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Australian Centre for International Agricultural Research

Final report

Small research and development activity

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1 Acknowledgments

We wish to acknowledge the Secretariat of the Pacific Community (SPC) for providing additional funding and for valuable in-kind assistance. Their contributions included hosting the symposium at the SPC headquarters in Noumea, assisting with travel, transfers, translation services, a symposium website and printing, plus a multitude of small but essential tasks. We would like to thank Mrs Helena Heasman of NSW Industry for preparing the book of abstracts and Dr Geoff Allan for chairing the meeting. Last but not least, we are grateful to all participants for their enthusiasm, and for freely sharing their expertise and vision in order to make the symposium a success.

2 Executive summary

Stocks of high-value sea cucumber species have been chronically over-exploited throughout the Asia-Pacific. Better fisheries management must be a priority but in the case of a small number of species, aquaculture and farming activities can assist in conserving wild stocks while generating income and boosting natural recovery. Sea cucumber is a high priority in the all Asia-Pacific countries where they occur, driven by the depletion of stocks and subsequent loss of livelihoods and export dollars. There is overfishing of most high value sea cucumber species but culture success is limited to a much smaller subset of species. Most research effort has been concentrated on the 'sandfish' (*Holothuria scabra*) and hatchery production for this species is well established, although some production of white teatfish (*H. fuscogilva*) has also been achieved.

ACIAR has funded (primarily through the WorldFish Center) significant, long-term research investment into sandfish culture in Asia-Pacific: three large projects covered large-scale hatchery culture of sandfish, techniques for releasing them into the wild, and sea ranching and pond culture. Research has reached a crucial stage, large numbers of small juveniles can be reliably produced in a hatcheries using relatively simple techniques. These can be on-grown and transferred to ponds (ex-shrimp or fish ponds) or suitable inshore habitats where they reach commercial size in one to three years. It was considered timely to review this work, together with recent research from other parts of the world, in order to develop a logical and effective way to best utilise the results and progress.

A three-day international symposium on tropical sea cucumber aquaculture was organised and funded by ACIAR and the Secretariat of the Pacific Community (SPC), and held from 15–17 February 2011. The symposium reviewed the current status of research on tropical sea cucumber aquaculture, with emphasis on recent ACIAR work in the Asia-Pacific region. One of the main aims of the symposium was to identify gaps in current knowledge and generate recommendations for future research to support development of sustainable tropical sea cucumber aquaculture, primarily but not exclusively by ACIAR. The symposium covered a range of topics such as recent advances in hatchery production technology, release strategies, farming techniques, management practices, post-harvest technologies for value adding, supply chains and marketing.

The symposium was hosted by SPC at their headquarters in Noumea, New Caledonia. It was chaired by Dr Geoff Allan (ACIAR aquaculture consultant) and Dr Tim Pickering (SPC aquaculture officer) and provided with simultaneous French-English interpretation by the SPC translation team. A total of 57 participants from 20 countries registered for the symposium but a number of casual observers also attended various sessions of specific interest. Fisheries agencies, commercial companies, universities, non-government organisations, regional and international agencies were represented. Related activities included a pre-symposium round-table meeting of nine Pacific islands countries and territories.

Results of the symposium will guide ACIAR's strategic research into sea cucumber aquaculture in the Asia-Pacific region for the next 7-10 years, and have already contributed to project planning. The book of abstracts, PDFs of presentations, discussion summaries, economic decision-making tools and list of participants are available on a website on the SPC portal. In addition, a Symposium Proceedings (ACIAR Proceedings No. 137) is currently with the ACIAR Publications Unit and will be published in early 2012.

3 Introduction

As elsewhere in the world, stocks of high-value sea cucumber species have been chronically over-exploited throughout the Asia-Pacific region. Their high value as a food and medicine in China and other parts of Asia, the apparently insatiable demand, ease of capture and lack of effective management indicates that this situation is unlikely to change any time soon. Better fisheries governance must be a priority but in many cases the situation is beyond the point where improved management alone can restore populations. Sea cucumber aquaculture is a recurring priority in development aspirations for Asia and the Pacific, driven by the depletion of stocks and subsequent loss of livelihoods and export dollars. Fortuitously, for a small number of species, aquaculture and farming activities can assist in conserving wild stocks while generating income and boosting natural recovery. Consequently, there has been a great deal of research carried out on the culture of tropical sea cucumbers in the last two decades. In 2003, the United Nations Food and Agriculture organization (FAO) held a large workshop on the 'Advances in Sea Cucumber Aquaculture and management' (ASCAM) in Dalian, China—the first of its kind for sea cucumber aquaculture research. Interestingly, the major drivers for that workshop were no different to those operating today: 'the intense fishing efforts on an increasing number of sea cucumber species, the constantly growing market pressure for these species and the recent advances in farming technologies'. Experts at ASCAM concluded that, although significant breakthroughs and advances have been made by in the field of sea cucumber aquaculture, aspects still need to be investigated in order to allow further development: especially for tropical species of sea cucumbers being cultivated in developing countries (Lovatelli et al. 2004).

Today, nearly 8 years on, there is still enormous interest in the topic and research has reached a critical juncture. In the Asia-Pacific region, most research effort has been concentrated on the 'sandfish' (*Holothuria scabra*): large numbers of small juveniles can be reliably produced in hatcheries using relatively simple techniques and these can be on-grown and transferred to ponds (ex-shrimp or fish ponds) or suitable inshore marine habitats where they reach commercial size in one to three years. ACIAR has provided significant, long-term research investment into sandfish culture in the region (primarily through the WorldFish Center). Three major projects have investigated large-scale hatchery culture of sandfish (Solomon Islands 1995 to 1999), techniques for releasing cultured juveniles into the wild (New Caledonia 2000 to 2006), and sea ranching and pond culture (Philippines, Vietnam and Australia from 2007 to 2011). In recent years, hatchery technology transfer has also been directed to the Pacific Islands region. Other ACIAR initiatives include publication of the Sea Cucumber Fishery Manager's Toolbox (outcome of an ACIAR workshop in PNG in 2006: Friedman et al. 2008) and funding for development of decision-making software tools to support culture and farming of sandfish.

Momentum is building but the best ways to apply the research outcomes to deliver maximum impact are still not well defined. It is timely to review this work, together with recent research from other parts of the world, In order to encourage collaboration and technology transfer and to develop a logical and effective way to best move forward so that the technology can deliver real benefits to poor rural communities. To this end, ACIAR, in collaboration with the Secretariat of the Pacific Community (SPC), organised the Asia-Pacific tropical sea cucumber aquaculture symposium at SPC Headquarters in Noumea, New Caledonia in February 2011. This symposium was the next logical step in this research path: drawing together the many strands of ACIAR research on tropical sea cucumber culture together with other current global research. Importantly, it also provided a platform for experts from the scientific, technical and business sectors to exchange ideas and promote collaboration on sea cucumber aquaculture.

There were three project objectives:

1. Review recent research in the arena of tropical sea cucumber (with emphasis on sandfish) culture and release technology. Culture refers to hatchery production and grow-out of juveniles to release size, harvest and marketing. Release technology refers to the processes of restocking, sea ranching or farming in the wild or pond grow-out.
2. Generate information and expert opinion that will provide input into ACIAR strategic research in sandfish culture and release research in Asia-Pacific for next 7 to 10 years.
3. Provide recommendations on future research priorities in this field.

This report outlines the achievements and outputs from the project.

4 Methodology

Funding agencies for the symposium were ACIAR and Secretariat of the Pacific Community (SPC). The organising team for the Symposium was Ms Cathy Hair (JCU, based in Cairns, Australia) and Dr Tim Pickering (SPC Aquaculture Officer, based in Suva, Fiji). Genevieve Mirc (SPC Aquaculture Section PA, based in Noumea, New Caledonia) provided administrative support. Dr Dave Mills (WorldFish Center, based in Townsville, Australia) was a key advisor in organising the Symposium as he is the current project leader of the ACIAR-WorldFish sea cucumber research being conducted in Philippines, Vietnam and Australia. Dr Steve Purcell also provided valuable advice during the planning phases of the symposium.

Four activities were undertaken to achieve the stated objectives:

1. A three-day international symposium on tropical sea cucumber aquaculture was organised and funded by the Australian Centre for International Agricultural Research (ACIAR) and the Secretariat of the Pacific Community (SPC), and held from 15–17 February 2011 at the SPC headquarters in Noumea.
2. A pre-symposium round-table meeting of nine Pacific islands countries and territories was held the day before the symposium (Monday 14 February 2011) at SPC, specifically to develop a regional synthesis and highlight PICT regional priorities.
3. A one-day meeting of the expert group met on the day after the Symposium (Friday 18 February 2011). This group comprised Cathy Hair, Tim Pickering, Dave Mills and Steve Purcell. They commenced planning for two major project outputs: a peer-reviewed journal paper that will review progress in the field and outline priority strategic research and the ACIAR symposium proceedings.
4. Manuscripts, based on the symposium PowerPoint presentations, were collected from the majority of presenters.

5 Outcomes

The ACIAR-SPC Asia-Pacific tropical sea cucumber aquaculture symposium promoted sharing of information between ACIAR partner countries, in particular disseminating results of recent and ongoing research in Philippines, Vietnam and the Pacific. It also brought in expertise from other countries who are actively engaged in progressing tropical sea cucumber culture technology. All participants and observers agreed that the presentations were of a high standard and that the meeting was valuable and timely. The gathering together of key personnel to exchange ideas and debate on all aspects of the technology was stated as an outstanding outcome of the symposium.

The project achieved all of its stated objectives, which are reported below.

5.1 ACIAR-SPC Asia-Pacific tropical sea cucumber aquaculture symposium

The ACIAR-SPC Asia-Pacific tropical sea cucumber aquaculture symposium was held on 15-17 February 2011 at the Jacques Iekawé Conference Centre, SPC headquarters, Nouméa, New Caledonia. The symposium focused on work that has been supported by ACIAR, particularly in the Asia-Pacific region, but researchers from other parts of the world were invited to provide additional expertise where deemed of value to the symposium objectives. A total of 57 participants registered for the symposium (Appendix 1): 22 participants were funded by ACIAR and 15 funded by SPC. Eighteen participants were primarily self-funded, although many of these were from New Caledonia. A number of casual observers also attended various sessions of specific interest. Participants travelled from 20 countries (Australia, Belgium, Canada, Federated States of Micronesia, Fiji, Indonesia, Italy, Japan, Kiribati, Madagascar, Malaysia, Maldives, New Caledonia, Philippines, Samoa, Solomon Islands, Tonga, Vietnam, Vanuatu, Wallis and Futuna). Fisheries agencies, commercial companies, universities, non-government organisations, regional and international agencies were represented.

Twenty-three speakers presented 27 papers over three days (Appendix 2). The symposium was opened by Dr Mike Batty (SPC Marine Resources Division Director) and chaired by Dr Geoff Allan (ACIAR Aquaculture Consultant) and Dr Tim Pickering (SPC aquaculture officer). The SPC translation team provided simultaneous French-English interpretation throughout the programmed oral presentations. The symposium content was limited to aspects of tropical sea cucumber aquaculture and associated activities (e.g. post-harvest processing) that would maximise benefits to rural communities, such as: advances in production technology, experiences in release of hatchery reared sandfish into the wild, pond grow-out, post harvest processing and value-adding, options for business models, marine tenure issues, supply chain and markets. At the end of each session of presentations, break-out groups were convened to catch discussion of the major issues for future research and group plenary discussion also held. Discussion focussed on constraints and identification of knowledge gaps (summarised in Appendix 3).

A pre-symposium round-table meeting of nine Pacific Islands Countries and Territories (PICTs) held on Monday 14 February at SPC, specifically to develop a regional synthesis and highlight PICT regional priorities. This status reports provided by PICTs formed the basis for the symposium Pacific region overview presentation and manuscript for the proceedings.

A small expert group comprising Cathy Hair, Tim Pickering, Dave Mills and Steve Purcell then met on Friday 18 February. This group discussed the format of a journal publication based on the outcomes of the symposium. The lead author will be Steve Purcell. They also decided on a format and editing team for a symposium proceedings (e.g. an ACIAR technical report or Proceedings Series).

Aymeric Desurmont (SPC Fisheries Information Specialist) created a website on the SPC Aquaculture Portal providing access to the symposium program, book of abstracts, presentations PDFs, participants contact list, economic models and discussion summaries (http://www.spc.int/coastfish/en/component/content/article/380-aciar-spc-asia-pacific-tropical-sea-cucumber-aquaculture-symposium.html). According to the website administrator, the site generated most interest in the weeks immediately after the symposium but no visitor or download data are available for that period. However, in the six months since mid May 2011, it has been visited 1908 times, by 464 different people.

5.2 Key publications arising from the symposium

Manuscripts collected following the symposium have been reviewed, edited and submitted to ACIAR Publications Unit. They are currently undergoing final editing and formatting an ACIAR Proceedings volume (No. 137). There are 22 full papers and 3 abstract-only contributions (Appendix 4). ACIAR Publications Unit will be responsible for publishing and distributing the proceedings. It is expected that the proceedings will be published in early 2012 as the following:

Hair, C.A., Pickering T.D. and Mills, D.M. 2012. Asia–Pacific tropical sea cucumber aquaculture symposium. ACIAR Proceedings No. 137, Australian Centre for International Agricultural Research: Canberra. [in press].

Dr Steve Purcell has taken the lead in preparing a manuscript for a scientific, peer-reviewed journal, based on the outcomes of the symposium. The paper will review progress in the field, examine current issues and outline priority strategic research areas in tropical sea cucumber sea ranching and farming. The paper is in the early draft phase and is also due for publication in early 2012 as the following:

Purcell S.W., Hair C.A., Mills D.M. and Pickering T.D. (in prep) Farming and sea ranching of tropical sea cucumbers: progress, problems and opportunities.

6 Conclusions and recommendations

An important outcome of the symposium was the bringing together of sea cucumber aquaculture experts from the scientific, technical and business sectors: the first such forum since the 2004 FAO ASCAM Workshop in Dalian, China. It was agreed that this meeting was a valuable and timely opportunity to gather key personnel to develop networks, promote collaboration, and generate debate and discussion. All participants encouraged the development of a regular forum for sea cucumber aquaculture.

The proceedings, which are due for publication in early 2012, detail recent progress from current research programs around the globe. They will be a valuable resource for all practitioners in the field and guide ACIAR's strategic planning for further research in the arena of tropical sea cucumber aquaculture. Already, the priority researchable issues identified during the symposium have been used to guide research in two upcoming ACIAR projects: FIS/2010/054 'Mariculture Development in New Ireland, Papua New Guinea' and FIS/2010/042 'Expansion and Diversification of Production and Management Systems for Sea cucumbers in the Philippines, Vietnam and northern Australia'.

7 References

7.1 References cited in report

Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J-F. and Mercier A. 2004. Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper No. 463. Food and Agriculture Organization of the United Nations: Rome. 425 p.

Friedman K., Purcell S., Bell J. and Hair C. 2008. Sea cucumber fisheries: a manager's toolbox. ACIAR Monograph No. 135, 32 pp.

7.2 List of publications produced by project

Hair, C.A., Pickering T.D. and Mills, D.M. 2012. Asia–Pacific tropical sea cucumber aquaculture symposium. ACIAR Proceedings No. 137, Australian Centre for International Agricultural Research: Canberra. [in press].

Hair, C., Pickering T 2012. The 2011 ACIAR-SPC Asia-Pacific Tropical Sea Cucumber Aquaculture Symposium. SPC Beche-de-mer Information Bulletin 32 [in press].

Purcell S.W., Hair C.A., Mills D.M. and Pickering T.D. (in prep) Farming and sea ranching of tropical sea cucumbers: progress, problems and opportunities.

8 Appendixes

8.1 Appendix 1: Symposium participant list

Name	Affiliation	Country
Akamine Jun	Nagoya City University	Japan
Alessandro Lovatelli	FAO	Italy
Ann Fleming	Darwin Aquaculture Centre	Australia
Annette Menez	Marine Science Institute, UP	Philippines
Annie Mercier	Memorial University, Canada	Canada
Antoine Teitelbaum	SPC	New Caledonia
Aymeric Desurmont	SPC	New Caledonia
Beni Giraspy	Sea Cucumber Consultancy	Australia
Bernard Fao	Province Sud Fisheries	New Caledonia
Bill Johnston	QLD DEEDI	Australia
Bruno Mugneret	Service de la peche,	Wallis et Futuna
Cathy Hair	James Cook University	Australia
Chris Barlow	ACIAR	Australia
Claire Marty	Province Nord Fisheries	New Caledonia
Coline Drain	SEA Societe Elevage Aquacole	New Caledonia
Dave Mills	WorldFish Center	Australia
Geoff Allan	NSW DPI/ACIAR	Australia
Georgina Robinson	Blue Ventures	Madagascar
Gerald Billings	Fiji Fisheries Department	Fiji
Gilbert Hanson	Northern Land Council, NT	Australia
Grant Leeworthy	Tasmanian Seafoods	Australia
Gunnar Lee-Miller	Sampa Farms	Maldives
Hampus Eriksson	University of Sweden	Sweden
Igor Eeckhaut	Mons-Hainaut University	Belgium
Jayven Ham	Vanuatu Fisheries Department	Vanuatu
Jean-Francois Hamel	SEVE	Canada
Jens Knauer	NT Darwin Aquaculture Centre	Australia
Johann Bell	SPC	New Caledonia
John Hutapea	AMAFRAD (GRIM)	Indonesia
Joyce Ah Leong	Samoa Fisheries	Samoa
Kalo Pakao	SPC	New Caledonia
Karibanang Aram	Kiribati MFMRD	Kiribati
Maripaz Perez	WorldFish Center	Philippines
Masahiro Ito	Sea Grant	FSM
Michael Mintz	Private hatchery	Philippines
Mike Hasurmai	FSM Fisheries	FSM
Natacha Agudo	Noumea Aquarium	New Caledonia
Nathaniel Cornuet	Province Nord Fisheries	New Caledonia
Nguyen Dinh Quang Duy	RIA3,	Vietnam
Olivier Meraud	Madagascar Holothuria	Madagascar
Paul Chabre	SAB	New Caledonia
Paul Southgate	James Cook University	Australia

Poasi Ngaluafe	Tonga Fisheries	Tonga
Robert Costa	Directeur ERPA	New Caledonia
Robert Jimmy	SPC	New Caledonia
Ruth Gamboa	UP, Mindanao	Philippines
Sabrina Virly	SAB	New Caledonia
Satoshi Watanabe	JIRCAS	Japan
Semisi Meo	USP (FLMMA)	Fiji
Steve Holloway	Sampa Farms,	Maldives
Steve Purcell	NMI, Southern Cross University	Australia
Sylvester Diake Jr	Sol Is. MFMRD	Solomon Islands
Theo Simos	ACIAR consultant	Australia
Thomas Requillart	Province Sud,	New Caledonia
Tim Pickering	SPC	New Caledonia
Will Bowman	Tasmanian Seafoods	Australia
Woro Perwitasari	Lombok Aquaculture Centre	Indonesia

8.2 Appendix 2: Symposium program

ACIAR-SPC ASIA-PACIFIC TROPICAL SEA CUCUMBER AQUACULTURE SYMPOSIUM PROGRAM

(15-17 February 2011, Noumea, New Caledonia)

Day 1 (Tuesday Feb 15)

Welcome

08.30	Mike Batty	Opening welcome
08.35	Chris Barlow	Introduction to Symposium

Regional overviews

08.45	Alessandro Lovatelli	The global potential of sea cucumber aquaculture
09.05	Robert Jimmy	Overview of sea cucumber aquaculture and stocking research in the Western Pacific region
09.25	Dave Mills	Overview of sea cucumber aquaculture and stocking research in the South-East Asian region
10.00	*Morning tea*	

Sea cucumber hatchery production

10.30	Nguyen Dinh Quang Duy	Large-scale production of sandfish for pond culture in Vietnam
10.50	Igor Eeckhaut	In vitro fertilization of sea cucumbers, a new method to boost aquaculture production
11.10	Satoshi Watanabe	Evaluation of nutritional condition of juvenile sandfish, *Holothuria scabra*
11.30	Annette Menez	Ocean nursery systems for scaling-up juvenile sandfish (*Holothuria scabra*) production: ensuring opportunities for small fishers
11.50	Ruth Gamboa	Small-scale hatcheries and simple technologies for sandfish production
12.10	Will Bowman	Sandfish production and development of sea ranching in northern Australia
12.30	*Lunch*	
14.00	Annie Mercier	Hatchery experience and useful lessons from *Isostichopus fuscus* in Ecuador and Mexico
14.20	Plenary	Identification of major hatchery issues
15.00	*Afternoon tea*	
15.30	Break out groups to identify knowledge gaps for each major issue.	
16.30	Reconvene to collate these and prioritise as a group. Rank each hatchery issue.	
17.00	Finish	

Day 2 (Wednesday Feb 16)

Sandfish sea ranching and farming

08.30	Steve Purcell	Principles and science of stocking sea cucumbers into the sea
08.50	Natacha Agudo	New Caledonia sandfish grow-out in earthen ponds
09.10	Satoshi Watanabe	Ability of the sandfish, *Holothuria scabra*, to utilise organic matter in the black tiger shrimp pond
09.30	Dave Mills	Pond farming and co-culture options in Vietnam
09.50	Annette Menez	Establishment and management of communal sandfish (*Holothuria scabra*): sea ranching in the Philippines
10.10	*Morning tea*	
10.40	Beni Giraspy	Maldives sea cucumber farming experience
11.00	Cathy Hair	Sandfish production and sea ranching trial in Fiji
11.20	Georgina Robinson	Development of sea cucumber farming as an alternative livelihood in SW Madagascar
11.40	Ann Fleming	Sea ranching in an Indigenous community within a well regulated sea cucumber fishery (Northern Territory, Australia)
12.00	*Lunch*	

Resource tenure issues

13.30	Meo Semisi	Marine tenure and the role of MPAs for sandfish grow-out in the Pacific
13.50	Kalo Pakoa	Sandfish (*Holothuria scabra*) fisheries in the Pacific; present status, management overview and outlook for rehabilitation
14.10	Plenary	Identification of the major release and grow-out issues
15.00	*Afternoon tea*	
15.30	Break out groups to identify knowledge gaps for each major issue.	
16.30	Reconvene to collate these and prioritise as a group. Rank each issue.	
17.00	*Finish*	

Day 3 (Thursday Feb 17)

Post-harvest value adding, marketing & supply chain, socio-economics

08.30	Maripaz Perez	Marketing sea cucumber in southeast Asia: challenges and opportunities
08.50	Theo Simos	Pacific Islands region sea cucumber and beche-de-mer market analysis
09.10	Steve Purcell	Processing cultured tropical sea cucumbers into export product: issues and opportunities
09.30	Hampus Eriksson	Ecological and social considerations for an expanding sea cucumber farming industry
09.50	Jun Akamine	Sea cucumber markets in the world: Hong Kong, Guangzhou and New York
10.00	*Morning tea*	

10.30	Decision making tools and their role in sandfish aquaculture development (Bill Johnston)	
10.40	Practical session using draft sea cucumber decision making tools	
11.30	Group feedback on models.	
11.45	Plenary	Identification of the major marketing issues.
12.00	*Lunch*	
13.30	Break out groups to identify knowledge gaps for each marketing issue.	
14.30	Participatory session to collate and prioritise issues identified throughout the Symposium	
15.30	Facilitator	Final summing up of all sessions.
15.50	Alessandro Lovatelli	Upcoming FAO activities.
16.00	*Symposium Closing*	

8.3 Appendix 3: Summary of breakout group discussion

8.3.1 Summary of Day 1 Discussion: Hatchery Technology Issues

Issue 1: Genetics

- **TAXONOMIC ISSUES**
  a. **Need baseline genetic diversity data**. Identify stocks, assess gene flow, map gentotypes (**everywhere**, but may be too late for some places, e.g. Madagascar and Ecuador).
  b. Pacific and Indian Ocean sandfish stocks probably distinct species – not tested yet (different hatchery techniques?)
  c. Tonga golden sandfish (*H. lessoni*) or different
- **BROODSTOCK AND HATCHERY GENETIC DIVERSITY ISSUES**
  a. Need to identify risks (are there risks? – how do we know? Paucity of evidence and studies). Need strong scientific evidence to encourage or enforce regulation.
  b. **Need for guidelines for hatcheries** (how many broodstock to use (esp. Since few spawn at any time, how often variety is needed, will genetic bottleneck affect bottom line)
  c. Ideals versus economic reality
  d. Inevitability of movement of stock within most countries
  e. Preservation of genetic diversity is more a question for restocking than commercial production question.
  f. Enforcement of guidelines (role of government in legislating for this issue, scientists must play a role in advising the decision makers).
- **TRANSLOCATION ISSUES (WHERE SPECIES DOES NOT OCCUR NATURALLY)**
  a. Biosecurity (precautionary approach)
  b. Habitat –chances of success
  c. Effect/displacement on other species in similar niches. Survey area first

Important notes

- Accept that the ideal situation is to use hatchery-produced progeny to release to areas where broodstock originate.
- Need advice from geneticists. Theory based, lot of work for other species (Current WorldFish Center study into genetic risk)
- If aquaculture progress continues, likely that selective breeding (genetic improvement) programs will eventuate.
- If precautionary approach to be followed, need strong scientific proof, who will fund this?

Possible actions

- Develop a set of best practice guidelines (based on advice from geneticists).
- Genetic studies.
- Write genetic research components into new project proposals where appropriate

Issue 2: Hatchery scale-up, efficiency, etc

Biological issues – more basic science is required.

- **Better understanding of the biology of the farmed species** for existing species of interest and potential aquaculture candidates (including nutritional requirements, feeding mechanics, growth performance, etc.)
- **Adequate documentation for practical reference purposes.** Information may or may not be know, but eventually it should be collated in such a way to make research findings available to practical applications.

In terms of the ideal hatchery technology choice and management protocols, these will vary among species, but also for the same species depending on 1) geographical location (i.e. depending on local environmental conditions) and 2) scale of operation intended (i.e. large- or small-scale).

Technological issues

- **Flow-through and static systems** – the choice of which may well be species specific.

- Setup and operation costs may be higher, but on a longer term the overall returns may be better as a result of a significantly higher survival of the larvae and the large quantity of seed material produced;
- It is essential to determine the **optimal rate of water exchange** that would allow optimal performance of the facility and avoid unnecessary operational expenses.

- **More research and/or better documentation if the information is available on:**

- Optimal stocking densities at different stages of larval and post-larval development;
- Improving efficiency in transfers and manipulation (nursery stage);
- Microalgae selection (optimal species for one sea cucumber species);
- Alternative feed sources other than live microalgae;
- Understanding density dependence (stage dependent)

- **Production statistics** – indicating possible performance results under specific culture conditions.
- **Nursery systems**
- **Modular hatchery design (hatchery components)**
- **Aeration technology**
- **Develop hatchery standard operating procedures** – this would include a “what to do manual” if something goes wrong.
- **Develop/access to diagnostic tools**
- **Develop hatchery operating protocols**
- **Better understanding of technical staff requirement according to production scale**

Issue 3: Nutrition

Generic Issues:

- Greater understanding of nutritional requirements/physiology (all stages/spp.)
- Database of current knowledge/methods

Broodstock:

- Greater nutritional knowledge for conditioning (maximise gamete quality/fecundity, prolong spawning period)
- Methods for assessing gamete quality
- Understanding how local environment influences condition

Larval:

- Investigate potential of 'off-the-shelf' feeds (alternatives to live algae)
- Optimise quality of live algae (related to training/facilities/capacity/skills)
- Identify best spp. of live algae (accounting for species/age specificity)
- Optimise feeding protocols (i.e. ration vs. larval density vs. age/stage)
- Optimise water quality to maximise nutritional benefits of feeds

Settlement/Juvenile Culture:

- Need database of methodologies
- Food availability – what do they eat?
- More information on required characteristics of biofilms
    - composition vs. nutritional value
    - composition vs. stocking density
    - digestion/assimilation of biofilm components
- Optimise substrate conditioning methods

Net/cage:

- More information on required characteristics of biofilms – what are the important components?
- Optimising stocking density vs. food availability

Pond Culture:

- Determine appropriate organic content of substrate (vs. age)
- Methods for assessing appropriate substrate characteristics prior to stocking
- What do they eat? Need more info on optimal particle size/assimilation/digestion etc
- Detailed knowledge of important fractions of substrate and substrate composition (organic and mineral)
- Need more information on nutritional needs of animal – better targeting of feeds used (i.e. shrimp feed)
- Optimise ration vs. stocking density vs. age/stage
- Development of specific diets
- Potential of biofloc

Issue 4: Species Diversification / Broodstock Conditioning

Species Diversification

What are the drivers for diversification?

- species of lower value but higher growth may be commercially viable

-the species available may not be high value. Bring in other species –environmental issues with this, particularly if species not native. The biology/ecology of alternative species not well understood.

-target habitat restoration as a conservation arm of commercial model. Enhancement of depleted species – perhaps as part of a government program.

- don't make assumptions of what is and isn't low value. Markets not well understood, marketing not undertaken on these lesser value species. Alternative product to meat from a variety of species

-differing habitat requirements of different species may make grow-out problematic

Hatchery issues:

-Need hatchery methods for these additional species, likely to be a different protocol. Some thought this may not be so in the early larval stages, but perhaps more likely for settlement cues as metamorphosis may differ depending on habitat.

-using two species with reproduction cycles out of phase with each other allows optimal utilisation of hatchery investment.

Broodstock conditioning

-Classical conditioning versus chemical spawning induction

- Classic conditioning approach requires understanding of control using temperature, light, lunar cycle. Determining biological zero point to reset gametogenesis to zero.

- understand what conditions are required for 'healthy' broodstock. Both nutritional and environmental requirements. Suitable systems for holding broodstock.

- Instead of extending the species' spawning period, could look at holding two groups of broodstock. Each group is held out of phase with the other by manipulating conditioning ques.

- should start with a thorough literature review. Bring together available data – field studies and hatchery work.

-research level conditioning systems not necessarily scalable to commercial situation. Would like to see data from hatcheries that report year-round conditioning ease. Production of numbers year round for small-scale operations is different to that required for larger commercial situations.

- Better understand what is happening at the individual level during a spawning run. When a population of animals are spawned, each individual is out of phase with each other.

- In relation to spawning cues, could utilise by-product from fishermen to extract the gonads/inducer.

- Reference for spawning inducer – Eeckhaut et al. 200?? Invertebrate Reproduction & Development

Issue 5: Health and well being

Three main disease issues to date:

Bloodworms (larvae of Dipteran flies)

- cause fouling of substrates, attach to sea cucumber juveniles, can bloom rapidly if not controlled.
- only control mechanism to date is to cover tanks to stop ingress of adult flies - not totally successful.
- some hatcheries remove the blood worms by hand - difficult and very time consuming.

Copepod infestations

- Big issue but little information available.

- Chemical (dipterex) treatment of settlement substrates prior to adding to larval tanks is effective.
- Similarly, using algal pastes to condition settlement substrates precludes copepod colonisation.

Protozoans (genera-species unknown)

- Disease issue seen in many hatcheries
- Chlorine treatment for intake water plus screening through 1 micron filters helps avoid the problem.
- Temperature / salinity manipulations of water can eliminate (some?) protozoan diseases.

General conclusions:

- Urgent need to document best management practices, including simple diagnostic procedures and treatments
- This will involve a review and collation of information from multiple hatcheries.
- Best practice includes hatchery biosecurity procedures to prevent disease organisms entering culture tanks, and to avoid spread between tanks.
- Recommendation that more hatcheries test the flow-through system for larval rearing (Annie Mercier's presentation) (Possible if we have a "manual" from Annie and her team)
- Poor nutrition and Trauma recognised as the major pre-cursors to disease problems. Therefore, must have good nutrition at all larval stages; need to minimise handling / physical damage; need to know larval tolerances (e.g. salinity, temperature).

Issue 6: Transfer and dissemination of hatchery technology

- Micro-algae culture techniques – Training and Extension
    - These are aquaculture techniques with generic application so there should be a lot of information available, but which source is most applicable to sea cucumber hatchery work?
    - Explore and make available any new techniques which can eliminate live micro-algae altogether
    - Compile a directory of opportunities for work experience attachments in live micro-algal production, and for reputable sources of starter cultures
- Do we need a new Hatchery Manual that consolidates and supplements the two manuals already available?
    - These are good basic manuals for general technique, which can now be supplemented by Compendia of Recent Advances whereby these techniques have been fine-tuned and adapted for site-specific conditions to improve growth and rates of survival.
    - These Compendia should include a Checklist of Simplified Techniques to help make hatchery technology more accessible to those in low-cost low-tech economies.
    - There should be elaboration of underlying Biological Principles to increase understanding of the basis for recommended culture conditions and hatchery parameters, to further encourage development of local solutions for local hatchery problems

  - It would be useful to develop a "Sea cucumber Hatchery Operation Trouble-shooting Guide", with a decision-tree and descriptions of simple diagnostic tests to elucidate hatchery problems
  - Develop a database of "typical values" for hatchery parameters and production outputs, upon which to base project proposals and economic forecasts, for a range of hatchery scales and scenarios. Include a selection of Case Studies and identify ranges of values as well as mean values.
- Improved transfer of technology, accessibility of knowledge and expertise
  - Web-based tools for Knowledge Management should be explored and implemented to increase accessibility of information pertinent to hatchery work, and to foster the creation of an international on-line community of practitioners in "real-time" communication with each other.
  - Options include a Slug Wikipedia site, a Slug-List Yahoo Group, and/or a Slug Site (on FAO, or SPC websites) with downloadable pdf's, directory of contacts and suppliers, a Frequently Asked Questions page, and a Slug Bibliography of key references.

8.3.2 Summary of Day 2 Discussion: Sandfish sea ranching and farming, resource tenure issues

Issue 1: Grow-out

Potential risks effects of releasing

Translocations

1. Genetic risks
   - The main risk stems from the lack of knowledge about introgression, out-breeding depression, or other potential risks
   - This knowledge gap must be filled to develop a Code of Best Practice for translocations, taking into account "depleted" vs. "locally-extinct" release areas.
   - Where knowledge is lacking the Precautionary Principle applies – the FAO Code of Conduct Part 5 provides guidelines for aquaculture generally, however to guidelines specific to sea cucumber need to be developed?
2. Ecological risks
   - Is there risk from OVER-restocking? For example, irreversible shifts in community structure, potential for genetic bottlenecks if releases impede natural recruitment. Or is it already too late, because over-fishing has already caused irreversible shifts so current structure is not pristine or "ideal" anyway?
3. Biosecurity risks
   - Potential for spread of pathogens, parasites, or hitch-hiker species into hatcheries, and from there to multiple release sites.
   - We need guidelines in Best Management Practice, and Quarantine Protocols (see, for example, those for Marine Ornamental spp.)

New-species Introductions

4. Competent-Authorities that are responsible for decisions about introductions find there is a paucity of information about ecological, genetic or pathogen risks to inform Risk Assessments.

   Quarantine protocols to manage risk have not yet been developed specifically for sea cucumbers. Pathogens will largely be "unknowns" for which there are no

diagnostic tests like PCR. A Manual to identify "known" slug pathogens needs to be compiled.

Priority Actions

a. Base-line genetic research to estimate diversity and detect structure to estimate homogeneity of stocks and connectivity between them.
b. Code of Best Practice for translocations, that addresses management of genetic, ecological and pathogen risks of hatchery-based releases
c. Quarantine protocol for new-species introductions
d. Base-line benthic community structure should be described before releases (but are we already 200 years too late?)

Issue 2: Pond culture, co-culture and integrated systems

Pond culture

- Bioremediation – Needs for more science.
- Cost-benefit analysis of mariculture
- Suitable (or optimal) substrates for farming
  - Known environmental-chemical parameters will allow optimal pond preparation and management
- Ideal conditions for growth
  - Feeding rates
  - Stocking density
- Best pond management practices
  - Water supply
  - Dealing with water quality issues
- Predators are an issue
  - How to manage (remove or exclude) them
- Nursery ponds
  - Allow for mass production of large size seed material
  - Allow for easier grading among slow and fast growers – smaller sizes will grow faster if separated from larger specimens.
- Ideal stocking size

Co-culture

- Is co-culture viable with some species. More investigation needed. Importantly the culture environment must remain optimal for sea cucumber growth performance.
- Brackish water co-culture. Probably not an option.
- Identify co-culture species that are adaptable to other conditions.
- Need to look at co-culture options at different sizes of sandfish. Size refuge?
- Is polyculture/co-culture with seaweeds an option for tropical species?
- Polyculture with different species of sea cucumbers.
- More work required on rotational culture.
- Setting conditions when polyculture can be promoted (if an option).
- Sea ranching options should be further investigated.
- Fallowing of open water culture sites deemed important. More investigation needed

Issue 3: Governance and social issues

Definition

Governance is about the people who are affected, empowering them to namage their resources and get the most out of the profits

Important to identify the players/ stakeholders

-Regional players, NGO's, advocacy groups,

- all relevant levels of government,

-private sector (must work with government),

- local community,

-community leaders/elders/headmen,

- resource owners (land owners/traditional owners),

-economic development groups,

Interrelatedness of issues means agencies must work together and fisheries management strategies must be broad

-Must have within governance not only the aquaculture stakeholders but the wild fishery and environment agencies/bodies. They are interrelated. Each relevant department must work together.

-Must consider impact/negative consequences on wild fishery of the introduction of aquaculture practices in a region. Eg, governments may lessen management with aquaculture as a fallback. Same with wild fishermen – can now exploit the wild stocks as government will repair.

-Sea cucumber culture should be integrated into the broader fisheries management strategy – encompassing multi- species and operating at the regional and municipal level. Not just targeted to address a single fishery problem or a commodity need.

-Community-based management plans- must define the scale of the management area. Need to ensure influencing factors outside the community region is brought into management strategies.

Consultation

-good consultation of stakeholders is required. Needs to be with the right people at all levels.

- Important to avoid 'big promises/ big expectations' misunderstanding around aquaculture. Need to communicate realistic timeframes for delivery of benefits and realistic expectations of benefits.

Governance arrangements are country/region specific

Best governance arrangements are location specific. Each country has its unique issues/government arrangements/community capacities.

- Village is the key to success, need social cohesion/ good governance framework in operation.

Social equity

-Governance must seek to capture profits at the low level – ensure social equity.

For eg. Co-operatives, short market chains.

In China co-ops are a very effective way for farmers to have their interests met. Small co-ops that by-pass government governance. Co-ops are under broader species-specific umbrella organisations that manage at the regional/ market level.

-permits are a mechanism to ensure equity in access rights

-Need to develop models for social equity for sea cucumber culture. Important to set the goals up front, eg food security or restocking, etc

Poaching/unscrupulous traders

-Important to identify who is doing the poaching and understand why – drivers for poaching. The can manage it more effectively. More targeted education within the community.

- Be good to do a social-economic study of poaching to identify the drivers.

- Best management of poaching is achieved at the community level. They can do their own surveillance and enforcement.

-who is responsible legally for poaching? Are there legal powers for them to do their job? Are there Codes of Practice? Aim to put community management of poaching within a legal framework.

- Poaching increases after disasters (cyclones) and during celebrations, at times when surveillance is low.

-Sea cucumber is particularly vulnerable to poaching as it is readily accessible – no gear is required.

Issue 4: Releasing animals to the sea

Issues for consideration, some requiring research:

- **Acclimation and Release methods**

Many issues here, including transport to the release site; acclimation to receiving water; release times - day/night; tides; others.

Techniques for release of non-*scabra* species need to be considered - could be quite different to *H scabra*

- **Criteria for site selection**

Need to review and document site selection criteria, of which there will be many

Biophysical - substrate, nutrients, tides, wind, grain size, presence / absence sea grass, other fauna including predators.

Governance - must have community support - but note the community's preferred site will often not be the same as the preferred biophysical site.

Also, best or preferred nursery sites may be different to grow-out sites. Note we do not have a lot of information on biology of juveniles in the wild.

- **Carry capacity - assessment methods**

Need criteria for estimating carrying capacity of sites

- **Rehabilitating degraded environments prior to stocking** - a possible consideration

For instance degraded sea grass meadows - could they be replanted / enhanced prior to stocking

Could extend to providing artificial shelters or habitat at the time of stocking.

- **Predation**

How to minimise predation, what are the predators in each situation

Predator removal prior to stocking may be an option in some cases

- **Longitudinal surveys - sequential surveys pre- and post-stocking**

Systematic surveys to monitor stocked animals is necessary to build the pool of knowledge on success and failure.

- **Security**

Recognised as a major and possibly limiting factor in most ranching situations.

Approaches to managing the issue will vary from site to site, country to country

A more general comment

- **Production chain economic models**

Much effort goes into improving the efficiency of hatchery systems, but relatively little into release methods. It would be good to look at the "economic efficiency" all along the production cycle. W e may find much better return on investment could be gained from, for instance, redirecting effort to improving survival over the first couple of months post-stocking.

8.3.3 Summary of Day 3 Discussion: Post-harvest, value adding, and marketing of aquacultured product

Statistics

- Collate\update fragmented information (anything is good, even if inaccurate)
- Traceability of product
- FAO\National statistics should recognise sea cucumber as a separate commodity – input by FAO members to ongoing Aquaculture Statistics review? New form lists SC separately, so in two years time should have a better data set.
- Data-collection capacity of members themselves needs to be increased. Real gaps in domestic activity and exports (e.g. under-invoiced, species ID suspect, where sold and destination)
- Harmonisation of data collection and definition of units\lifecycle-stages, for comparability of production measures, product types, and marketing statistics.
- Ranching, farms and ponds provide an opportunity to collect better data as harvest will be larger, controlled and contained somewhat
- Opportunity to obtain data from assembled experts – require benchmark figures for the economic decision tools

Standards and grades

- Compendium of processing methods that lead to high-grade product
- Pricing is all over the shop, very different price structures in different countries.
- Grass roots level does not know value of product they are selling. Don’t eat it therefore don’t have good concept of looking after it well to obtain highest price. Small changes in traditional processing practices could make a large improvement in value. Adherence to GMP and HCCP guidelines would be a good start.

Rationalisation of market chains

- Very secretive industry, so difficult but need to look for opportunities for aquaculture to reduce steps in market chain.

- Ranching, farms and ponds provide an opportunity to have more control over marketing, sell directly to processor or exporter.

Opportunities for producers

- Diversification to non-food products (e.g. Malaysian gamat soap, etc)
- New SC food products (tinned, fresh vacuum packed, frozen, freeze dried, part dried, viscera, etc)
- Use JICA expert to advise on alternative products for local processing
- Ranching, farms and ponds provide an opportunity to have more control over processing and prices, may be able to negotiate with buyers as larger quantities for sale at harvest times of the grower's choice.

8.4 Appendix 4: List of contributions to the symposium proceedings

Overview of sea cucumber aquaculture and stocking research in the Western Pacific region, *by Robert A. Jimmy, Timothy D. Pickering and Cathy A. Hair*.

An overview of sea cucumber aquaculture and ranching research in South-East Asia, *by David J. Mills, Nguyen D.Q. Duy, M. Antonette Juinio-Meñez, Christina M. Raison and Jacques M. Zarate*.

Large-scale sandfish production from pond culture in Vietnam, by *Nguyen D.Q. Duy.*

In-vitro fertilisation, a simple, efficient method for obtaining sea cucumber larvae year round, *by Igor Eeckhaut, Thierry Lavitra, Aline Léonet, Michel Jangoux, Richard Rasolofonirina*.

Evaluation of nutritional condition of juvenile sandfish, *Holothuria scabra*, *by Satoshi Watanabe, Jacques M. Zarate, Maria J. H. Lebata-Ramos , Marie F. J. Nievales*.

Ocean nursery systems for scaling-up juvenile sandfish (*Holothuria scabra*) production: ensuring opportunities for small fishers, *by M. Antonette Juinio-Meñez, Glycinea M. de Peralta, Rafael J.P. Dumalan, Christine M.A. Edullantes, Tirso O. Catbagan*.

Small-scale hatcheries and simple technologies for sandfish (*Holothuria scabra* Jaeger) production, *by Ruth U. Gamboa, Remie A. Aurelio, Daisy A. Ganad, Lance B. Concepcion, Neil A. S. Abreo*.

Sandfish production and development of sea ranching in northern Australia, *by William M. Bowman*.

Hatchery experience and useful lessons from *Isostichopus fuscus* in Ecuador and Mexico, *by Annie Mercier, Roberto H. Ycaza, Ramon Espinoza, Victor M. Arriaga Haro and Jean-François Hamel*.

Principles and science of stocking sea cucumbers into the sea, *by Steven W. Purcell*.

Pond grow-out trials for sandfish, *Holothuria scabra*, in New Caledonia, *by Natacha S. Agudo*.

Ability of the sandfish, *Holothuria scabra*, to utilise organic matter in black tiger shrimp ponds, *by Satoshi Watanabe, Masashi Kodama, Jacques M. Zarate, Maria J. H. Lebata-Ramos, Marie F. J. Nievales*.

Establishment and management of communal sandfish (*Holothuria scabra*) sea ranching in the Philippines, *by M. Antonette Juinio-Meñez, Marie A. Paña, Glycinea M. de Peralta, Tirso O. Catbagan, Ronald D. Olavides, Christine M. Edullantes, Bryan D. Rodriguez*.

Maldives sea cucumber farming experience, *by Beni G.D. Azariand Grisilda I. Walsalam* (abstract only).

Sandfish (*Holothuria scabra*) production and sea ranching trial in Fiji, *by Cathy A. Hair*.

Sea cucumber farming experiences from south-west Madagascar, *by Georgina Robinson and Benjamin Pascal*.

Sea ranching in an Indigenous community within a well regulated sea cucumber fishery (Northern Territory, Australia), *by Ann E. Fleming*.

Marine tenure and the role of marine protected areas for sea cucumber grow-out in the Pacific, *by Semisi V. Meo*.

Sandfish fisheries in the Pacific: present status, management overview and outlook for rehabilitation, *by Kalo M. Pakoa, Ian Bertram, Kim J. Friedman and Emmanuel Tardy*.

Market Potential and Challenges for Expanding the Production of Sea Cucumber in South-East Asia, *by Maripaz L. Perez and Ernesto O. Brown*.

Understanding the sea cucumber and bêche-de-mer value chain in Fiji and Tonga, *by Theo Simos*.

Processing cultured tropical sea cucumbers into export product: issues and opportunities, *by Steven W. Purcell and Nguyen D.Q. Duy* (abstract only).

Sandfish (*Holothuria scabra*) farming in a social-ecological context: conclusions from Zanzibar, *by Hampus Eriksson*.

S**ea cucumber markets in the world: Hong Kong, Guangzhou and New York**, *by Jun Akamine* (abstract only).

Applying economic decision tools to improve management and profitability of sandfish industries in the Asia-Pacific region, *by Bill Johnston*.