Thus, the idea of farming fish on an herbivorous diet before finishing on fish meal arose. Researchers are investigating the culture sea chubb on an herbivorous diet and then finish off on fish meal a few weeks prior to slaughter.

The Kampachi Farms are also involved with Giant Pacific Grouper conservation. Groupers are protogynous hermaphrodites, beginning life as females with the ability of becoming male. This can happen when the large male is removed from an area and a harem of females are left unattended. The next most dominant fish will gradually become male over time. This characteristic slows the reproductive rate and threatens the long-term survival of the species. Furthermore, they have no fear of humans, making them easy targets for anglers and spear fishers. The last wild fish known to be caught from the wild was reported in 1997 and there have been no confirmed sightings of wild specimens. Thus, the fish are cultured at the Kampachi Farms to be reintroduced to the wild.



Fig. 7.7.B The juvenile giant Pacific groupers are protogynous hermaphrodites, beginning life as females and capable of changing into males should the need arise

7.8 Big Island Abalone

Contact - Frank R. Olinares, Presenter, Kailua-Kona, Hawaii, USA

Objectives

1. To see if there were differences in culture techniques.

Outcomes

Abalone culture had its origins in 1950s in Japan and China and was followed by other countries some 20 years later. Big Island Abalone is the largest abalone farm in the USA. It produces Kona Coast Abalone, a premium stock of coldwater and Ezo (Japanese Northern) abalone. This species was permitted to be cultured here because they are not tolerant of the surrounding warm waters and would

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die if they escaped. At the same time, it is viable to produce these abalone because water sourced from the bore is naturally cool and it is regulated to be delivered at $\leq 18.3^{\circ}\text{C}$.



Fig. 7.8.A The Ezo abalone (*Haliotis discus hannai*) is a premium live product that has sweet tender flesh.

This farm had initially trialed California Red abalone culture, but their slow growth rate (taking between five to fifteen years to reach market size) was not conducive for commercial production. The Ezo abalone on the other hand takes only two and a half years to reach marketable size. Additionally, because their meat is naturally sweet and tender, it is sold as a live, premium product. Even their viscera is edible.

Big Island Abalone is nearly a fully self-sufficient farm. They spawn their own animals with a 60 per cent survival rate of larvae, having 250,000 hatch. They spend six to twelve months in the nursery, four to six months as juveniles, four to six months as intermediates with the total time from spawning to market taking approximately 24 months. Those for broodstock production are grown on for a further three to six months.

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The grow-out abalone are held in long tanks, but water jets down and flows transversely in a direction parallel to the short sides and drains through the centre (Fig. 7.8.B). This ensures the animals receive optimal oxygenated water quality conditions. The abalone live in submerged vertical hides made of polyvinyl under a 90-95 per cent shade cloth cover.



Fig. 7.8.B Abalone grow out tanks with water flow parallel to the short sides of the tank allows for better water quality.

They are producing a significant amount of Dulse algae (red algae – Fig. 7.8.C) in concrete tanks holding 500,000 gallons of seawater as fresh supplementary food for the abalone. Their staple diet consists of artificial feed (bought from South Africa) and dried red kelp (from China, Vietnam and Mexico). There are plans to expand the algal culture with the intention to produce 120 tonnes/year, which would require ten acres. Having access to their own feed supply will mean better control over production and lead towards a vertically integrated business. The algae are harvested by pumping out into a sieve. Magnesium is the only macro element added to aid in algae culture.

Carbon dioxide is used as an anaesthetic when grading and a plastic spatula is used to ease abalone off their attachments. In a farm of this size, grading is conducted four days per week.

Due to the pristine water quality and the absence of native wild stocks of abalone, common endemic issues that occur on most other abalone farms (like mudworm) do not exist. The only health issues they face is bloat. This occurs when they are given too much feed and so the amount of feed is carefully controlled. If new broodstock is acquired, they are held in quarantine for one and a half years.

This species of abalone is sold as a live product. The company ships to any destination that can be reached within 24 hours; however, they are packed in such a way that the abalone can survive at least 40 hours, in case of delays. Fifty percent of their product is shipped to Japan and the rest is consumed locally, principally the west coast of USA.

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Fig. 7.8.C Dulse algae are grown on site with plans to expand its culture to make this farm fully vertically integrated.

The farmer shared with the Fellow that with aquaculture, the limiting factor is more to do with the capital requirements and not the technical processes.



Fig. 7.8.D In addition to abalone meat production, the farm runs tours and sells jewellery, sea salt and company merchandise.

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7.9 Ocean Rider Seahorse Farm

Contact - Carol Schmarr, Owner, Ocean Rider, Kona, Hawaii, USA

Objectives

1. To investigate different management strategies to maintain healthy aquarium systems for Sygnathids.
2. To investigate any special techniques used for seadragons (*Phycodurus eques*).
3. To investigate whether there had been success in spawning seadragons.

Outcomes

The Fellow visited the Ocean Rider Seahorse Farm in Hawaii, which holds 20 to 36 species of Sygnathids. Husbandry of Sygnathids was discussed and more specifically, concentrated on their seadragons. The leafy seadragon is endangered and requires more study to ensure survival of the species. The aim of this establishment is to hold a stock of Sygnathids and to investigate ways to breed for wild stock enhancement and also to supply to public aquaria so that they can dedicate resources onto other critical projects.

Seadragons are difficult to maintain in aquaria. Apart from being a protected animal, success in keeping them has been largely confined to the public aquarium sector, due to funding and knowledge that would not be available to the average enthusiast. Attempts to breed the leafy seadragon in captivity have so far been unsuccessful.

Among their collection were three leafy seadragons. The management of fish health at the Ocean Rider Seahorse Farm is based on a dynamic system rather than static. Fish are kept in flow-through systems, drawing filtered seawater from bores and in conjunction with this, the fish are moved every five to six days to newly prepared tanks. This aids in avoiding build up of pathogens in any particular system. Seadragons (the most sensitive of the family) have been successfully reared in this way for more than five years in this way. They are fed a relatively pathogen-free diet of red shrimp that naturally inhabit their deep water intake pipes. Female seadragons have deposited eggs onto tank walls on two occasions, but not onto their male yet.

Two observations made by Ms Schmarr that were consistent with many Sygnathid keepers are:

1. When disturbed, seadragons head straight to the water surface and swallow air creating buoyancy control issues
2. They develop snout injuries when they accidentally snap at the glass tank wall, not realising that is a solid surface.

This facility has been able to avoid these issues by allowing visitors to view seadragons only from above and have solid opaque tank walls. They also cover the tank with a black shade cloth.

However, in public aquaria, these measures may detract from the human-fish interaction and the Fellow has come up with two suggestions:

1. Use a one-way glass for display aquaria
2. Incorporate kelp type artificial plants that drape along the water surface so that they know and recognise the water surface.

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7.10 Aquaponics in Hawaii Conference

Presented by - Hawaii Aquaculture and Aquaponics Association, Winward Community College, Career and Community Education, College of Tropical Agriculture and Human Resources, Winward Community College, Hale Akoakoa, Hawaii, USA

Objectives

1. To investigate advances in aquaponics technology.
2. To investigate its commercial potential.
3. To understand other applications such as a facility for outreach.

Outcomes

This conference attracted more than 250 attendees. It was opened with three welcoming speeches. The rest of the day's events were split into themes. There were three specific presentations from commercial aquaponics producers, four from backyard aquaponics practitioners, four from aquaponics suppliers and service providers, four on the benefits of aquaponics to the community and then eight on the findings from research into the technical aspects of aquaponics including nutrient cycling, yield, chemical-free integrated pest management and good agricultural practices.

Currently, 85 per cent of Hawaii's fresh produce is freighted to the island. Honolulu topped the online keyword search for 'aquaponics', with five of Australia's capital cities taking the second, third, fourth, fifth and sixth place on Google Trends (Fig. 7.10.A). This has occurred as more and more people realise its potential to make Hawaii become more self-sufficient. A local movement of creating sustainable food production has spread to the urban garden, which is now becoming a growth area.

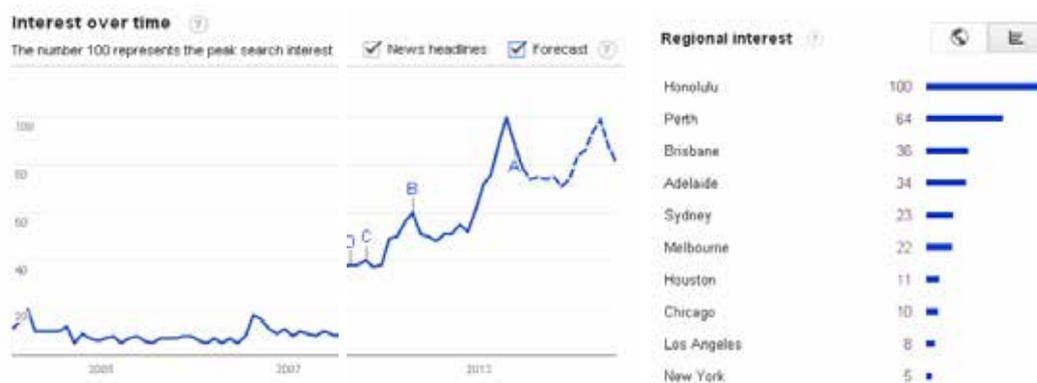


Fig. 7.10.A Google trends "aquaponics" by city (source <http://www.google.com/trends/explore?q=aquaponics#q=aquaponics&cmpt=q>)

The Hawaii Aquaculture and Aquaponics Association initially began as the Prawn Association, but as time went on, the focus changed to finfish aquaculture and now incorporates aquaponics. The association is also heavily involved in the legislature. The most recent success is moving the Senate Bill 586, which exempts aquaponics farmers from the building code. This helps to reduce the cost and time spent applying for building permits (see section 11.7.10.1). The association also facilitates knowledge and technology transfer and with the formation of co-operatives.

The conference website with the presentations from the recent conference on Aquaponics in Hawaii is now available to download from this site – <http://www.ctahr.hawaii.edu/sustainag/workshop/Aquaponics-May2013.html>

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7.10.1 Commercial Aquaponics in Hawaii

Jason Brand, with a business and finance background, operates Kunia Country Farms. He identified that they would grow produce that:

1. Has a high turnover
2. Is currently expensive due to refrigerated shipping costs from the mainland
3. Is easy to sell because there is no processing involved.

With these requirements in mind, he identified lettuce and other leafy vegetables and berries as the best options. The farm site characteristics of his farm include access to potable water (via a bore), low rainfall, 800 metres above sea level for good ventilation, power source and room for expansion. The farm started as 4500 ft² and has grown to 16,000 ft², producing 325,000 heads of lettuce annually using a tilapia and catfish crop and is looking to expand to 30,000 ft². The main issues experienced on the farm are acid rain at a pH of 4.5, pests and high electricity costs to run the refrigerator, blowers and water pumps. He emphasised that profitability is more to do with efficiency rather than space. Apart from food for the fish, iron is the only other supplement added to the water for the plants. Water quality is monitored regularly, with daily pH reads, iron is tested twice a week, weekly tests for ammonia, nitrite and nitrate and trace elements are tested twice a month. For the moment, fish are only used to fertilise the plants because food fish production is difficult due to the legalities. The farm is looking towards shifting to ornamental fish culture.

Karen Ching from Ili'iili Farm talked more about the steps involved in the startup process. This farm uses tilapia to grow Chinese leafy vegetables. Ms Ching spoke about the process involved in obtaining food safety and organic certification and used <https://gap-pro.com> as a tool for record-keeping and reporting to meet USDA requirements for Good Agricultural Practices.

Fred Lau from Mari's Gardens talked more about the possibilities and the future of aquaponics and pondered on what the limitations were and what action is required to improve. He encouraged others to participate.

7.10.2 Urban Garden Aquaponics in Hawaii

This session was to encourage more people to get involved in this as a pastime. Brian Leonida spoke on how he had to install solar panels and have a huge bank of batteries to generate power for his backyard system. Rick White talked about how to source second-hand equipment (e.g. IBC tanks) and to improvise. Rachel Watkins went further to add that almost any junk could be turned into aquaponics systems. Having said this, it is recommended that only food grade material be used for all tanks, pipes and fittings (see Table 7.10.2.A). If purchasing second-hand items, make sure there are written records of previous uses of the equipment for surety. Albert Fung talked about the online community he had attracted onto his website – aquaponicsinparadise.com.

Plastic resin code	Material	Uses	Safety
1	Polyethylene terephthalate (PETE)	Soda bottles, water bottles, shampoo bottles, mouthwash bottles, peanut butter jars.	Can leach dioxins, carcinogens, hormone-disrupting phthalates with long-term use.

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Plastic resin code	Material	Uses	Safety
2	High density polyethylene (HDPE)	Milk, water and juice jugs, detergent bottles, yoghurt and margarine tubs, grocery bags.	Durable in sun, mostly food-safe.
3	Vinyl (V)	Clear food packaging, shampoo bottles.	May not be food safe. Schedule 40 PVC pipe is food-safe.
4	Low density polyethylene (LDPE)	Bread bags, frozen food bags, squeezable bottles (mustard, honey).	Not know to leach toxic chemicals.
5	Polypropylene (PP)	Tomato sauce bottles, yoghurt and margarine tubs.	Not know to leach toxic chemicals.
6	Polystyrene (PS)	Meat trays, disposable cups and plates.	Some types are food-safe.
7	Other	Some juice bottles.	Combination of any kind of plastic. May contain BPA (Bisphenol A) which is an endocrine disrupting chemical.
9/ABS	Acrylonitrile butadiene styrene	Drain-waste-vent pipe systems, musical instruments (recorders, plastic clarinets), small kitchen appliances, and toys.	Leaches toxic chemicals.

7.10.3 Aquaponic Services

This session provided a run down on the services available to aquaponics practitioners from a range of suppliers. Reyn Horner from Hapa Farms explained that they breed fish to supply to aquaponics. Travis Sato from Aquaponics Plus described his 'one-stop-shop' when it comes to aquaponics setups and how they can even retrofit aquaponics systems to existing fish ponds. Louis Primavera and Fred Mencher from Primavera Aquaponics outlined that they specialised in vertical design aquaponics for those with limited space. Robert Burns from Olamana Gardens talked about employing the help of Willing Workers on Organic Farms (WWOOFers), volunteers willing to progress the organic movement. Here, the host provides food, accommodation and opportunities to learn, in exchange for assistance with farming or gardening activities. He also mentioned about the Glenn Martinez airlift system as a more economical way of moving water than water pumps. The demonstration on how it works can be found at this link <http://www.youtube.com/watch?v=Dx0gtyMCurE>

7.10.4 Aquaponics in the Community

This session focused on aquaponics as a tool for outreach. Ilima Ho-Lastimosa presented 'Ma Ka Hana Ka `Ike – How Hawaiians Learn, By Doing'. She used aquaponics to reach out to the native Hawaiians and to get the community involved. Showing them that farming fish is not against tradition and empowering individuals by giving them the skills to build and maintain their own aquaponics setups. The key to success was that it was a culture-based education. The fish and fresh vegetables that are grown would contribute towards healthier eating and hence, living. Other beneficial elements include

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expanding knowledge of the various components of the food system, produce documentation of the system set-up process and plant growth and most importantly it encourages the people outdoors and facilitates social interaction. The coordinator was able to integrate Hawaiian cultural values such as the ahupua'a system (living mountain to sea) and malama (take care of) and participatory education with aquaponics. More information can be found at this link -<http://makahanakaike.weebly.com/>

The Hawaii State Hospital is the only hospital in Hawaii dedicated solely to serving adults with serious and persistent mental illnesses. The Hospital's mission is to provide safe, integrated, evidence-based psychiatric treatment and rehabilitation to individuals suffering from mental illness and concurrent disorders. Tiffany Kawaguchi spoke on the use of aquaponics for psychosocial rehabilitation. The therapeutic outcomes include enhanced mood, reduced arousal/agitation, improved concentration, task engagement, problem solving and frustration tolerance, development of interpersonal skills and personal identity within a social group with similar interests and goals and increased physical activity and awareness of healthy diet. Moreover, since its inception in 2010, the Aquaponics Program has provided over 800 pounds of vegetables and herbs to the Hospital's kitchen and patient care units. The Hospital's menu has expanded to include culturally diverse and healthy options like Thai basil chicken and Japanese ozoni soup. Regarding the fish, over 400 pounds of golden tilapia have been donated, sold and served.

Lynn Fujioka from the Internet sister (ISIS) organisation in Hawaii talked about engaging students in science and math education through real world companies and technologies like aquaponics to teach elementary to intermediate grade students.

Susan Miller from Hawaii Aquaponics Workforce spoke on the development of a high-tech, innovative farm project which incorporates aquaponics greenhouse growing for the purpose of commercial food production, workforce development training and certification as well as agri-tourism, education and technology transfer.

7.10.5 CTAHR Aquaponic Research

Luisa Castro presented on Good Agricultural Practices (GAPs) as they apply to food producers employing aquaponics. She stated that many of the rules created by the Food and Drug Administration (FDA (of the USA)) are related to agriculture and may not be suitable for aquaponics and so it would be necessary to employ auditors who are aware of the differences. She drew attention to issues such as using food-safe materials in the construction of water handling portions of the farm (Table 7.10.2.A), positioning of culture units away from potential contaminating structures (such as trees and roofs) and organisms (e.g. wildlife) and training staff in food handling. She advised on water sources and ensuring that culture water did not come into contact with edible parts of the plants.

Leina'ala Bright presented her research on comparison of 'ōlena (turmeric) grown in soil versus aquaponics systems with the following results:

- 'Ōlena grown in soil was significantly higher in ash, iron, potassium and boron
- 'Ōlena grown aquaponically was significantly higher in crude protein, acid fiber, lignin, copper, manganese, zinc, magnesium, curcumin, gallic acid equivalent and bisdemethoxycurcumin
- No statistical differences in dry matter, neutral fiber, phosphorus, calcium, sodium, fat and cellulose.

Theodore Radovich did a similar experiment using pak choi and beets and concluded that aquaponically grown vegetables are at least comparable to soil-grown, in terms of quality and quantity and this can be optimised by selecting the best varieties to grow.

Work by Clyde Tamaru (pictured below) suggests that much of the nutrients fed to fish remain within the fish and are not excreted. The amount of nutrients released into the water (WCC Testing) is below

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what is required for growing plants hydroponically (Static Hydroponic), with iron being deficient by the greatest degree by a factor of 85. Thus, it was recommended that chelated iron is added weekly. Other vital water quality parameters to monitor include maintaining nitrate above 40 mg/L for optimum plant growth and ensuring dissolved oxygen is kept above three milligrams per litre for good fish health.

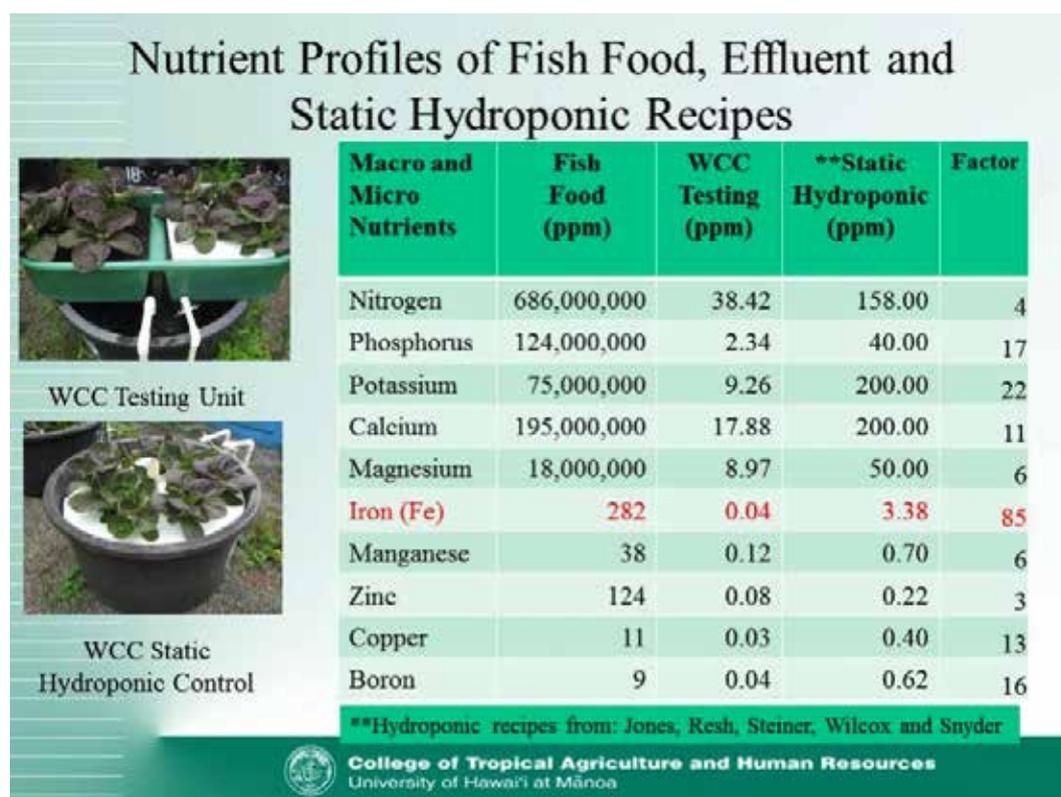


Fig. 7.10.5.A Comparison of the dissolved mineral availability in cultured fish water and of that required by hydroponically grown plants.

Perhaps the most practical session was by Harry Ako who presented the 'rules of thumb' for a particular system size (Fig. 7.12.5.B). The nutrient flux hypothesis was tested whereby the investigator needed to match the ratios of fish to water to plants. It was concluded that to grow 50 lettuce plants, it would need 200 litres of water to house five pounds of tilapia fed at a rate of 40 grams of fish food per day.

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For aeration, it was necessary to have two or three, six inch long air stones per 200 litres of water to prevent dissolved oxygen ever decreasing to below three milligrams per litre to avoid the chance of denitrification. He also tested the efficiency of cinder as a biofiltration and concluded that each litre of cinder can handle 50-60 grams of feed (protein content 41 per cent). Using cinder as a growth medium for plants, he found that some systems performed better than others. These are listed below in descending order of plant growth and productivity ('1' being the best method and '5' being the least successful method):

1. Water 'trickle' method
2. 'Flood and drain' (also known as the 'ebb and flow')
3. 'Raft with air gap'
4. 'Raft without air-gap but with vigorous aeration'
5. 'Raft without air-gap' technique.

Zhen Hu presented on the nutrient retention efficiency and showed that tomato was more efficient than pak choi in utilising the nitrate from the water (42.2 per cent compared to 33.5 per cent) making it a better choice for aquaponics.

Jensen Uyeda presented on the use of Integrated Pest Management (IPM) strategies with the aim of retaining or improving production without negative impact on the environment, humans and aquacultured animals. It all starts with proper plant pest identification and then understanding the characteristics of the pest in order to select the best strategy. Pests were categorised as follows: chewing pests, sucking pests, thrips, mites, fruit flies, plant hoppers, slugs/snails, nematodes, fungal, bacterial, viral, phytoplasma and weeds. Monitoring tools such as sticky traps, pheromone traps, light traps, sweep nets and plain observation were discussed. Preventive measures include habitat modification (e.g. removing detritus and altering water management), installation of physical barriers (e.g. screens for flying organisms, reflective mulches, copper wires for slugs/snails), manipulating culture practices to disadvantage the pest (e.g. crop rotation, fallowing periods, crop spacing, companion planting, crop selection, aeration, introduction of earthworms to help breakdown solid wastes, overhead irrigation), biological strategies (e.g. predatory insects like wasps and ladybugs) and chemicals being the last resort. If chemical use became necessary, it was advised to choose one with the lowest risk of toxicity and the one that is more selective rather than a broad spectrum. The chemical should also be rotated with other chemicals to avoid selecting for resistant organisms and the label instructions must be adhered to.

Koon-Hui Wang expanded on Jensen Uyeda's presentation, showing her experimental design of insecticide-free plant pest control using wasps as a biological control agent against caterpillars and using vermicompost tea on seedlings prior to transplanting would decrease the incidence of aphids.

The final presentation at the conference was by Clyde Tamaru who gave a summary of the economics of aquaponics based on the three local commercial aquaponics farmers, finishing with these concluding remarks, "Currently, vegetable production is the driving force of aquaponics production in Hawaii where a premium is paid for locally produced product. At the moment, 800,000 pounds of tilapia are imported into Hawaii for consumption. Aquaponics is a single footprint for the production of fish and vegetables. It is very low cost when compared to seacage aquaculture farming. It is a very profitable technology and we need to pay attention to it. It is worth pursuing".

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7.11 University of Florida, Tropical Aquaculture Laboratory

Contacts - Roy Yanong, Assoc. Professor and Extension Veterinarian, Tropical Aquaculture Laboratory, Ruskin, Florida, USA and Craig Watson, Director

Objectives

1. To learn about the extension services provided by the University of Florida for aquaculturists.
2. To see first-hand, the types of operations of their clients.

Outcomes

The Tropical Aquaculture Laboratories (TAL) offers a diagnostic service and training as their mainstay operation. They also conduct research programs, such as breeding techniques for the different species, based on the requests of producer groups. There are also drug companies that contract the TAL to run studies on Investigational New Aquaculture Drugs (INADs) and to help with regulatory issues such as the 'indexing' (grouping) of multiple species of fish as it relates to drug use. Also, during the 1997 Mediterranean fruit fly incident in the state of Florida, extension officers of TAL notified the pesticide sprayers to avoid spraying near fish farms by providing the GPS co-ordinates of at-risk areas. These are just some of the ways the TAL services the ornamental fish aquaculture industry.

Included in this visit were site visits to three ornamental fish farms:

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7.11.1 Carter's Fish Hatchery

Contact - Jeffrey Carter, Carter's Fish Hatchery, Wimauma, Florida, USA

This farm produces silver dollars, angelfish and plecostomus catfish amongst others. One of the major challenges is the proliferation of tadpoles in the ponds because they compete for space, oxygen and food; however, this is unavoidable given the nature of the issue. The most interesting part of this operation is that the plecostomus catfish egg masses are actually collected from the wild by the locals and the farmer purchases these to be hatched and grown.

7.11.2 Golden Pond Tropicals

Contact - John Skidmore, Golden Pond Tropicals, Wimauma, Florida, USA

There is the abundance of tadpoles at this site as well; however, the farm manager chose to take advantage of this and raise the tadpoles to be sold. The issue this farm sees is the presence of crayfish in the ponds and tanks. During grow out, these do not pose a problem; however, when water is drained and the fish are crowded, the crayfish can cause considerable physical damage to the fish.

7.11.3 '5-D Tropical'

Contact - 5-D Tropical, 6507 Bob Head Rd, Plant City, Florida, USA

The indoor facilities of this company contain a total of 490,000 gallons of water and the farm has nearly 900 ponds with an additional capacity of 2,250,000 gallons. Fish are imported weekly from South America, the Far East and Africa. Imported fish are quarantined for seven days to ensure they are free from diseases. Quality control procedures consist of five checkpoints before any of the fish are packaged for distribution. The farm also breeds fish for trading. At the time of the visit, they were breeding GloFish (a patented and trademarked brand of genetically modified fluorescent zebrafish). These fish are bred in a similar manner to standard zebrafish.

7.12 Seavet

Contact - Michael Walsh, University of Florida, College of Veterinary Medicine, Gainesville, Florida, USA

Objectives

1. To appreciate the environment.
2. How to treat diseases.
3. How to prevent diseases.
4. How to protect the environment.

Outcomes

Much information on fish health, disease and medicine whilst known, have not been documented or officially published. This is the experience of colleagues. It was beneficial to learn not only about the successes, but also about what did not work. These are the key reasons for attending workshops and conferences.

The speakers emphasised a shift from memorising facts, to learning, for your client's health. They stated that many people make decisions based on the choices they know, and commented that sometimes

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it is essential to challenge these. Everyone can progress by working together toward a common goal.

The discussion was provided according to topic, initially by species or animal groups, and then by subject matter. The full itinerary of the course is in attachment 11.7.1.

7.12.1 Bony fish

Disease is complex and is rarely a simple association between fish and pathogen. Successful fish health management begins with prevention of disease rather than treatment – the key areas being water quality, nutrition, sanitation and fish health.

Fish show a limited range of clinical signs of illness and these are usually not specific enough to make a diagnosis by clinical examination alone. With the tools available at hand, many veterinarians can provide the service for clients with fishes.

Several different presenters gave their take on veterinary aspects. The presenters had a research, extension, pathology or public aquarium background.

Diagnostic techniques, water quality and treatment considerations were discussed and there was emphasis on diagnosing infectious diseases.

Management of large fish populations for marine aquaria is somewhat challenging. The biggest difference is when it came to quarantine. Some public aquaria have their own facilities for quarantine, but those that do not, have the option of an off-site facility or be able to outsource their quarantine.

7.12.2 Sharks and Rayfish

Throughout the world, sharks and rays are the draw card species for public aquaria and so the health and welfare of these animals are a priority. There are degrees of intervention when it comes to the care and management of sharks and it can range from observation without intervention through to preventive medicine. The former method of management involves interaction with sharks only for feeding and during crisis events. On the other end of the scale, fish are trained to swim into holds, nets or stretchers on a daily basis and this is so that body weights and diagnostic samples can be taken to monitor their health and growth on a regular basis.

Captive sharks and rays are normally caught and examined twice a year in which a complete physical examination and a blood samples are taken. This will give early indication of disease. It is critical that sharks and personnel are practiced with the process of capturing and immobilising the large animals so that necessary steps can be taken in case of emergency.

MS 222 is the drug of choice used in almost every aquarium in the USA as it is reliable and safe for many species. In sharks it is used at 50-75 milligrams per litre and in stingrays, up to 100 milligrams per litre is necessary. Intravenous propofol via the cranial dorsal fin sinus is also used if weights of sharks are known. Sometimes it is necessary to administer diazepam to a distressed whale shark at a dose of four to five milligrams per kilogram.

When giving intramuscular injections to sharks, there is usually considerable back pressure from the compact tissues forcing the injected material to exude from the site. This can be prevented by applying orthopaedic bone wax to the site which will form a temporary seal sufficient to allow the drug to dissipate.

Some other techniques were demonstrated using pictures or videos such as drawing blood from the pectoral fin from an unsedated whale shark whilst swimming using a 3-way tap, performing a caesarian

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in a rayfish, obtaining body weight of sharks, behavioural conditioning of sharks and rays to feed from particular areas and more.

There are many possible conditions that can affect sharks. Some of the pathological conditions were discussed. One such condition was the development of spinal deformities that were noticed in some of their sand tiger sharks (*Carcharias taurus* known in Australia as grey nurse sharks). Experts suggested causal factors such as nutritional imbalance or inappropriate tank designs causing abnormal swim patterns. An X-ray study of newly caught sharks revealed that as many as 60 per cent of juvenile sharks delivered to the public aquaria already had spinal fractures, attributed to the longline method of capture.

Another physical deformity seen is pectoral fin curling. There has been no conclusive explanation for this condition; however, inappropriate water current has been suggested as a cause.

The most common parasitic condition faced by rayfish is flukes. These are maintained under control by the use of organophosphate, freshwater or praziquantel baths. Some collections of sharks are dealing with leech infestations. These are kept under control by organophosphate baths or by hand removal with fish under sedation.

Of lesser frequency is the presence of *Eimeria* within the coelomic cavity. Flushes of the coelomic cavity to diagnose this condition may be obtained by introducing a three to five, French gauge catheter into the coelomic cavity via the pore on the medial aspect of the blind-ending sacs in the cloaca. Other than parasitic conditions, other illnesses can develop. For instance, it is not uncommon for rays to develop areas of pressure necrosis if there is insufficient sandy substrate for them to rest on. Also, egg yolk peritonitis can occur because they produce large yolks and there is limited protection for these structures from external forces.

Rayfish are commonly used in visitor interactions and the barbs may be trimmed short with large secateurs on a regular basis, or the barb and germinal tissue be excised permanently using electrosurgery.

Table 7.12.2.A *Elasmobranch formulary by Dr Mike Walsh.*

Medicine	Dose Rate	Mode of administration
Tricaine methanosulfonate (Finquel)	50-100mg/L	Bath
Medetomidine + Ketamine	60-80µg/kg + 4-10mg/kg	IM
Reversal: Atipamizole	As necessary	IV / IM
Doxapram	As necessary	IM
Midazolam	0.75mg/kg	
Propofol	0.5-2mg/kg	IV
Diazepam	4-5mg/kg	IM
Amikacin	3mg/kg	q3d
Gentamycin	3mg/kg	
Chloramphenicol	20mg/kg	q12h
Enrofloxacin	5mg/kg	IM q5d

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Medicine	Dose Rate	Mode of administration
Enrofloxacin	10mg/kg	IM q7-10d

Dr Walsh also alerted attendees to the Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives. The Elasmobranch Husbandry Manual is a single-reference guide detailing the hands-on care of elasmobranchs; a 'how to care for' sharks, rays and chimaeras. This volume is intended to assist in the development of new exhibits, aid in the training of husbandry personnel, prepare scientists for hands-on work with elasmobranchs, and answer specific questions about this important taxonomic group. The entire Elasmobranch Husbandry Manual is available to download free of charge from this site <https://sites.google.com/site/elasmobranchhusbandry/manual>

7.12.3 Sea turtles

Turtle strandings commonly occur during late winter to early spring. It has been suggested that cold (<55oF) waters well up and catch turtles unaware. Typically, cold stunned turtles present thin, sick and with bradycardia (low heart rate). In the past, bradycardia was treated by administering atropine; however, this will slow gut transit time and so it is no longer practiced. Instead, turtles are slowly warmed up by increasing their hospital tank water temperature.

The standard stranded turtle protocol would involve the following steps:

1. A complete physical examination is performed and its body temperature and blood samples are taken for analysis. The most critical blood parameters for testing include the Packed Cell Volume (PCV) and the Blood Glucose Level (BGL).
2. Body condition scoring is assessed by checking the depth of their eyes, the degree of protuberance of the occipital bone, prominence of dorsal neck tendons, whether the soft tissue in the shoulder region is receded behind the carapace and by the diameter of the proximal parts of their limbs.



Fig. 7.12.3.A Blood sample being taken from the dorsal neck cervical sinus.

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3. An oral dose of Toxiban (the suspension contains 10.4 per cent charcoal and 6.25 per cent kaolin (in an aqueous base) to adsorb any ingested toxin.
4. Turtles are then placed in hospital tanks (shallow for the very sick and deep tanks for relatively healthier individuals) and the water temperature slowly raised to within their optimal ranges (they are not dry-docked like their terrestrial counterparts as much as possible). Hospital tanks are round and smooth, and the plumbing designed such that there are no obstacles within reach of the turtle. Highly stressed turtles may be given a dose of Valium.
5. Once the blood test results are available, therapy will be implemented. Those with low BGL will be given subcutaneous fluids of three percent dextrose and IV fluid of three percent dextrose. Dr Mike Walsh pioneered the use of a visco-elastic balloon (e.g. Homepump Eclipse Series) strapped on to the back of the turtle to provide a sustained slow release of fluids if it was necessary (Fig. 7.12.3.A). It is crucial to maintain BGL within reference values to prevent brain death. If BGL drops a second time, then the chance of recovery is greatly diminished.

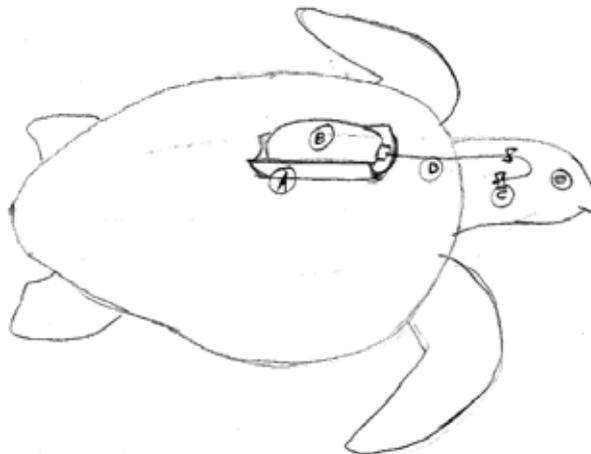


Fig. 7.12.3.A A turtle with a half PVC pipe cut (A) longitudinally and secured to the carapace to act as a cradle for the visco-elastic balloon (B) that is directed into the dorsal neck cervical sinus via a catheter (C) via a giving set (D).

6. Those animals with critically low PCV may be given a blood transfusion from a healthy turtle, collected into heparinised blood collection bags. Those with low PCV are given iron fumarate or iron sulphate injections at 10-12 milligrams per kilogram twice a day and this dose is reduced to six milligrams per kilogram twice a day when they resume eating.
7. The most crucial next step is to get them eating to meet their caloric needs. Turtles eat three percent of their body weight daily but the food given during therapy needs to be highly energy dense to get them back into positive energy balance. Turtles may need to be offered feed up to five times per day. Failing this, and between food offers, they are force fed a liquid diet. An average size turtle can take approximately 20+ millilitres of gruel. The formulation is 16 millilitres of seafood gruel, two millilitres of menhaden oil, three millilitres of dextrose and vitamins (including vitamin K). Green sea turtles are supplemented with avocado and spinach. Turtles are force-fed close to their tanks so that they can be replaced immediately to prevent aspiration pneumonia.

However, if the animal had sustained traumatic injuries, it will be assessed on whether efforts for rehabilitation are warranted. Shell fractures or wounds are usually left to heal by second intention. The wounds are cleaned with dilute betadine solution and topical antiseptic pastes are applied. The paste is made of 50 per cent sulfadiazine cream (antibacterial cream) and 50 per cent iLEX (a patented biomedical topical skin barrier that contains 'special white petrolatum copolymers' with a distinct ability to adhere to wet/moist areas) mix. Tegaderm (a calcium alginate dressing) is then applied over the

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surface and cyanoacrylate glue is used to seal it the edges, avoiding contamination and desiccation (Fig 7.12.3.A). If the shell requires stability, small fractures can be stabilised by attaching porous tape/bandage material to the shell approximately three layers thick and then hardened by adding cyanoacrylate (super glue). A screw and plate technique can also be used for larger fractures and screws should go no deeper than 50 per cent through the thickness of the shell.



Fig. 7.12.3. A Antiseptic cream and iLEX protectant paste (left) is applied to cleaned wounds and then Tegaderm is affixed and its edges sealed with super glue.

Antibiotics commonly used include metronidazole for anaerobic infections and ceftazidime as a broad spectrum. Other antibiotics include amikacin, chloramphenicol, enrofloxacin and penicillin. Those that have been on antibiotics for any protracted period of time are usually given antifungals as well.

Turtles are frequently wormed with praziquantel or fenbendazole to obviate other contributing factors to illness. Metamucil or mineral oil may be given to help clear intestinal blockage naturally, but sometimes, metaclopramide or cisapride may be given.

Approximately 80 per cent of Florida's turtles have papillomaviral infection. Small external lesions can be treated by resection and laser surgery and systemic antiviral drug such as acyclovir, but not with great success. New techniques incorporate the use of cryosurgery using needles to penetrate the core in order to direct the cryotherapy deep within. However, if external tumours are greater than ten centimetres in diameter, or if there are more than four masses or if X-ray reveals the presence of disseminated internal papillomas, then these animals are euthanased.

After a minimum of two weeks in rehabilitation, shell fouling can be addressed. Barnacles and areas of shell calcification are removed and the defects are filled in with iLEX. Other forms of epibiota are killed with a rinse of 1:5 dilution of vinegar.

7.12.4 Environment quality for marine mammals

The water quality requirement and treatment for marine mammals is similar to fish. However, their objective differs slightly due partly to their greater tolerance to poorer water quality. Water clarity is of the greatest importance in public aquaria displays and efforts are directed mainly towards reducing algal growth for greater visitor viewing experience. Chlorination, ozonation and the addition of copper sulphate are some of the methods employed. Caution needs to be exercised though because overzealous application of ozone and chlorine has contributed to serious eye damage in the animals. Water is regularly tested for pH (6.5-8.5), chlorine (0.5-2.0mg/L), salinity (15-36 g/L), coliform counts

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(less than 1000 MPN/100ml) and any other chemicals that may be added to the water.

Cetaceans are adapted to the open oceans, for rapid breathing and for breath holding. Thus, good air quality is crucial to their health. Dust, exposed dirt piles, chemicals, fumes and dirty water sprinklers can be deleterious to the health of these animals. There should be a 'no dust and no aerosols' policy. Overhanging structures can also pose a threat and all shade structures should be impervious to water and drain away from pool surfaces, avoiding shade cloth material because the material can harbor fungi.

Environment enrichment and design of tanks are essential. It is also crucial to observe their behavior as a species, gender specific and during different seasons.

A variety of disease conditions were shown, diagnostic sampling techniques demonstrated and treatment options described.

7.12.5 Pinnipeds

The presentations relating to pinnipeds touched on the animal handling and diagnostic sampling techniques, nutrition and diseases with an emphasis on ophthalmic issues. The reason for this is that they are prone to eye disease. This can occur if salinity falls below 30g/L, if there is chemical irritation from chlorine or ozone, physical damage from sand or trauma from conspecifics and from excessive UV exposure (insufficient shade, reflective surfaces). Corneal ulcer treatment involves flushing with hypertonic saline (five percent solution); antibiotic drops three to four times per day and applying autogenous plasma or serum. The use of antioxidants in their diet (e.g. grape seed extract and lutein) will protect their eyes from oxidative damage.

7.12.6 Dolphins

Dolphins are popular creatures that pull at the heart-strings of people. But for what purpose do we study dolphins? Dolphin research began in the early 1970s and continues to the present day. The focus for research has changed over time. In the:

- » 1970s it was to establish their ranging pattern and social pattern
- » 1980s for health assessment of the dolphin
- » 1990s to assess environmental contamination (pesticides, industrial pollutants, heavy metals)
- » 2000s to indicate the availability of prey.

Monitoring of aquatic animal health is essential to provide baseline data for the rehabilitation of the area or other similar areas.

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Fig. 7.12.6.A A slide from Dr Walsh's lecture on the variety of diagnostic samples and tests that are taken as part of the monitoring.

Dolphins show great resilience. Females mature between five to ten years and can bear young from 6-48 years of age. Studies have found that the older females tend to have greater success at rearing offspring, which may be due to their larger size or because of greater adaptability due to having more knowledge about their environment and have a greater network of close associates. Studies have also shown that female dolphins can excrete 80 per cent of accumulated toxins through their milk. It is common for the first-born calves to die from contaminated milk.

The incidence of dolphins becoming impaled by rayfish spines has been on the rise and this is likely due to the decrease in the number of sharks which are the natural predators of rayfish.

Four percent of dolphins feature boat collision scars. Eleven per cent have entanglement scars sustained as a calf or sub-adult, with the most common object being crab traps. Red tide is blamed for dolphin populations decline by ten percent, with losses of calves in the order of 50 per cent. The reason for this is due to a greater than 90 per cent decline in some of their primary preyfish.

A captive dolphin has a monetary value in the vicinity of US\$150,000-250,000 and their high profile affords them a higher level of care than most other aquatic animals. In many establishments, the most common training dolphins receive is for 'husbandry' purposes. This includes any 'veterinary behaviours' that allow dolphins to voluntarily participate to allow carers to take diagnostic samples for the purpose of monitoring their health on a regular basis (Fig. 7.12.6.B).

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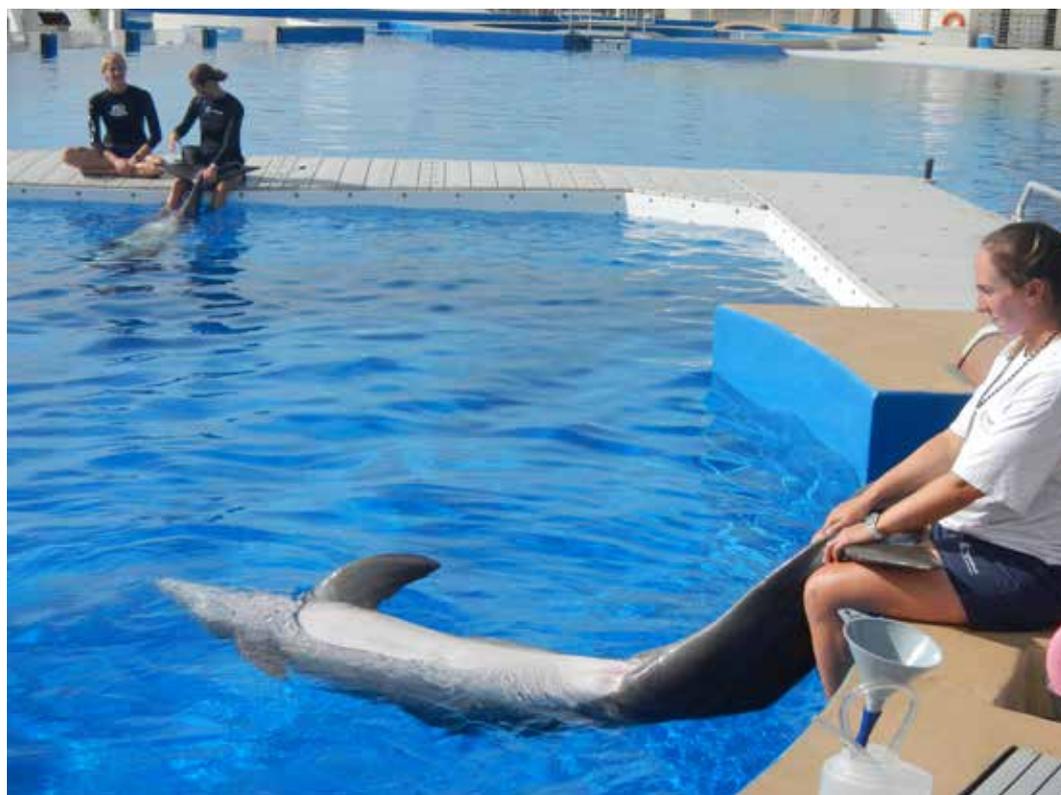


Fig. 7.12.6.B Dolphins presenting their flukes for blood draws. Marineland, Florida, USA.

There was a full lecture dedicated on the nutritional management for dolphins. Fish stocks are ordered and the dolphin's dietary formulation would depend on the nutritional value of the fish. Of course, this will be dependent on the species and the season in which they were caught and so subsamples from the batches of fish ordered in are routinely submitted for nutritional analysis.

7.12.7 Whales

Most of the presentations around whales tended to be associated with strandings or sick and injured whales at sea. One of the biggest challenges to rescuing whales is the ability to safely get near the animal to remove entangled rope. Dr Walsh utilised PaxArms MK24C remote injection equipment that could deliver 57 ml darts with 6-12" needles through a 15 meter range. The combination of drugs used were midazolam HCl 0.1mg/kg and butorphanol HCl 0.1mg/kg. To remove the entangled rope, a large spring-loaded blade attached to the end of a rod is used.



Fig. 7.12.7.A The dart that was used to sedate the mentioned whale. The needle bent as the whale kept swimming with the dart embedded.

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Methods to decrease ship strikes include lowering boat speeds, enforcing shipping lanes, positioning of buoys and for ships to remain in radio contact so they can be alerted.

7.12.8 Marine mammal strandings

Marine mammal strandings occur from time to time. There are organisations that study the reasons for these incidents. Determination of a cause of death provides valuable information for the management, mitigation and prosecution of unintentional and sometimes malicious human impacts, such as vessel collision, fishing gear entanglement and gunshot. Marine mammals are a crucial part of the food web and studying these animals will provide data that can be used as a benchmark for future research on the group as well as for the monitoring of trends in population health.

There is an average of eight strandings per year in the north-east Florida region; however there were 20 cases seen part way through 2012. More than 75 per cent of the time, the animals are already dead by the time of notification or arrival. There are many theories surrounding why dolphins and whales strand. The accepted reasons are that they were lost, sick, or followed their leader to the shallows. Unusual mortality events have been tallied and 13 per cent were due to infectious diseases, 27 per cent from biotoxins, seven per cent from ecological factors, seven per cent from human interactions (fish net, boat, crab trap) and a large proportion unknown (46 per cent). A major part of the emphasis at necropsy is to identify whether the death/s are due to human interactions and it will inform management decisions about high priority mitigation strategies (e.g. speed regulations, fishing gear regulations).

The equipment necessary to perform necropsies on the animals is not necessarily standard. Additional equipment include stretchers/tarps, shovel, shade, saw, rope, anchors, tagging device (cattle tags or spray paint when there are multiple animals). The emphasis at necropsy is on conducting a small subset of thorough necropsies and getting quality samples. The details of methodology for necropsy, morphometric measurements and sampling can be found in a manual – Young N. (ed.) 2007 *Odontocete Salvage, Necropsy, Ear Extraction, and Imaging Protocols*, Ocean Research, Conservation and Solutions (ORCAS) Consulting. This manual can be downloaded from <http://www.nmfs.noaa.gov/pr/health/noise/docs/protocols.pdf>.

Occupational health and safety measures were also discussed.

Some of the common patterns of lesions have been studied. Those associated with boat impact tend to have contusions, fractured mandible, cranium or ribs, with or without internal haemorrhage. Those that encountered the propeller of boats generally have multiple, parallel, bread-slice type lacerations that may be linear, curved or sigmoid. These can be distinguished from the 'rake' marks created by teeth of conspecifics, shallow, narrow parallel markings (Fig. 7.12.8.A). Skeg/rudder/hull injuries may create skin abrasions, tearing, chop wounds or incisions. Those entangled in fishing line or ropes will have strangulation type injuries (linear lesions and furrows), with or without evidence of the gear present. In chronic cases, there may be amputation of an extremity (e.g. tail stock and flipper). Those that present with circular lesions may be due to cookie-cutter sharks or fungal infection. Holes in the body may be due to ballistic trauma, a fistulous tract for an abscess or due to penetration by a stingray barb. Lesions from gun shot injuries may have more obvious exit wounds than entrance wounds and typically have extruded margins. Running X-rays, metal detectors and probing tracts with can facilitate detection of a projectile and extent of injuries. Dolphins with hypoxia would have pulmonary oedema and emphysema, persistent froth in airways and generalized congestion. Debris ingestion is easily identifiable by examination of the gastrointestinal tract for foreign material.

Some of the more uncommon post-mortem findings of stranded dolphins include gas bubble disease with lesions typically in the kidney, liver and muscle and this happens if the animal was inadvertently caught at depths of >100 meters. Pathology caused by anthropogenic noise can be investigated by

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examining the ears and especially in the organ of Corti. All these gross lesions need to be differentiated from post-mortem damage, scavenging and from post-mortem autolysis which can be done by utilising other test methods such as histopathology. In cases of ante-mortem traumatic injury, microscopic changes such as haemorrhage, myonecrosis, oedema and inflammatory cell infiltration can give clues. More information can be found in this paper – Moore, M (ed.) et al. (2013) Criteria and case definitions for serious injury and death of pinnipeds and cetaceans caused by anthropogenic trauma, *Diseases of Aquatic Organisms*, Vol 103: 229-264. Also, refer to the manuals - Barco S & Touhey K (2006) Handbook for Recognizing, Evaluating, and Documenting Human Interaction in Stranded Cetaceans and Pinnipeds, Virginia Aquarium Stranding Response and Cape Cod Stranding Network which is available at http://www.nmfs.noaa.gov/pr/interactions/injury/pdfs/day1_rowles_hi_handbook.pdf and Pugliares KR, et al. (2007) *Marine Mammal Necropsy: An introductory guide for stranding responders and field biologists*, Woods Hole Oceanographic Institution which is available at <http://www.bahamaswhales.org/strandings/necropsy.pdf>



Fig. 7.12.8.A A model of a dolphin at Marineland showing propeller injury to its dorsal fin and rake marks to the dorsal aspect of the thorax/neck region.

The method of euthanasia can be difficult at times and factors that need to be accounted for include size of the animal, availability of the drug, presence of on-lookers and volunteers and the destiny of the carcass. Euthanasia protocols follow the standards set by the AVMA for particular species and is done in a way to minimise stress, pain and suffering for the animal. For smaller animals (less than four metres long) barbiturates are recommended. It is acceptable to euthanase in a two-stage technique, by initially sedating the animal and then an intracardiac delivery of potassium chloride (Fig. 7.12.8.B). When dealing with large marine mammals and there is concern over the fate of the carcass in terms of secondary toxicity, then implosion devices are appropriate. The charge is applied to the brain, just caudal to the blowhole.

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Fig. 7.12.8.B The euthanasia device fashioned for rapid delivery of large volumes of KCl direct into the heart of large, stranded marine mammals. A large hollow steel rod with a pointed tip and fenestration at the distal end that is connected to a pressure spray canister.

Disposal of the carcass may sometimes be difficult. They may be towed to a remote location, buried on the beach, taken to landfill, rendered or left in-situ.

Table 7.12.8 Marine Mammal Emergency Formulary – Georgia Aquarium, Conservation Field Station.

Medicine	Mode of Administration	Concentration	Per 100kg
Solu-Delta-Cortef	IM or IV	50mg/mL	10mL
Epinephrine	IM	1mg/mL	17.5mL
Doxapram HCl	IV	20mg/mL	5mL
Selenium/Calcium	-	-	-
Atropine sulfate	IM or IV	0.54mg/mL	11mL
Xylazine	IM	100mg/mL	2.2mL
Xylazine	IV	100mg/mL	1.1mL

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Medicine	Mode of Administration	Concentration	Per 100kg
Midazolam HCl	IM	5mg/mL	2mL
Flumazenil	IV	5mg/mL	10mL
Pre-euthanasia Midazolam	IM	5mg/mL	10mL
Socumb	IV	24mg/mL	22mL

7.12.9 Manatee

The manatee has been a protected species under US regulation for many years. Any sick or injured animals are taken in for rehabilitation. By far, the most common reason manatees become candidates for rehabilitation are when red tide is prevalent. This is caused by the dinoflagellated algae, *Karenia brevis*, which produces a neurotoxin. Mortalities involving fish, birds, turtles, manatees and dolphins have been reported since 1844. It is seen when there is high salinity (greater than 24 g/L) coinciding with manatee migration. Clinical signs of affected manatees include seizures, paralysis, abnormal position in the water and facial tremors. Manatees contract illness when they ingest seagrass and epiphytes that contain the toxic algae. There is regular monitoring of seagrasses using an enzyme-linked immunosorbent assay (ELISA) test for brevetoxin concentrations. At necropsy, findings are non-specific and include pulmonary oedema and congested viscera. Manatees in rehabilitation facilities are only released back to the wild when seagrass and water testing results show it is safe to do so. Heaviest mortalities were seen in 2010, 2011 and 2013. Affected manatees are treated with atropine and provided a contraption to aid with floatation.

Manatees are also prone to boat strike injury and in 2010, it accounted for 10.8 per cent of the mortalities in which a known cause of death could be determined. Of the living, 70 per cent of manatees have been hit by boats at least once in their life, and of those, 70 per cent have been hit more than once. Skin wounds are treated by packing with sugar or honey. Other causes of manatee mortality include cold stress (36.5 per cent), perinatal (12.5%), natural (3 per cent) and other human interactions (0.7 per cent). Undetermined (27.6 per cent) and unrecovered (8.9 per cent) account for the remainder.

Much of the concentration had been on anthropogenic causes of death or decline in populations of manatees due to loss of habitat, loss of grasses and toxicological factors. However, not all human activity has a negative impact on the manatee population. In fact, during the winters when water temperatures drop below 20°C, some manatees seek refuge in the cooling water discharge canals of power stations.

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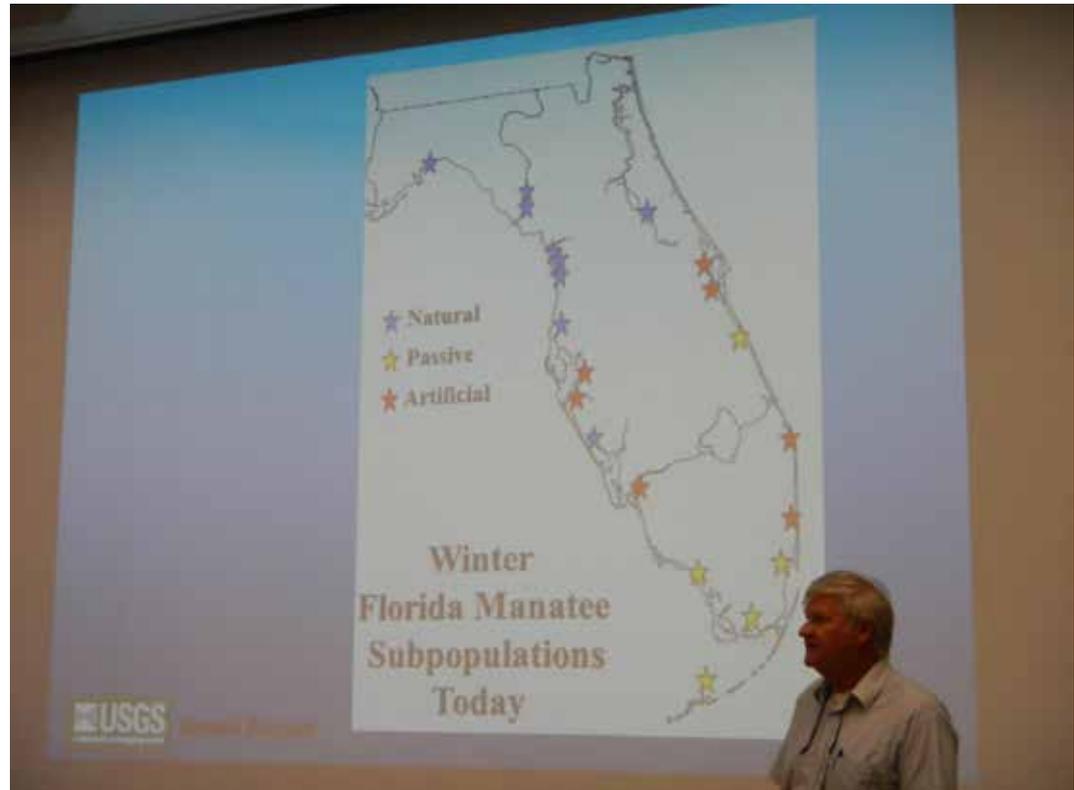


Fig. 7.12.9.A Dr Bonde presented on wild manatee populations.

The reason for this is that manatees lack a blubber layer and avoid the cold. Some discharge canals have even been sanctioned by the state as manatee sanctuaries. Chronic cold stress is seen when manatees are trapped in water temperatures below 20°C for protracted periods. Affected individuals may have skin lesions, serous atrophy of fat and gut compromise, constipation and dehydration.

Helminth fauna of the Florida manatee include six identified species: *Heterocheilus tunicatus* (Nematoda: Ascaridoidea); *Anoplocephala* sp. (Cestoda: Cyclophyllidea); and four species of trematodes, *Pulmonicola cochleotrema* (Digenea: Opisthotrematidae), *Chiorchis fabaceus* (Digenea: Paramphistomatidae), *Nudacotyle undicola* (Digenea: Nudacotylidae), and *Moniligerum blairi* (Digenea: Opisthotrematidae); the latter two causing enteritis. More detailed information may be found at this link <http://www.ncbi.nlm.nih.gov/pubmed/3397825>

The government provides US\$1.2M/year towards three institutions for the rehabilitation of manatees. There is no such fund for other animals such as turtles; however, fundraising through the sale of special car license plates depicting the specific mammal or turtle may be channeled to such works.

In terms of rehabilitating sick or injured animals, the mainstay of supportive care include hydration, nutritional support, encouraging gut motility and possibly aids to help with floatation. Good facilities will have a 'false floor' that can be raised up such that the manatees can be manipulated above water.

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Fig. 7.12.9.B Dr Loh monitoring the carbon dioxide levels in the manatee.

Manatee Formulary

Table 7.12.9. A These are the medicines that are commonly used at the Lowry Park Zoo.

Medicine	Dose Rate	Mode and frequency
Tulothromycin	2.5mg/kg	SC q7-9d.
Ceftiofur	6-10mg/kg	SC q7d
Amikacin	14mg/kg	IV q24h PRN
Ketoprofen	2mg/kg	SC q24h
Sucralfate	2-4g	PO q24h
Metoclopramide	0.1mg/kg	PO q8h PRN
Magnesium citrate	600-1200ml	PO SID
Atropine	0.22mg/kg	¼ IV, ¾ SC

Technical reports on manatees can be found at <http://myfwc.com/research/publications/scientific/technical-reports/>

7. The International Experience

7.12.10 Penguins

There are seventeen penguin species and all are found in the southern hemisphere. The most common captive species include the Adelie, Chin strap, Emperor, Macarone, Rockhopper and Magellanic. All except for the latter require expensive cooling systems to keep them healthy. Adequate air-handling with dehumidifiers, filtration and adequate air exchange are integral to optimal health, otherwise conditions such as aspergillosis and bacterial infections can occur. Many species also require the seasonal cues to meet their physiological needs, especially for moulting. Regions where Malaria is a problem, captive penguin populations are maintained on anti-malarial medicines (e.g. Daraprim and sulfadiazine) their entire life if they are kept outdoors. A common condition that can arise as a result of misunderstanding the animals' behavioural habits include pododermatitis. This occurs when aquatic birds spend too much time on a single type of hard surface, if facilities are over-crowded and there is a degree of territoriality or if the ground is contaminated. Preventive measures include provision of sufficient space, providing different substrates and encouraging more time in the water (e.g. feeding them in the water).

7.12.11 Managing a rehabilitation facility

All humans, animal species and the environment are closely tied together in increasingly crowded and stressed relationships. Changes in one can affect the others. Wildlife act as sentinels, as early indicators of environmental issues.

Why do we rehabilitate animals?

1. To release the individual back to the wild for population support.
2. To learn about the animal.
3. To save the species.
4. To satisfy own needs for compassion.
5. To satisfy a government mandated mitigation program.

But the most significant aspect of rehabilitation effort is to educate the public. Education is the only way societal attitudes and behaviours will truly change bringing with it long term conservation solutions. Members of the public can also be a source of funding.

It is a game of resource management with the major limited resources being funding, facilities and staffing. It also requires the acquisition of permits.

Budgetary constraints make it unfeasible to provide the gold standard diagnostics and treatment for all patients; however, a minimum standard of care is needed and requires decisions made on whether to euthanise or persist.

By far, the most effective way of educating and appealing to the public and at the same time, gather considerable funds is to create a television show or movie. Clearwater Marine Aquarium was on the brink of collapse when Disney decided it would make *Dolphin Tale*; a story about 'Winter' the dolphin that was in rehabilitation due to severe tail damage from being entangled in a crab trap. The aquarium has since expanded and has a dedicated showroom featuring all the props from the movie and merchandise.

7. The International Experience



Fig. 7.12.11. A Movie merchandise aid fund raising for the aquarium.

But this is only a rare case of good luck. Most rehabilitation centres struggle with how to make resources stretch. Some ways include teaching staff to maximise their capabilities and make sure everyone has a sense of ownership/obligation. Funds for resources may be sought through grants, donations and collaborators. Private companies or hospitals may donate supplies, medicine and equipment. Information and advice is normally given freely by other experts in the field. The centre may also seek support from the state and federal agencies.

Successful conservation programs rely on an engaged, informed and caring public. It must be remembered that the provision of outreach with research and education will have larger impact on species survival than simple rehabilitation efforts.

7.12.12 Advanced diagnostic imaging

The use of a range of diagnostic equipment was presented through the workshop as potential tools that would be useful with working up cases. Many of these are non-standard in the veterinary field due to budgetary constraints, but it was useful to know what is available when money is no object. Those already employed in the veterinary field include endoscopy, X-ray and ultrasound and the following imaging equipment can complement the standard tests or be used in research.

Thermography is based on using an infrared camera to measure the surface temperature of a tissue and it was shown to be very useful in detecting pododermatitis in aquatic birds, locating dental issues in marine mammals and locating abscesses. It is not a new invention but the veterinary fraternity has not embraced the technology due largely to unfamiliarity.

7. The International Experience

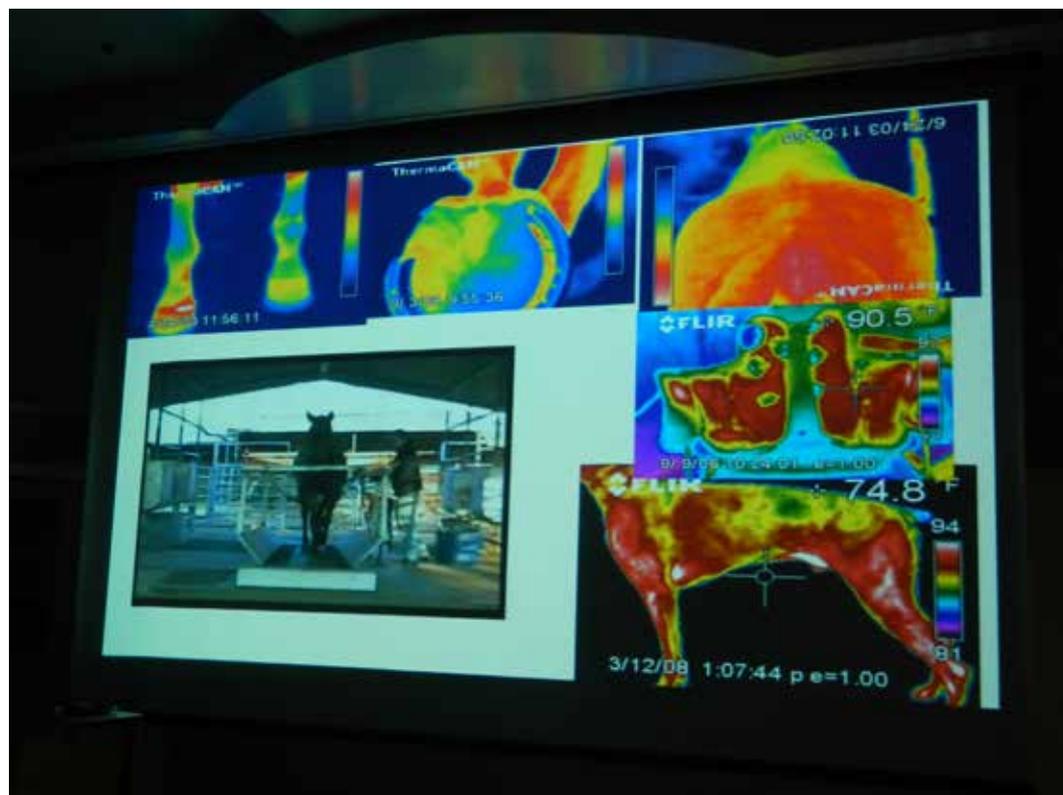


Fig. 7.12.12.A A slide from Dr Walsh's lecture showing the versatility of thermography in localising the source of lameness in horses. Picture taken at Dr Walsh's lecture.

The Computed Tomography (CT) scan is a medical imaging procedure that uses x-rays and digital computer technology to create cross-section images of the entire body. It can be used to show portions of the body such as the bony structure, or blood vessels, etc.

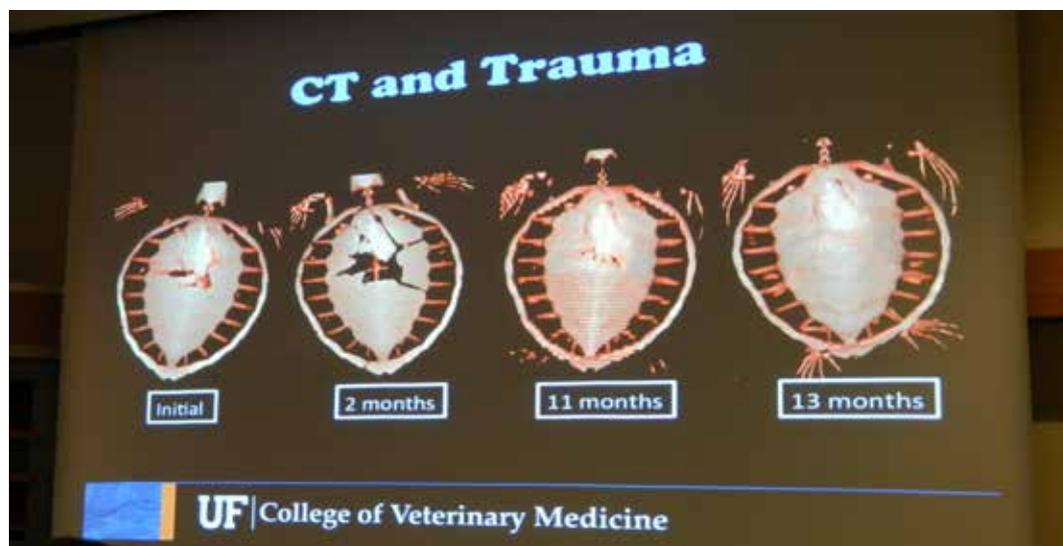


Fig. 7.12.12.B CT scan of a sea turtle showing stages of carapace repair. Picture taken at Dr Walsh's lecture.

7. The International Experience

Magnetic Resonance Imaging (MRI) uses a magnetic field and radio waves to take pictures of the body's interior. A MRI is used to investigate or diagnose conditions such as tumours, joint or spinal injuries or diseases, soft tissue injuries or diseases of internal organs such as the brain or heart.

7.13 QUESTIONS ANSWERED

Prior to embarking on the overseas research trip, the Fellow approached stakeholders on matters they wished the Fellow to investigate. The questions and findings are presented below.

7.13.1 Relating to fish

7.13.1.1 Are there treatment options for Cryptocaryon safe for marine invertebrates (e.g. coral tank)?

Perennial question about whether there is a chemical or product that can be used to treat against Cryptocaryon irritans that is safe for corals and other invertebrates. The Fellow came across a product on the shelves of a local pet store called 'Kordon Ich-Attack 100% Natural Ich Treatment'. It contains naphthoquinone and other herbs.

The product description states it is safe for use in all kinds of freshwater and saltwater aquariums, including reef and live-rock marine aquariums and is effective against white spot disease (Ich), other protozoans, amoebae, ciliates and dinoflagellates and safe to use with most aquatic invertebrates, including snails, shrimp and crabs. Coelenterates (coral, anemones, polyps) may shrivel-up during use, recovering days after treatment. Some specimens that are not in adequate health may not survive treatment. It is non-toxic to humans, pets and aquatic life. More information can be found at <http://www.petsmart.com/product/index.jsp?productId=11066250>

7.13.1.2 Canada prohibits import of vaccinated fish. What is the regulation of importation of vaccinated fish in other countries?

Such questions will be difficult to answer because they are layered with biology, acceptable risk, politics and economics. The Fellow also referred the enquirer to a Free CE Webinar entitled 'Understanding Canadian Import Requirements for Aquatic Animals' which was promoted through AquaVetMed e-News.

7.13.1.3 What are your thoughts on summer stress in salmonids ('Salmon summer sulks')?

The issue may be multifactorial and it may be related to genetics, environmental factors and even infectious agents. Poorer cardiac function at higher temperatures has been reported (see <http://jeb.biologists.org/content/199/3/663.full.pdf>). Anoxia or hypoxia may be a factor (see <http://jeb.biologists.org/content/157/1/75.short>). Reovirus may also play a role (see <http://ejournals.ebsco.com/direct.asp?ArticleID=4F948FD160688861678E>).

7.13.1.4 What are the most common parasitic infections experienced on your captive teleost and elasmobranch fishes?

Gill flukes, white spot disease (caused by Cryptocaryon) and other protozoal conditions are common in marine teleosts kept in public aquaria. In sharks and rays, skin flukes, gill flukes and leeches feature. Intestinal parasites discovered in sharks include tapeworms, coccidia and trematodes. Eimeria have been found within the coelomic cavity of certain rayfish.

7. The International Experience

7.13.1.5 Do sharks have lymphoid tissue in their gills? Is the presence of inflammatory cells in the gills of sharks always abnormal?

The pictures taken by the enquirer show lymphoid cellular collections with a follicular arrangement. This article located by a colleague (<http://www.jimmunol.org/content/184/12/6950.full>) identified T-cells within the gills for gill mucosal immunity and so it is likely that those observed by the enquirer are a normal feature, except perhaps they were hyperplastic.

7.13.1.6 What special care do you need for geriatric sharks (greater than 20-year-old Grey Nurse)?

Typically, geriatric animals would need a lower fat diet. One way of monitoring the health of the animal is to take regular blood samples to test for various parameters such as serum biochemistry, haematology, trace elements, vitamins, hormones, etc.

7.13.2 Marine mammals

7.13.2.1 What experience have you had of nematode infections in the lungs of your cetaceans? What have you determined about their lifecycle?

Nematode infections are not an issue in captive animals. Only the wild-caught animals may carry these organisms; however, not much is known about the lifecycle. Treatment is by fenbendazole. Levamisole is avoided because it was purported to be lethal to Cetaceans based on two beluga whales (see http://articles.chicagotribune.com/1992-09-24/news/9203270142_1_beluga-whales-shedd-aquarium-two-whales/2). No one is certain about what the toxic principle is, but since this event, the cetacean fraternity avoids the use of levamisole,

7.13.2.2 What experience have you had of nematode infections in the lungs of your pinnipeds? What have you determined about their lifecycle?

In the respiratory tract, there are two common species of lungworms. Parafilaroides decorus has the opal-eyed fish (*Girella nigricans*) as its intermediate host. It can transmit *Brucella* sp. And causes secondary granulomatous bronchopneumonia. The *Otostrongylus circumlitus* causes bronchiectasis, secondary verminous pneumonia and may cause DIC if it evokes arteritis of the pulmonary artery. Not exactly in the lungs, but affecting the cardiovascular system are *Dirofilaria immitis* and *Dipetalonema spirocauda*. They have the sea louse as their intermediate host. The adult worms are found in the right ventricle and pulmonary arteries causing dilatation of the right ventricle and myocardial hypertrophy with or without passive congestion. Captive pinnipeds need to be on monthly heartworm prevention (ivermectin at 0.006mg/kg).

7.13.2.3 Have you experienced any unusual mortality events for cetaceans, pinnipeds or manatees in your area and what have been the main causes of these?

These are discussed in the reports under their animal groupings and also in the section on 'marine mammal strandings'. There is usually a relationship with physical factors such as pneumoconiosis. *Crassicauda* and *Nasotrema* were two that came to mind.

7.13.2.4 Have you observed ingestion of natural but inappropriate food items in cetaceans?

See 'marine mammal strandings' section. It is more common in younger animals and walrus.

7. The International Experience

7.13.2.5 Do you have experience in identifying or protocols for recording anthropogenic injuries to cetaceans, pinnipeds and sirenians e.g. boat strike marks (not just propeller scars) and fisheries-related entanglements and differentiating these from natural predation attempts by sharks etc.?

See section '7.12.8 Marine mammal strandings'.

7.13.2.6 Do overseas institutions train field officers in basic field necropsies for targeted disease surveillance / mortality investigations? Are there specific safety issues which this training must incorporate?

See section '7.12.8 Marine mammal strandings'. In terms of safety issues, people need to be aware of their physical environment in terms of rocks, waves, sun exposure, wind and chill. With live specimens, people need to be careful being potentially hit by the tail. PPE should be worn because of zoonotic potential of some diseases, particularly brucellosis.

7.13.2.7 Are pox type lesions regularly observed in alive/dead dolphins in the Florida population? Are a particular age class affected?

This question was answered by Professor Carlos Romero, "Although we have diagnosed several cases of dolphin pox in animals from Florida waters based on PCR and sequencing, the infection is not currently being reported consistently or frequently. It may just be that clinicians have become used to it and most likely know that eventually the superficial pox lesions will heal and disappear".

7.13.2.8 Have you detected morbillivirus in some cetacean species more than others? Also do particular age/sex classes seem more affected?

This question was answered by Professor Carlos Romero, "I have not been involved in Florida with morbillivirus diagnosis in cetaceans as the disease may be occurring sporadically (no massive outbreaks) in individual dolphins, which most of the times are autolysed and difficult to diagnose with certainty. Suspected animals are usually *Tursiops truncatus*. In the European outbreaks, dolphins mainly affected were striped dolphins and this time, affected animals were not only juveniles but also adults. No difference in occurrence was observed between males and females".

See also <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1312&context=usdeptcommercepub>

7.13.3 Penguin

7.13.3.1 What is the prevalence of avian malaria and other blood parasites in wild Penguin populations (e.g. *Eudyptula minor*)?

Unsure, but captive penguins maintained in known malaria-affected areas (e.g. mid-west and Chicago area) outdoors are on permanent anti-malarial therapy.

7.13.3.2 Does proximity to urban areas increase risk of infection/prevalence of blood parasites in penguins?

This would largely be determined by the abundance of vectors which would be influenced by season and habitat availability.

7. The International Experience

7.14 Concluding remarks

“The field of veterinary medicine is diverse, furthermore, the practice of veterinary medicine encompasses aquatic animals, including aquatic livestock and pets. Veterinarians are licensed to diagnose disease, prescribe therapy, and implement programs for the prevention, control and treatment of disease in all vertebrate and invertebrate species. Because of their education in comparative anatomy, pathophysiology, pharmacology, toxicology, epidemiology, surgery, therapeutics, as well as preventive and regulatory medicine, veterinarians are familiar with bio-security, disease prevention and control, the use of pharmaceuticals, biologics, pesticides and their potential for adverse affects. The principles acquired in this education also apply to aquatic species and their environments.” This is the introductory passage to the position statement by the American Veterinary Medical Association on Veterinarians in Aquatic Veterinary Medicine.

Following this, there is a duty for the veterinarian to pursue continuing education. There is a considerable wealth of knowledge available in the USA and the educators are setup to impart that knowledge. Pioneers in this area tended to have to learn by a combination of research, comparative medicine and by trial and error. Although in Australia, the case-load is lower and there is the tyranny of distance, we need not be left in the dark. The Fellowship program gave Dr Loh the opportunity to learn from those who have preceded him and be able to provide those who follow, a good point of contact for challenging issues. The networks forged during this trip will be lifelong. The Fellow will be able to build on this knowledge base and help progress this field in Australia.

8. Knowledge Transfer: Applying the Outcomes

As result of this Fellowship, Dr Loh will be passing on the information he has gained to strengthen the skills and capabilities of those involved in aquatic animal health.

In September of 2013, he travelled to Prague, Czech Republic to make presentations on fish medicine at the World Veterinary Congress.

He is part of a group that have submitted an 'Expression of Interest' to the Fisheries Research and Development Corporation (FRDC) on developing a national curriculum on aquatic animal health for Australian tertiary institutions. At the time of publication of this report, he was still awaiting the outcome of this proposal.

In addition, the Fellow has also been presenting free webinars in conjunction with Veterinary Classrooms and the WAVMA on fish health, diseases and treatments. Judging by the feedback from a number of people, these webinars were well received. The Fellow will also work with Connecting Spaces' Project Neptune to deliver more webinars related to aquatic veterinary medicine.

Throughout the activities involved in his overseas research and preparation of this report, the Fellow has been publicising the learnings and experiences gained and taking any opportunity to spread these learnings throughout his profession.

Through the networks made, the Fellow is submitting an 'Expression of Interest' to the FRDC under the 'Aquatic Animal Health Training Scheme' to organise and hold an international aquatic veterinary biosecurity symposium & training workshop. At the time of publication of this report, he was still awaiting the outcome of this proposal.

The Fellow is working with AQWA and the DEC to improve the standards of care for sea turtles during rehabilitation.

9. Recommendations

Government – Federal, State, Local

Due to the lack of specialised training for aquatic animal health professionals, it is imperative that the government support the development of a national curriculum on aquatic animal health for Australian tertiary institutions.

It is imperative that the Government continue to fund activities that prevent the introduction of foreign aquatic animal pathogens and to develop programs for their control or eradication, similar to established control programs for terrestrial species.

Regulations at the Federal and State levels (when impacting wild fisheries), should be developed and implemented in close collaboration with the agency that oversees wildlife and natural resources.

Regulations must be structured to be practical and effective for the intended purposes without undue excessive or unnecessary industry actions, activities, requirements or burdens, with the least bureaucracy possible.

With increasing intensification of farming, comes the increasing cost of disease. Sometimes good management alone cannot alleviate disease and chemotherapeutants may become necessary. Minor use permits (MUPs) are few and far between and they are difficult to obtain. Grants and workshops to support the development of drugs, chemicals and biologics for use in aquatic animals would be highly beneficial.

Furthermore, the government and regulatory bodies must devise methods for the development drugs to support food security and sustainability on a global scale, to ensure access to safe and effective medicines.

Hawaii has an Economic Development Specialist embedded within the fish laboratory. This is a unique way of providing, not only technical services, but also business assistance to farmers who require them. Working closely in the same office location helps blend technical and business processes, valuable for commercial farms.

Gradual erosion of funding for aquatic pathology resources has been occurring. Well-equipped aquatic pathology laboratories have ceased operation in the last two years and there is danger in replacing traditional morphologic pathology with molecular genetics. Veterinary comparative pathology is critical for conducting research into new diseases. These spell disaster for retaining and maintaining highly skilled aquatic veterinary professionals. Veterinary pathology need to be valued, supported and funded. The scientific community needs to be educated about the value of pathology. This discipline is able to identify diseases that are not only infectious, but also, those associated with nutrition, water quality, toxins, trauma and neoplasia. The field of aquatic pathology lags behind mammalian pathology. The government needs to invest more resources into training and mentoring schemes for young scientists.

The government needs to maintain a working system and ensure funding, staffing and expertise across all dependent and related departments are equitable, such that there are no bottle necks that could lead to inefficiencies and reduced serviceability.

The demand for food is expected to rise considerably, yet land-based farming is limiting. There is a diminishing supply of arable land for agriculture (urban development and other competition for land use), there is increasing competition for produce from land-based farms (towards livestock feed and fuel production) and there is evidence that yield growth may plateau in the near future. Thus, land-based farming cannot support the increasing global demand for food. The government of Australia needs to invest more into farming with water to insure our food security. This includes supporting aquaculture and aquaponics.

9. Recommendations

Mr Frank Olinares from Big Island Abalone pointed out that the limiting factor in aquaculture is not the technology and the absence of expertise. It is more to do with having the capital. An analysis should be instigated, to determine if it is possible for government to start up aquaculture with the intention of selling it to investors once it is established.

A small but significant fundraising example exercise could be implemented, through the sale of special car license plates depicting specific animals with the funds gained being channeled to those organisations.

Industry

Consider other issues that enhance the health of aquatic animals, including their humane treatment, welfare and euthanasia, environmental issues, zoonotic diseases and seafood safety.

Partnerships to be formed when conducting research or farming. A useful partnership would be between crab farmers and octopus researchers/farmers. Octopus larval rearing requires a diet of crab larvae.

Revisit commercial aquaponics - a single footprint for the production of fish and vegetables. Research and backing is needed to reinvigorate this promising area. It is very low cost when compared to sea cage aquaculture farming. It is a very profitable technology and we need to pay attention to it. It has been proven by other countries to be worth pursuing.

Investigate the merits of integrated multi-trophic aquaculture. Environmentally conscious integrated farming such as farming sea cucumbers, sea urchins or molluscs beneath fish farm cages as scavengers for 'secondhand' nutrients will help reduce the impact of nutrient loading at farm sites.

Investigate the culture of herbivorous fish that utilise plant proteins for growth. Research has shown that the flavour and flesh quality can be enhanced by changing their diet just before harvest (e.g. to fish meal).

More and more terrestrially grown crops are being diverted towards biofuels as oil prices continue to rise and more and more land is committed to pasture. We need to seriously look into farming in the sea to supply for aquacultured animals. We could be growing aquatic-based plant proteins that can be used for aquatic feeds.

Professional Associations

The various industry associations to be involved in developing the necessary legislature impacting on their respective industries.

It should be a mandatory requirement for veterinarians and veterinary students to:

- Join the various relevant groups such as the WAVMA, NOVICE and IAAAM
- Enroll for examinations in the Aquatic Animal Health Chapter of the ANZCVS.

The ANZCVS invite expert speakers to Australia to present at local conferences.

The ANZCVS actively engaged with appropriate entities, as necessary, to promote the optimisation of the health of aquatic animal and for the prevention, control and possible eradication of aquatic animal diseases that are pivotal to the future of commercial aquaculture, wild fisheries and ornamental (pet), research and exhibit aquatic animal industries.

9. Recommendations

For the professional associations within Australia, and worldwide, to recognise the skills set of members of other organisations and certifications systems, and to work collaboratively towards a common goal.

Education and Training

There needs to be the development of a national curriculum on aquatic animal health for Australian tertiary institutions.

With the extension of the veterinary curricula from a 5-year degree to a 6-year course, and with the increasing profile of aquatic animal health, this area needs to be represented in undergraduate teaching as core curricula.

With the advent of faster internet speeds, we can start utilising skills and expertise of international colleagues. Guest lectures may be presented by experts in their field via platforms such as Adobe Connect and GoToMeeting.

There are many courses available around the world dealing with aquaculture systems, husbandry and pathology. But to date, there are no courses available that cover the medicine aspect satisfactorily. These can be found in bits and pieces at various conferences, but not all in the one place. This gives Australia the opportunity to create such a course.

Community

The rapid pace of urban development is taking its toll on the most productive land. There is a global movement for organic farming and eating local products. Aquaponics is a way of producing high yields of crop with virtually a zero footprint, independent of soil quality. Aquaponics can be used as a tool for health promotion that goes beyond healthy lifestyle to well-being. It was demonstrated overseas to the Fellow that the quality of life for disabled and also for young students and for the unemployed can be significantly enhanced. Involvement in this activity creates a warm and friendly atmosphere, a supportive environment and a strong community spirit. Participants develop personal skills, raising their morale, giving them a sense of achievement.

Anglers appreciate that great habitat equals great fishing. Seagrass meadows are habitat for worms, crabs, shrimp and snails and are fish nurseries. Thus, they play a vital role in maintaining water quality and a 'seed' supply for fish stock replenishment. We need to protect threatened species because these animals contribute significantly to the biodiversity of the ecosystem. They are a crucial part of the food web and studying these animals will provide data that can be used as a benchmark for future research on the group.

The Fellow had the opportunity to swim in the freshwater springs in Florida and marveled at the abundance of aquatic fauna and flora. At the marine aquarium in Disney's Aulani Resort, guests could swim in the marine display and feed the fish. Instead of the normal, sterile, chlorinated, aquatic centres (swimming pools), it is possible make swimming more fun and interesting and at the same time, expose members of the public to the natural world in the form of swimming pool sized aquaria. It will certainly give the community a unique experience.

By far, the most effective method to appeal to the masses is by the power of television. Dolphin Tale put Clearwater Marine Aquarium back on the map as a tourist destination. There may be similar stories that could be made by enlisting professional movie producers to draw attention to conservation efforts in a way that appeals to the public. In doing so, it can bring much needed funds to carry out the valuable work.

9. Recommendations

International Specialised Skills Institute

ISS Institute facilitate the bringing together of other Fellows with appropriate and relevant skill sets to present workshops and seminars to promote continuing learning, share experiences, new skills and knowledge.

10. References

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11. Attachments

11.7.1 Seavet 2013 Conference Program



SeaVet Clinical Training 2013



	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	
	6/3/13	6/4/13	6/5/13	6/6/13	6/7/13	6/30/13	6/11/13	6/12/13	6/13/13	
8:00	Welcome: Meet and Greet 8:30	Marineland Dolphin Swim	Tours of the Vet School	Water Issues Case Studies (Walsh)	Clearwater Marine Aquarium (depart at 6am) 9am Tour 10am: Sea Turtle case studies	Radiology - Cetaceans Imaging (Vanderhart)	Lowry Park Zoo (depart at 6am)	Pinniped Natural History, Anatomy (Cassle)	Stranded Cetaceans: First Aid, Stabilization, Monitoring (Pelton)	
9:00	Foundations of Knowledge, Problem Solving, Course Goals		Fish Medicine (Yanong)	Fish Eaters (Walsh)		Radiology- Manatee Sea Turtle Imaging (Vanderhart)		Pinniped & Walrus Medicine (Walsh)		
10:00	Water Quality (Francis-Floyd) (Walsh)		Large fish collection, Fish management (Claus)	Penguin Medicine (Walsh)		Clinical Research in Rehab facility (Manire)		Pinniped Field Anesthesia (Bailey)		Stranding Medicine- desentanglement intoxication, sound, Euthanasia (Walsh)
11:00	Environment Air quality, Noise Issues (Walsh)		Whale sharks (Claus)	Stingray Medicine (Walsh)		Manatee Anatomy (Walsh)		Manatee Pathology (deWit)		Cetacean Sedation and Anesthesia (Bailey)
12:00	Lunch (provided)	Lunch (on own, in route to UF)	Lunch (provided)	Lunch (provided)	Lunch (provided)	Lunch (provided)	Lunch (on own, in route to UF)	Lunch (Provided)	End of course Evaluations	
1:00	Cetacean Anatomy (Walsh)	Travel or Lecture	Sea Otter Medicine (Claus)	Veterinary Management of a Rehab facility (Pelton)	Basics of Training (Martin)	Wild Manatee Behavior (Bonde)	Travel	Wild bottlenose dolphin life history, ecology, behavior, health, and conservation (Wells)		
2:00	Cetacean Medicine (Walsh)	Special Senses Marine Mammal eyes (Samuelson)	Sharks (Walsh)	Case Studies (Pelton) Sea Turtle Medicine (Walsh)	Dolphin Medical behavior (Walsh)	Manatee Medicine (Walsh)	Travel or Lecture upon return			
3:00	Cetacean Medicine (Walsh)	Clinical Ophthalmology Pinnipeds (Colitz)	Infectious Disease (Walsh)	Sea Turtle Medicine (Walsh)	Otters (Walsh)	Manatee Medicine cont. (Walsh)	Cetacean Management Reproductive Issues and complications (Walsh)	Wild Cetacean Health Assessments (Walsh)		
4:00	Cetacean Medicine Case Studies (Walsh)	Clinical Ophthalmology Cetaceans (Colitz)	Zoonotic Disease (Cassle)	Treatment of Traumatic Injuries, Hooks removal (Walsh)	Travel back to UF	Manatee Medicine Health Assessments (Walsh)	Cytology (Stacy)	Large whale issue: Entanglement & Sedation (Walsh)		

11. Attachments

11.7.10.1 Senate Bill 586

NB: The following Appendix is provided as an example of legislation that applies to the development and operation of non-residential buildings or structures (in Hawaii), on commercial farms and ranches located outside the urban district.

Sourced from -

<http://openstates.org/hi/bills/2013%20Regular%20Session/SB586/documents/HID00062099/>

THE SENATE	S.B. NO.	586
TWENTY-SEVENTH LEGISLATURE, 2013		S.D. 1
STATE OF HAWAII		H.D. 1

A BILL FOR AN ACT

RELATING TO AGRICULTURAL BUILDING PERMITS.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that compliance with existing building codes and permitting processes negatively impacts the State's agriculture and aquaculture industries by adding significant time and costs to farming and ranching enterprises for such fundamental activities as constructing or installing greenhouses, shade houses, storage containers, indigenous Hawaiian hale, and many other agricultural and aquacultural buildings and structures, which, by their nature or location, pose little risk to life or property. In contrast to building codes in many other states, county building codes in Hawaii generally do not distinguish between low-risk agricultural structures and residential or commercial buildings. Ultimately, this results in excessive costs for code compliance for farmers and ranchers. Act 114, Session Laws of Hawaii 2012, may help to reduce the cost and time spent applying for building permits for specified nonresidential agricultural and aquacultural buildings and structures and their appurtenances, but Act 114 does not offer relief from county building code requirements.

The purpose of this Act is to encourage and support diversified agriculture and agricultural self-sufficiency in the State by providing, under certain circumstances, an exemption from building code and permit requirements for nonresidential buildings or structures on farms and ranches located outside the urban district.

SECTION 2. Section 46-88, Hawaii Revised Statutes, is amended to read as follows:

“~~[[~~§46-88~~]]~~ Agricultural and aquacultural buildings and structures; no building permit required. (a) ~~[Each]~~ Notwithstanding any law to the contrary, each county ~~[shall establish]~~ may adopt or amend an agricultural buildings and structures exemption list of buildings and structures that are exempt from existing building permit requirements. ~~[The list shall be established by each county no~~

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~~later than January 1, 2013.~~ Agricultural buildings, structures, or appurtenances thereto, which are not used as dwelling or lodging units, may be exempted from existing building permit and building code requirements where they are no more than [1,000] one thousand square feet in floor area[;] or, if greater than one thousand square feet in floor area and compliant with building code requirements or prescriptive construction standards, may be exempted from building permit requirements pursuant to subsection (d); provided that ~~the~~:

(1) The aggregate floor area of the exempted agricultural building~~, structure, or appurtenance thereto~~ shall not exceed [5,000]:

(A) Five thousand square feet per zoning lot for lots of two acres or less;

(B) Eight thousand square feet per zoning lot for lots greater than two acres but not more than five acres; and

(C) Ten per cent of the acreage per zoning lot for lots greater than five acres; ~~and the~~

(2) The minimum horizontal separation between each agricultural building, structure, or appurtenance thereto is fifteen feet~~, and the~~;

(3) The agricultural buildings, structures, or appurtenances thereto are located on a commercial farm or ranch and are used for general agricultural or aquacultural operations, or for purposes incidental to such operations; ~~provided further that:~~

~~(4)~~ (4) The agricultural building, structure, or appurtenance thereto is constructed or installed on property that is used primarily for agricultural or aquacultural operations, and is two or more contiguous acres in area or one or more contiguous acres in area if located in a nonresidential agricultural or aquacultural park;

~~(2)~~ (5) Upon completion of construction or installation, the owner or occupier shall provide written notice to the appropriate county fire department and county building permitting agency of the size, type, and locations of the building, structure, or appurtenance thereto. Such written notification shall be provided to the county agencies within thirty days of the completion of the building, structure, or appurtenance thereto. Failure to provide such written notice may void the building permit exemption, which voidance for such failure is subject to the sole discretion of the appropriate county building permitting agency;

~~(3)~~ (6) No electrical power and no plumbing systems shall be connected to the building or structure without first obtaining the appropriate county electrical or plumbing permit, and all such installations shall be installed under the supervision of a licensed electrician or plumber, as appropriate, and inspected and approved by an appropriate county or licensed inspector~~; and~~ or, if a county building agency is unable to issue an electrical permit because the building or structure is permit-exempt, an electrical permit shall be issued for an electrical connection to a meter on a pole beyond the permit-exempt structure in accordance with the installation, inspection, and approval requirements in this paragraph:

~~(4)~~ (7) Disposal of wastewater from any building or structure constructed or installed pursuant to this section shall comply with chapter 342D~~]; and~~

(8) Permit-exempt structures shall be exempt from any certificate of occupancy requirements.

(b) For purposes of subsection (a), the following buildings ~~and~~, structures, and appurtenances thereto ~~shall~~ may be included in each county's agricultural ~~building~~ buildings and structures exemption list~~]; and~~ may be exempt from county building permit and code requirements:

(1) Nonresidential manufactured pre-engineered commercial buildings and structures consisting

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of no more than ~~[1,000]~~ one thousand square feet ~~[that have no electrical power and have no potable water, sewage, or other plumbing related services, or have such electrical or plumbing related services installed and inspected in accordance with subsection (a)(3) and (4)];~~

(2) Single stand alone recycled ocean shipping or cargo containers that are used as nonresidential commercial buildings;

(3) Notwithstanding the ~~[1,000]~~ one thousand square foot floor area restriction in subsection (a), agricultural shade cloth structures, cold frames, or greenhouses not exceeding ~~[20,000]~~ twenty thousand square feet in area per structure; provided that where multiple structures are erected, the minimum horizontal separation between each shade cloth structure, cold frame, or greenhouse is fifteen feet;

(4) Aquacultural or aquaponics structures, including above-ground water storage or production tanks, troughs, and raceways with a maximum height of six feet above grade, and in-ground ponds and raceways, and piping systems for aeration, carbon dioxide, or fertilizer or crop protection chemical supplies within agricultural or aquacultural production facilities;

(5) Livestock watering tanks, water piping and plumbing not connected to a source of potable water, or separated by an air gap from such a source;

(6) Non-masonry fences not exceeding ten feet in height and masonry fences not exceeding six feet in height;

(7) One-story masonry or wood-framed buildings or structures with a structural span of less than twenty-five feet and a total square footage of no more than ~~[1,000]~~ one thousand square feet, including farm buildings used as:

(A) Barns;

(B) Greenhouses;

(C) Farm production buildings including aquaculture hatcheries and plant nurseries;

(D) Storage buildings for farm equipment or plant or animal supplies or feed; or

(E) Storage or processing buildings for crops; provided that the height of any stored items shall not collectively exceed twelve feet in height and the storage of any hazardous materials shall comply with any and all applicable statutes, regulations, and codes;

(8) Raised beds containing soil, gravel, cinders, or other growing media or substrates with wood, metal, or masonry walls or supports with a maximum height of four feet; ~~[and]~~

(9) Horticultural tables or benches no more than four feet in height supporting potted plants or other crops; and

(10) Nonresidential indigenous Hawaiian hale that do not exceed five hundred square feet in size, have no kitchen or bathroom, and are used for traditional agricultural activities or education;

provided that the buildings, structures, and appurtenances thereto comply with all applicable state and county ~~[codes, including but not limited to applicable building, fire, health, safety, and]~~ zoning codes and are properly anchored.

(c) ~~[In the event that]~~ If a county fails to establish ~~[the]~~ an agricultural buildings and structures exemption list ~~[within the time period as required under subsection (a),]~~ before July 1, 2014, the buildings and structures specified in subsection (b) shall constitute that county's agricultural ~~[building]~~ buildings and structures exemption list~~;~~ until such a time as the county establishes an exemption list specific to that particular county.

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(d) For purposes of subsection (a), and notwithstanding the one thousand square foot floor area restriction in subsection (a), the following buildings, structures, and appurtenances thereto may be exempt from building permit requirements when compliant with relevant building codes or county, national, or international prescriptive construction standards:

(1) Nonresidential manufactured pre-engineered and county pre-approved commercial buildings and structures consisting of a total square footage greater than one thousand square feet but no more than eight thousand square feet; and

(2) One-story wood-framed or masonry buildings or structures with a structural span of less than twenty-five feet and a total square footage greater than one thousand square feet but no more than eight thousand square feet constructed in accordance with county, national, or international prescriptive construction standards, including buildings used as:

(A) Barns;

(B) Greenhouses;

(C) Farm production buildings, including aquaculture hatcheries and plant nurseries;

(D) Storage buildings for farm equipment, plant or animal supplies, or feed; or

(E) Storage or processing buildings for crops; provided that the height of any stored items shall not collectively exceed twelve feet in height and the storage of any hazardous materials shall comply with all applicable statutes, regulations, and codes.

~~(f)~~ (e) As used in this section:

“Agricultural building or aquacultural building” means a nonresidential building or structure located on a commercial farm or ranch constructed or installed to house farm or ranch implements, agricultural or aquacultural feeds or supplies, livestock, poultry, or other agricultural or aquacultural products, used in or necessary for the operation of the farm or ranch, or for the processing and selling of farm or ranch products.

“Agricultural operation” means the planting, cultivating, harvesting, processing, or storage of crops, including those planted, cultivated, harvested, and processed for food, ornamental, grazing, feed, or forestry purposes, as well as the feeding, breeding, management, and sale of animals including livestock, poultry, honeybees, and their products.

“Appurtenance” means an object or device in, on, or accessory to a building or structure, and which enhances or is essential to the usefulness of the building or structure, including but not limited to work benches, horticultural and floricultural growing benches, aquacultural, aquaponic, and hydroponic tanks, raceways, troughs, growbeds, and filterbeds, when situated within a structure.

“Aquacultural operation” means the propagation, cultivation, farming, harvesting, processing, and storage of aquatic plants and animals in controlled or selected environments for research, commercial, or stocking purposes and includes aquaponics or any growing of plants or animals in or with aquaculture effluents.

“Manufactured pre-engineered commercial building or structure” means a building or structure whose specifications comply with appropriate county codes, and have been pre-approved by a county or building official.

“Nonresidential building or structure” means a building or structure that is used only for agricultural or aquacultural operations, including an agricultural building or aquacultural building, and is not intended for use as, or used as, a dwelling.

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~~[(e)]~~ (f) This section shall not apply to buildings or structures otherwise exempted from building permitting or building code requirements by applicable county ordinance.

~~[(f)]~~ (g) This section shall not be construed to supersede public or private lease conditions.

~~[(g)]~~ (h) This section shall not apply to the construction or installation of any building or structure on land in an urban district.

(i) The State or any county shall not be liable for claims arising from the construction of agricultural buildings, structures, or appurtenances thereto exempt from the building code and permitting process as described in this section, or as otherwise described in a list adopted by the counties, unless the claim arises out of gross negligence or intentional misconduct by the State or county.”

SECTION 3. Statutory material to be repealed is bracketed and stricken. New statutory material is underscored.

SECTION 4. This Act shall take effect on July 1, 2013.

Report Title:

Agricultural Building Permits; Exemptions

Description:

Provides, under certain circumstances, an exemption from building code and permit requirements for nonresidential buildings or structures, including indigenous Hawaiian hale, on commercial farms and ranches located outside the urban district. Effective July 1, 2013. (SB586 HD1)

The summary description of legislation appearing on this page is for informational purposes only and is not legislation or evidence of legislative intent.