Inland saline aquaculture - past progress, new opportunities and a synthesis of available knowledge

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Executive Summary

The New South Wales Department of Primary Industries (NSW DPI) Fisheries, other state governments, the Fisheries Research and Development Corporation (FRDC), the Australian Government (then DAFF) and the Australian Centre for International Agricultural Research (ACIAR) made a major contribution to research and coordination to identify and evaluate opportunities for inland saline aquaculture in Australia (and overseas) in the early 2000s. Research has been translated into significant industry development in some areas (e.g. India) but commercial progress in Australia has been slow.

Unfortunately, with time, much of the collective research is difficult to access especially for prospective farmers and investors. New development will stand a better chance if fully informed of past progress. New technical challenges will need to be addressed. This project sought to address the following objectives:

1. Collate existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture over the last twenty years.

2. Examine commercial developments and impacts from previous research.

3. Identify new opportunities.

4. Recommend ways these opportunities might be further explored and captured.

This was a desktop project complimented by a special Inland Saline Aquaculture session which was conducted as part of the World Aquaculture Society Conference in Darwin, May/June 2023. Experts with a strong history in inland saline aquaculture research from NSW, Victoria, South Australia, and Western Australia were invited as well as two international experts, from India and the USA. Invited experts were asked to give presentations summarising past progress, including commercial developments, challenges and future opportunities.

Objective 1. Existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture were collated and listed in a searchable excel bibliography categorised by country/region and topic. The vast majority of publications are available online and a web link is provided in the bibliography.

There were 587 unique publications listed. Almost all publications deal with the technical issues and solutions for farming in inland saline areas. They concentrate on the growth and performance of selected species.

Of the 587 publications, 116 were from Australia. The vast majority of these arose from research from NSW DPI Fisheries, other state governments, the Fisheries Research and Development Corporation (FRDC), the Australian Government (then DAFF), the Australian Centre for International Agricultural Research (ACIAR) or Universities linked to projects supported by those agencies.

There were 157 publications from India, many of which arose from collaborative ACIAR projects in India conducted in collaboration with a NSW DPI project leader.

The international sharing of technology has been greatly facilitated by the World Aquaculture Society conferences, supported by many agencies, including FRDC, ACIAR, NSW DPI and other state and Commonwealth governments.

It is overwhelmingly obvious from the literature that it is technically possible to farm a number of species in inland saline water, although sometimes an adjustment of the water chemistry is required, for example by adding potassium in saline waters in the Murray Darling Basin in NSW.

Objective 2. There is limited commercial production from inland saline aquaculture in Australia. Small-scale commercial operations in Western Australia have ceased operation and there are currently no commercial operations in South Australia or NSW.

In Victoria, commercial production of Barramundi (*Lates calcarifer*) (up to 750 tonne/yr) uses geothermally heated (29 ^{o}C) groundwater with a salinity of 2-3 g L-1g L^{-1}.

In Queensland, a fish farm located southwest of Chinchilla, grows Murray cod *(Maccullochella peelii)* and uses saline groundwater (3-5 g L^{-1}) to reduce pathogen load in fingerlings and to purge market fish. Also in Queensland, a commercial farm near Esk, Marine Garden produces small quantities of Black Tiger Prawns (*Penaeus monodon*) using salt water trucked from the coast.

In contrast, commercial aquaculture development using inland saline water is well established in other countries. In India, for example, many species have been cultured and several are in commercial production. The main species cultured on a large scale using saline groundwater is the white leg shrimp (*Litopenaeus vannamei).* The inland culture environment is preferred to coastal areas because of the more stable environmental conditions and fewer cyclones.

Israel also has substantial commercial inland saline aquaculture production. Tilapia (*Oreochromis niloticus)*, carp (*Cyprinus carpio*), and mullet (*Mugil cephalus*), are the main species.

Commercial culture is also progressing in the Middle east and the USA. A large Australian Barramundi farming company has purchased facilities in Arizona to farm Barramundi (*Lates calcarifer*) in saline ground water in a farm that used to commercially farm white leg shrimp (*Litopenaeus vannamei)*.

Objective 3. In South Australia, a commercial development based on culture of Yellowtail Kingfish, using saline groundwater, is seeking investors. This development, the Waikerie Project, would not have built their model for farming without the research on inland saline aquaculture funded by the South Australian government, the National Action Plan for Salinity and Water Quality and FRDC. The aim is to develop the farm in 250 t per annum production modules, with each module to be brought on-line when the market from earlier modules is satisfied.

Opportunities exist for inland saline aquaculture groundwater, including for the whole production cycle and parts of the cycle, for example hatchery, nursery, and purging. The use of inland saline groundwater as a relatively pathogen-free water source is an opportunity.

Objective 4. A special inland aquaculture session was organised in association with the World Aquaculture Society Conference in Darwin, May/June 2023. Recommendations to identify barriers to commercial development in Australia were drafted. These included, ensuring water supply is adequate and secure over long term (e.g. decades), retaining a focus on high value species, and supporting the exploration and trial of new technologies and innovations. Government together with industry should support consistent strategies and regulations for aquaculture in general and encourage and fund enduring knowledge transfer, particularly with private sector investors.

Keywords

Inland saline aquaculture, saline groundwater

Introduction

NSW DPI Fisheries, other state governments, the Fisheries Research and Development Corporation (FRDC), the Australian Government (then DAFF) and the Australian Centre for International Agricultural Research (ACIAR) made a major contribution to research and coordination to identify and evaluate opportunities for inland saline aquaculture in Australia (and overseas) in the early 2000s. Research has been translated into significant industry development in some areas (e.g. India) but commercial progress in Australia has been slow.

However, there is renewed interest in inland saline opportunities as significant overseas developments come online and new investment has been proposed. Unfortunately, much of collective research is difficult to access for farmers and investors interested in new opportunities. New development will stand a better chance if fully informed of past progress that has addressed technical challenges with utilisation of inland saline groundwater for aquaculture.

Objectives

1. To collate existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture over the last twenty years.
2. To examine commercial developments and impacts from previous research.
3. To identify new opportunities.
4. To recommend ways these opportunities might be further explored and captured.

Methods

This was a desktop projects. The approach to deliver on each objective is summarised below:

Objective 1. Collate existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture over the last twenty years.

The project team attempted to obtain all available relevant documents and references, including unpublished material. This involved literature searches, contacting researchers who have been involved in this research over the past twenty years, and searching the databases of R&D Corporations (FRDC, ACIAR etc).

Objective 2. Examine commercial developments and impacts from previous research.

The project team sought information on recent developments and opportunities by utilising existing networks, literature searches and social media advertising, including contacting key experts overseas.

Objective 3. Identify new opportunities.

The project team contacted potential investors to ensure they are aware of previous research; what worked and what didn't and discussed current barriers to development.

Objective 4. Recommend ways these opportunities might be further explored and captured.

A special inland aquaculture session was organised and held in association with the World Aquaculture Society Conference in Darwin, May/June 2023. Recommendations to identify barriers to commercial development in Australia were drafted and seminars/meetings with potential investors were held to try to ensure these are commercially focused.

Results

Objective 1. To collate existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture over the last twenty years.

The bibliography in Excel is searchable using all fields (columns) and is reproduced in Appendix 1 in Word format, sorted by Country/region (Australia first) and then alphabetically. The count of publications from each Country/region are listed in Table 1 below. Of the 587 unique publications, 116 were from Australia, the vast majority of which arose from research from NSW DPI Fisheries, other state governments, the Fisheries Research and Development Corporation (FRDC), the Australian Government (then DAFF), the Australian Centre for International Agricultural Research (ACIAR) or Universities linked to projects supported by those agencies. There were 157 publications from India, a large number of which arose from collaborative ACIAR projects in India with a NSW DPI project leader.

Of the 587 unique publications, there is a weblink for 571. The other 16 are conference abstracts (5), reports (5), proceedings of workshops (5) and an invitation to submit an EOI (1).

Almost all publications deal with the technical issues and solutions for farming in inland saline areas. They concentrate on the growth and performance of selected species.

The international sharing of technology has been greatly facilitated by the World Aquaculture Society conferences, supported by many agencies, including FRDC, ACIAR, NSW DPI and other governments.

It is overwhelmingly obvious from the literature (i.e. past research) that it is technically possible to farm a number of aquatic species in inland saline water, although the adjustment of water chemistry is sometimes required, for example by adding potassium in saline waters in the Murray Darling Basin in NSW.

Table1. Count of Inland Saline Aquaculture Publications by country/region.

Country/*region*	**Count**	**Country/region**	**Count**
Australia	116	Lebanon	2
Algeria, Egypt, Oman	1	Malaysia	2
Persian Gulf	1	Vietnam	1
Bangladesh	2	Mexico	19
Brazil	13	*Near east region*	1
Caribbean	1	Netherlands	6
Chile	1	Norway	1
China	40	Oman	1
Crimea	1	Pakistan	8
Egypt	15	Philippines	2
Europe	1	Portugal	3
Europe and central Asia	1	Saudi Arabia	1
France	1	Taiwan	7
Germany	1	Tanzania	1
Greece	1	Thailand	2
India	157	Turkey	2
Indonesia	6	Uganda	1
Global	36	UAE	1
Iran	15	USA	93
Iraq	2	USA, Canada	1
Israel	14	Uzbekistan	2
Japan	1	**Grand Total**	**587**
Kuwait	2		

Objective 2. To examine commercial developments and impacts from previous research.

There is extremely limited commercial production from inland saline aquaculture in Australia.

In Western Australia, a small-scale commercial operation produced approximately 20 t per annum of Barramundi (*Lates calcarifer*) and Queensland grouper (*Epinephelus lanceolatus*) but the farm has since ceased production.

In Victoria, commercial production of Barramundi (*Lates calcarifer*) (up to 750 t per annum in recirculating aquaculture system (RAS)) is operated by one of the largest mainstream barramundi operations in Australia.

In Queensland, a fish farm located southwest of Chinchilla, on the western edge of the Darling Downs, grows Murray cod *(Maccullochella peelii).* As part of their operation, saline groundwater (3-5 g L^{-1}) is used at two parts of the production cycle. Firstly, fingerlings at approximately 1 g are held in saline water to reduce pathogen load and secondly, market-size fish are held in saline groundwater for purging and to improve flesh texture. The saline groundwater is an integral part of the successful operation of the farm (Pers. Com, Mark Oliver, Manager, 2023).

In Queensland, a commercial farm, Marine Garden (https://marinegarden.com.au/), aims to produce Black Tiger Prawns (*Penaeus monodon*) using salt water trucked from the coast.

Despite considerable interest over the years, no commercial inland saline aquaculture farms are operating in South Australia or NSW.

In contrast, commercial aquaculture development using inland saline water is well established in other countries. In India, for example, many species have been cultured and several are in commercial production. The main species cultured is the white leg shrimp (*Litopenaeus vannamei)* and the inland culture environment, with saline groundwater, has been found to be preferred to coastal areas because of more stable environmental conditions and fewer cyclones. Other species farmed are: Black Tiger Prawns (*Penaeus monodon*), Giant Freshwater Prawn (*Macrobrachium rosenbergii*), Milkfish (*Chanos chanos*), Tilapia (*Oreochromis niloticus)*, and Striped Catfish (*Pangasianodon hypophthalmus*). Barramundi (*Lates calcarifer*), European Sea Bream (*Sparus aurata*), Cobia (*Rachycentron canadum*), Silver Pompano/Snubnose Dart (*Trachinotus blochii*) and Amur carp (*Cyprinus carpio haematopterus*) have all been cultured in small quantities (see Varghese, 2023, Inland Saline Aquaculture session, World Aquaculture 2023, section below).

Another country with substantial inland saline aquaculture production is Israel. Tilapia (*Oreochromis niloticus)*, Carp (*Cyprinus carpio*), Sea Mullet (*Mugil cephalus*), and to a lesser extent European Sea Bass (*Dicentrarchus labrax*), European Sea Bream (*Sparus aurata*), Red Drum (*Sciaenops ocellatus*) have been successfully cultured and more recently, Barramundi (*Lates calcarifer*) is widely cultured. The largest RAS in Israel is capable of producing 1,000 t per annum (Fitzsimmons, 2023, Inland Saline Aquaculture session, World Aquaculture 2023, see section below).

Commercial culture is also progressing in the Middle east and the USA. A large Australian Barramundi farming company has purchased facilities in Arizona (https://www.mainstreamaquaculture.com/home/) to Barramundi (*Lates calcarifer*) in saline ground water in a farm that used to commercially farm White Leg Shrimp (*Litopenaeus vannamei)*.

2. *Objective 3. To identify new opportunities*

There are still opportunities for aquaculture using inland saline water. To realise those opportunities, proponents will need information on the resources needed (water, land, infrastructure, potential staff, markets, etc). Opportunities include the use of saline groundwater for the complete production cycle as well as parts of the cycle, for example hatchery, nursery, purging, etc. The use of inland saline groundwater for culturing marine or estuarine species in a relatively pathogen-free environment remains a clear opportunity.

One existing opportunity for investors is the inland saline aquaculture project, the Waikerie Project:

The following information was provided by John Carragher, Logifish Consulting:

- In South Australia, in the Riverland near Waikerie, a commercial development, the Waikerie Project (https://a-culture.com.au/the-waikerie-project/) is seeking investors to culture Yellowtail Kingfish (*Seriola lalandi*) using saline water from an underground saline aquifer.

- The project proponents are fully aware of the previous research that has been done by the South Australian Research and Development Institute (SARDI) (Hutchinson, W., & Flowers, T. [2008], Appendix 1). Without the positive results on performance of fish in the saline groundwater near Waikerie, the proposal would not have been possible.

- One of the other key benefits from previous research was the provision of key data, including for water chemistry, needed when applying for operating permits.

- The saline water is currently considered an environmental problem. This operation will not release any to the environment.

- This project involves a multi species, indoor tank system using commercially-in-confidence technology.

- The aim is to develop the farm in 250 t per annum production modules. Following the first module, subsequent modules will be brought on-line when market demands indicates prices are not likely to decline with the increase in production.

Objective 4. To recommend ways these opportunities might be further explored and captured.

A special session on Inland Saline Aquaculture was held at the World Aquaculture Society. Key experts were invited from India and the USA as well as from all the states in Australia, except Queensland, where the opportunities for commercial development were identified and the majority of inland saline research was conducted. These include New South Wales, Victoria, South Australia and Western Australia.

The session included presentations, where experts were asked to discuss status, opportunities and challenges, and a panel discussion, where directed questions were discussed as well as a Q&A with the audience (see Figures 1, 2 & 3 and Table 3). A copy of the powerpoint presentations (six slides per page) for all the presentations in the session is provided in Appendix 2.

Figure 1. Inland Saline Aquaculture Session, World Aquaculture 2023.

Figure 2. Presenters: Inland Saline Aquaculture Session

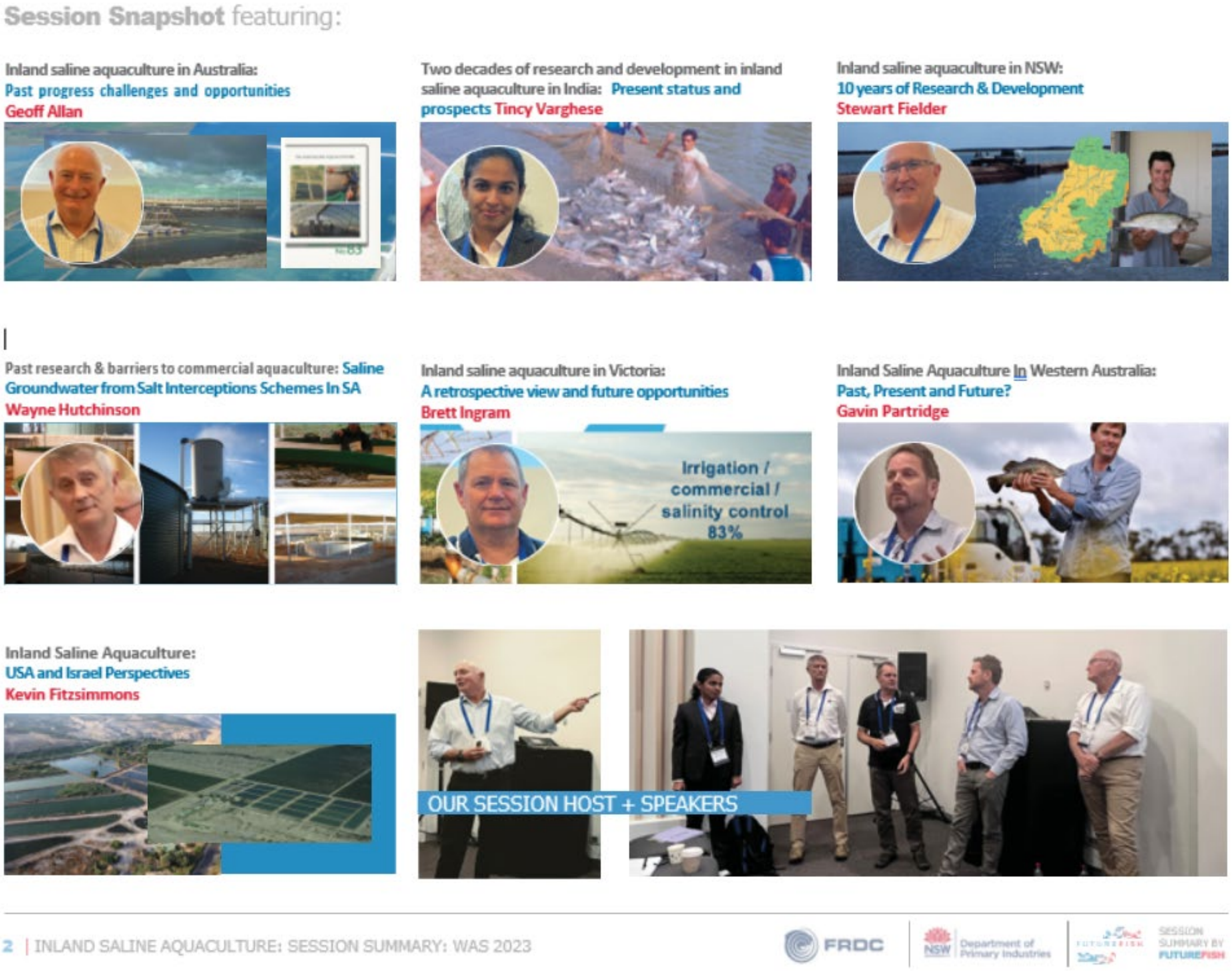


Table 3. Agenda: Inland Saline Aquaculture session plan.

Inland Saline Aquaculture Session, World Aquaculture Society, Darwin May/June 2023			
INLAND SALINE AQUACULTURE IN AUSTRALIA: PAST PROGRESS CHALLENGES AND OPPORTUUNITIES	Geoff	Allan	NSW DPI
TWO DECADES OF RESEARCH AND DEVELOPMENT IN INLAND SALINE AQUACULTURE IN INDIA: PRESENT STATUS AND PROSPECTS	Tincy	Varghese	CIFI, India
INLAND SALINE AQUACULTURE IN NSW: 10 YEARS OF RESEARCH & DEVELOPMENT	Stewart	Fielder	NSW DPI
PAST RESEARCH AND BARRIERS TO COMMERCIAL AQUACULTURE UTILISING SALINE GROUNDWATER FROM SALT INTERCEPTIONS SCHEMES IN SOUTH AUSTRALIA	Wayne	Hutchinson	FRDC (ex SARDI, SA)
INLAND SALINE AQUACULTURE IN VICTORIA – A RETROSPECTIVE VIEW AND FUTURE OPPORTUNITIES	Brett	Ingram	VFA, Victoria
INLAND SALINE AQUACUTLURE IN WESTERN AUSTRALIA; PAST, PRESENT AND FUTURE?	Gavin	Partridge	Harvest Road (ex Challenges TAFE, WA)
INLAND SALINE AQUACULTURE - USA AND ISRAEL PERSPECTIVES	Kevin	Fitzsimmons	University Arizona USA)
INLAND SALINE AQUACULTURE IN AUSTRALIA: PANEL DISCUSSION	Geoff	Allan	NSW DPI

Panel discussion and Q&A

The figure below (Figure 3), summarises the panel discussion and the Q&A.

Figure 3. Panel discussion and Q&A

INLAND SALINE AQUACULTURE (ISA) IN AUSTRALIA: PANEL DISCUSSION

- What characterises successful ISA?
- Are there some fundamentals that are important for commercial potential?
- What did previous R&D miss?
- What has prevented ISA ventures from thriving?
- How much water is enough?
- How big do commercial ventures need to be or become?
- Is there still potential for ISA in Australia?
- If so, where and for what species?
- What can be done to limit future failure of ISA?

The panel discussion revolved around the topic of Inland Saline Aquaculture, specifically focusing on the challenges, opportunities, and strategies for commercialising this type of aquaculture.

The discussion covered various aspects, including how many species could be successfully grown in inland saline water, often with relatively inexpensive adjustment to the water chemistry. The development of inland saline industries in India, the USA and other countries demonstrates the potential. The challenges with commercial development of inland saline aquaculture in Australia were discussed. The panelists highlighted the need for long-term water security, selection of higher-value species, a unified national strategy and long-term support from Government, effective knowledge dissemination programs, and the need to attract both small and large-scale investors. The importance of new technological advancements, for example for recirculating aquaculture systems (RAS), waste management, and the potential for overseas niche markets were also discussed.

3 | INLAND SALINE AQUACULTURE: SESSION SUMMARY: WAS 2023

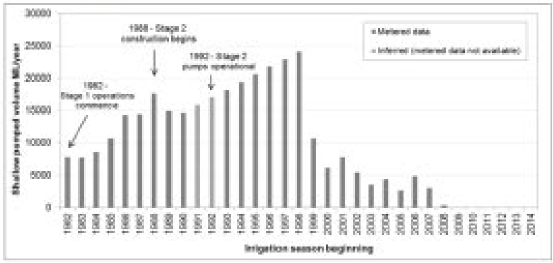
FRDC
NSW Department of Primary Industries
FUTUREFISH
SESSION SUMMARY BY FUTUREFISH

Panel Discussions Questions + Answers 1

QUESTION: In regards to the Murray Darling groundwater evaporation system (with 56 groundwater bores) wells), why was ongoing water availability a limitation? Secondly, was there any problem with water quality, particularly variation in the salinity, nutrient load or microbiota in the water?

ANSWERS

+ For the Wakool Sub Surface Drainage Scheme (WSSDS), the largest such scheme on the Murray Darling Basin, and in Australia, there was 13,000 ML pumped from the groundwater table to prevent rising saline groundwater from reaching the surface. All this water was disposed of using the constructed 1600 ha evaporation ponds.
+ Over time the groundwater was depleted. This was not anticipated by the scheme architects or us. But this was the single major reason why commercial development of aquaculture using the WSSDS did not proceed. The graph below illustrates the decline:



+ With regard to water quality from the WSSDS, the salinity overall was stable from each bore. It did vary from bore to bore, but not by a huge amount. Overall it was about 15 to 18 ppt so it was high salinity. The water temperature was very consistent (around 18 C). Nutrient concentrations were very low. The ponds were huge (about 30 ha each), with very little micro algae production - they were low productivity ponds.
+ In other areas of the Murray Darling Basin, we targeted particular aquifers for the quality of the water in that aquifer. It depends where, how deep and which aquifer you're using.
+ One common feature of all the water from the Murray Darling Basin is that it is relatively sterile. We considered using this water for bio secure hatcheries. For example, SPF (Specific Pathogen Free) Hatcheries. This still has potential.

QUESTION: In regards to the Waikerie (SA) commercial agreement that didn't go through, you said one factor was the fact that water security could only be guaranteed for three years. Can you talk about why they decided that was the maximum? What risks they were trying to manage?

ANSWERS

+ Potential investors get the water for free when the scheme is operating, but because the operators run the scheme to manage rising salinity in the landscape, when that need changes, for example during a flood or prolonged drought, guaranteeing water availability is difficult. This is why the operators at Waikerie were only prepared to guarantee three years of water supply. They couldn't be sure the scheme would be operating beyond that time and there was no mechanism for the potential investor to either run the scheme themselves, just to obtain their water, nor to pay the scheme operators to run the scheme when it was not needed for saline groundwater management.

QUESTION: Why doesn't Australia as a whole have a strategy? Why do we have separate state strategies?

Comment: India is a good example of commitment. There the government stayed in in inland saline R&D for the long haul while in Australia we walked away after 10-15 years.

+If an investor saw that the government (Commonwealth and State) agreed to a strategy, irrespective of where it was, investors would be more willing to take a risk if they thought the government was there, not just for the 3 years but for the 20 years of support, infrastructure, R&D.

Panel Discussions Questions + Answers 2

QUESTION: Tincy, you're saying that in India, despite the fact you had good commercial production of shrimp from coastal areas, risks from weather events like cyclones, made inland areas more attractive. Is that an attraction for Inland Saline Aquaculture farmers in India?

ANSWERS

+ There are also other issues for farmers - the effluent treatment system, training systems and awareness of land access and what land (owned by government) and availability is also an issue with coastal aquaculture. On the other hand, farmers in inland areas face challenges coastal farmers don't. In general the farmers are less educated than other farmers globally. We give our farmers simple leaflets and we have our own demonstration farms so we can expose farmers to the best farming practices.
+ We help farmers at the start with subsidies and many farmers are still continuing farming even after the subsidy stops.

Integrated discussion points – lessons from success in India

+ In India there is a huge population. There's a big market for the product. A lot of potentially on each farm, to drive livelihoods and employ people - women and youth.
+ Australia are known to sell high value species -like Barramundi. In India the people eat low value species and the high value species we export.
+ There are two different ends of the spectrum when it comes to India and Australia. Biology wise there is possibility of exchange of information, but how things work in India and how they work here in Australia is very different. For example, every research organisation in India has a huge extension wing for each government body. Your job in India is dependent on how many farmers who have adopted your technology and the production from those farmers. Promotions and the future of researchers is dependent on those metrics.

Panel Discussions Questions + Answers 3

Integrated discussion points: Barriers to inland saline aquaculture in Australia

+ **Water security:** The Operators at Waikerie Interception Scheme could not guarantee that they were going to run the interception schemes indefinitely. They committed to three years but the potential investors wanted more like three decades. Similarly, in the Murray Darling Basin, at the Wakool Sub Surface Drainage Scheme (WSSDS), the water flow dried up following prolonged drought. Without water security, the investors also dried up.
+ Water security was the number one barrier for commercial development of inland saline aquaculture at Waikerie(SA) and Wakool (NSW), two of the sites with the highest potential for aquaculture. The scheme operators could not commit to long term water security and the aquaculture investors can't commit to develop an enterprise without long-term water security.
+ The use of the scheme for aquaculture helps justify the interception scheme, which is a positive, the availability of "free" water for aquaculture is a positive, but the conflicting drivers for the interception schemes and for aquaculture can sometimes be a barrier.
+ Potential investors have to negotiate water security.
+ The inland saline aquaculture research in Australia demonstrated you could solve water quality deficiencies, e.g. potassium, easily and relatively cheaply. However, it does add another complexity to the water security challenge.

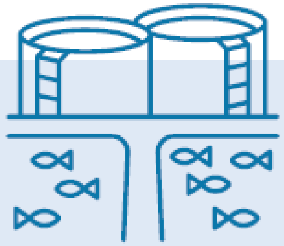
+ **Environmental management:** A problem at some sites, for example Waikerie, was effluent disposal. When the scheme operates as planned, salty ground water is disposed of via a natural basin that acted as an evaporation basin. During the R&D phase, effluent from the aquaculture trials was also disposed of in the evaporation basin. Initially, the basin was just considered as waste, salt-affected land. Over time, with saline water inflow, the basin became an attractive habitat for wildlife, including birds. The potential for aquaculture effluent to harm this new ecosystem and the need for potential investors to consider environmental expectations as part of their planning became an additional barrier.

+ **Asset management:** Investors using assets owned by others (e.g. saltwater interception schemes, including water supply and disposal) also need a commitment that those assets will be available and maintained, and at a known cost to the investor, for the long term.

+ **Government commitment and support:** is also needed, particularly at a policy level.

+ **The potential "scalability"** using inland saline water is also needed. Is there enough water and land for the planned venture. Can investors expand if they are successful?

+ **Access to markets,** labour, energy, transport, etc. In remote areas affected by saline groundwater, the location can make access difficult. This is a consideration for development at scale.



Integrated discussion points: Inland Aquaculture

+ Consider. If we focus just on developing Inland Aquaculture - it does change the whole dynamic for Australia because then we've got lots of land. The term ARID Aquaculture has been used to describe "Aquaculture activities practised in desert and arid lands characterized by low precipitation (<250 mm/year), high solar radiation, high rate of evaporation, using subsurface and surface water".
+ What are new technology changes that have happened in the last 20 years (feeds and electricity systems)? Does this alter the potential for arid aquaculture?
+ Recirculating Aquaculture Systems (RAS) are one technology that could change the potential for arid aquaculture. Less water is needed per kg fish produced, and effluent disposal is less of a problem as it is more concentrated and could be buried, etc. Effluent from using freshwater makes good soil conditioner.
+ There are many water bodies in WA that stink with sulfide - there is a lot of carbon, and gases - is there some kind of commercial and profitable option that can be used to reduce those gases? Could this add another dimension to the Inland Saline Aquaculture story.
+ Should we focus on having a Carbon Neutral approach?

Panel Discussions Questions + Answers 4

QUESTION: We know about some new investors are interested in inland saline Aquaculture. What information would help them? Do they need biology research or are they looking at other constraints to possibly attract finance?

ANSWERS

+ I think this year we've got a lot of people looking to regional communities to create new lifestyles. It's very expensive to live in Australian cities, and then they're looking at alternatives.
+ We're seeing an upsurge in interest in the aquarium industry and by products and other things.
+ We get a little bit stuck on just seafood for seafood sake. You don't you need the same water volume,land, and other resources to produce corals for example in inland saline areas. You don't need a lot of space and you can run a very good aquarium system.
+ We do things like rainbow fish, for the aquarium industry, which are incredibly valuable. You can run them in quite good systems.
+ People are out there with very novel solutions, and they're looking for unique niche markets.
+ Aquaculture Australia works well when you've got a very small niche of a high value product with a very good market and no one else producing.
+ Or you have a incredibly good, innovative system that just drives labour costs out of the business. So just get all the labour out and innovate, to get the best production system with no labour.
+ They seem to be approaches that have worked. Less labour and niche markets

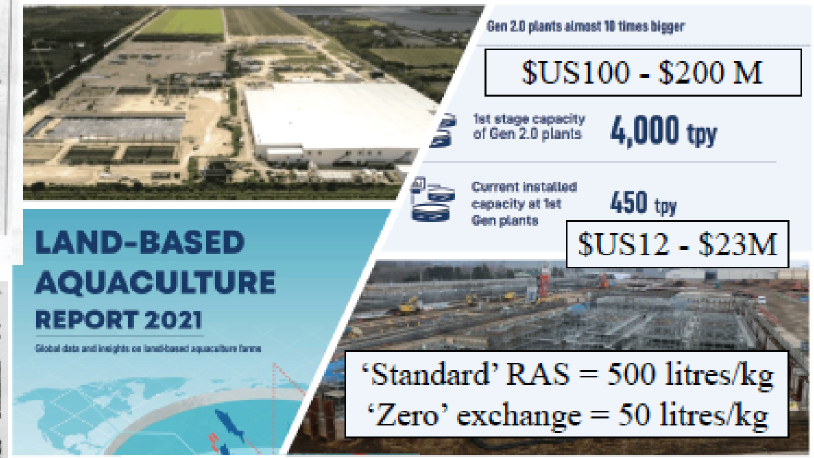
QUESTION: I heard a recent talk in a session here of a company looking for equity investors, and it strikes me that the characteristics of these systems are not the sort of characteristics that an equity investor will be looking for, in terms of things like global market scalability. To me it means you're relying on bank finance, and that for that banks have to understand the characteristics of these systems to make them bankable - have you looked at that?

ANSWERS

+ We did have some work on investment + activities analysis- but it may not be fit for purpose in today's market. We look at a framework investment from a banking position that clearly wasn't adequate.
+ Clearly, it's a bankable thing its not an Investor thing at the moment, so how do you turn it to the other? Banks don't like really investing for long term. Equity investors would.
+ That is the reason why Prawn farms work. If the prawn farm fails, it's may still be very valuable for agriculture or even urban development (e.g. canal estates). It can be used for sugar cane or range of other things. It's hard to sell the land used for inland saline aquaculture so once you've spent a lot of money developing the farm, there is not much potential for selling the land if the venture fails.


Salt water ends trout drought


Fish trials step closer to commercial venture



Panel Discussions Questions + Answers 5

QUESTION: Are obtaining permits stopping inland saline aquaculture development in Australia?

COMMENT

When you look globally, countries like Ecuador, Mexico, Brazil and other countries where aquaculture really thrives, their aquaculture businesses are supported. I believe it's a country agenda. It's a coordinated effort between different institutions, organisations to truly put together an aquaculture agenda and to create jobs with great opportunities. Most of the time, it seems to me that excessive permits and regulations stop aquaculture development in many countries.

ANSWERS

+ No, it's been a problem with aquaculture generally. I would say the Inland Saline Aquaculture is less of a problem than coastal aquaculture, and some fresh water inland. Certainly a whole lot less of the stakeholders around whereas on the coast you're fighting a lot of negativity and population - for us policy isn't the main issue.

QUESTION: Do we actually have the development of inland aquaculture right, to support long term investors? We do it by states. From an investor's view - Brazil, Israel, India, they do it at the country level. Do we have that right ?

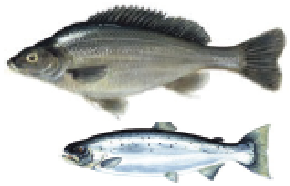
ANSWERS

+ We had the 2000 Aquaculture strategy – with some aspirational goals, but that wasn't supported by long term investment. We end up being conflicted by our inventory responsibilities and in our development and economic promotion. Often the same departments to do both and this causes a diversion of effort.
+ Projects in SA in particular work on a 3-4 year infrastructure cycle. They are set up to get some initial results, identify the problems, but then run out of money before investment is secured and before new businesses can stand on their own feet. We need to invest in project funding vehicles more like the Cooperative Research Centres approach (10 year) to allow you to tackle problems you actually don't foresee. One the short term funding model, there is a lot of infrastructure - built up and then lost.

QUESTION: The fish that you were using – were all first / second generation fish throughout all the trials - has the broodstock been kept and has there been any improvement in genetics since then and why – can it support profitable ventures for 2023?

ANSWERS

+ The fish and prawns used in all the studies were at least first generation and hatchery reared juveniles produced in our respective government hatcheries or purchased from commercial trout hatcheries. The stock certainly went through a range of bottlenecks including high temperature. This research was done almost 20 years ago, and any broodfish associated with juvenile production have long gone. We also didn't maintain progeny from the fish or crustaceans that were grown in the ISA systems.
+ Rainbow Trout now are relatively temperature tolerant given the industry has been developing in Australia for many years and selection of temperature tolerant stock has been done; - but mortality is usually experienced once water temperature reaches 22C.
+ Kingfish - would be better performing now after many years of hatchery rearing improvement and we would be in a much better place in terms of supply and genetic traits.
+ In general, we are now in a better position: better fish, better facilities, better feeds – we just need to look at the economic margin now.
+ Wayne: In Waikerie we didn't explore other opportunities like micro algae or other marine bio products.



Panel Discussions Questions + Answers 6

QUESTIONS: Can you outline the production systems that were evaluated to use saline groundwater for aquaculture and what were some of the key technical outcomes from that research.

ANSWERS

Various methods to use saline groundwater were tested. In NSW, Victoria, South Australia and Western Australia, we evaluated the saline groundwater that was collected in evaporation systems used to dispose of the salty water table from surrounding irrigated agricultural enterprises. In Queensland, saltwater extracted from coal-seam gas extraction was evaluated. A range of experiments was done, starting with small-scale bioassays in tanks followed by long-term growout trials in ponds and Recirculating Aquaculture Systems. One common result for saline groundwater sourced away from the coast, was that compared with equivalent salinity seawater, the saline groundwater was highly deficient in potassium. For some freshwater species including silver perch, barramundi, rainbow trout and artemia, that were tolerant of saline water, the low potassium concentration did not result in any reduced growth performance; however, for other estuarine species including mulloway and prawns, it was necessary to add potassium into the groundwater. This was done easily using agricultural potash. Saline groundwater sourced from coastal aquifers such as at the Coorong in SA, was not deficient in potassium and the water chemistry resembled seawater. Some of the biggest issues we identified at the inland locations, were related to the environment, especially the annual and daily temperature ranges which were much more variable (colder in winter and hotter in summer) than those experienced on the coast. This limited the potential growth period for tropical species. After scoping studies were completed, species with the most potential for production in inland saline groundwater were selected and included rainbow trout (NSW), mulloway (SA), barramundi (WA), Penaeid prawns (Qld) and Artemia (Victoria). Growout trials were completed and product was sold to local outlets in each state to provide market acceptance information. The ISA farmed produce had very high market acceptance.

QUESTION: What happened to the McRobert Aquaculture System? (If you recall you trialled it for mud crabs as well as it had that ability with some novel concepts).

ANSWERS

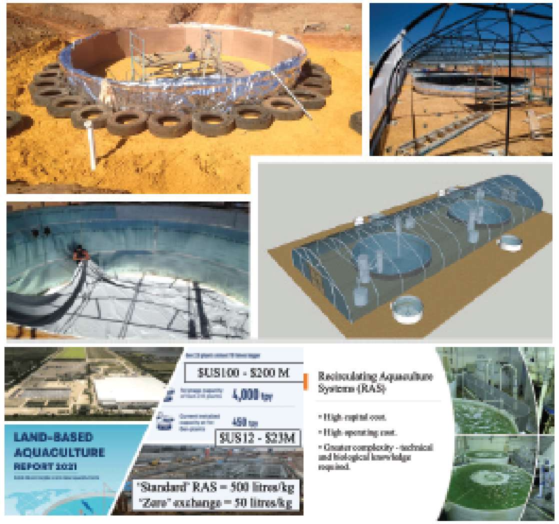
+ The McRoberts System was a very good system for aquaculture and was unique in the way it operated. In Western Australia (WA), the Semi-Intensive Floating Tank System (SIFTS) designed by Ian McRobert was compared with floating raceways and simple floating cages in ponds filled with saline groundwater. Barramundi were successfully produced from juvenile to market-size. SIFTS was also trialled in Victoria for Murray Cod production in freshwater farm dams. We evaluated the performance of SIFTS in various harbour environments in WA - but the system engineering was not robust enough to withstand the wave action of commercial shipping activity in the otherwise protected harbour environment. Ian McRoberts has since moved on from building aquaculture systems and now uses water to make whisky, rather than fish.

QUESTION: Given that SIFTS only used mechanical filtration of recirculating water, was there any investigation into the potential to include biofiltration of wastewater before it was released into the environment.

ANSWERS

+ Yes, we did explore the use of biofilters with water that was discharged directly from the SIFTS. We found that there was very little dissolved ammonia in the SIFTS wastewater because it was completely extracted by microalgae that was growing in the pond water that was recirculated through the SIFTS. As a consequence, we couldn't see any value by including biofiltration to remove ammonia from culture water.
+ We also investigated heterotrophic pond management. The year that we did the study we had a weird microalgae bloom that migrated up and down through the water column. This resulted in the algae bloom blanketing the sludge at the bottom of the pond and subsequently hydrogen sulphide was released into the pond water which killed fish - we had plenty of challenges.

Panel Discussions Questions + Answers 7



QUESTION: You said the cost to run a RAS system is very high at the moment and that you can't use the product to lower cost at the moment as it does not work-is that true in the current market? Why do you use it year by year if you are at a loss?

ANSWERS

+ RAS have to scale to be profitable.
+ That's why they've jumped from 400tpy and the average successful RAS is now 4000tpy. It's all about scale to be profitable. The fish produced in RAS is generally a commodity product. Its low value compared to niche markets, so high volume production is necessary. I think it's quite easy to make a business case that's shows profit on paper -but needs proving of every single aspect of the costs to be confident.

Q: Does the RAS System work for Silver Perch?

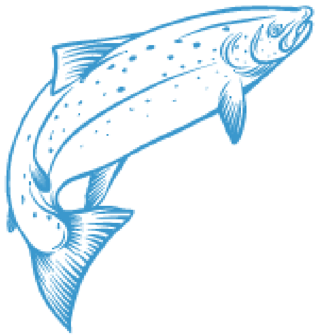
ANSWERS

+ The main production method used to culture silver perch is in ponds and not in RAS Systems.

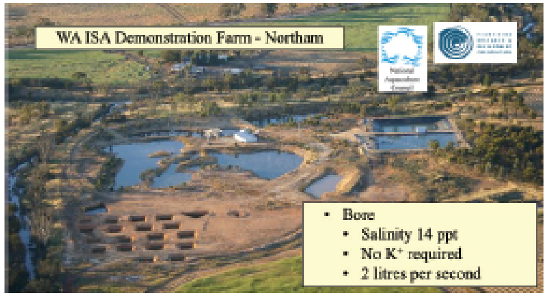
QUESTION: In salmon farming we use RAS to grow the smolt - one of the problems experienced is the seasonal temperature issue. So, what about the merging of the two technologies where RAS is used during the during the coldest months followed by ongrowing in ponds when the outside environmental conditions are suitable. Is anybody been thinking about that type of concept using the ponds? Trout grown in saline groundwater actually look quite good.

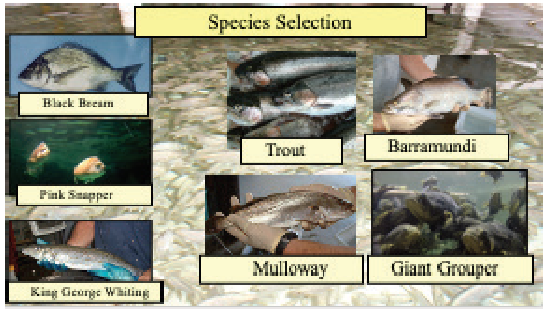
ANSWERS

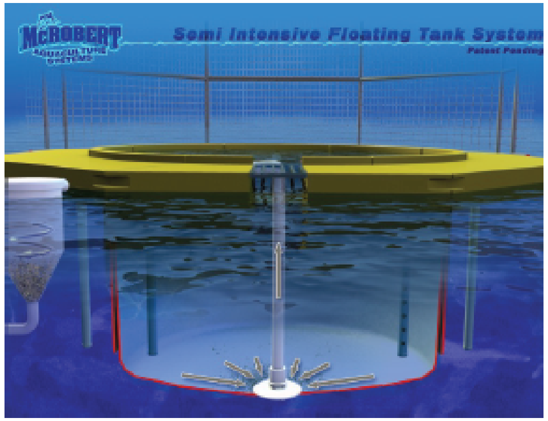
+ I think we've thought about that for sure.
+ The issue in NSW, WA and SA wasn't so much the warming temperatures, but the reliability of saline groundwater supply.
+ The volumes of saline groundwater available to us at the ISARC at Wakool weren't sufficient to generate a commercial return when the real effects of long-term drought were felt. The lack of irrigation of agricultural crops resulted in the saline groundwater table staying well below the root zone and there was no need to pump the saline groundwater to the surface to the evaporation basins. So, our saline water resource literally dried up. Future ISA projects associated with saline groundwater evaporation basins will be aware of this potential problem and will need to develop strategies to deal with drought conditions.
+ In the end, successful ISA projects will need a guaranteed supply of saline groundwater for more than a couple of years. Wayne, talked about what happened in SA at Waikerie - they asked the investors who were ready to sign on the line for commercial farming what guarantee of water supply could be given by the managers of the saline water disposal system. They were guaranteed 3 years supply of water. Investors Response: We need 30 years - not 3 years. The tenure on the water and the licensing was just too short term. The fact they couldn't guarantee water supply, proved it as too high risk for investment- so they moved away.
+ 20,30 -50 year tenure for water needs to be considered - like the same you get on land.
+ This is pretty much the single most important issue we have going forward for development. That, and the scalability issues - we need get it to a scale that makes it commercially viable.
+ Finding a suitable production model was difficult and especially trying to develop a product that only works for a short period of the year is hard to commercialise.



Panel Discussions Questions + Answers 8







QUESTION: Lots of technologies and research are being done, but what is being done to transfer that knowledge? Are there any programs where they can actually come and look at what's being done? Are there experienced workshops or training available so people can come and see and experience, then take decisions to start a venture?

ANSWERS

+ Yes, one of the main outputs of our research program was to develop demonstration facilities in all States using the different ISA technologies. We had demonstration facilities to show the operations to potential investors who would come and see them. They were operating for a 4-5 year period but they weren't maintained once the project was finished.
+ We have harvested most of the commercial interest and for one reason or another, most of that was fallen by the way-side.
+ The reason to hold and maintain those demonstration facilities wained.
+ We also had open days and people from the community were aware of what was going on.

QUESTION: What could government do to drive a resurgence? The constraints now aren't necessarily biological constraints, there are other issues. Is there a way that we can turn our attention to try and make more productive investments work - what do they need to do? Do they need to know about species or better understand niche markets?

ANSWERS

+ I'd comment at the moment, that First Nations people in building self sufficiency, around economic opportunities and we look for things like the new hatchery in Victoria, where we're actually building First Nations opportunities to self sufficiency.
+ First Nations look at the landscape very differently. They build a different economic model - a more long term sustainable model.
+ There's a lot of opportunity around First Nations people, and they have significant amount of native title on inland, waters and water systems. I think that's changed since when we did this.
+ We have to address climate change. There is a lot of rural Australia that won't be able to produce crops that are going to produce for the future - we need a whole of government approach to that.
+ And lastly, notwithstanding the fact that we've got such a large coastline (third world's largest coastline in the world) - it's either incredibly rough, or it's right opposite Sydney.
+ Our real asset is INLAND.
+ So how do you use inland? - I don't think we've solved that problem
+ The government needs a 10 15 yr strategy, you can do 3 to solve resources issues. So that requires collective government action, (the role of government to remove risk for investors).
+ Have inception schemes that are guaranteed to run for decades.

Panel Discussions Questions + Answers 9

QUESTION: With all the great database knowledge created - (500+ publications), how can we best package or make the information available to people, First Nations people or Commercial Investors? Are there any ideas of how that would be best received or best used?

ANSWERS

+ Initially, open access publications and social media.
+ Show and visit successful cases and call for more promotion.
+ Refresh: Go to countries, location farms that are operating with long term profitability and learn from them and their integrated systems and Government structures.
+ Look at First Nations people, their specific communities, ambassadors and leaders. They are the ones that create the climate which creates the stories from the culture.
+ It's important to extract information, connect with key people of influence.
+ Look at the life expectancy of that information. Look at key principles and fundamentals and keep refreshing that information - keep it top of mind - front page news and update.
+ Packages for the audiences: One for the investor, one for the farmer, one for the Aboriginal nations with several layers. Hook someone in from that first level - ask questions. Don't produce things that look so overwhelming. Give choice - have some layers so if you want to dig deep you can.
+ In the past we have had a big push. We've learned stuff. We're trying to push it to investors push it to the market, where we need the pull.
+ The database of 500 should not be in the thing that is good for scientists. New things like Chat GTP, all the new technologies and outcomes of this project, is to build a better way of taking science knowledge. Put spacial layers, financial institution + geographic layers to make it easier. Then put new AI tools to extract from 100 papers, something that synthesizes the info.
+ There are tools we haven't explored. There's clearly is a lot of information there, its the great unknown - unknown and we don't know how someone else might use it and can't find it.
+ Look at the sustainability metrics and R+D to understand the social impacts.

QUESTION: We've got a lot of successful industries in Australia and it seems like Inland Saline ticks the boxes for so much. Do we have any comparison strategies that show why some cases are successful? And for those that are not successful-why not? Can we see any gaps of what makes a successful industry? Are there success pathways to help you perform? It seems to range from very small hobby farms to large commercial production facilities which have all been successfully run. Have comparisons that people can use been made?

ANSWERS

+ We appreciate the insights, but successful commercial ventures are focused on making money. While we can demonstrate and ignite potential, it may be challenging to attract investors to take a risk. However, circumstances can change, and now might be a good opportunity to revisit our approach. I believe that would be a useful exercise.
+ I enjoyed a talk I heard yesterday that discussed the values within the farming system and the human dimensions that contributed to its success.
+ What's really important is that when we started, we tried to consider as much as our biological minds would allow. However, perhaps we involved the wrong people to thoroughly explore the commercial aspects.
+ Wayne: Our project took place during the 2008 Global Financial Crisis, which was not favorable for investors. However, now is a good time to reassess it in light of current opportunities and advancements in technology.

QUESTION: I find there is an isolation of information when it comes to getting your high quality product to market, the barriers of such a large coastline and limited population. We've seen climate change, extreme weather events where whole states have been cut off from that supply chain. Do we need to look at how are we going to value add or find different ways of preserving product? How do we market our products overseas and if you have Inland Aqua farming, how do we get there?

ANSWERS

+ There are issues with remoteness. For instance, Delivering products - it can take one full day of the week to drive a truckload of fish to a fish market.
+ We need to think about the distances we might be traveling on from coast to coast and change that perspective to similar distances inland. Perhaps its not that different?
+ Look at your products with a long shelf life?
+ We should consider carbon neutral as an export market. Australia's still exporting a lot of stuff that's carbon heavy and not very sophisticated. Have you made the industry more carbon neutral?
+ If you're going to do it in aquaculture strategy you wouldn't do it divorced from the other food strategies. If you're going to do a food strategy for Inland Australia, you would solve the logistics once at the same time. Look at things like carbon, getting rid of diesel engines, renewable energies, employment - making sure you've got a reliable workforce. You do the whole thing once - not just for Inland Aquaculture. - That may have been one of our problems last time - we tried to do it alone.
+ Integration is good - but we have to watch not to become too big - its hard to nail down what the intentions are.
+ Look at carbon credit metrics.

CALL TO ACTION AREAS

Inland Aquaculture

Our Australian Asset is INLAND and how we use our resources.

The term "Inland saline aquaculture" can be limiting and instead we recommend a focus on the term "Inland Aquaculture". This will broaden the appeal, increase the scope of appropriate technologies and assist scalability. This should help attract investment. It will help showcase aquaculture businesses that already operate efficiently, are able to scale faster, and create more value in society.

Water Supply and Security

- Ensure long-term availability and waterbody tenures with government support.
- Ensure interception schemes can be used to supply water for decades.
- Secure effluent disposal (e.g. evaporation basins) approvals for long-term environmental security

Government Support and Regulation:

- Advocate for a unified national strategy instead of fragmented state strategies.
- Collaborate with an integrated food strategy that addresses areas like carbon, renewable energy sources and employment benefits.
- Establish long-term government support for infrastructure, research, and development and investments.

Factors and Lessons:

Compare successful industries and identify key factors for success.

Reassess the industry based on current technology advancements and market trends.

$$-Show potential value of Inland Saline Aquaculture.

Species Selection

- Continue to focus on higher-value species such as Barramundi and Trout.
- Market development required for some more niche species
- Consider temperature-tolerant species for better performance.
- Potential for sterile bio-secure hatcheries to produce SPF (specific pathogen free) juveniles

Knowledge Transfer:

- Develop programs for potential investors to visit and experience aquaculture operations.
- Professionalise, Personalise and Categorise a new database, targeting groups like The Farmer | The Investor | First Nations People or Regional Community Groups.
- Maintain demonstration facilities for a longer duration to showcase the industry's potential.

Database note:

Add various layers to the database - financial, geographic, social, local networks, carbon credit metrics and comparisons.

Technological Advancements

- Explore new technologies and innovations, particularly for RAS systems, electricity systems, and waste disposal.
- Emphasize the advantages of circular economy and waste nutrient utilisation.
- Integrated cultivation techniques with conventional crops.

Attracting (Equity) Investors

- Highlight and promote the economic and scalable viability.
- Understanding the scale necessary to support commercial industries.
- Explore partnerships with investors interested in regional communities and alternative lifestyles (also define remote attributes, bankable systems + comparisons).
- Focus on investors with an integrated vision and values that also focuses on sustainability, economic, social and environmental impact

Call to Action Promotions

Promote the asset of Inland Aquaculture and how we can best access our resources and the economic drivers attached to this. Showcase the benefits of community building, remote living lifestyles and livelihoods.

Discussion and Conclusion

This project was initiated to ensure that potential new investors in inland saline aquaculture in Australia were aware of all the work done since the early 2000s and could easily access the information. The outputs of past work were compiled and are now available in a searchable bibliography. This will allow any commercial developments to consider impacts arising from previous research, identify new opportunities, and investigate ways these opportunities might be further explored and captured.

587 individual publications were found, 116 from Australia, that we collated in a searchable excel spreadsheet. These are easily accessible and 568 are available on the internet. Of the 16 publications not available on the internet, five are conference abstracts, five are reports (most of the information in these reports are published elsewhere and available on the internet), five are proceedings of workshops and one is an invitation to submit an expression of interest to the South Australian Government issued in 2001.

The research questions that were addressed in the 2000s can be summarised as follows:

1. Is there **demand** for aquaculture products from inland saline aquaculture?
2. Is there **sufficient saline ground water**?
3. Is the water **suitable for culture** of priority species? (Technical assessment.)
4. What **facilities** are needed for inland saline aquaculture? (Technical assessment.)
5. Can species be cultured **cost-effectively**? (Technical assessment.)
6. Will **people eat** fish grown using inland saline waters? (Market acceptance.)
7. Will people **invest**? (Commercialisation potential.)

Current users of inland saline aquaculture research were asked if they were aware of previous work and if so, was it useful? Although only a small sample, both the Manager of Condabilla Fish Farm (the farm uses saline groundwater for pathogen treatment of fingerlings and for purging fish prior to sale) and the consultant seeking investors for the Waikerie project in South Australia (an inland saline aquaculture commercial venture), reported that not only were they well aware of previous research on inland saline aquaculture in Australia, but that results from previous work were of critical importance to their operation of plans. In the case of the Waikerie project, the venture would not have been initiated without the research conducted by the South Australian Government (Hutchinson and Flowers, 2008; in bibliography).

The other commercial developments, in Western Australia and Victoria, not only had access to information from scientists involved in the research but arguably would have not proceeded without access to that information. Those operations ceased for reasons other than lack of research results (G. Partridge, June 2023, Pers. Comm.; B. Ingram, June 2023, Pers. Comm.).

However, it is apparent that despite the past investment in research, and the comprehensive outputs and outcomes, current commercial development is far smaller than expected when inland saline aquaculture research started in Australia. This project sought to understand why this is the case and examined if something was missing from the approach taken in the 2000s?

Demand

Globally, and in Australia, aquaculture was, and still is, growing rapidly in response to increasing demand for seafood and static or declining capture fisheries. Inland aquaculture (49 Mt in 2020) dominates global aquaculture production (122.5 Mt in 2020) (FAO, 2022).

In Australia, total aquaculture production of 132,000 t in 2020/21 was mainly marine species with the top five species salmon, tuna, edible oysters, pearl oysters and prawns, although inland aquaculture is also growing in Australia with species, including Barramundi, Murray cod, Rainbow Trout, Silver Perch, and Red Claw Crayfish, among those cultured (Tuynman and Dylewski, 2022). There is a long-term trend of increasing per capita consumption of seafood in Australia, equivalent to 13.9 kg per person in 2020-21. This includes imported seafood products which accounted for 62 per cent of consumption (https://seafoodindustryaustralia.com.au/good-for-you-good-for-the-planet-data-shows-australians-are-eating-more-seafood/#:~:text=Australians%20consumed%20around%20356%2C000%20tonnes,of%2015.5%20in%202003%2D4).

In summary, the strong overall demand for seafood in Australia, and globally, that was projected before the new millennium was genuine. The growth of aquaculture both globally, and in Australia, demonstrates that this was not a barrier to inland saline aquaculture production. Of course, localised demand needs to be considered and the transport and logistical considerations needs to be factored into any aquaculture venture. Lack of demand was not raised as a factor in the lack of commercial inland saline aquaculture developments.

Sufficient saline groundwater

In the early 2000s, constraints to the expansion of marine aquaculture, including because of conflict over the use of oceans and harbours, encouraged advocates to consider using saline groundwater. The Murray Darling Basin, the southeast of Western Australia and many other arid areas of Australia contain vast stores of salt in the soil and shallow groundwater. In the early 2000s, rising groundwater salinity, long a problem in the Australian landscape, particularly in the Murray Darling Basis, and related vegetation die-off, was identified as one of the greatest environmental problems facing the country.

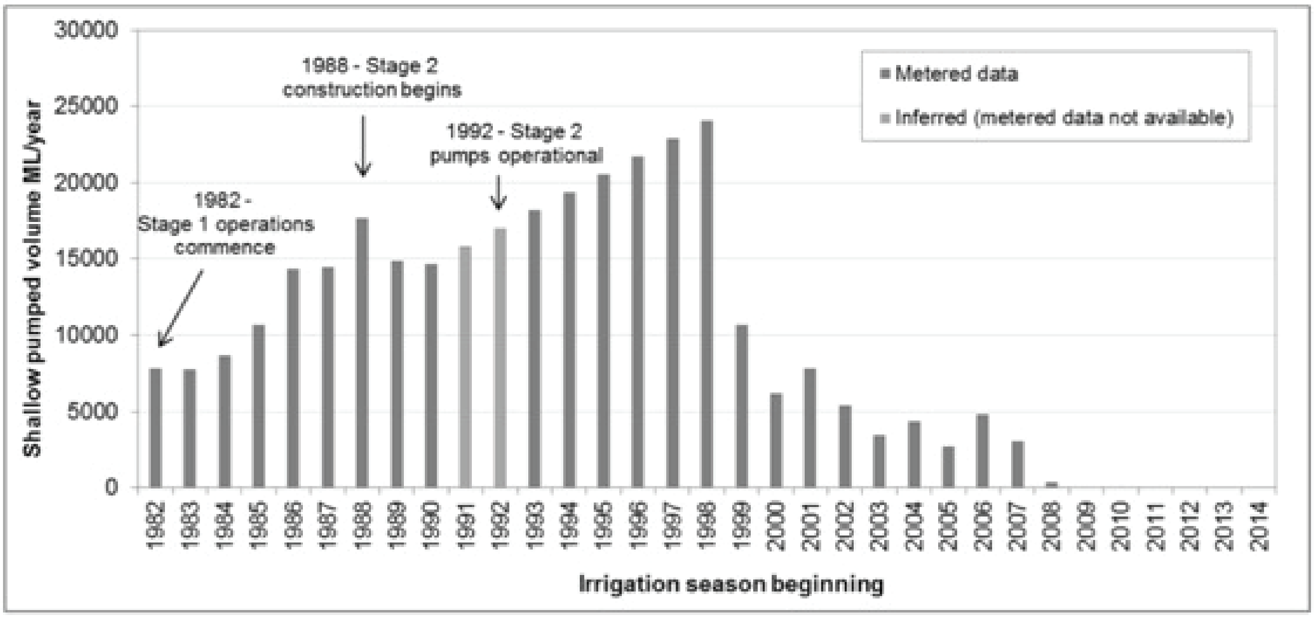
The scale of the issue is evident by the scale of saline lakes, salt disposal basins and salt interception schemes in Australia. The biggest saline lake is Lake Eyre in South Australia at 9,500 km^2 but the nine Kerang saline lakes collectively occupy about 2,500 ha and the ten Saline Western District Lakes occupy about 44,000 ha (Allan, et al., 2001, see bibliography Appendix 1). One particularly effective solution was to intercept rising saline groundwater, before it reached the root zone of plants, and pump it into evaporation basins. The use of evaporation basins for the disposal of intercepted saline water was first used in 1917 (Allan et al., 2001). There are 11 large salt interception schemes in the Murray Darling Basin (approximately 5,344 ha) and, in 2000, there were another eight being constructed or planned (Allan, et. al., 2001). These are very effective at controlling rising salinity, although they are very expensive to construct and maintain.

The opportunity for aquaculture to offset some of these costs, or at least to benefit from the availability of saline water, was an attractive consideration. In the early 2000s, the conclusion, supported by resource assessments (e.g. Allan et al., 2001), was there was plenty of saline groundwater available.

With so much saltwater in the inland landscape, why wasn't it used for aquaculture?

Moving forward to 2023, the experts consulted during this review almost all cited long-term security of water as a primary reason commercial investment did not proceed. Two examples explain this apparent paradox. In the first, a commercial development was proposed using trout cultured in water supplied at the outlet into evaporation ponds at the Wakool Tullakool Sub Surface Drainage System (WTSSDS) the largest saltwater interception scheme in Australia. Initiall, the WTSSDS pumped a maximum of 25,000 ML pa, but as the millenium drought took hold, this volume declined. By 2009, pumping had stopped altogether (Figure 4). It had not resumed by 2023. There was plenty of saline groundwater but it was not a secure supply. The investors lost confidence and Murray Irigation Limited, the company who owned and operated WTSSDS, were hesitant to commit. Consequently, the investment never eventuated.

Figure 4. Volume of water pumped into evaporation ponds at Wakool-Tullakool Sub Surface Drainage System Scheme from 1982-2014 (figure courtesy Murray Irrigation Limited).



The second example relates to the proposed commercial opportunity for aquaculture using saline groundwater from the Woolpunda, Waikerie, Qualco-Sunlands Salinity Interception Scheme (SIS) in the Riverland region of South Australia. The scheme comprises 93 bores adjacent to the Murray River that intercept approximately 30 ML day^{-1} saline groundwater. The saline groundwater is pumped to the 350ha Stockyard Plains Disposal Basin. Research by the South Australian Research and Development Institute (SARDI) demonstrated commercially attractive performance of marine species including Mulloway (*Argyrosomus japonicus*) and Yellowtail Kingfish (*Seriola lalandi*) using this saline water (Hutchinson and Flowers, 2008, see bibliography Appendix 1). A significant effort was made to provide information to potential investors, including GIS mapping to help with site selection, documenting the policy and regulatory framework, and conducting economic and sensitivity analysis. There was genuine commercial interest but ultimately investors walked away when long-term (e.g. 30 years) water security could not be guaranteed by the scheme operators. A secondary problem was difficulties with approvals to use the Stockyard Plains Disposal Basin to dispose of aquaculture effluent (Hutchinson, *pers comm*., 2023). The saline groundwater supply was not secure enough for lon-term commercial investment.

There is still commercial interest in using saline groundwater from this SIS for aquaculture in the Riverland region of South Australia and investors are being sought. The proposed operation is for an indoor, tank-based farm (using proprietary technology), constructed in stand-alone modules each producing 250 t per annum. Water use would be minimised and no saline water would leave the farm obviating the problem with disposeal of effluent.

Our conclusion is that although there are vast quantities of saline groundwater available in Australia, the amounts in any single location are limited and obtaining the long-term water security needed for large-scale aquaculture prevented commercial inland aquaculture development and remains a challenge.

Potential solutions to the problem of water security is to construct recirculating aquaculture systems (RAS) that use less water per unit of production. The is similar to the approach being adopted by the Waikerie Project in South Australia (https://a-culture.com.au/the-waikerie-project/). An added advantage is that these systems produce less effluent, especially when technology for the concentration and removal of solid waste is incorporated.

Scale is a factor increasing the challenge with the availability of saline groundwater. In general, aquaculture companies are getting larger to better exploit market power and to adopt new technologies that incease net efficiency (e.g. salmon farms [Pandey, et al., 2023]). In Australia, the four largest aquaculture companies acount for over 40% industry revenue, and this is only described as moderate market share concentration (Ibisworld, 2023 [https://www.ibisworld.com/au/industry/aquaculture/4225/#IndustryStatisticsAndTrends]). It is likely that investors will look twice at opportunities that do not offer the potential to scale up.

Is the water suitable for culture of priority species? (Technical assessment.)

The suitability of these inland sources of saline water for aquaculture was the next question. Allan et al. (2001), used thirteen broad resource assessment categories to help determine the overall suitability of identified resources for inland saline aquaculture. These were:

1. Resource availability (quantity and quality of available water).
2. Resource salinity.
3. Ionic composition.
4. Other water quality.
5. Availability of freshwater.
6. Availability of land.
7. Nature of soil.
8. Environmental sensitivity.
9. Existing structures.
10. Availability of labour and commercial services.
11. Proximity of power supply.
12. Proximity to transport corridors.
13. Opportunities for cost-sharing.

The first phase of almost every evaluation of saline groundwater, in Australia and elsewhere, was "do fish survive and grow in the water?" Of the 113 publications from Australia related to inland saline aquaculture (Appendix 1), 65 concerned the suitability of saline groundwater or documented attempt to modify the groundwater to ameliorate sub-optimum conditions. Matching the species with the environmental conditions is paramount for commercially-successful aquaculture, including inland saline aquaculture.

The desert environment presents different challenges to coastal environments, including the diurnal and seasonal temperature regime, and selecting species that can thrive in those conditions is important. This applies to all aquaculture not just inland saline aquaculture. In some areas, an ionic inbalance in saline groundwater, compared with oceanic waters of equivalent salinity, (e.g. a potassium deficiency in parts of the Murray Darling Basin), needs to be adjusted (e.g. by the simple addition of potassium salts). However, in summary, almost all species trialled in inland saline waters could be cultured and, for the best species at every site, performance was equivalent to that achieved using coastal water (for marine species) or freshwater (for anadromous or catadromous species).

The “suitability” of inland saline water was not a barrier to commercial development.

Are there suitable facilities for inland saline aquaculture? (Technical assessment.)

The facilities investigated during the research phase included small tanks, particularly for initial experiments, large tanks, including commercial-scale, RAS systems, ponds and raceways. The question about what are the “most appropriate” facilities for the planned operation applies to almost all aquaculture and is not specific to inland saline aquaculture. There are no reports that the type of facilities available to aquaculturists generally were unsuitable for inland saline aquaculture.

The issue of scale of facilities and farms is, however, a factor. As mentioned above, investors around the world are scaling-up, individual companies are more interested in larger farms (in terms of production potential) and industries are rationalising with company acquisitions and mergers increasingly common (Pandey et al., 2023). For example, the largest salmon farming companies are now multi-national. Pandey et al., (2023) attributes this to an attempt for companies to become large enough to exploit market power, and/or becoming large enough to adopt new technologies that increase the efficient scale.

Can species be cultured cost-effectively? (Technical assessment.)

A considerable effort was invested in economic modelling for inland saline aquaculture, including for inland saline aquaculture of prawns and trout, and for using recirculating aquaculture systems (RAS) for inland saline aquaculture (Johnstone, 2014a,b,c, see Bibliography Appendix 1).These and other attempts to quantify potential investment returns in NSW, Victoria and South Australia and Western Australia, led to some since-lapsed commercial development (in Western Australia), to an initial commercial proposal that didn’t proceed in NSW, and to a state government publication of an expression of interest for investment in inland saline aquaculture in Riverland region of South Australia, that also didn’t proceed. The proposals in NSW and South Australia didn’t proceed primarily due to the failure to guarantee long-term (i.e. decades) water security.

The investment proposal in South Australia demonstrates, that at least on paper, species can be cultured cost-effectively in inland saline groundwater (https://a-culture.com.au/the-waikerie-project/) although uncertainties have clearly constrained commercial development so far.

Will people eat fish grown using inland saline waters? (Market acceptance.)

Taste panel studies and practical trials in most jurisdictions conclusively showed that consumers accepted fish cultured in inland saline aquaculture. This wasn’t a barrier to development.

Will people invest? (Commercialisation potential.)

Inland saline aquaculture research and development in every jurisdiction was predicated on the assumption that once research questions were addressed and results were encouraging, investors would commit. The research approach asked the right questions but scientists and Government may have been overoptimistic about the results, and underestimated problems with guaranteeing long-term water security for the volumes needed to attract significant commercial investment. The misunderstanding of the potential for development at scale may have also been a factor.

Significant investment is likely to require removal of risks to long term viability of projects including secure access to the water resource, likely production performance of target species that can be cultured in saline groundwater, and the need to achieve a scale of production that can provide attractive returns that will likely only be possible if the product can be supplied to large national and international markets.

Conclusion

The research approach followed throughout Australia, had considerable support from the Commonwealth Government (including the Fisheries Research and Development Corporation, the Australian Centre for International Agricultural Research, and the Department of Agriculture Fisheries and Forestry), various State Governments including NSW, South Australia, Victoria, Queensland and Western Australia, Universities and private landholders and investors. There is a wealth of published, easily available information about inland saline aquaculture in every state of Australia where there is potential. These publications and data are a valuable resource for anyone contemplating commercial development.

The reason commercial development has not proceeded as expected in Australia, ultimately, is mainly due to the failure to secure long-term water security of sufficient quantity to underpin large scale development.

There is still potential for more modest commercial development. Advances in technology, for example in RAS, and some of the underlying advantages of aquaculture away from the coast and population centres, and some of the pathogens that are difficult to manage, may make inland saline aquaculture more attractive to investors.

Commercial investors will also need to prepared to reach the scale of production and product price needed to remain profitable within a competitive national or global seafood market.

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Pandey, R., Asche, F., Misund, B., Nygaard, R., Adewumi, O., Straume, H-M., and Zhang, D., 2023. Production growth, company size, and concentration: The case of salmon. Aquaculture 577 (2023) https://doi.org/10.1016/j.aquaculture.2023.739972

Tuynman, H and Dylewski, M 2022, Australian fisheries and aquaculture statistics 2021, Fisheries Research and Development Corporation, ABARES, Canberra, December, DOI: https://doi.org/10.25814/amdt-x682)

Recommendations

The following recommendations are made for investors looking at inland saline aquaculture:

Water Supply and Security

• Ensure long-term availability and waterbody tenures with government support.
• Ensure interception schemes can be used to supply water for decades.
• Secure approvals for effluent disposal (e.g. evaporation basins) for long-term environmental security

Species Selection

• Continue to focus on higher-value species such as yellowtail kingfish, barramundi and trout.
• Market development should be carried out for some more niche species
• Focus on temperature-tolerant species for better performance.
• Examine the potential for sterile bio-secure hatcheries to produce SPF (specific pathogen free) juveniles

Technological Advancements

• Explore new technologies and innovations, particularly for RAS systems, electricity systems, and waste-disposal.
• Examine opportunities through the circular economy and waste nutrient utilisation.
• Explore the integration of cultivation with conventional crops.

Government Support and Regulation

• Advocate for a unified national strategy instead of fragmented state strategies.
• Collaborate with an integrated food strategy that addresses areas like carbon, renewable energy sources and employment benefits.
• Establish long-term government support for infrastructure, research, and development and investments.

Knowledge Transfer

• Develop programs for potential investors to visit and experience aquaculture operations.
• Professionalise, Personalise and Categorise by developing a new approach including reaching groups like The Farmer | The Investor | First Nations People or Regional Community Groups.
• Maintain demonstration facilities for a longer duration to showcase the industry's potential.

Attracting (Equity) Investors

• Highlight and promote the economic and scalable viability.
• Understand the scale necessary to support commercial industries.
• Explore partnerships with investors interested in regional communities and alternative lifestyles (also define remote attributes, bankable systems + comparisons).
• Focus on investors with an integrated vision and values that also focuses on sustainability, economic, social and environmental impact.

Extension and Adoption

The primary method of extending the project was through the Inland Saline Aquaculture session at World Aquaculture 2023, held in Darwin, NT, in May-June 2023.

Project materials developed

A bibliography of 587 Inland Saline Aquaculture publications sortable by category/species and country/region (Appendix 1).

Appendices

Appendix 1. Inland Saline Aquaculture Publications

Sorted with publications from Australia first in alphabetical order followed by all other countries by alphabetical order. (Please note a fully sortable excel file is available separately to improve access for those interested.)

Category/species	Country/region	Reference
General status and opportunities	Australia	Allan, G. L., & Fielder, S. (1999a). Inland mariculture activities in NSW. Proceedings of a Workshop Held on 6-7 August 1997, Perth, W.A., No. 83, 1–61. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf
General status and opportunities	Australia	Allan, G. L., & Fielder, S. (1999b). Potential for inland saline water culture of crustaceans. Proceedings of a Workshop Held on 6-7 August 1997, Perth, W.A., No. 83, 1–61. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf
Resourcespolicysystems	Australia	Allan, G. L., Banens, B., & Fielder, S. (2001). Developing commercial inland saline aquaculture in Australia. part 2. resource inventory and assessment. Final Report to Fisheries Research and Development Corporation, Project 98/225. NSW Fisheries Final Report Series No. 31. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/545615/FFRS-31_Allan-et-al-2001.pdf
Economics	Australia	Allan, G. L., Blackburn, J., & Fielder, D. S. (2008). Toward commercialisation of inland saline aquaculture in the Murray Darling Basin. Skretting Australasian Aquaculture Conference, 3-6 August, Brisbane.
Economics	Australia	Allan, G. L., Dignam, A., & Fielder, S. (2001). Developing commercial inland saline aquaculture in Australia: Part 1. R & D Plan. Final Report to Fisheries Research and Development Corporation, Project 98/335. NSW Fisheries Final Report Series No. 30. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/545613/FFRS-30_Allan-et-al-2001.pdf
Economics	Australia	Allan, G. L., Fielder, D. S., Fitzsimmons, K. M., Applebaum, S. L., & Raizada, S. (2009). Inland saline aquaculture. In G. Burnell & G. L. Allan (Eds.), New Technologies in Aquaculture: Improving Production Efficiency, Quality and Environmental Management (pp. 1119–1147). Woodhead Publishing Limited. https://doi.org/10.1533/9781845696474.6.1119
General status and opportunities	Australia	Allan, G., & Fielder, S. (2002). Inland saline aquaculture - progress & priorities. Austasia Aquaculture, 16(2), 36–37.
Economics	Australia	Allan, G., Heasman, H., & Bennison, S. (2008). Development of industrial-scale inland saline aquaculture: Coordination and communication of R&D in Australia. Final Report to FRDC Project No. 2004/241. https://www.frdc.com.au/sites/default/files/products/2004-241-DLD.PDF
Algae seaweed	Australia	Awal, S., & Christie, A. (2015). Suitability of inland saline ground water for the growth of marine microalgae for industrial purposes. Journal of Aquaculture & Marine Biology, 3(2). https://doi.org/10.15406/jamb.2015.03.00063

Algae seaweed	Australia	Barokoni, R., Awal, S., & Christie, A. (2015). Growth performance of the marine microalgae Pavlova salina and Dunaliella tertiolecta using different commercially available fertilizers in natural seawater and inland saline ground water. Journal of Algal Biomass Utilization, 6(1), 15–25. https://www.researchgate.net/profile/Sadiqul-Awal/publication/299389546_
Integrated ISA Agriculture	Australia	Blackwell, J. (1999). Using serial biological concentration to combine irrigation and saline aquaculture in Australia. In B. Smith & C. Barlow (Eds.), Inland Saline Aquaculture. Proceedings of a workshop held on 6-7 August 1997 in Perth, Western Australia. ACIAR Proceedings No. 83 (pp. 1–61). https://ageconsearch.umn.edu/record/135193/files/PR083.pdf#page=27
Marine finfish	Australia	Booth, M., & Fielder, D. (2016). Fortification of an aquafeed with potassium chloride does not improve survival of juvenile Australian snapper Pagrus auratus reared in potassium deficient saline groundwater. Fishes, 1(1), 52–64. https://doi.org/10.3390/fishes1010052
Algae seaweed	Australia	Bui, H. T. T. (2018). Technical feasibility of cultivating local seaweed species in inland saline water of Western Australia [PhD Thesis]. In espace.curtin.edu.au. https://espace.curtin.edu.au/handle/20.500.11937/70550
Algae seaweed	Australia	Bui, H. T. T., Luu, T. Q., & Fotedar, R. (2018a). Effects of enriching nitrogen and phosphorus on the growth of Sargassum podacanthum cultured in potassium-fortified inland saline water. American Journal of Applied Sciences, 15(3), 149–161. https://doi.org/10.3844/ajassp.2018.149.161
Algae seaweed	Australia	Bui, H. T. T., Luu, T. Q., & Fotedar, R. (2018b). Effects of temperature and pH on the growth of Sargassum linearifolium and S. podacanthum in potassium-fortified inland saline water. American Journal of Applied Sciences, 15(3), 186–197. https://doi.org/10.3844/ajassp.2018.186.197
Algae seaweed	Australia	Bui, H. T. T., Luu, T. Q., Fotedar, R., & Tantulo, U. (2017). Productivity of Sargassum linearifolium in potassium fortified inland saline water under laboratory conditions. Aquaculture Research, 48(11), 5631–5639. https://doi.org/10.1111/are.13385
Algae seaweed	Australia	Chipchase, T., & Awal, S. (2012). Investigation into the suitability of inland ground saline water for the growth of marine microalgae for industrial purposes. International Journal on Algae, 79–92. https://www.dl.begellhouse.com/journals/7dd4467e7de5b7ef,4fc8aedf026987a5,6f73fd0020cb8b9d.html
Environmental	Australia	Coleman, M. (2019). Saline Discharges into Natural Wetlands in Western Australia Preliminary Review of Issues and Options. Report to the Department of Environmental Protection (p. 31). actis Environmental Services. https://library.dbca.wa.gov.au/static/FullTextFiles/630599.pdf
Penaieds (not vannamei)	Australia	Collins, A., & Russell, B. (2003, April 1). Inland prawn farming trial in Australia - responsible seafood advocate. Global Seafood Alliance. https://www.aquaculturealliance.org/advocate/inland-prawn-farming-trial-in-australia/?headlessPrint=AAAAAPIA9c8r7gs82oWZBA

Penaieds (not vannamei)	Australia	Collins, A., Russell, B., Walls, A., & Hoang, T. (2005). Inland prawn farming. Studies into the potential for inland marine prawn farming in Queensland (pp. 1–95). The State of Queensland, Department of Primary Industries. http://era.daf.qld.gov.au/id/eprint/5756/1/Inland%20prawn%20farming_studies%20into%20the%20potential%20for%20inland%20marine%20prawn%20farming%20in%20Queensland_QI05051_2005_collins.pdf
Algae seaweed	Australia	Cordover, R. (2007). Seaweed Agronomy Cropping in inland saline groundwater evaporation basins. A report for the Rural Industries Research and Development Corporation (p. 60). RIRDC Publication No 07/033. https://agrifutures.com.au/wp-content/uploads/publications/07-033.pdf
Molluscs Echinoderms	Australia	Dinh, H. Q., & Fotedar, R. (2016). Early development of the blue mussel Mytilus edulis (Linnaeus, 1758) cultured in potassium-fortified inland saline water. Aquaculture, 452, 373–379. https://doi.org/10.1016/j.aquaculture.2015.11.025
Marine finfish	Australia	Doroudi, M. S., Fielder, D. S., Allan, G. L., & Webster, G. K. (2006). Combined effects of salinity and potassium concentration on juvenile mulloway (Argyrosomus japonicus, Temminck and Schlegel) in inland saline groundwater. Aquaculture Research, 37(10), 1034–1039. https://doi.org/10.1111/j.1365-2109.2006.01525.x
Freshwater fish (not carp)	Australia	Doroudi, M. S., Webster, G. K., Allan, G. L., & Fielder, D. S. (2007). Survival and growth of silver perch, Bidyanus bidyanus, a salt-tolerant freshwater species, in inland saline groundwater from southwestern New South Wales, Australia. Journal of the World Aquaculture Society, 38(2), 314–317. https://doi.org/10.1111/j.1749-7345.2007.00102.x
Marine finfish	Australia	Doroudi, M., Allan, G., & Fielder, S. (2003). Inland saline culture of marine species in NSW. Proceedings of the Aquafin CRC Snapper Workshop Held on 26 September 2002 at the Airport Motel & Convention Centre, Melbourne (Aquafin CRC 2001/208), 22–24. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/134564/Output-Aquafin.pdf
Penaieds (not vannamei)	Australia	Doroudi, M., Allan, G., & Fielder, S. (2003). Preliminary study on the survival and growth of post-larvae of black tiger prawns in inland saline groundwater, southern NSW, Australia. Proceedings of 2003 Ridley Aqua-Feed Prawn and Barramundi Farmers Conference, 24-31 July 2003.
Marine finfish	Australia	Doupé, R. G., & Lymbery, A. J. (2002). Justification for genetic improvement in growth rates of black bream(Acanthopagrus butcheri):A partial budgeting analysis. Aquaculture Economics & Management, 6(5-6), 339–347. https://doi.org/10.1080/13657300209380323
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Environmental	Australia	Doupé, R. G., Alder, J., & Lymbery, A. J. (1999). Environmental and product quality in finfish aquaculture development: an example from inland Western Australia. Aquaculture Research, 30(8), 595–602. https://doi.org/10.1046/j.1365-2109.1999.00371.x
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Marine finfish	Australia	Doupé, R. G., Sarre, G. A., Partridge, G. J., Lymbery, A. J., & Jenkins, G. I. (2005). What are the prospects for black bream Acanthopagrus butcheri (Munro) aquaculture in salt-affected inland Australia? Aquaculture Research, 36(14), 1345–1355. https://doi.org/10.1111/j.1365-2109.2005.01350.x
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Crustaceans (not penaeids)	Australia	Fielder, D. S., & Raizada, S. (2006). Production of giant freshwater prawns in saline groundwater in inland northwestern India. Australasian Aquaculture 2006, Adelaide, Australia, August 28-30.
Marine finfish	Australia	Fielder, D. S., Allan, G. L., Pepperall, D., & Pankhurst, P. M. (2007). The effects of changes in salinity on osmoregulation and chloride cell morphology of juvenile Australian snapper, Pagrus auratus. Aquaculture, 272(1), 656–666. https://doi.org/10.1016/j.aquaculture.2007.08.043

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General status and opportunities	Australia	Fielder, D. S., Raizada, S., & Chadha, N. K. (2012). Development of aquaculture in degraded inland areas in India and Australia. Final Report for Australian Centre for International Agricultural Research. Canberra, Australia. 72 pp. https://www.researchgate.net/publication/265787494_Developing_aquaculture_in_degraded_inland_areas_in_India_and_Australia_project_number_Dr_Sudhir_Raizada_Central_Institute_of_Fisheries_Education_Contents
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Marine finfish	Australia	Fielder, D. Stewart., Bardsley, W. J., & Allan, G. L. (2001). Survival and growth of Australian snapper, Pagrus auratus, in saline groundwater from inland New South Wales, Australia. Aquaculture, 201(1-2), 73–90. https://doi.org/10.1016/s0044-8486(01)00555-5
Marine finfish	Australia	Fielder, D. Stewart., Bardsley, W. J., Allan, G. L., & Pankhurst, P. M. (2002). Effect of photoperiod on growth and survival of snapper Pagrus auratus larvae. Aquaculture, 211(1-4), 135–150. https://doi.org/10.1016/s0044-8486(02)00006-6
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Marine finfish	Australia	Flowers, T. J. (2010). Metabolic and osmregulatory responses of snapper (Pagrus auratas), mulloway (Argyrosomus japonicus) and yellowtail kingfish (Seriola lalandi) in saline groundwater [Master of Applied Science in Aquaculture by Research]. In eprints.utas.edu.au. https://eprints.utas.edu.au/10404/
Molluscs Echinoderms	Australia	Fotedar, R., Harries, S., & Savage, S. (2008). Survival, growth and osmolality of greenlip abalone Haliotis laevigata (Donovan 1808) when exposed to different ionic profiles of inland saline water. Aquaculture Research, 39(5), 441–448. https://doi.org/10.1111/j.1365-2109.2007.01721.x
Resourcespolicysys tems	Australia	Gavine, F., & Bretherton, M. (2007). Aquaculture in saline groundwater evaporation basins. A Report for the Rural Industries Research and Development Corporation. RIRDC Publication No 07/114. https://agrifutures.com.au/wp-content/uploads/publications/07-114.pdf

Economics	Australia	Gibson, T. S., Allan, G. L., File, G., Mullen, J. D., & Scott-Orr, H. (2007). Priorities and principles for investment in aquaculture research by NSW Department of Primary Industries. In AgEcon Search. NSW Department of Primary Industries. Economic Research report No. 36. https://ageconsearch.umn.edu/record/37665/
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Resourcespolicysys tems	Australia	Gooley, G., & Gavine, F. (Eds.). (2003). Integrated agri-aquaculture systems. A resource handbook for Australian industry development. A Report for the Rural Industries Research and Development Corporation Edited by. http://www.backyardaquaponics.com/Travis/03-012.pdf#page=20
General status and opportunities	Australia	Gooley, G., Ingram, B., & McKinnon, L. (1999). Inland saline aquaculture - a Victorian perspective. Inland Saline Aquaculture Workshop. Proceedings of a Workshop in Perth, Western Australia, 6-7 August 1997., 83, 16–19. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf
Economics	Australia	Government of South Australia. (2010). Invitation to submit an expression of interest to utilise water from the Woolpunda / Waikerie / Qualco salt interception scheme information memorandum.
Marine finfish	Australia	Haddy, J. A., & Pankhurst, N. W. (2000a). The effects of salinity on reproductive development, plasma steroid levels, fertilisation and egg survival in black bream Acanthopagrus butcheri. Aquaculture, 188(1-2), 115–131. https://doi.org/10.1016/s0044-8486(00)00326-4
Marine finfish	Australia	Haddy, J. A., & Pankhurst, N. W. (2000b). The efficacy of exogenous hormones in stimulating changes in plasma steroids and ovulation in wild black bream Acanthopagrus butcheri is improved by treatment at capture. Aquaculture, 191(4), 351–366. https://doi.org/10.1016/s0044-8486(00)00445-2
Resourcespolicysys tems	Australia	Hauck, E. (2004). Evaporation basin guidelines for disposal of saline water. (p. 23). The Department of Agriculture WA. https://library.dpird.wa.gov.au/cgi/viewcontent.cgi?article=1007&context=misc_pbns
Integrated ISA Agriculture	Australia	Heuperman, A., Bethune, M., Mann, L., & Batey, T. (2000). Management of saline drainage water on irrigation farms in Northern Victoria. 10th World Water Congress: Water, the Worlds Most Important Resource, 888–897. https://search.informit.org/doi/abs/10.3316/INFORMIT.516892551097612
Integrated ISA Agriculture	Australia	Heuperman, A., Mann, L., Greenslade, R., Heath, J., Gooley, G., Ingram, B., & McKinnon, L. (1999). Value adding to serial biological concentration for improved environmental management. Final Report. (pp. 1–35). Institute of Sustainable Irrigated Agriculture.
Economics	Australia	Hutchinson, W., & Flowers, T. (2008). Research to foster investor attraction and establishment of commercial aquaculture parks aligned to major saline groundwater interception schemes in south Australia. SARDI Research Report Series No: 317 (pp. 1–443). SARDI Aquatic Sciences. https://pir.sa.gov.au/__data/assets/pdf_file/0007/231694/No

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Integrated ISA Agriculture	Australia	Ingram, B. A., Gooley, G. J., McKinnon, L. J., & De Silva, S. S. (2000). Aquaculture-agriculture systems integration: An Australian prospective. Fisheries Management and Ecology, 7(1-2), 33–43. https://doi.org/10.1046/j.1365-2400.2000.00182.x
General research	Australia	Ingram, B. A., McKinnon, L. J., & Gooley, G. J. (2002). Growth and survival of selected aquatic animals in two saline groundwater evaporation basins: an Australian case study. Aquaculture Research, 33(6), 425–436. https://doi.org/10.1046/j.1365-2109.2002.00691.x
General status and opportunities	Australia	Ingram, B., Gooley, G., & McKinnon, L. (1996). Potential for inland mariculture in Victorian saline groundwater evaporation basins. Austasia Aquaculture, 10(3), 61–63. https://www.researchgate.net/profile/Brett-Ingram-2/publication/283738429_Potential_for_inland_mariculture_in_Victorian_saline_groundwater_evaporation_basins/links/5649239808ae54697fbe5f04/Potential-for-inland-mariculture-in-Victorian-saline-groundwater-evaporation-basins.pdf
General status and opportunities	Australia	Jenkins, G. (1999). Potential for inland saline aquaculture of fishes. Inland Saline Aquaculture Workshop. Proceedings of a Workshop in Perth, Western Australia, 6-7 August 1997, 37–39. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf
General/Economic decision	Australia	Johnstone, W. (2014a). Inland Saline Recirculation Aquaculture . Decision Tool . Queensland Government. https://www.publications.qld.gov.au/dataset/agbiz-tools-fisheries-aquaculture/resource/cda06968-016e-474b-8f7f-44ed8d71117f
Prawns/Economic decision	Australia	Johnstone, W. (2014b). Inland Saline Prawn Culture. Decision Tool. Queensland Government. https://www.publications.qld.gov.au/dataset/agbiz-tools-fisheries-aquaculture/resource/629fcf1b-022e-483b-b347-899962e06d7d?inner_span=True
Trout/Economic decision	Australia	Johnstone, W. (2014c). Inland Saline Trout Culture. Decision Tool. Queensland Government. https://www.publications.qld.gov.au/dataset/ba57f75c-2f52-4692-9e9b-1d735984ad65/resource/cfe749c7-9233-4aa4-9ea8-3b66d403860f/download/inland-saline-finfish-culture.xls
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General status and opportunities	Australia	Kolkovski, S. (2011). An overview on desert aquaculture in Australia. In V. Crespi & A. Lovatelli (Eds.), Aquaculture in desert and arid lands: development constraints and opportunities. FAO Technical Workshop. 6–9 July 2010, Hermosillo, Mexico. FAO Fisheries and Aquaculture

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Algae seaweed	Australia	Kumar, V., Fotedar, R., & Dods, K. (2009). Effect of inland saline water ionic profiles on growth, chemical composition and agar characteristics of Gracilaria cliftonii (Withell, Miller and Kraft 1994) under laboratory conditions. Aquaculture International, 18(5), 869–881. https://doi.org/10.1007/s10499-009-9306-y
Algae seaweed	Australia	Kumar, V., Fotedar, R., & Longbottom, S. (2011). Effect of nutrient media on the growth, physicochemical and agar properties of Gracilaria cliftonii cultured in ocean and inland saline water. Journal of Applied Aquaculture, 23(4), 317–328. https://doi.org/10.1080/10454438.2011.626371
Molluscs Echinoderms	Australia	Lee, C. (1999). Potential of inland saline water for aquaculture of molluscs. In B. Smith & C. Barlow (Eds.), Inland Saline Aquaculture Workshop. Proceedings of a workshop held on 6 and 7 August 1997 in Perth, Western Australia. ACIAR Proceedings No. 83, 61 pp.
Freshwater fish (not carp)	Australia	Lever, C., Lymbery, A. J., & Doupé, R. G. (2004a). Preliminary comparisons of yield and profit achieved from different rainbow trout, Oncorhynchus mykiss, production systems in inland Western Australia. Journal of Applied Aquaculture, 16(1-2), 63–73. https://doi.org/10.1300/j028v16n01_05
Freshwater fish (not carp)	Australia	Lever, C., Lymbery, A. J., & Doupé, R. G. (2004b). Preliminary comparisons of yield and profit achieved from different rainbow trout,oncorhynchus mykiss, production systems in inland Western Australia. Journal of Applied Aquaculture, 16(1-2), 63–73. https://doi.org/10.1300/j028v16n01_05
Integrated ISA Agriculture	Australia	Lymbery, A. J., Doupé, R. G., Bennett, T., & Starcevich, M. R. (2006). Efficacy of a subsurface-flow wetland using the estuarine sedge Juncus kraussii to treat effluent from inland saline aquaculture. Aquacultural Engineering, 34(1), 1–7. https://doi.org/10.1016/j.aquaeng.2005.03.004
Integrated ISA Agriculture	Australia	Lymbery, A. J., Kay, G. D., Doupé, R. G., Partridge, G. J., & Norman, H. C. (2013). The potential of a salt-tolerant plant (Distichlis spicata cv. NyPa Forage) to treat effluent from inland saline aquaculture and provide livestock feed on salt-affected farmland. Science of the Total Environment, 445-446, 192–201. https://doi.org/10.1016/j.scitotenv.2012.12.058
Freshwater fish (not carp)	Australia	Lymbery, A., Starcevich, M., & Doupé, R. (2007). Managing environmental impacts in inland saline aquaculture. A Case Study for Trout Production from Saline Groundwater in Western Australia. A report for the Rural Industries Research and Development Corporation (pp. 1–78). RIRDC Publication No 05/166.
Crustaceans (not penaeids)	Australia	McDowall, S., Awal, S., & Christie, A. (2016). Investigation into the potential use of inland saline groundwater for the production of live feeds for commercial aquaculture purposes. Journal of Aquaculture & Marine Biology, 4(1). https://doi.org/10.15406/jamb.2016.04.00071
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Marine finfish	Australia	Michael, R. J., Partridge, G. J., Hofmann, T., & Caro, E. D. (2010). Evaluation of mosquito fish Gambusia holbrooki (Girard) as a partial and complete pellet replacement for juvenile barramundi Lates calcarifer (Bloch). Aquaculture Research, 41(11), e788–e794. https://doi.org/10.1111/j.1365-2109.2010.02595.x
Freshwater fish (not carp)	Australia	Molony, B. (2001). Environmental requirements and tolerances of rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta) with special reference to Western Australia: A review. Fisheries Research Report No 130. http://www.sjrdotmdl.org/concept_model/bio-effects_model/documents/Molony2001.pdf
Environmental	Australia	Ogburn, M. D. (2007). Environmental impacts in Australian aquaculture. In T. M. Bert (Ed.), Ecological and Genetic Implications of Aquaculture Activities. Methods and Technologies in Fish Biology and Fisheries, Vol 6. Springer Netherlands. https://doi.org/10.1007/978-1-4020-6148-6
General status and opportunities	Australia	Partridge, G. (2008). Inland saline aquaculture: Overcoming biological and technical constraints towards the development of an industry (p. 169) [PhD Thesis]. https://researchrepository.murdoch.edu.au/id/eprint/245/2/02Whole.pdf
Marine finfish	Australia	Partridge, G. J., & Creeper, J. (2004). Skeletal myopathy in juvenile barramundi, Lates calcarifer (Bloch), cultured in potassium-deficient saline groundwater. Journal of Fish Diseases, 27(9), 523–530. https://doi.org/10.1111/j.1365-2761.2004.00567.x
Marine finfish	Australia	Partridge, G. J., & Lymbery, A. J. (2008). The effect of salinity on the requirement for potassium by barramundi (Lates calcarifer) in saline groundwater. Aquaculture, 278(1-4), 164–170. https://doi.org/10.1016/j.aquaculture.2008.03.042
Marine finfish	Australia	Partridge, G. J., & Lymbery, A. J. (2009). Effects of manganese on juvenile mulloway (Argyrosomus japonicus) cultured in water with varying salinity—Implications for inland mariculture. Aquaculture, 290(3-4), 311–316. https://doi.org/10.1016/j.aquaculture.2009.02.020
Marine finfish	Australia	Partridge, G. J., Lymbery, A. J., & Bourke, D. K. (2008). Larval rearing of barramundi (Lates calcarifer) in saline groundwater. Aquaculture, 278(1-4), 171–174. https://doi.org/10.1016/j.aquaculture.2008.03.023
General status and opportunities	Australia	Partridge, G. J., Lymbery, A. J., & George, R. J. (2008). Finfish mariculture in inland Australia: A review of potential water sources, species, and production systems. Journal of the World Aquaculture Society, 39(3), 291–310. https://doi.org/10.1111/j.1749-7345.2008.00169.x
General status and opportunities	Australia	Partridge, G. J., Sarre, G. A., Ginbey, B. M., Kay, G. D., & Jenkins, G. I. (2006). Finfish production in a static, inland saline water body using a Semi-Intensive Floating Tank System (SIFTS). Aquacultural Engineering, 35(2), 109–121. https://doi.org/10.1016/j.aquaeng.2005.09.001
General status and opportunities	Australia	Partridge, G., Sarre, G., Lymbery, A., Jenkins, G., Doupé, R., Kay, G., Michael, R., Willett, D., & Erler, D. (2008). New technologies for sustainable commercial finfish culture. Fisheries Research and Development Corporation Report FRDC Project 2005/213 I.

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General status and opportunities	Australia	Paust, G. (1999). Inland saline aquaculture in Western Australia. Proceedings of a Workshop in Perth, Western Australia, 6-7 August 1997, 83, 1–61. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf
Economics	Australia	PIRSA Aquaculture. (2008a). Economic impact analysis for the use of salt interception schemes for aquaculture development (pp. 1–24). EconSearch Pty Ltd.
Economics	Australia	PIRSA Aquaculture. (2008b). Financial sensitivity analysis for the use of salt interception schemes for aquaculture development (pp. 1–56). EconSearch Pty Ltd.
Penaieds (not vannamei)	Australia	Prangnell, D. I., & Fotedar, R. (2005). The effect of potassium concentration in inland saline water on the growth and survival of the western king Shrimp, Penaeus latisulcatus Kishinouye, 1896. Journal of Applied Aquaculture, 17(2), 19–34. https://doi.org/10.1300/j028v17n02_02
Penaieds (not vannamei)	Australia	Prangnell, D. I., & Fotedar, R. (2006a). The growth and survival of western king prawns, Penaeus latisulcatus Kishinouye, in potassium-fortified inland saline water. Aquaculture, 259(1-4), 234–242. https://doi.org/10.1016/j.aquaculture.2006.05.023
Penaieds (not vannamei)	Australia	Prangnell, D. I., & Fotedar, R. (2006b). Effect of sudden salinity change on Penaeus latisulcatus Kishinouye osmoregulation, ionoregulation and condition in inland saline water and potassium-fortified inland saline water. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 145(4), 449–457. https://doi.org/10.1016/j.cbpa.2006.08.029
Penaieds (not vannamei)	Australia	Prangnell, D. I., & Fotedar, R. (2009). Effect of sudden change in potassium concentration on Penaeus latisulcatus Kishinouye survival, osmolality and health in inland saline water cultures. Hydrobiologia, 626(1), 145–153. https://doi.org/10.1007/s10750-009-9742-8
Economics	Australia	Primary Industries and Resources South Australia. (2008). SIS aquaculture planner user guide. EconSearch Pty Ltd.
Penaieds (not vannamei)	Australia	Romano, N., & Zeng, C. (2009). Evaluating the newly proposed protocol of incorporated potassium in nitrate toxicity experiments at different salinities: A case study with the tiger prawn, Penaeus monodon, juveniles. Aquaculture, 289(3-4), 304–309. https://doi.org/10.1016/j.aquaculture.2009.01.035
Crustaceans (not penaeids)	Australia	Romano, N., & Zeng, C. (2011). Importance of balanced Na+/K+ ratios for blue swimmer crabs, Portunus pelagicus, to cope with elevated ammonia-N and differences between in vitro and in vivo gill Na+/K+-ATPase responses. Aquaculture, 318(1-2), 154–161. https://doi.org/10.1016/j.aquaculture.2011.05.016
Penaieds (not vannamei)	Australia	Romano, N., & Zeng, C. (2012). Osmoregulation in decapod crustaceans: implications to aquaculture productivity, methods for potential improvement and interactions with elevated ammonia exposure. Aquaculture, 334-337, 12–23. https://doi.org/10.1016/j.aquaculture.2011.12.035
Freshwater fish (not carp)	Australia	Rowland, S. J. (2009). Review of aquaculture research and development of the Australian freshwater fish silver perch, Bidyanus bidyanus. Journal of the World Aquaculture Society, 40(3), 291–324. https://doi.org/10.1111/j.1749-7345.2009.00252.x

General status and opportunities	Australia	Rozema, J., & Flowers, T. (2008). Crops for a salinized world. Science, 322(5907), 1478–1480. https://doi.org/10.1126/science.1168572
Marine finfish	Australia	Sarre, G., Partridge, G., Jenkins, G., Potter, I., & Tiivel, D. (2003). Factors required for the successful aquaculture of black bream (Acanthopagrus butcheri) in inland water bodies (p. 81). FRDC Final Report Project No. 1999/320. https://researchrepository.murdoch.edu.au/id/eprint/19802/1/successful_aquaculture_of_black_bream.pdf
Freshwater fish (not carp)	Australia	Schultz, A. G., Healy, J. M., Jones, P. L., & Toop, T. (2008). Osmoregulatory balance in Murray cod, Maccullochella peelii peelii (Mitchell), affected with chronic ulcerative dermatopathy. Aquaculture, 280(1-4), 45–52. https://doi.org/10.1016/j.aquaculture.2008.04.011
Penaieds (not vannamei)	Australia	Slattery, S. L., & Palmer, P. J. (2008). Growing organic prawns - in inland saline waters. In era.daf.qld.gov.au (pp. 1–119). RIRDC Publication No 08/126. https://era.daf.qld.gov.au/id/eprint/3505/
General status and opportunities	Australia	Smith, B., & Barlow, C. (Eds.). (1999). Inland saline aquaculture. (pp. 1–61). Proceedings of a workshop held on 6-7 August 1997 in Perth, Western Australia. ACIAR Proceedings No. 83. https://www.aciar.gov.au/sites/default/files/legacy/node/308/pr83_pdf_14323.pdf#page=6
Freshwater fish (not carp)	Australia	Starcevich, M. R., Lymbery, A. J., & Doupé, R. G. (2003). Potential environmental impacts from farming rainbow trout using inland saline water in Western Australia. Australasian Journal of Environmental Management, 10(1), 15–24. https://doi.org/10.1080/14486563.2003.10648569
Penaieds (not vannamei)	Australia	Tantulo, U., & Fotedar, R. (2006). Comparison of growth, osmoregulatory capacity, ionic regulation and organosomatic indices of black tiger prawn (Penaeus monodon Fabricius, 1798) juveniles reared in potassium fortified inland saline water and ocean water at different salinities. Aquaculture, 258(1-4), 594–605. http://dx.doi.org/10.1016/j.aquaculture.2006.04.038
Penaieds (not vannamei)	Australia	Tantulo, U., & Fotedar, R. (2007). Osmo and ionic regulation of black tiger prawn (Penaeus monodon Fabricius 1798) juveniles exposed to K+ deficient inland saline water at different salinities. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 146(2), 208–214. https://doi.org/10.1016/j.cbpa.2006.10.020
Penaieds (not vannamei)	Australia	Tantulo, U., & Fotedar, R. (2017). Physiological performance and serum Na+, K+ Ca2+ and Mg2+ regulation of black tiger prawn (Penaeus monodon Fabricius 1798) reared in varying Na+/K+ ratios of inland saline water. Aquaculture, 479, 52–59. https://doi.org/10.1016/j.aquaculture.2017.05.023
Environmental	Australia	Trendall, J., Aldert, J., & Lymbery, A. (1999). A national environmental management policy for land-based fish farming. In B. Smith & C. Barlow (Eds.), Inland Saline Aquaculture Workshop. Proceedings of a workshop held on 6 and 7 August 1997 in Perth, Western Australia. ACIAR Proceedings No. 83, 61 pp. https://ageconsearch.umn.edu/record/135193/files/PR083.pdf#page=31

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Economics	Arabia/Persian Gulf	Brown, J. J., Das, P., & Al-Saidi, M. (2018). Sustainable agriculture in the Arabian/Persian Gulf region utilizing marginal water resources: Making the best of a bad situation. Sustainability, 10(5), 1364. https://doi.org/10.3390/su10051364
Vannamei	Bangladesh	Kabir, M. H., & Eva, I. J. (2014). Environmental impacts of shrimp aquaculture: The case of Chandipur village at Debhata upazila of Satkhira district, Bangladesh. Journal of the Asiatic Society of Bangladesh, Science, 40(1), 107–119. https://doi.org/10.3329/jasbs.v40i1.31738
Vannamei	Bangladesh	Naser, M. N., Sarker, M. N., & Hosain, M. E. (2022). Whiteleg shrimp Litopenaeus vennamei: Current status, future prospects and opportunities for Bangladesh Aquaculture. Bangladesh Journal of Zoology, 50(2), 143–184. https://doi.org/10.3329/bjz.v50i2.62051
Vannamei	Brazil	Esparza-Leal, H. M., Amaral Xavier, J. A., & Wasielesky, W. (2016). Performance of Litopenaeus vannamei postlarvae reared in indoor nursery tanks under biofloc conditions at different salinities and zero-water exchange. Aquaculture International, 24(5), 1435–1447. https://doi.org/10.1007/s10499-016-0001-5
Vannamei	Brazil	Esparza-Leal, H. M., Ponce-Palafox, J. T., Aragón-Noriega, E. A., Arredondo-Figueroa, J. L., García-Ulloa Gómez, M., & Valenzuela-Quiñonez, W. (2009). Growth and performance of the whiteleg shrimp Penaeus vannamei (Boone) cultured in low-salinity water with different stocking densities and acclimation times. Aquaculture Research, 41(6), 878–883. https://doi.org/10.1111/j.1365-2109.2009.02367.x
Vannamei	Brazil	Esparza-Leal, H. M., Ponce-Palafox, J. T., Cervantes-Cervantes, C. M., Valenzuela-Quiñónez, W., Luna-González, A., López-Álvarez, E. S., Vázquez-Montoya, N., López-Espinoza, M., & Gómez-Peraza, R. L. (2019). Effects of low salinity exposure on immunological, physiological and growth performance in Litopenaeus vannamei. Aquaculture Research, 50(3), 944–950. https://doi.org/10.1111/are.13969
Vannamei	Brazil	Esparza-Leal, H. M., Ponce-Palafox, J. T., Valenzuela-Quiñónez, W., Arredondo-Figueroa, J. L., & García-Ulloa Gómez, M. (2010). Effects of density on growth and survival of juvenile Pacific white shrimp, Penaeus vannamei, reared in low-salinity well water. Journal of the World Aquaculture Society, 41(4), 648–654. https://doi.org/10.1111/j.1749-7345.2010.00406.x
Vannamei	Brazil	Esparza-Leal, H. M., Ponce-Palafox, J. T., Valenzuela-Quiñónez, W., Beltrán, H. C., & Figueroa, J. L. A. (2009). The effect of low salinity water with different ionic composition on the growth and survival of Litopenaeus vannamei (Boone, 1931) in intensive culture. Journal of Applied Aquaculture, 21(4), 215–227. https://doi.org/10.1080/10454430903113958

Vannamei	Brazil	Espinoza Ortiz, M., Apún Molina, J. P., Peinado Guevara, H. J., Herrera Barrientos, J., Belmonte Jiménez, S. I., Ladrón de Guevara Torres, M. de los Á., & Delgado Rodríguez, O. (2021). Evaluation of groundwater in the coastal portion of Guasave, Sinaloa for white shrimp farming (Penaeus vannamei) through VES, chemical composition, and survival tests. Journal of Marine Science and Engineering, 9(3), 276. https://doi.org/10.3390/jmse9030276
Vannamei	Brazil	Maicá, P. F., Borba, M. R. de, Martins, T. G., & Wasielesky Junior, W. (2014). Effect of salinity on performance and body composition of Pacific white shrimp juveniles reared in a super-intensive system. Revista Brasileira de Zootecnia, 43(7), 343–350. https://www.scielo.br/j/rbz/a/f8vvcPgDnfsQZYwpxLFct3m/
Algae seaweed	Brazil	Matos, Â. P., da Silva, T., & Sant'Anna, E. S. (2020). The feasibility of using inland desalination concentrate (DC) as an alternative substrate for Spirulina platensis mass cultivation. Waste and Biomass Valorization, 12(6), 3193–3203. https://doi.org/10.1007/s12649-020-01233-9
Integrated ISA Agriculture	Brazil	Miranda, F. R., Lima, R. N., Crisóstomo, L. A., & Santana, M. G. S. (2008). Reuse of inland low-salinity shrimp farm effluent for melon irrigation. Aquacultural Engineering, 39(1), 1–5. https://doi.org/10.1016/j.aquaeng.2008.04.001
Vannamei	Brazil	Oliveira, C. R. do R., de Oliveira, V. Q., Pimentel, O. A. L. F., dos Santos, E. P., de Oliveira Filho, P. R. C., Gálvez, A. O., & Brito, L. O. (2022). Growth performance and proximate composition of Penaeus vannamei reared in low-salinity water with different ionic compositions in a synbiotic system. Aquaculture International, 30(6), 3123–3141. https://doi.org/10.1007/s10499-022-00952-1
Integrated ISA Agriculture	Brazil	Sánchez, A. S., Nogueira, I. B. R., & Kalid, R. A. (2015). Uses of the reject brine from inland desalination for fish farming, Spirulina cultivation, and irrigation of forage shrub and crops. Desalination, 364, 96–107. https://doi.org/10.1016/j.desal.2015.01.034
Vannamei	Brazil	Silva, G. C., Limeira, A. C., de Almeida Costa, G. K., da Silva, S. M. B. C., de Oliveira Filho, P. R. C., & Brito, L. O. (2022). Effects of different forms of artificially salinized in low-salinity water of Penaeus vannamei in the grow-out phase in a synbiotic system. Aquaculture International. https://doi.org/10.1007/s10499-022-01025-z
Vannamei	Brazil	Zacarias, S., Schveitzer, R., Arantes, R., Galasso, H., Pinheiro, I., Espirito Santo, C., & Vinatea, L. (2018). Effect of different concentrations of potassium and magnesium on performance of Litopenaeus vannamei postlarvae reared in low-salinity water and a biofloc system. Journal of Applied Aquaculture, 31(1), 85–96. https://doi.org/10.1080/10454438.2018.1536009
Tilapia	Caribbean	Watanabe, W., Ernst, D., Olla, B., & Wicklund, R. (1989, February 1). Aquaculture of red tilapia Oreochromis sp. in marine environments: State of the art. Advances in Tropical Aquaculture, Workshop at Tahiti, French Polynesia, 20 Feb - 4 Mar 1989. https://archimer.ifremer.fr/doc/00000/1493/
Crustaceans (not penaeids)	Chile	De los Rios Escalante, P., & Salgado, I. (2012). Artemia (Crustacea, Anostraca) in Chile: A review of basic and applied biology. Latin American Journal of Aquatic Research, 40(3), 487–496. https://doi.org/10.3856/vol40-issue3-fulltext-1

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Environmental	China	Cao, N. (2015). Study on desalination of brackish water and causes of arid area. Proceedings of the First International Conference on Information Sciences, Machinery, Materials and Energy. https://doi.org/10.2991/icismme-15.2015.400
Integrated ISA Agriculture	China	Chang, Z., Neori, A., He, Y., Li, J., Qiao, L., Preston, S. I., Liu, P., & Li, J. (2020). Development and current state of seawater shrimp farming, with an emphasis on integrated multi-trophic pond aquaculture farms, in China – a review. Reviews in Aquaculture, 12(4), 2544–2558. https://doi.org/10.1111/raq.12457
Vannamei	China	Changbo, Z. H. U., & Shuanglin, D. (2005). Advances, problems and prospect of inland shrimp farming. South China Fisheries Science, 1(5), 63–69. https://www.schinafish.cn/en/article/id/5f4f675a-0477-4e3c-b81c-8c0c066230b8
Vannamei	China	Chen, K., Li, E., Xu, C., Wang, X., Lin, H., Qin, J. G., & Chen, L. (2015). Evaluation of different lipid sources in diet of Pacific white shrimp Litopenaeus vannamei at low salinity. Aquaculture Reports, 2, 163–168. https://doi.org/10.1016/j.aqrep.2015.10.003
Crustaceans (not penaeids)	China	Chen, Y., Qin, K., Liang, G., Li, X., Niu, M., Wang, H., Wang, C., Mu, C., & Zhu, R. (2023). Comparative study on non-volatile flavor substances of Scylla paramamosain cultured in inland low saline-alkaline water. Journal of Food Composition and Analysis, 118, 105157. https://doi.org/10.1016/j.jfca.2023.105157
Tilapia	China	Cheng, Y., Zhao, J., Ayisi, C. L., & Cao, X. (2022). Effects of salinity and alkalinity on fatty acids, free amino acids and related substance anabolic metabolism of Nile tilapia. Aquaculture and Fisheries, 7(4), 389–395. https://doi.org/10.1016/j.aaf.2020.06.005
General research	China	Gao, F., Li, C., & Jin, W. (2011). Study on saline aquaculture wastewater treatment by constructed wetland. In 2011 International Conference on Electronics, Communications and Control (ICECC), Ningbo, China, 2011, pp. 3938-3941 (pp. 3938–3941). https://doi.org/10.1109/ICECC.2011.6068041
Vannamei	China	Gao, W., Tian, L., Huang, T., Yao, M., Hu, W., & Xu, Q. (2016). Effect of salinity on the growth performance, osmolarity and metabolism-related gene expression in white shrimp Litopenaeus vannamei. Aquaculture Reports, 4, 125–129. https://doi.org/10.1016/j.aqrep.2016.09.001
Integrated ISA Agriculture	China	Geng-Mao, Z., Liu, Z.-P., Ming-Da, C., & Wei-Feng, K. (2006). Effect of saline aquaculture effluent on salt-tolerant Jerusalem artichoke (Helianthus tuberosus L.) in a semi-arid coastal area of China. Pedosphere, 16(6), 762–769. https://doi.org/10.1016/S1002-0160(06)60112-4
Resourcespolicysys tems	China	He, Z., & Zhao, W. (2002). Biological resource in inland saline waters in North China. Journal of Dalian Fisheries College, 17(3), 157–166. https://europepmc.org/article/cba/371280
Environmental	China	Higgins, S., Overeem, I., Tanaka, A., & Syvitski, J. P. M. (2013). Land subsidence at aquaculture facilities in the Yellow River delta, China. Geophysical Research Letters, 40(15), 3898–3902. https://doi.org/10.1002/grl.50758

Vannamei	China	Huang, H.-H., Luo, T., Lei, Y.-J., Kuang, W.-Q., Zou, W.-S., & Yang, P.-H. (2021). Water quality, shrimp growth performance and bacterial community in a reusing-water biofloc system for nursery of Penaeus vananmei rearing under a low salinity condition. Aquaculture Reports, 21, 100894. https://doi.org/10.1016/j.aqrep.2021.100894
Marine finfish	China	Huang, Z., Song, X., Zheng, Y., Peng, L., Wan, R., Lane, T., Zhai, J., Hallerman, E., & Dong, D. (2013). Design and evaluation of a commercial recirculating system for half-smooth tongue sole (Cynoglossus semilaevis) production. Aquacultural Engineering, 54, 104–109. https://doi.org/10.1016/j.aquaeng.2012.12.004
Vannamei	China	Li, E., Chen, L., Zeng, C., Chen, X., Yu, N., Lai, Q., & Qin, J. G. (2007). Growth, body composition, respiration and ambient ammonia nitrogen tolerance of the juvenile white shrimp, Litopenaeus vannamei, at different salinities. Aquaculture, 265(1-4), 385–390. https://doi.org/10.1016/j.aquaculture.2007.02.018
Vannamei	China	Li, E., Wang, X., Chen, K., Xu, C., Qin, J. G., & Chen, L. (2015). Physiological change and nutritional requirement of Pacific white shrimp Litopenaeus vannamei at low salinity. Reviews in Aquaculture, 9(1), 57–75. https://doi.org/10.1111/raq.12104
Vannamei	China	Li, E., Xu, C., Wang, X., Wang, S., Zhao, Q., Zhang, M., Qin, J. G., & Chen, L. (2018). Gut microbiota and its modulation for healthy farming of Pacific white shrimp Litopenaeus vannamei. Reviews in Fisheries Science & Aquaculture, 26(3), 381–399. https://doi.org/10.1080/23308249.2018.1440530
General research	China	Li, L., Dong, S., Tian, X., & Boyd, C. E. (2013). Equilibrium concentrations of major cations and total alkalinity in laboratory soil-water systems. Journal of Applied Aquaculture, 25(1), 50–65. https://doi.org/10.1080/10454438.2012.758074
Integrated ISA Agriculture	China	Li, T., Zhang, B., Zhu, C., Su, J., Li, J., Chen, S., & Qin, J. (2021). Effects of an ex situ shrimp-rice aquaponic system on the water quality of aquaculture ponds in the Pearl River estuary, China. Aquaculture, 545, 737179. https://doi.org/10.1016/j.aquaculture.2021.737179
General status and opportunities	China	Li, Z., Liu, J., Wang, Q., & Silva, S. S. D. (2018). Inland aquaculture: Trends and prospects. In J.-F. Gui, Q. Tang, Z. Li, J. Liu, & S. S. De Silva (Eds.), Aquaculture in China (pp. 25–37). https://doi.org/10.1002/9781119120759.ch1_2
Crustaceans (not penaeids)	China	Liang, G., Qin, K., Chen, Y., Niu, M., Wang, H., Wang, C., Mu, C., Chen, L., Wang, F., Su, Q., & Zhu, R. (2022). Transcriptomic analysis of adaptive mechanisms in response to inland saline-alkaline water in the mud crab, Scylla paramamosain. Frontiers in Marine Science, 9. https://doi.org/10.3389/fmars.2022.974501
Molluscs Echinoderms	China	Lin, T., Zhou, K., Liu, X., Lai, Q., Zhang, D., & Shi, L. (2016). Effects of clam size, food type, sediment characteristic, and seawater carbonate chemistry on grazing capacity of Venus clam Cyclina sinensis (Gmelin, 1791). Chinese Journal of Oceanology and Limnology, 35(5), 1239–1247. https://doi.org/10.1007/s00343-017-5334-z
Vannamei	China	Liu, H., Tan, B., Yang, J., Chi, S., Dong, X., & Yang, Q. (2014). Effects of aqueous Na/K and dietary K on growth and physiological characters of the Pacific white shrimp Litopenaeus vannamei, reared in low-salt well water. Aquaculture Research, 47(2), 540–553. https://doi.org/10.1111/are.12513

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Penaieds (not vannamei)	China	Pan, L.-Q., Luan, Z.-H., & Jin, C.-X. (2006). Effects of Na+/K+ and Mg2+/Ca2+ ratios in saline groundwaters on Na+–K+-ATPase activity, survival and growth of Marsupenaeus japonicus postlarvae. Aquaculture, 261(4), 1396–1402. https://doi.org/10.1016/j.aquaculture.2006.09.031
Molluscs Echinoderms	China	Peng, M., Li, Z., Liu, X., Lan, T., Niu, D., Ye, B., Dong, Z., & Li, J. (2019). Survival, growth and physiology of the juvenile razor clam (Sinonovacula constricta) under Na+/K+ ratio stress. Aquaculture Research, 51(2), 794–804. https://doi.org/10.1111/are.14429
Molluscs Echinoderms	China	Peng, M., Li, Z., Liu, X., Niu, D., & Li, J. (2020). Inland alkaline brackish water aquaculture of juvenile razor clam: Survival, growth, physiology and immune responses. Aquaculture Reports, 18, 100463. https://doi.org/10.1016/j.aqrep.2020.100463
General status and opportunities	China	Qin, K., Jiang, Z., & He, Z. (2002). Fish species and diversity of inland saline waters in northern part of China. Journal of Dalian Fisheries College. https://europepmc.org/article/cba/371356
Tilapia	China	Song, L., Zhao, Y., Song, Y., Zhao, L., Ma, C., & Zhao, J. (2021). Effects of saline-alkaline water on growth performance, nutritional processing, and immunity in Nile tilapia (Oreochromis niloticus). Aquaculture, 544, 737036. https://doi.org/10.1016/j.aquaculture.2021.737036
Marine finfish	China	Teng, G., Huang, W., Ji, C., Chen, Y., & Shan, X. (2022). Morphological changes and variations in Na+/K+-ATPase activity in the gills of juvenile large yellow croaker (Larimichthys crocea) at low salinity. Aquaculture and Fisheries, 7(3), 313–320. http://dx.doi.org/10.1016/j.aaf.2020.08.003
General status and opportunities	China	Wang, Q., Cheng, L., Liu, J., Li, Z., Xie, S., & De Silva, S. S. (2014). Freshwater aquaculture in PR China: Trends and prospects. Reviews in Aquaculture, 7(4), 283–302. https://doi.org/10.1111/raq.12086
Vannamei	China	Wang, X. D., Li, E. C., Wang, S. F., Qin, J. G., Chen, X. F., Lai, Q. M., Chen, K., Xu, C., Gan, L., Yu, N., Du, Z. Y., & Chen, L. Q. (2014). Protein-sparing effect of carbohydrate in the diet of white shrimp Litopenaeus vannamei at low salinity. Aquaculture Nutrition, 21(6), 904–912. https://doi.org/10.1111/anu.12221
Marine finfish	China	Wang, Y., Li, W., Li, L., Zhang, W., & Lu, W. (2015). Effects of salinity on the physiological responses of the large yellow croaker Pseudosciaena crocea under indoor culture conditions. Aquaculture Research, 47(11), 3410–3420. https://doi.org/10.1111/are.12788
Resourcespolicysys tems	China	Wen, Z., & Zhi-hui, H. (1999). Biological and ecological features of inland saline waters in North Hebei, China. International Journal of Salt Lake Research, 8(3), 267–285. https://doi.org/10.1023/a:1009091216842
Vannamei	China	Xu, C., Li, E., Liu, Y., Wang, S., Wang, X., Chen, K., Qin, J. G., & Chen, L. (2017). Effect of dietary lipid level on growth, lipid metabolism and health status of the Pacific white shrimp Litopenaeus vannamei at two salinities. Aquaculture Nutrition, 24(1), 204–214. https://doi.org/10.1111/anu.12548

Environmental	China	Zhang, T.-T., Zeng, S.-L., Gao, Y., Ouyang, Z.-T., Li, B., Fang, C.-M., & Zhao, B. (2011). Assessing impact of land uses on land salinization in the Yellow River delta, China using an integrated and spatial statistical model. Land Use Policy, 28(4), 857–866. https://doi.org/10.1016/j.landusepol.2011.03.002
Crustaceans (not penaeids)	China	Zhao, W., Wang, Q., Zheng, M., Zhao, Y., & Wang, H. (2002). A preliminary study on the biology of Daphniopsis tebitana Sar. Journal of Dalian Fisheries College, 17(3), 209–214. https://europepmc.org/article/cba/371357
Vannamei	China	Zhu, C., Dong, S., Wang, F., & Huang, G. (2004). Effects of Na/K ratio in seawater on growth and energy budget of juvenile Litopenaeus vannamei. Aquaculture, 234(1), 485–496. https://doi.org/10.1016/j.aquaculture.2003.11.027
Vannamei	China	Zhu, C.-B., Dong, S.-L., Wang, F., & Zhang, H.-H. (2006). Effects of seawater potassium concentration on the dietary potassium requirement of Litopenaeus vannamei. Aquaculture, 258(1), 543–550. https://doi.org/10.1016/j.aquaculture.2006.03.038
Vannamei	China	Zhu, Chang-Bo, Dong, Shuang-Lin, & Wang. (2006). The interaction of salinity and NA/K ratio in seawater on growth, nutrient retention and food conversion of juvenile Litopenaeus vannamei. Journal of Shellfish Research, 25(1), 107–112. http://dx.doi.org/10.2983/0730-8000(2006)25[107:TIOSAK]2.0.CO;2
Crustaceans (not penaeids)	Crimea	Yakovenko, V., Shadrin, N., & Anufriieva, E. (2022). The prawn Palaemon adspersus in the hypersaline Lake Moynaki (Crimea): Ecology, long-term changes, and prospects for aquaculture. Water, 14(18), 2786. https://doi.org/10.3390/w14182786
Algae seaweed	Egypt	El Semary, N. A. (2017). Algae and chain aquaculture: An approach towards sustainable agriculture. In A. Negm & M. Abu-hashim (Eds.), Sustainability of Agricultural Environment in Egypt: Part II. The Handbook of Environmental Chemistry (pp. 311–323). Springer, Vol 77. https://doi.org/10.1007/698_2017_161
Resourcespolicysys tems	Egypt	Elbehiry, F., Mahmoud, M. A., & Negm, A. M. (2018). Land use in Egypt's coastal lakes: Opportunities and challenges. In A. Negm, M. Bek, & S. Abdel-Fattah (Eds.), Egyptian Coastal Lakes and Wetlands: Part I . The Handbook of Environmental Chemistry, Vol 71 (pp. 21–36). Springer, Cham. https://doi.org/10.1007/698_2018_250
Resourcespolicysys tems	Egypt	Elnwishy, N. H., Ramadhane, M. S., & Zalat, S. M. (2008). Combating desertification through fish farming. In C. Lee & T. Schaaf (Eds.), The Future of Drylands (pp. 507–518). Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-6970-3_46
Integrated ISA Agriculture	Egypt	Farrag, M. M. S., Toutou, M. M. M., Sedik, F. Sh., Mursy, E. E.-D. I. A., & Osman, A. G. M. (2021). Towards the integrated agri-aquaculture in the desert using groundwater reservoirs for plants and Nile tilapia farming "Evaluating study in upper Egypt." Egyptian Journal of Aquatic Biology and Fisheries, 25(2), 215–235. https://doi.org/10.21608/ejabf.2021.161839
Penaieds (not vannamei)	Egypt	Ishak, M. M., Alsayes, A. A., & Abdel Razek, F. A. (1980). Bionomics of Penaeus kerathurus transplanted into Lake Quarun (Egypt). Aquaculture, 21(4), 365–374. https://doi.org/10.1016/0044-8486(80)90072-1
Crustaceans (not penaeids)	Egypt	M. Heneash, A. M., Al-Rahman, K. A., & Y. Omer, M. (2021). Effect of different diets on the growth rate of the rotifer, Brachionus plicatilis under 40 g L-1 Salinity Stress. Asian Journal of Environment & Ecology, 16(4), 263–271. https://doi.org/10.9734/ajee/2021/v16i430276

Tilapia	Egypt	Magouz, F. I., Radwan, I. A., Soltan, H. O., & El-Keredy, A. (2022). Synbiotic Lactic Dry® enhanced the growth performance, growth-related genes, intestinal health, and immunity of Nile tilapia reared in inland brackish groundwater. Annals of Animal Science. https://doi.org/10.2478/aoas-2022-0066
Resourcespolicysys tems	Egypt	Nasr-Allah, A. M. (2022). Expansion prospects of integrated agriculture-aquaculture systems (IAAS) in new lands in Egypt workshop presentations merged. Digitalarchive.worldfishcenter.org. https://hdl.handle.net/20.500.12348/5452
Freshwater fish (not carp)	Egypt	Nawareg, M. M., Bahnasawy, M. H., El-Sisy, D. M., & Abdel-Rahim, M. M. (2020). Does the polyculture system of thinlip grey mullet, Chelon ramada (Risso, 1827) have positive impacts on water quality, fish performance, and hematological analyses of hybrid red tilapia, Oreochromis mossambicus × O. urolepis reared in concrete tanks with underground brackish water? Aquaculture, Aquarium, Conservation & Legislation, 13(6), 3360–3375. https://www.proquest.com/docview/2495514639?pq-origsite=gscholar&fromopenview=true
Resourcespolicysys tems	Egypt	Sadek, S. (2013). Aquaculture site selection and carrying capacity estimates for inland and coastal aquaculture in the Arab Republic of Egypt. In L. Ross, T. Telfer, L. Falconer, D. Soto, & J. Aguilar-Manjarrez (Eds.), Site Selection and Carrying Capacities for Inland and Coastal aquaculture, pp. 183–196. FAO/Institute of Aquaculture, University of Stirling, Expert Workshop, 6–8 December 2010. https://www.fao.org/fishery/docs/CDrom/P21/root/11.pdf
Economics	Egypt	Sallam, G., Abdel, G., & Sallam, H. (2017). Comparative analysis of using aquaculture versus agriculture land reclamation in saline-sodic clayey soils in tina plain area of Egypt. International Journal of Agricultural Sciences and Natural Resources, 4(5), 32–42. https://www.researchgate.net/publication/343700533
Resourcespolicysys tems	Egypt	Sallam, G., Abdel, G., & Sallam, H. (2017). Comparative analysis of using aquaculture versus agriculture land reclamation in saline-sodic clayey soils in tina plain area of Egypt. International Journal of Agricultural Sciences and Natural Resources, 4(5), 32–42. https://www.researchgate.net/publication/343700533_Gehan_Abdel_Hakeem_Sallam_Comparative_Analysis_of_Using_Aquaculture_Versus_Agriculture_Land_Reclamation_in_Saline-Sodic_Clayey_Soils_in_Tina_Plain_Area_of_Egypt
General status and opportunities	Egypt	Soliman, N. F., & Yacout, D. M. M. (2016). Aquaculture in Egypt: Status, constraints and potentials. Aquaculture International, 24(5), 1201–1227. https://doi.org/10.1007/s10499-016-9989-9
Integrated ISA Agriculture	Egypt	Suloma, A., & Ogata, H. Y. (2006). Future of rice-fish culture, desert aquaculture and feed development in Africa: The case of Egypt as the leading country in Africa. Japan Agricultural Research Quarterly: JARQ, 40(4), 351–360. https://doi.org/10.6090/jarq.40.351
Integrated ISA Agriculture	Egypt	Van Der Heijden, P., Roest, K., Farrag, F., Elwageih, H., & Sadek, S. (2014). Integrated agri-aquaculture with brackish waters in Egypt; Mission Report (March 9 – March 17, 2014). Wageningen, Alterra Wageningen UR (University & Research centre), Alterra report 2526. 52 pp. https://edepot.wur.nl/307733

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Resourcespolicysys tems	Europe, Asia	Zadereev, E., Lipka, O., Karimov, B., Krylenko, M., Elias, V., Pinto, I. S., Alizade, V., Anker, Y., Feest, A., Kuznetsova, D., Mader, A., Salimov, R., & Fischer, M. (2020). Overview of past, current, and future ecosystem and biodiversity trends of inland saline lakes of Europe and Central Asia. Inland Waters, 10(4), 438–452. https://doi.org/10.1080/20442041.2020.1772034
Algae seaweed	France	Gagneux-Moreaux, S., Cosson, R. P., Bustamante, P., & Moreau, C. (2006). Growth and metal uptake of microalgae produced using salt groundwaters from the Bay of Bourgneuf. Aquatic Living Resources, 19(3), 247–255. https://doi.org/10.1051/alr:2006025
Integrated ISA Agriculture	Germany	Buhmann, A., & Papenbrock, J. (2013). Biofiltering of aquaculture effluents by halophytic plants: Basic principles, current uses and future perspectives. Environmental and Experimental Botany, 92, 122–133. https://doi.org/10.1016/j.envexpbot.2012.07.005
General research	Greece	Tsertou, M. I., Antonopoulou, E., & Katharios, P. (2022). Chronic diseases of the lateral line organ in fish. In F. S. B. Kibenge, B. Baldisserotto, & R. S.-M. Chong (Eds.), Aquaculture Pathophysiology. Volume 1. Finfish Diseases (pp. 721–725). Academic Press. https://imbbc.hcmr.gr/wp-content/uploads/2022/10/2022-Tsertou-EUD-preprint-67-1.pdf
General research	India	Abisha, R., Krishnani, K. K., Sukhdhane, K., Verma, A. K., Brahmane, M., & Chadha, N. K. (2022). Sustainable development of climate-resilient aquaculture and culture-based fisheries through adaptation of abiotic stresses: a review. Journal of Water and Climate Change, 13(7). https://doi.org/10.2166/wcc.2022.045
Resourcespolicysys tems	India	Abishag, M. M., Betsy, C. J., & Sampath Kumar, J. S. (2019). Resources and productivity of Indian aquaculture – status and prospects. Agricultural Reviews, 40(03). https://doi.org/10.18805/ag.r-1889
Vannamei	India	Affarin Tinku, D. M., Xavier, K. A. M., Nayak, B. B., Krishna, V. H., Krishna, G., & Balange, A. K. (2021). Comparative evaluation of patties prepared from Pacific white shrimps (Litopenaeus vannamei) grown in inland saline water and brackish water regimes during frozen storage. Journal of Aquatic Food Product Technology, 30(7), 826–834. https://doi.org/10.1080/10498850.2021.1949653
General status and opportunities	India	Aklakur, M. (2017). Nutritional intervention for sustainable production in inland saline aquaculture: A Budding Perspective in India. Journal of Aquaculture & Marine Biology, 6(6). https://doi.org/10.15406/jamb.2017.06.00172
General research	India	Amirtharaj, K. S. V., Ahilan, B., Rajagopalsamy, C. B. T., George, R. M., & Jawahar, P. (2022). Effects of different substrates on the growth and composition of periphyton in the low saline groundwater system. ScienceAsia, 48(1), 82. https://doi.org/10.2306/scienceasia1513-1874.2022.005
Resourcespolicysys tems	India	Anand, A., Krishnan, P., Suryavanshi, A. S., Choudhury, S. B., Kantharajan, G., Srinivasa Rao, Ch., Manjulatha, C., & Babu, D. E. (2020). Identification of suitable aquaculture sites using large-scale land use and land cover maps factoring the prevailing regulatory frameworks: A case study from India.

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Carp	India	Anand, G., dar, S., Srivas, P. P., Varghese, T., & Gupta, S. (2022). Rearing in hypersaline inland ground saline water affect growth and osmoregulatory responses of Common carp (Linnaeus 1758). Research Square. https://doi.org/10.21203/rs.3.rs-1164718/v2
Carp	India	Anand, G., Srivastava, P. P., Varghese, T., Sahu, N. P., Harikriskna, V., Xavier, M., Jahan, I., & Patro, D. (2020). Sesbania aculeata leaf meal as replacer of de-oiled rice bran in aquaculture feed: Growth, IGF-1 expression, metabolic and biochemical responses in Cyprinus carpio (Linnaeus 1758). Aquaculture Research, 51(6), 2483–2494. https://doi.org/10.1111/are.14591
General status and opportunities	India	Ansal, M. D., & Singh, P. (2019). Development of inland saline-water aquaculture in Punjab, India. Global Aquaculture Advocate. https://www.researchgate.net/profile/Prabjeet-Singh/publication/333161512_Development_of_inland_saline-water_aquaculture_in_Punjab_India/links/5fc5c8534585152e9be822eb/Development-of-inland-saline-water-aquaculture-in-Punjab-India.pdf
Carp	India	Ansal, M. D., Dhawan, A., Singh, G., & Kaur, K. (2016). Species selection for enhancing productivity of freshwater carps in inland saline water of Punjab-A field study. Indian Journal of Ecology, 43(Special Issue-1), 45–49. https://www.researchgate.net/profile/Dhara-Gurjar/publication/320245522_Spatial_Variation_of_Groundwater_Quality_of_IARI_Farm_New_Delhi/links/5a9cca4da6fdcc3cbacd5c67/Spatial-Variation-of-Groundwater-Quality-of-IARI-Farm-New-Delhi.pdf#page=57
Marine finfish	India	Antony, J., Reddy, A. K., Sudhagar, A., Vungurala, H. K., & Roy, L. A. (2020). Effects of salinity on growth characteristics and osmoregulation of juvenile cobia, Rachycentron canadum (Linnaeus 1766), reared in potassium-amended inland saline groundwater. Journal of the World Aquaculture Society, 52(1), 155–170. https://doi.org/10.1111/jwas.12741
Penaieds (not vannamei)	India	Antony, J., Sandeep, K. P., Aravind, R., Panigrahi, A., & Balasubramanian, C. P. (2019). Growth, survival, and osmoregulation of Indian white shrimp Penaeus indicus juveniles reared in low salinity amended inland saline groundwater and seawater. Journal of Coastal Research, 86(sp1), 21. https://doi.org/10.2112/si86-004.1
Penaieds (not vannamei)	India	Antony, J., Vungurala, H., Saharan, N., Reddy, A. K., Chadha, N. K., Lakra, W. S., & Roy, L. A. (2015). Effects of salinity and Na+/K+ ratio on osmoregulation and growth performance of black tiger prawn, Penaeus monodon fabricius, 1798, juveniles reared in inland saline water. Journal of the World Aquaculture Society, 46(2), 171–182. https://doi.org/10.1111/jwas.12179
General research	India	Aralappanavar, V. K., Bharti, V. S., Mukhopadhyay, R., Prakash, S., Harikrishna, V., Bhuvaneswari, G. R., Tripathi, G., Krishna, G., & Sarkar, B. (2021). Inland saline aquaculture increased carbon accumulation rate and stability in pond sediments under semi-arid climate. Journal of Soils and Sediments, 22(2), 672–681. https://doi.org/10.1007/s11368-021-03101-y

Vannamei	India	Aruna, S., & Felix, S. (2017). The effect of ionic concentration of low saline waters on growth characteristics of Penaeus vannamei. International Journal of Fisheries and Aquatic Studies 2017; 5(3): 73-76. https://www.fisheriesjournal.com/archives/2017/vol5issue3/PartB/5-2-58-548.pdf
General research	India	Ayyappan, S., & Gopalakrishnan, A. (2008). Resilience in fisheries and sustainability of aquaculture. 8th Indian Fisheries Forum, Kolkata 22-26 November, 2008, 1–8. http://eprints.cmfri.org.in/8850/
Tilapia	India	Barman, U. K., & Garg, S. (2013). Effect of inland water salinity on growth performance and nutritive physiology in Nile tilapia: Field and laboratory studies. Journal of Nature Science and Sustainable Technology, 7(1), 29–43. https://www.proquest.com/docview/1627151167?pq-origsite=gscholar&fromopenview=true
Marine finfish	India	Barman, U. K., Jana, S. N., Garg, S. K., Bhatnagar, A., & Arasu, A. R. T. (2005). Effect of inland water salinity on growth, feed conversion efficiency and intestinal enzyme activity in growing grey mullet, Mugil cephalus (Linn.): Field and laboratory studies. Aquaculture International, 13(3), 241–256. https://doi.org/10.1007/s10499-004-2479-5
Marine finfish	India	Barman, U., Garg, S., & Bhatnagar, A. (2012). Effect of different salinity and ration levels on growth performance and nutritive physiology of milkfish, chanos chanos (forsskal) - field and laboratory studies. Fisheries and Aquaculture Journal, Annual 2012, 1–12. https://go.gale.com/ps/i.do?id=GALE%7CA357969026&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=21503508&p=AONE&sw=w&userGroupName=anon%7E37b06018
Molluscs Echinoderms	India	Belsare, S., Ghatge, S., Rathod, R., & Sukhdahane, K. (2018). Preliminary study on suitability of saline ground water of Purna River basin for development inland saline aquaculture. Contemporary Research in India, 104–108. https://www.researchgate.net/profile/Shashikant-Meshram/publication/323656107_Proximate_Composition_and_Growth_study_of_Green_Mussel_Perna_viridis_L_From_Mirya_Creek_in_Ratnagiri_MaharshtraIndia/links/5cdbad0192851c4eaba061bb/Proximate-Composition-and-Growth-study-of-Green-Mussel-Perna-viridis-L-From-Mirya-Creek-in-Ratnagiri-Maharshtra-India.pdf#page=110
Freshwater fish (not carp)	India	Bhatt, D., Kaur, V. I., Ansal, M. D., & Kumar, P. (2014). Salinity tolerance of freshwater Shubunkin gold fish, Carassius auratus (Linn.): Suitability for rearing in inland saline water. Indian Journal of Ecology, 45(4), 876–880. https://www.indianjournals.com/ijor.aspx?target=ijor:ije1&volume=45&issue=4&article=035
Crustaceans (not penaeids)	India	Chadha, N. K., Kumar, A., Agrahari, R. K., Raizada, S., Hasan, J., Rahaman, M., Kumar, S., Fielder, D. S., Kumar, D., & Maheshwari, U. K. (2007). Commercial production of giant freshwater prawn Macrobrachium rosenbergii in inland saline ground water. Fisheries and Aquaculture: Strategic Outlook for Asia. Book of Abstracts., 118. https://www.afsconferences.net/wp-content/uploads/2019/10/8AFF-Abstract-Book_20141016063123.pdf
General research	India	Chakraborty, P., & Krishnani, K. K. (2022). Climate smart eco-management of water and soil quality as a tool for fish productivity enhancement. In A. Kumar, P. Kumar, S. Singh, B. H. Trisasongko, & M. Rani (Eds.), Agriculture, Livestock

		Production and Aquaculture (pp. 277–290). Springer. https://doi.org/10.1007/978-3-030-93262-6_14
Vannamei	India	Chuphal, N., Sardar, P., Sahu, N. P., Shamna, N., Harikrishna, V., Maiti, M. K., Mannur, V. S., Jana, P., Paul, M., & Krishna, G. (2021). Effects of graded dietary lipid levels on growth, feed utilization, body composition and metabolism in juvenile white leg shrimp, Penaeus vannamei (Boone, 1931) reared in inland saline water of 10 g/L salinity. Aquaculture Nutrition, 27(6), 1811–1824. https://doi.org/10.1111/anu.13319
General status and opportunities	India	Dagar, J. (2005). Salinity research in India: An overview. Bulletin of the National Institute of Ecology, 15, 69–80. https://d1wqtxts1xzle7.cloudfront.net/72762908/Salinity_research_in_India_An_overview20211015-28008-9wmt9r.pdf?1634355844=&response-content-disposition=inline%3B+filename%3DSalinity_Research_in_India_An_Overview.pdf&Expires=1677549804&Signature=PL8TvlK8ypZXz6CKJZcRCUI1vvAiEovV6B1YF6EJCYRm5Rvdm4i3Dpfqf~EDMEFrSEwwCLtm3oUsOsvcxmXVygG1uolElv04C-oPVC5pDlyEm~26RssYHqI144REejw9BZFfVnTTdrzRsNOLR4vkL-6XSoRit-x3TLDXAU37YKK1vtl-PI1CCMf9ysr1CcnR5PoHxIrsEpH728xG8i5vFPCFOqfRgURWTYy2V-lD1q1vbj41mRbmkALv0IBJJu3BopCHMybTmToXF0jSWNZoUEDPns5HCEkcvQZ6AomRRKniIbpDSqV-85BEr~AR~WfvZrS-UtftZ0IAs6gpq5rkLg__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA
Resourcespolicysys tems	India	Das, S. K., Mandal, A., & Khairnar, S. O. (2022). Aquaculture resources and practices in a changing environment. In P. Kumar, A. Pandey, S. Kumar Singh, S. Singh, & V. Singh (Eds.), Sustainable Agriculture Systems and Technologies (pp. 169–199). https://doi.org/10.1002/9781119808565.ch8
Tilapia	India	Datta, A. N., Garg, S., & Bhatnagar, A. (2015). Effects of dietary calcium and phosphorus on growth performance and nutritive physiology of Chanos chanos (Forsskal) and Nile tilapia, Oreochromis niloticus (Linn.), kept in inland saline water. Journal of Nature Science and Sustainable Technology, 9(1). https://www.proquest.com/docview/1769723739?pq-origsite=gscholar&fromopenview=true
Freshwater fish (not carp)	India	Debroy, S., Chadha, N. K., Prakash, S., Sawant, P. B., Harikrishna, V., Pathan, M. A., Haque, R., Jana, P., & Roy, U. (2022). Effect of salinity on growth, survival, haemato-biochemical and antioxidative status of Anabas testudineus (Bloch, 1792) juveniles reared in inland saline water. Aquaculture Research, 53(18), 6832–6845. https://doi.org/10.1111/are.16149
Vannamei	India	Debroy, S., Paul, T., & Biswal, A. (2020). Shrimp culture in inland saline waters of India: A step towards sustainable aquafarming. In Food and Scientific Reports 1 (4) (pp. 84–88). https://foodandscientificreports.com/assets/uploads/issues/1588089094shrimp_culture_in_inland_saline_waters_of_india.pdf
Economics	India	Devaraj, M., Pillai, V. K., Appukuttan, K. K., Suseelan, C., Murty, V. S., Kaladharan, P., Rao, G. S., Pillai, N. G. K., Pillai, N. N., Balan, K., Chandrika, V., George, K. C., & Sobhana, K. S. (1999). Packages of practices for sustainable, ecofriendly mariculture (land-based saline aquaculture and seafarming). In M. Mohan Joseph (Ed.), Aquaculture and the Environment (pp. 33–70). Asian Fisheries Society. http://eprints.cmfri.org.in/8589/

Vannamei	India	Dorothy, M. S., Vungarala, H., Sudhagar, A., Reddy, A. K., & Rani Asanaru Majeedkutty, B. (2021). Growth, body composition and antioxidant status of Litopenaeus vannamei juveniles reared at different stocking densities in the biofloc system using inland saline groundwater. Aquaculture Research, 52(12), 6299–6307. https://doi.org/10.1111/are.15493
General status and opportunities	India	Dubey, S. K., Trivedi, R. K., & Chand, B. K. (2021). Culture possibilities of certain brackishwater species at freshwater: A climate change adaptation strategy for salinity intrusion prone areas of Indian Sundarban delta. Aquaculture Studies, 22(2). https://www.aquast.org/abstract.php?lang=en&id=534
General status and opportunities	India	Dubey, S. K., Trivedi, R. K., Chand, B. K., Mandal, B., & Rout, S. K. (2017). Farmers' perceptions of climate change, impacts on freshwater aquaculture and adaptation strategies in climatic change hotspots: A case of the Indian Sundarban delta. Environmental Development, 21, 38–51. https://doi.org/10.1016/j.envdev.2016.12.002
General research	India	Dubey, S., Singh, A., Kumar, B. T. N., Singh, N. K., & Tyagi, A. (2021). Isolation and characterization of bacteriophages from inland saline aquaculture environments to control Vibrio parahaemolyticus contamination in shrimp. Indian Journal of Microbiology, 61(2), 212–217. https://doi.org/10.1007/s12088-021-00934-6
Carp	India	Ezhilarasi, V., Verma, A. K., Babitha Rani, A. M., Harikrishna, V., Chandrakant, M. H., Ahmad, I., & Nageswari, P. (2019). Effect of different carbon sources on growth, non-specific immunity and digestive enzyme activity of amur carp (Cyprinus rubrofuscus Lacepede 1803) fingerlings in biofloc based rearing system using inland saline groundwater. Indian Journal of Fisheries, 66(3). https://doi.org/10.21077/ijf.2019.66.3.86206-11
Tilapia	India	Garg, C. K., Sardar, P., Sahu, N. P., Maiti, M. K., Shamna, N., Varghese, T., & Deo, A. D. (2023). Effect of graded levels of dietary methionine on growth performance, carcass composition and physio-metabolic responses of genetically improved farmed tilapia (GIFT) juveniles reared in inland saline water of 10 g L-1. Animal Feed Science and Technology, 115602. https://doi.org/10.1016/j.anifeedsci.2023.115602
Tilapia	India	Garg, C. K., Sardar, P., Sahu, N. P., Maiti, M. K., Shamna, N., Varghese, T., Deo, A. D., & Harikrishna, V. (2022). Dietary lysine requirement of genetically improved farmed tilapia (GIFT) juvenile reared in inland saline water of 10 g L-1 salinity. Aquaculture, 555, 738223. https://doi.org/10.1016/j.aquaculture.2022.738223
General research	India	Garg, S. (2006). Chapter 21 - Development of sustainable aquaculture technology for inland saline groundwater: Role of periphyton. In B. Pandey (Ed.), Ecology and Environment. APH Publishing. https://books.google.com.au/books?hl=en&lr=&id=5XmnKkViZrUC&oi=fnd&pg=PA195&dq=inland+saline+water+aquaculture&ots=T6xf9_2TEi&sig=wJdfbnNa1-dP2gXxRRZbA-sgrAY#v=onepage&q=inland%20saline%20water%20aquaculture&f=false
Carp	India	Garg, S. K. (1996). Brackishwater carp culture in potentially waterlogged areas using animal wastes as pond fertilizers. Aquaculture International, 4(2), 143–155. https://doi.org/10.1007/bf00140595

Tilapia	India	Garg, S. K., & Bhatnagar, S. (2017). Effect of cow dung and poultry droppings on periphyton development and growth performance of Nile tilapia, Oreochromis niloticus (L) in inland saline groundwater ponds. Asian Journal of Experimental Science, 31(2), 1–16. http://www.ajesjournal.com/PDFs/2017-2/PP1.pdf
Marine finfish	India	Garg, S., Barman, U., & Bhatnagar, A. (2013). Optimization of fertilization rate for maximizing periphyton production on additional substrate and growth performance of milkfish in inland saline groundwater ponds. Journal of Nature Science and Sustainable Technology, 7(2), 139–157. https://www.proquest.com/docview/1626716726?pq-origsite=gscholar&fromopenview=true
Tilapia	India	Garg, S., Bhatnagar, S., Sudhir, C., & Garg, K. (2016). Influence of periphyton substrate density on hydrobiological characteristics and growth performance of Nile tilapia, Oreochromis niloticus (Linnaeus 1758) stocked in inland saline groundwater ponds. International Journal of Fisheries and Aquatic Studies, 4(4), 444–452. https://www.fisheriesjournal.com/archives/2016/vol4issue4/PartF/4-4-13-471.pdf
Economics	India	Giri, S., Daw, T. M., Hazra, S., Troell, M., Samanta, S., Basu, O., Marcinko, C. L. J., & Chanda, A. (2022). Economic incentives drive the conversion of agriculture to aquaculture in the Indian Sundarbans: Livelihood and environmental implications of different aquaculture types. Ambio, 51(9), 1963–1977. https://doi.org/10.1007/s13280-022-01720-4
General status and opportunities	India	Gopakumar, K. (2003). Indian aquaculture. Journal of Applied Aquaculture, 13(1-2), 1–10. https://doi.org/10.1300/j028v13n01_01
Carp	India	Iffat, J., Tiwari, V. K., Pavan-Kumar, A., Verma, A. K., Harikrishna, V., Babitha Rani, A. M., Chadha, N. K., & Anand, G. (2020). The effect of inland saline groundwater on growth, maturation, and osmoregulation of common carp. North American Journal of Aquaculture, 83(1), 15–25. https://doi.org/10.1002/naaq.10165
Carp	India	Iffat, J., Tiwari, V. K., Verma, A. K., & Pavan-Kumar, A. (2020). Effect of different salinities on breeding and larval development of common carp, Cyprinus carpio (Linnaeus, 1758) in inland saline groundwater. Aquaculture, 518, 734658. https://doi.org/10.1016/j.aquaculture.2019.734658
Vannamei	India	Jaffer, Y. D., Saraswathy, R., Ishfaq, M., Antony, J., Bundela, D. S., & Sharma, P. C. (2020). Effect of low salinity on the growth and survival of juvenile pacific white shrimp, Penaeus vannamei: A revival. Aquaculture, 515, 734561. https://doi.org/10.1016/j.aquaculture.2019.734561
Vannamei	India	Jahan, I., Ahmad Dar, S., Anand, G., Singh, S., Reddy, A. K., Sudhagar, A., Harikrishna, V., & Srivastava, P. P. (2017). Enzymatic alterations in Litopenaeus vannamei (Boone, 1931) juveniles exposed to different levels of dietary potassium and magnesium reared in inland saline water. International Journal of Current Microbiology and Applied Sciences, 6(11), 773–780. https://doi.org/10.20546/ijcmas.2017.611.091
Vannamei	India	Jahan, I., Reddy, A. K., Srivastava, P. P., Harikrishna, V., S. Sudhagar, A., & Singh, S. (2017). Histo-Architectural changes in the selected tissues of Litopenaeus vannamei (Boone, 1931) juveniles reared in inland ground saline water (IGSW) fed with graded levels of potassium (K+) and magnesium (Mg2+) through feed. International Journal of Current Microbiology

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Vannamei	India	Jahan, I., Reddy, A. K., Sudhagar, S. A., Harikrishna, V., Singh, S., Varghese, T., & Srivastava, P. P. (2018). The effect of fortification of potassium and magnesium in the diet and culture water on growth, survival and osmoregulation of Pacific white shrimp, Litopenaeus vannamei reared in inland ground saline water. Turkish Journal of Fisheries and Aquatic Sciences, 18(10). https://doi.org/10.4194/1303-2712-v18_10_10
Carp	India	Jahan, I., Tiwari, V., & Ranjan, A. (2020). Effect of salinity on lipid profile of Cyprinus carpio reared in inland saline water. Journal of Environmental Biology, 41, 228–233. http://www.jeb.co.in/journal_issues/202003_mar20/paper_12.pdf
Crustaceans (not penaeids)	India	Jain, A. K., Raju, K. D., Kumar, G., Ojha, P. K., & Reddy, K. (2007). Strategic manipulation of inland saline groundwater to produce Macrobrachium rosenbergii (De Man) post larvae. Journal of Biological Research-Thessaloniki, 8, 151–157. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=3f815f784139425151549891a8db819510cad11b
Crustaceans (not penaeids)	India	Jain, K., Gupta, R., & Singh, B. (2008). Specific growth rate and proximate carcass composition of fresh-water prawn cultured in different salinity conditions in fresh water ponds of Haryana. Livestock Research for Rural Development, 20(7). http://www.lrrd.cipav.org.co/lrrd20/7/jain20111.htm
General status and opportunities	India	James, C. (2000). Potential of marine fish farming in India. http://library.enaca.org/Grouper/E-Newsletter/Potential_of_marine_fish_farming_in_India.pdf
Vannamei	India	Jana, P., Prasad Sahu, N., Sardar, P., Shamna, N., Varghese, T., Dharmendra Deo, A., Harikrishna, V., Paul, M., Panmei, H., Gupta, G., Nanda, C., & Krishna, G. (2021). Dietary protein requirement of white shrimp, Penaeus vannamei (Boone, 1931) juveniles, reared in inland ground water of medium salinity. Aquaculture Research, 52(6), 2501–2517. https://doi.org/10.1111/are.15100
Vannamei	India	Jana, P., Sahu, N. P., Sardar, P., Varghese, T., Deo, A. D., Shamna, N., Harikrishna, V., Paul, M., Chuphal, N., & Krishna, G. (2022). Dietary lipid requirement of juvenile white-leg shrimp, Penaeus vannamei (Boone, 1931) reared in inland ground saline water of 15 g L-1. Aquaculture Research, 53(15), 5270–5286. https://doi.org/10.1111/are.16012
Marine finfish	India	Jana, S. N., Garg, S. K., & Patra, B. C. (2004). Effect of periphyton on growth performance of grey mullet, Mugil cephalus (Linn.), in inland saline groundwater ponds. Journal of Applied Ichthyology, 20(2), 110–117. https://doi.org/10.1046/j.1439-0426.2003.00530.x
Marine finfish	India	Jana, S. N., Garg, S. K., & Patra, B. C. (2006). Effect of inland water salinity on growth performance and nutritional physiology in growing milkfish, Chanos chanos (Forsskal): field and laboratory studies. Journal of Applied Ichthyology, 22(1), 25–34. https://doi.org/10.1111/j.1439-0426.2006.00698.x
Marine finfish	India	Jana, S. N., Garg, S. K., Barman, U. K., Arasu, A. R. T., & Patra, B. C. (2006). Effect of varying dietary protein levels on growth and production of Chanos chanos (Forsskal) in inland saline groundwater: laboratory and field studies. Aquaculture

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Marine finfish	India	Jana, S. N., Garg, S. K., Thirunavukkarasu, A. R., Bhatnagar, A., Kalla, A., & Patra, B. C. (2006). Use of additional substrate to enhance growth performance of milkfish,chanos chanos(Forsskal) in inland saline groundwater ponds. Journal of Applied Aquaculture, 18(1), 1–20. https://doi.org/10.1300/j028v18n01_01
Vannamei	India	Jarwar, A. (2015). Water quality in inland saline aquaculture ponds and its relationships to shrimp survival and production [PhD]. In etd.auburn.edu (pp. 1–87). http://etd.auburn.edu/handle/10415/4915
Vannamei	India	Jateen, S., Bharti, V. S., Prakash, S., Krishnan, S., Paul, T., & Kumar, S. (2023). Sugarcane bagasse biochar-amended sediment improves growth, survival, and physiological profiles of white-leg shrimp, Litopenaeus vannamei (Boone, 1931) reared in inland saline water. Aquaculture International. https://doi.org/10.1007/s10499-023-01077-9
Vannamei	India	Javith, M. A., Balange, A. K., Xavier, M., Hassan, Md. A., Sanath Kumar, H., Nayak, B. B., & Krishna, G. (2020). Comparative studies on the chemical composition of inland saline reared Litopenaeus vannamei. Journal of Culinary Science & Technology, 20(4), 336–349. https://doi.org/10.1080/15428052.2020.1840474
Vannamei	India	Joshi, V. (2019). Production of white leg shrimp (Litopenaeus vannamei) in inland saline waters of India. Advanced Agricultural Research & Technology Journal, 3(2), 157–162. http://www.isasat.org/Volume-iii,issue-2-July-2019/5_AARJ_III_2_2019_Joshi_157-162.pdf
Environmental	India	Kagoo, E., & Rajalakshmi, N. (2002). Environmental and social conflicts of aquaculture in Tamilnadu and Andhra Pradesh. Journal of Social and Economic Development, 13–26. http://www.isec.ac.in/JSED/JSED_V4_I1_13-26.pdf
Environmental	India	Kamra, S.K. (2014). An overview of subsurface drainage for management of waterlogged saline soils of India. Water and Energy International, 58r(6), 46–53. https://www.indianjournals.com/ijor.aspx?target=ijor:wei&volume=58r&issue=6&article=008
General status and opportunities	India	Koshy, N. E. (2021). A case for a human rights-based approach to Indian aquaculture systems: A literature review. In aquadocs.org. International Collective in Support of Fishworkers (ICSF). https://aquadocs.org/handle/1834/42134
Resourcespolicysystems	India	Krishnakumar, P., Lakshumanan, C., Kishore, V. P., Sundararajan, M., Santhiya, G., & Chidambaram, S. (2013). Assessment of groundwater quality in and around Vedaraniyam, South India. Environmental Earth Sciences, 71(5), 2211–2225. https://doi.org/10.1007/s12665-013-2626-2
Vannamei	India	Kuldeep, K. L. (2022). Training manual on shrimp culture and disease management in inland saline areas. ICAR-Central Institute of Brackishwater Aquaculture. https://ciba.icar.gov.in/wp-content/uploads/2022/12/Final-Training-Manual-shrimp-culture-and-disease-managment_c.pdf#page=52

Freshwater fish (not carp)	India	Kumar, A., Bhatnagar, A., & Garg, S. (2009). Growth performance, carcass composition and digestive enzyme activity of pearlspot, Etroplus suratensis (Bloch) reared in inland saline groundwater ponds providing substrate or feed. Livestock Research for Rural Development, 21(Article #180). http://www.lrrd.cipav.org.co/lrrd21/10/kuma21180.htm
General research	India	Kumar, A., Datta, N., Garg, S., & Bhatnagar, A. (2013). Role of Azotobacter, Pseudomonas and Gluconacetobacter in managing nutrient status and fish growth in inland saline groundwater ponds. Journal of Nature Science and Sustainable Technology, 7(2), 161–181. https://www.proquest.com/docview/1626715943?pq-origsite=gscholar&fromopenview=true
Freshwater fish (not carp)	India	Kumar, A., Harikrishna, V., Reddy, A., Chadha, N., & Babitha Rani, A. (2016). Effect of salinity on proximate composition of Pangasianodon hypophthalmus reared in inland saline water. International Journal of Zoological Studies, 1(3), 19–21. https://www.researchgate.net/publication/327339396_Effect_of_salinity_on_proximate_composition_of_Pangasianodon_hypophthalmus_reared_in_inland_saline_water
Freshwater fish (not carp)	India	Kumar, A., Harikrishna, V., Reddy, A., Chadha, N., & Babitha Rani, A. (2017). Salinity tolerance of Pangasianodon hypophthalmus in inland saline water: Effect on growth, survival and haematological parameters. Eco. Env. & Cons, 23(1), 475–482. https://www.researchgate.net/publication/312777447_Salinity_Tolerance_of_Pangasianodon_hypophthalmus_in_Inland_Saline_Water_Effect_on_Growth_Survival_and_Haematological_Parameters
Vannamei	India	Kumar, A., Reddy, A., Babita Rani, A., Rathore, G., & Lakra, W. (2018). Growth and digestive enzymatic activity of Litopenaeus vannamei raised in bio floc systems with different C/N ratios in ground saline water. Journal of Entomology and Zoology Studies, 6(4), 1166–1171. https://www.researchgate.net/profile/Appidi-Krishna-Reddy/publication/327051103_Growth_and_digestive_enzymatic_activity_of_Litopenaeus_vannamei_raised_in_bio_floc_systems_with_different_CN_ratios_in_ground_saline_water/links/5b7518aba6fdcc87df8041ac/Growth-and-digestive-enzymatic-activity-of-Litopenaeus-vannamei-raised-in-bio-floc-systems-with-different-C-N-ratios-in-ground-saline-water.pdf
General research	India	Kumar, A., Reddy, A., Rani, A. B., Rathore, G., Lakra, W., & Jayant, M. (2019). Water quality and nutrient dynamics of biofloc with different C/N ratios in inland saline water. Journal of Animal Research, 9(5). https://www.indianjournals.com/ijor.aspx?target=ijor:jar&volume=9&issue=5&article=023
Integrated ISA Agriculture	India	Kumar, M. S. (2002). Integrated farming for sustainable primary industry: Water and nutrient recycling through integrated aquaculture. In K. Warburton, U. Pillai-Mcgarry, & D. Ramage (Eds.), Integrated biosystems for sustainable development Proceedings of the InFoRM 2000 National Workshop on Integrated Food Production and Resource Management. RIRDC Publication No 01/174. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0e24fa77a494929f5cca103ea563643a6dd5f26e#page=70

Carp	India	Kumar, M. U., Ansal, M. D., & Kaur, V. I. (2014). Salinity tolerance and survival of freshwater carp, Labeo rohita Ham. (rohu) in inland saline water. Indian Journal of Ecology, 45(4), 872–875. https://www.indianjournals.com/ijor.aspx?target=ijor:ije1&volume=45&issue=4&article=034
Integrated ISA Agriculture	India	Kumar, N., Kumar, A., Marwein, B. M., Kumar Verma, D., Jayabalan, I., Kumar, A., & Ramamoorthy, D. (2021). Agricultural activities causing water pollution and its mitigation -a review. International Journal of Modern Agriculture, 10(1), 590–609. https://www.researchgate.net/profile/Agam-Kumar-2/publication/350276392_AGRICULTURAL_ACTIVITIES_CAUSING_WATER_POLLUTION_AND_ITS_MITIGATION_-A_REVIEW/links/60583d59a6fdccbfeaf84b4a/AGRICULTURAL-ACTIVITIES-CAUSING-WATER-POLLUTION-AND-ITS-MITIGATION-A-REVIEW.pdf
General status and opportunities	India	Kumar, P., & Sharma, P. K. (2020). Soil salinity and food security in India. Frontiers in Sustainable Food Systems, 4. https://doi.org/10.3389/fsufs.2020.533781
Economics	India	Kumar, P., Kaur, H., & Sharma, S. K. (2017). Aquaculture for doubling the farmer's income. Agro-Economist, 4(2), 99. https://doi.org/10.5958/2394-8159.2017.00017.2
Economics	India	Kumari, A., Ansal, M. D., Singh, P., & Holyappa, S. A. (2014). Evaluation of aquaculture units established in inland salt affected areas of district Fazilka, Punjab. Indian Journal of Ecology, 46(1), 196–200. https://www.indianjournals.com/ijor.aspx?target=ijor:ije1&volume=46&issue=1&article=034
Tilapia	India	Kumari, S., Harikrishna, V., Surasani, V. K. R., Balange, A. K., & Babitha Rani, A. M. (2021). Growth, biochemical indices and carcass quality of red tilapia reared in zero water discharge based biofloc system in various salinities using inland saline ground water. Aquaculture, 540, 736730. https://doi.org/10.1016/j.aquaculture.2021.736730
General status and opportunities	India	Lakra, W. S., & Gopalakrishnan, A. (2021). Blue revolution in India: Status and future perspectives. Indian Journal of Fisheries, 68(1). https://doi.org/10.21077/ijf.2021.68.1.109283-19
Economics	India	Lakra, W. S., & Krishnani, K. K. (2022). Circular bioeconomy for stress-resilient fisheries and aquaculture. In S. Varjani, A. Pandey, T. Bhaskar, S. V. Mohan, & D. C. W. Tsang (Eds.), Biomass, Biofuels, Biochemicals. Circular Bioeconomy: Technologies for Biofuels and Biochemicals (pp. 481–516). Elsevier. https://www.sciencedirect.com/science/article/pii/B9780323898553000108
Marine finfish	India	Linga Prabu, D., Ebeneezar, S., Chandrasekar, S., Anikuttan, K. K., Sayooj, P., & Vijayagopal, P. (2021). Culture of snubnose pompano, Trachinotus blochii (Lacepede, 1801) in indigenous re-circulatory aquaculture system using low cost fishmeal-based diet. Indian Journal of Geo Marine Sciences, 50(10), 787–794. http://eprints.cmfri.org.in/15839/
Vannamei	India	Maiti, M. K., Sahu, N. P., Sardar, P., Garg, C. K., Varghese, T., Shamna, N., Deo, A. D., & Harikrishna, V. (2022). Dietary lysine requirement of juvenile Pacific white shrimp, Litopenaeus vannamei (Boone, 1931) reared in inland saline water of 10 g L-1 salinity. Animal Feed Science and Technology, 291, 115378. https://doi.org/10.1016/j.anifeedsci.2022.115378

Integrated ISA Agriculture	India	Meena, L. L., Verma, A. K., Bharti, V. S., Nayak, S. K., Chandrakant, M. H., Haridas, H., Reang, D., Javed, H., & John, V. C. (2022). Effect of foliar application of potassium with aquaculture wastewater on the growth of okra (Abelmoschus esculentus) and Pangasianodon hypophthalmus in recirculating aquaponic system. Scientia Horticulturae, 302, 111161. https://doi.org/10.1016/j.scienta.2022.111161
Tilapia	India	Menaga, M., & Fitzsimmons, K. (2017). Growth of the tilapia industry in India. World Aquaculture, 49–52. https://www.researchgate.net/profile/Kevin-Fitzsimmons-4/publication/319681169_Growth_of_the_tilapia_industry_in_India/links/59b9501d458515bb9c486c4f/Growth-of-the-tilapia-industry-in-India.pdf
Carp	India	Murmu, K., Rasal, K. D., Rasal, A., Sahoo, L. D., Nandanpawar, P. C., Udit, U. K., Patnaik, M., Mahapatra, K. D., & Sundaray, J. K. (2019). Effect of salinity on survival, hematological and histological changes in genetically improved rohu (Jayanti), Labeo rohita (Hamilton, 1822). Indian Journal of Animal Research, 54(6), 673–678. https://doi.org/10.18805/ijar.b-3801
Resourcespolicysys tems	India	Nageswara Rao, K., Swarna Latha, P., & Ramesh Kumar, P. V. (2021). Groundwater quality assessment for irrigation use in the Godavari delta region of east coast India using IRWQI and GIS. Water Supply, 22(3), 2612–2629. https://doi.org/10.2166/ws.2021.454
Freshwater fish (not carp)	India	Nageswari, P., Verma, A. K., Gupta, S., Jeyakumari, A., & Chandrakant, M. H. (2022). Optimization of stocking density and its impact on growth and physiological responses of Pangasianodon hypophthalmus (Sauvage, 1878) fingerlings reared in finger millet based biofloc system. Aquaculture, 551, 737909. https://doi.org/10.1016/j.aquaculture.2022.737909
Crustaceans (not penaeids)	India	Nair, C. M., & Salin, K. R. (2012). Current status and prospects of farming the giant river prawn Macrobrachium rosenbergii (De Man) and the monsoon river prawn Macrobrachium malcolmsonii (H.M. Edwards) in India. Aquaculture Research, 43(7), 999–1014. https://doi.org/10.1111/j.1365-2109.2011.03074.x
General research	India	Nalle, D. A., Deshmukh, A. R., & Shembekar, V. S. (2021). Effective utilization of Azotobacter chroococcum, Pseudomonas and Gluconacetobacter diazotrophicus on fish growth status in freshwater and inland saline water. International Journal for Innovative Research in Multidisciplinary Field Specila Issue - 22, 96–102. https://www.researchgate.net/profile/Rajkumar-Pawar-2/publication/350958088_International_Web_Conference_on_Recent_Advances_in_Freshwater_Aquaculture_Special_Issue/links/607c5668907dcf667bab3da1/International-Web-Conference-on-Recent-Advances-in-Freshwater-Aquaculture-Special-Issue.pdf#page=97
Vannamei	India	Nathaniel, T. Paul., Varghese, T., Sahu, N. P., Panmei, H., Krishna, G., & Dasgupta, S. (2023). The effects of non-lethal heat-shock-induced cross-protection on survival and growth of Pacific whiteleg shrimp, Litopenaeus vannamei in response to ionic stress in inland saline waters. Aquaculture, 568, 739287. https://doi.org/10.1016/j.aquaculture.2023.739287
Vannamei	India	Nesapriyam, P. J., Mathew, R., Vidya, A., Rajalekshmi, M., Kaippilly, D., & Geeji, M. T. (2022). Mineral supplementation in low saline culture of Pacific white shrimp—Effects on growth and water quality. Aquaculture Research, 53(6), 2501–2508. https://doi.org/10.1111/are.15767

Vannamei	India	Pandey, A., Pathan, M. A., Ananthan, P. S., Sudhagar, A., Krishnani, K. K., Sreedharan, K., Kumar, P., Thirunavukkarasar, R., & Harikrishna, V. (2023). Stocking for sustainable aqua-venture: optimal growth, yield and economic analysis of Penaeus vannamei culture in inland saline water (ISW) of India. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-023-02993-9
Carp	India	Patel, R. K., Verma, A. K., Krishnani, K. K., Sreedharan, K., & Chandrakant, M. H. (2022). Growth performance, physio-metabolic, and haemato-biochemical status of Labeo rohita (Hamilton, 1822) juveniles reared at varying salinity levels using inland saline groundwater. Aquaculture, 559, 738408. https://doi.org/10.1016/j.aquaculture.2022.738408
Marine finfish	India	Pathak, M. S., Lakra, W. S., Reddy, A. K., Chadha, N., Tiwari, V., & Srivastava, P. (2019). Growth and survival of silver pompano Trachinotus blochii (Lacepede, 1801) at different salinities in inland saline ground water. Indian Journal of Animal Sciences, 89(5). https://doi.org/10.56093/ijans.v89i5.90033
Vannamei	India	Pathak, M., Reddy, A. K., Kulkarni, M., Harikrishna, V., Srivastava, P. P., Chadha, N., & Lakra, W. S. (2018). Histological alterations in the hepatopancreas and growth performance of Pacific white shrimp (Litopenaeus vannamei, Boone 1931) reared in potassium fortified inland saline ground water. Article in International Journal of Current Microbiology and Applied Sciences, 7(4). https://doi.org/10.20546/ijcmas.2018.704.398
Carp	India	Patro, D., Srivastava, P. P., Varghese, T., Gupta, S., Kumar, P., & Prabhakaran, A. (2021). Evaluation of growth and biochemical responses of Cyprinus carpio reared in freshwater and inland saline water. Journal of the Marine Biological Association of India, 63(1), 25–30. https://doi.org/10.6024/jmbai.2021.63.1.2150-04
Vannamei	India	Pattusamy, A., Hittinahalli, C. M., Chadha, N. K., Sawant, P. B., Krishna, H., & Verma, A. K. (2022). Water budgeting for culture of Penaeus vannamei (Boone, 1931) in earthen grow-out ponds using inland saline groundwater. Aquaculture Research, 53(12), 4521–4530. https://doi.org/10.1111/are.15949
Tilapia	India	Paul, M., Sardar, P., Sahu, N. P., Deo, A. D., Varghese, T., Shamna, N., Jana, P., & Krishna, G. (2022). Effect of dietary protein level on growth and metabolism of GIFT juveniles reared in inland ground saline water of medium salinity. Journal of Applied Aquaculture, 1–27. https://doi.org/10.1080/10454438.2022.2054672
Tilapia	India	Paul, M., Sardar, P., Sahu, N. P., Jana, P., Deo, A. D., Harikrishna, V., Varghese, T., Shamna, N., Kumar, P., & Krishna, G. (2022). Effect of dietary lipid level on growth performance, body composition, and physiometabolic responses of genetically improved farmed tilapia (GIFT) juveniles reared in inland ground saline water. Aquaculture Nutrition, 2022, 1–15. https://doi.org/10.1155/2022/5345479
Tilapia	India	Paul, M., Sardar, P., Sahu, N. P., Varghese, T., Shamna, N., Harikrishna, V., Deo, A. D., Jana, P., Singha, K. P., Gupta, G., Kumar, M., & Krishna, G. (2022). Optimal dietary protein requirement of juvenile GIFT tilapia (Oreochromis niloticus) reared in inland ground saline water. Journal of Environmental Biology, 43(2), 205–215. https://doi.org/10.22438/jeb/43/2/mrn-1905
General status and opportunities	India	Pillai, N., & Katiha, P. K. (2004). Evolution of fisheries and aquaculture in India (p. 240). Central Marine Fisheries

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Vannamei	India	Prabu, E., Felix, N., Ahilan, B., Uma, A., & Manikandan, K. (2020). Culture of Pacific white shrimp, Penaeus vannamei in low saline waters through water adaptations and diet modifications. Journal of Aquaculture in the Tropics, 34(3-4), 171–179. http://dx.doi.org/10.32381/JAT.2019.34.3-4.4
Algae seaweed	India	Pravesh, K. O., Bharti, V., Vennila, A., Shukla, S., Harikrishna, V., Gladston, Y., & Aravind, R. (2017). Efficacy of an integrated system incorporated with Eichhornia crassipes in phytoremediation of calcium from inland saline water. Nature Environment and Pollution Technology, 16(3), 687–694. https://neptjournal.com/upload-images/NL-61-4-(2)B-3434.pdf
Environmental	India	Prayag, A. G., Zhou, Y., Srinivasan, V., Stigter, T., & Verzijl, A. (2023). Assessing the impact of groundwater abstractions on aquifer depletion in the Cauvery Delta, India. Agricultural Water Management, 279, 108191. https://doi.org/10.1016/j.agwat.2023.108191
Penaieds (not vannamei)	India	Purushothaman, C. S., Raizada, S., Sharma, V. K., Harikrishna, V., Venugopal, G., Agrahari, R. K., Rahaman, M., Hasan, J., & Kumar, A. (2014). Production of tiger shrimp (Penaeus monodon) in potassium supplemented inland saline sub-surface water. Journal of Applied Aquaculture, 26(1), 84–93. https://doi.org/10.1080/10454438.2014.882214
General status and opportunities	India	Puthucherril, T. G. (2016). Sustainable aquaculture in India: Looking back to think ahead. Aquaculture Law and Policy, 289–312. https://doi.org/10.4337/9781784718114.00022
Vannamei	India	Raghuvaran, N., Sardar, P., Sahu, N. P., Shamna, N., Jana, P., Paul, M., Bhusare, S., & Bhavatharaniya, U. (2023). Effect of L-carnitine supplemented diets with varying protein and lipid levels on growth, body composition, antioxidant status and physio-metabolic changes of white shrimp, Penaeus vannamei juveniles reared in inland saline water. Animal Feed Science and Technology, 296, 115548. https://doi.org/10.1016/j.anifeedsci.2022.115548
Crustaceans (not penaeids)	India	Raizada, S., Javed, H., Ayyappan, S., Mukhergee, S. C., Maheshwari, U. K., & Fielder, D. S. (2013). Hatchery seed production of giant freshwater prawn, Macrobrachium rosenbergii using inland ground saline water in India. Aquaculture Research, 46(1), 49–58. https://doi.org/10.1111/are.12158
Crustaceans (not penaeids)	India	Raizada, S., Kumar, A., Hasan, J., Kumar, S., Chadha, N. K., Rahaman, M., Agrahari, R. K., Fielder, D. S., Maheshwari, U. K., & Kumar, D. (2007). The growth and survival of giant freshwater prawn Macrobrachium rosenbergii in potassium amended inland saline water. Fisheries and Aquaculture: Strategic Outlook for Asia. Book of Abstracts., 135. https://www.afsconferences.net/wp-content/uploads/2019/10/8AFF-Abstract-Book_20141016063123.pdf
Penaieds (not vannamei)	India	Raizada, S., Purushothaman, C. S., Sharma, V. K., Harikrishna, V., Rahaman, M., Agrahari, R. K., Hasan, J., Venugopal, G., & Kumar, A. (2014). Survival and growth of tiger shrimp (Penaeus monodon) in inland saline water supplemented with potassium. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 85(2), 491–497. https://doi.org/10.1007/s40011-014-0372-1

Resourcespolicysys tems	India	Raju, P., Reddy, M., Raghuram, P., Suri Babu, G., Rambabu, T., Kumar, J., Reddy, P., Raghuram, G., Suri Babu, T., Rambabu, J., & Kumar. (2014). Alkalinity and hardness variation in ground waters of east Godavari district due to aquaculture. International Journal of Fisheries and Aquatic Studies, 1(6), 121–127. https://www.researchgate.net/profile/Golla/publication/346670362_Alkalinity_and_Hardness_Variation_in_Ground_Waters_of_East_Godavari_District_due_to_Aquaculture/links/5fcdbd34299bf188d4fd7fb0/Alkalinity-and-Hardness-Variation-in-Ground-Waters-of-East-Godavari-District-due-to-Aquaculture.pdf
Vannamei	India	Rao, D. V., Borana, K., Shrivastava, P., Rao, K., Borana, P., & Shrivastava. (2022). Litopenaeus vannamei (whiteleg shrimp) farming in Indian inland saline ecosystem. ~ 68 ~ International Journal of Fauna and Biological Studies, 9(3), 68–72. https://www.faunajournal.com/archives/2022/vol9issue3/PartA/9-3-10-775.pdf
Environmental	India	Raul, C., Bharti, V. S., Dar Jaffer, Y., Lenka, S., & Krishna, G. (2020). Sugarcane bagasse biochar: Suitable amendment for inland aquaculture soils. Aquaculture Research, 52(2), 643–654. https://doi.org/10.1111/are.14922
General research	India	Raul, C., Prakash, S., Lenka, S., & Bharti, V. S. (2021). Sugarcane bagasse biochar: A suitable amendments for inland saline pond water productivity. Journal of Environmental Biology, 42(5), 1264–1273. https://doi.org/10.22438/jeb/42/5/mrn-1702
General status and opportunities	India	Raul, C., Priyadarshi, S., Bharti, V. S., & Prakash, S. (2019). Biochar: An emerging solution for sustainable aquaculture. World Aquaculture, 64–65. https://www.researchgate.net/profile/Chittaranjan-Raul/publication/337759327_Biochar_An_Emerging_Solution_for_Sustainable_Aquaculture/links/5de8d1d1299bf10bc3406764/Biochar-An-Emerging-Solution-for-Sustainable-Aquaculture.pdf
Vannamei	India	S, M. A. J., Xavier, K. M., Nayak, B. B., Kumar, H. S., & Balange, A. K. (2023). Comparative quality evaluation of frozen stored Litopenaeus vannamei reared in inland saline water and brackish water. Fishery Technology, 60, 48–54. https://www.researchgate.net/publication/368477851
Vannamei	India	Sahadevan, P. (2022). Studies on shrimp aquaculture in Kerala (p. 515) [PhD Thesis]. http://117.232.76.121/bitstream/handle/20.500.12818/765/1605.pdf?sequence=1&isAllowed=y
Environmental	India	Saini, J., & Pandey, S. (2022). Environmental threat and change detection in saline lakes from 1960 to 2021: Background, present, and future. Environmental Science and Pollution Research, 30(1), 78–89. https://doi.org/10.1007/s11356-022-23981-y
Vannamei	India	Salunke, M., Kalyankar, A., Khedkar, C. D., Shingare, M., & Khedkar, G. D. (2020). A review on shrimp aquaculture in India: Historical perspective, constraints, status and future implications for impacts on aquatic ecosystem and biodiversity. Reviews in Fisheries Science & Aquaculture, 28(3), 1–20. https://doi.org/10.1080/23308249.2020.1723058
Vannamei	India	Samadan, G., Rustadi, & Djumanto. (2018). Production performance of whiteleg shrimp Litopenaeus vannamei at different stocking densities reared in sand ponds using plastic mulch. Aquaculture, Aquarium, Conservation and Legislation, 11(4), 1213–1221. http://www.bioflux.com.ro/aacl

Vannamei	India	Sanathkumar, H., Ravi, C., Padinhatupurayil, S. B., Mol, M., Prasad, J. K., & Nayak, B. B. (2014). Microbiological investigation of persistent mortalities in Litopenaeus vannamei grown in low saline waters in India. Journal of Aquatic Animal Health, 26(3), 154–159. https://doi.org/10.1080/08997659.2014.902875
Algae seaweed	India	Sandeep, K. P., Shukla, S. P., Harikrishna, V., Muralidhar, A. P., Vennila, A., Purushothaman, C. S., & Ratheesh Kumar, R. (2013). Utilization of inland saline water for Spirulina cultivation. Journal of Water Reuse and Desalination, 3(4), 346–356. https://doi.org/10.2166/wrd.2013.102
Penaieds (not vannamei)	India	Shakeeb-Ur-Rahman, Jain, A. K., Reddy, A. K., Kumar, G., & Raju, K. D. (2005). Ionic manipulation of inland saline groundwater for enhancing survival and growth of Penaeus monodon (Fabricius). Aquaculture Research, 36(12), 1149–1156. https://doi.org/10.1111/j.1365-2109.2005.01322.x
General status and opportunities	India	Sharma, D. K., & Singh, A. (2015). Salinity research in India - achievements, challenges and future prospects. Water and Energy International, 58(6), 35–45. https://krishi.icar.gov.in/jspui/handle/123456789/3367
Environmental	India	Sharma, D., & Singh, A. (2017). Reclamation and management strategies under salty soils. In 5th National Seminar - Climate Resilient Saline Agriculture: Sustaining Livelihood Security 2017. https://krishi.icar.gov.in/jspui/bitstream/123456789/3859/1/Reclamation%20and%20Management%20Strategies%20under%20Salty%20Soils.pdf
Carp	India	Sharma, K., Dey, A., Kumar, S., Chaudhary, B. K., Mohanty, S., Kumar, T., Prasad, S. S., & Bhatt, B. P. (2020). Effect of salinity on growth, survival and biochemical alterations in the freshwater fish Labeo rohita (Hamilton 1822). Indian Journal of Fisheries, 67(2). https://doi.org/10.21077/ijf.2019.67.2.86894-06
Carp	India	Sharma, M., Kaur, V. I., & Ansal, M. D. (2017). Physiological responses of freshwater ornamental fish koi carp, Cyprinus carpio (L.) in inland saline water: Growth and hematological changes. Indian Journal of Ecology, 44(4), 864–868. https://www.researchgate.net/profile/Vaneet-Kaur-3/publication/322930435_Physiological_Responses_of_Freshwater_Ornamental_Fish_Koi_Carp_Cyprinus_carpio_L_in_Inland_Saline_water_Growth_and_Hematological_Changes/links/5c52e25292851c22a39d9e33/Physiological-Responses-of-Freshwater-Ornamental-Fish-Koi-Carp-Cyprinus-carpio-L-in-Inland-Saline-water-Growth-and-Hematological-Changes.pdf
General research	India	Singh, B., Tyagi, A., Billekallu Thammegowda, N. K., & Ansal, M. D. (2018). Prevalence and antimicrobial resistance of vibrios of human health significance in inland saline aquaculture areas. Aquaculture Research, 49(6), 2166–2174. https://doi.org/10.1111/are.13672
Environmental	India	Singh, G. (2009). Salinity-related desertification and management strategies: Indian experience. Land Degradation & Development, 20(4), 367–385. https://doi.org/10.1002/ldr.933
Carp	India	Singh, G., Ansal, M. D., & Kaur, V. I. (2018). Salinity tolerance and survival of freshwater carp, Cyprinus carpio linn. in inland saline water. Indian Journal of Ecology, 45(3), 598–601. https://www.indianjournals.com/ijor.aspx?target=ijor:ije1&volume=45&issue=3&article=030

Vannamei	India	Singh, P., Tyagi, A., & Kumar, B. N. (2020). Impact of shrimp farming technology for economic upliftment of rural societies in inland saline areas of Punjab. Journal of Krishi Vigyan, 9(si), 172–179. http://dx.doi.org/10.5958/2349-4433.2020.00100.2
Carp	India	Singh, S., & Srivastava, P. (2019). Influence of different salinity on carcass composition of Amur carp (Cyprinus carpio haematopterus) reared in semi-arid region of India. Journal of Experimental Zoology India, 22(1), 633–637. https://www.researchgate.net/profile/Appidi-Krishna-Reddy/publication/332671760_INFLUENCE_OF_DIFFERENT_SALINITY_ON_CARCASS_COMPOSITION_OF_AMUR_CARP_CYPRINUS_CARPIO_HAEMATOPTERUS_REARED_IN_SEMI-_ARID_REGION_OF_INDIA/links/5cc2cc25299bf120977fbdab/INFLUENCE-OF-DIFFERENT-SALINITY-ON-CARCASS-COMPOSITION-OF-AMUR-CARP-CYPRINUS-CARPIO-HAEMATOPTERUS-REARED-IN-SEMI-ARID-REGION-OF-INDIA.pdf
General status and opportunities	India	Singh, S., Jahan, I., Sharma, A., & Misra, V. K. (2017). Inland saline aquaculture-a hope for farmers. International Journal of Global Science Research, 4(2). https://doi.org/10.26540/ijgsr.v4.i2.2017.80
Carp	India	Singh, S., Reddy, A., Harikrishna, V., Srivastava, P., & Lakra, W. (2020). Growth and osmoregulatory response of Cyprinus carpio haematopterus (Amur carp) reared in inland saline water. Indian Journal of Animal Sciences, 90(1), 120–124. https://www.researchgate.net/profile/Shashank-Singh-24/publication/339363213_Growth_and_osmoregulatory_response_of_Cyprinus_carpio_haematopterus_Amur_carp_reared_in_inland_saline_water/links/5e8dd76f92851c2f528890dd/Growth-and-osmoregulatory-response-of-Cyprinus-carpio-haematopterus-Amur-carp-reared-in-inland-saline-water.pdf
Integrated ISA Agriculture	India	Singh, S., Singh, R., Kumar, S., Narjary, B., Kamra, S., & Sharma, D. (2014). Productive utilization of sodic water for aquaculture-led integrated farming system: A case study. Journal of Soil Salinity and Water Quality, 6(1), 28–35. https://www.researchgate.net/profile/Bhaskar_Narjary/publication/270280947_Productive_Utilization_of_Sodic_Water_for_Aquaculture-led_Integrated_Farming_System_A_Case_Study/links/54a663c00cf267bdb90843cd.pdf
Tilapia	India	Singha, K. P., Shamna, N., Sahu, N. P., Sardar, P., Harikrishna, V., Thirunavukkarasar, R., Chowdhury, D. K., Maiti, M. K., & Krishna, G. (2021). Optimum dietary crude protein for culture of genetically improved farmed tilapia (GIFT), Oreochromis niloticus (Linnaeus, 1758) juveniles in low inland saline water: Effects on growth, metabolism and gene expression. Animal Feed Science and Technology, 271, 114713. https://doi.org/10.1016/j.anifeedsci.2020.114713
Tilapia	India	Singha, K. P., Shamna, N., Sahu, N. P., Sardar, P., HariKrishna, V., Thirunavukkarasar, R., Kumar, M., & Krishna, G. (2020). Feeding graded levels of protein to genetically improved farmed tilapia (GIFT) juveniles reared in inland saline water: Effects on growth and gene expression of IGFI, IGF-IR and IGF-BPI. Aquaculture, 525, 735306. https://doi.org/10.1016/j.aquaculture.2020.735306
Vannamei	India	Sudan, P., Tyagi, A., Dar, R. A., Sharma, C., Singh, P., B. T., N. K., Chandra, M., & Arora, A. K. (2023). Prevalence and antimicrobial resistance of food safety related Vibrio species in inland saline water shrimp culture farms. International Microbiology. https://doi.org/10.1007/s10123-023-00323-7

Resourcespolicysys tems	India	Surinaidu, L., Nandan, M., Prathapar, S., Gurunadha Rao, V., & Rajmohan, N. (2016). Groundwater evaporation ponds: A viable option for the management of shallow saline waterlogged areas. Hydrology, 3(3), 30. https://doi.org/10.3390/hydrology3030030
Marine finfish	India	Talukdar, A., Deo, A. D., Sahu, N. P., Sardar, P., Aklakur, M., Prakash, S., Shamna, N., & Kumar, S. (2020). Effects of dietary protein on growth performance, nutrient utilization, digestive enzymes and physiological status of grey mullet, Mugil cephalus L. fingerlings reared in inland saline water. Aquaculture Nutrition, 26(3), 921–935. https://doi.org/10.1111/anu.13050
Freshwater fish (not carp)	India	Talukdar, A., Dharmendra Deo, A., Prasad Sahu, N., Sardar, P., Aklakur, M., & Prakash, S. (2021). Effects of different suboptimal dietary protein levels on growth, nutrient utilization and physio-metabolic status of Anabas testudineus fingerlings in inland saline water. Aquaculture Nutrition, 27(6), 2673–2689. https://doi.org/10.1111/anu.13394
Vannamei	India	Talukdar, A., Dharmendra Deo, A., Prasad Sahu, N., Sardar, P., Aklakur, M., Harikrishna, V., Prakash, S., Shamna, N., & Jana, P. (2020). Effects of different levels of dietary protein on the growth performance, nutrient utilization, digestive enzymes and physiological status of white shrimp, Litopenaeus vannamei juveniles reared in inland saline water. Aquaculture Nutrition, 27(1), 77–90. https://doi.org/10.1111/anu.13166
Tilapia	India	Thirunavukkarasar, R., Kumar, P., Sardar, P., Sahu, N. P., Harikrishna, V., Singha, K. P., Shamna, N., Jacob, J., & Krishna, G. (2022). Protein-sparing effect of dietary lipid: Changes in growth, nutrient utilization, digestion and IGF-I and IGFBP-I expression of genetically improved farmed tilapia (GIFT), reared in Inland Ground Saline Water. Animal Feed Science and Technology, 284, 115150. https://doi.org/10.1016/j.anifeedsci.2021.115150
Integrated ISA Agriculture	India	Thomas, R. M., Verma, A. K., Krishna, H., Prakash, S., Kumar, A., & Peter, R. M. (2021). Effect of salinity on growth of Nile tilapia (Oreochromis niloticus) and spinach (Spinacia oleracea) in aquaponic system using inland saline groundwater. Aquaculture Research, 52(12), 6288–6298. https://doi.org/10.1111/are.15492
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Carp	India	Tyagi, A., & Singh, B. (2017). Microbial diversity in rohu fish gut and inland saline aquaculture sediment and variations associated with next-generation sequencing of 16S rRNA gene. Journal of Fisheries and Life Sciences, 2(1), 1–8. https://www.fishlifesciencejournal.com/download/2017/v2.i1/8/8.pdf
General research	India	Tyagi, A., Dubey, S., Sharma, C., Sudan, P., Rai, S., Kumar, B. T. N., Chandra, M., & Arora, A. K. (2022a). Complete genome sequencing and characterization of single-stranded DNA Vibrio parahaemolyticus phage from inland saline aquaculture environment. Virus Genes, 58(5), 483–487. https://doi.org/10.1007/s11262-022-01913-9

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Resourcespolicysys tems	India	Tyagi, N. K., Agrawal, A., Sakthivadivel, R., & Ambast, S. K. (2005). Water management decisions on small farms under scarce canal water supply: A case study from NW India. Agricultural Water Management, 77(1-3), 180–195. https://doi.org/10.1016/j.agwat.2004.09.031
Tilapia	India	Velselvi, R., Dasgupta, S., Varghese, T., Sahu, N. P., Tripathi, G., Panmei, H., Singha, K. P., & Krishna, G. (2022). Taurine and/or inorganic potassium as dietary osmolyte counter the stress and enhance the growth of GIFT reared in ion imbalanced low saline water. Food Chemistry: Molecular Sciences, 4, 100058. https://doi.org/10.1016/j.fochms.2021.100058
General status and opportunities	India	Vijayan, K., Balasubramanian, C., Gopal, C., & Kailasam, N. (2016). Diversification of brackishwater aquaculture: Options and strategies. National Seminar on Aquaculture Diversification: The Way Forward for the Blue Revolution 01-03 December, 2016: ICAR-CIFA, Bhubaneswar. https://krishi.icar.gov.in/jspui/handle/123456789/47699
Crustaceans (not penaeids)	India	Vikas, P. A., Sajeshkumar, N. K., Thomas, P. C., Chakraborty, K., & Vijayan, K. K. (2011). Aquaculture related invasion of the exotic Artemia franciscana and displacement of the autochthonous Artemia populations from the hypersaline habitats of India. Hydrobiologia, 684(1), 129–142. https://doi.org/10.1007/s10750-011-0976-x
Vannamei	India	Zaffar, I., Varghese, T., Dasgupta, S., Sahu, N. P., Srivastava, P. P., Harikrishna, V., Mushtaq, Z., Dar, S. A., Prakash, S., & Krishna, G. (2021). Dietary potassium partially compensates the requirement of aqueous potassium of P. vannamei reared in medium saline inland groundwater. Aquaculture Research, 52(9), 4094–4104. https://doi.org/10.1111/are.15248
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Economics	Indonesia	Ariadi, H., Fadjar, M., & Mahmudi, M. (2019). Financial feasibility analysis of shrimp vannamei (Litopenaeus vannamei) culture in intensive aquaculture system with low salinity. Economic and Social of Fisheries and Marine Journal, 007(01), 81–94. https://doi.org/10.21776/ub.ecsofim.2019.007.01.08
General research	Indonesia	Novriadi, R. (2016). Vibriosis in aquaculture. Omni-Akuatika, 12(1). https://doi.org/10.20884/1.oa.2016.12.1.24
Environmental	Indonesia	Purnama, S., & Aris Marfai, M. (2011). Saline water pollution in groundwater: Issues and its control. Journal of Natural Resources and Development, 2. http://dx.doi.org/10.5027/jnrd.v2i0.06
Resourcespolicysys tems	Indonesia	Purnama, S., & Aris Marfai, M. (2011). Saline water pollution in groundwater: Issues and its control. Journal of Natural Resources and Development, 2. https://doi.org/10.5027/jnrd.v2i0.06
Economics	Indonesia	Supono, S. (2021). Current status of technical and economic analysis of inland shrimp culture in Lampung Province, Indonesia. AACL Bioflux, 14(1), 218–226. http://repository.lppm.unila.ac.id/id/eprint/33719

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Resourcespolicysys tems	International	Alcocer, J., & Escobar, E. (1994). Athalassohalinity (on the concept of salinity in inland waters). HIDROBIOLÓGICA, 3(1, 2), 81–88. https://hidrobiologica.izt.uam.mx/hidrobiologica/index.php/revHidro/article/view/547
Resourcespolicysys tems	International	Anufriieva, E. V. (2018). How can saline and hypersaline lakes contribute to aquaculture development? A review. Journal of Oceanology and Limnology, 36(6), 2002–2009. https://doi.org/10.1007/s00343-018-7306-3
Environmental	International	Ayyam, V., Palanivel, S., & Chandrakasan, S. (2019). Land and water conservation: dealing with agriculture and aquaculture conflicts. Coastal Ecosystems of the Tropics - Adaptive Management, 391–406. https://doi.org/10.1007/978-981-13-8926-9_17
Economics	International	Brugere, C., & Little, D. (2000). An approach to valuing ponds within farming systems for aquaculture (p. 37). Institute of Aquaculture, University of Stirling. http://hdl.handle.net/1834/20688
General status and opportunities	International	Crespi, V., & Lovatelli, A. (2011). Global desert aquaculture at a glance. In V. Crespi & A. Lovatelli (Eds.), Aquaculture in Desert and Arid lands: Development Constraints and opportunities. FAO Technical Workshop. 6–9 July 2010, Hermosillo, Mexico. FAO Fisheries and Aquaculture Proceedings No. 20. Rome, FAO. 2011. pp. 25-37. https://www.fao.org/3/ba0114e/ba0114e00.htm
Integrated ISA Agriculture	International	Custódio, M., Villasante, S., Cremades, J., Calado, R., & Lillebø, A. (2017). Unravelling the potential of halophytes for marine integrated multi-trophic aquaculture (IMTA)— a perspective on performance, opportunities and challenges. Aquaculture Environment Interactions, 9, 445–460. https://doi.org/10.3354/aei00244
Integrated ISA Agriculture	International	Fierro-Sañudo, J. F., Rodríguez-Montes de Oca, G. A., & Páez-Osuna, F. (2020). Co-culture of shrimp with commercially important plants: A review. Reviews in Aquaculture, 12(4), 2411–2428. https://doi.org/10.1111/raq.12441
Algae seaweed	International	García-Poza, S., Leandro, A., Cotas, C., Cotas, J., Marques, J. C., Pereira, L., & Gonçalves, A. M. M. (2020). The evolution road of seaweed aquaculture: Cultivation technologies and the industry 4.0. International Journal of Environmental Research and Public Health, 17(18), 6528. https://doi.org/10.3390/ijerph17186528
General status and opportunities	International	Gunning, D., Maguire, J., & Burnell, G. (2016). The development of sustainable saltwater-based food production systems: A review of established and novel concepts. Water, 8(12), 598. https://doi.org/10.3390/w8120598
Integrated ISA Agriculture	International	Ibrahim, L. A., Abu-Hashim, M., Shaghaleh, H., Elsadek, E., Hamad, A. A. A., & Alhaj Hamoud, Y. (2023). A comprehensive review of the multiple uses of water in aquaculture-integrated agriculture based on international and national experiences. Water, 15(2), 367. https://doi.org/10.3390/w15020367
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Crustaceans (not penaeids)	International	Lavens, P., & Sorgeloos, P. (2000). The history, present status and prospects of the availability of Artemia cysts for aquaculture. Aquaculture, 181(3-4), 397–403. https://doi.org/10.1016/s0044-8486(99)00233-1
Vannamei	International	Liao, I. C., & Chien, Y.-H. (2011). The Pacific white shrimp, Litopenaeus vannamei, in Asia: The world's most widely cultured alien crustacean. In B. Galil, P. Clark, & J. Carlton (Eds.), In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts. Invading Nature (pp. 489–519). Springer Series in Invasion Ecology, vol 6. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0591-3_17
General status and opportunities	International	Lothmann, R., & Sewilam, H. (2022). Potential of innovative marine aquaculture techniques to close nutrient cycles. Reviews in Aquaculture. https://doi.org/10.1111/raq.12781
Environmental	International	Mukhopadhyay, R., Sarkar, B., Jat, H. S., Sharma, P. C., & Bolan, N. S. (2021). Soil salinity under climate change: Challenges for sustainable agriculture and food security. Journal of Environmental Management, 280, 111736. https://doi.org/10.1016/j.jenvman.2020.111736
General status and opportunities	International	Ottaviani, D. (n.d.). Food and agriculture of the UN SEEA for inland capture fisheries & aquaculture working document. Retrieved February 26, 2023, from https://seea.un.org/sites/seea.un.org/files/5_23.pdf
Resourcespolicysys tems	International	Person, M. A., & Sazeed, N. (2022). Continental brackish groundwater resources. In M. Qadir, V. Smakhtin, S. Koo-Oshima, & E. Guenther (Eds.), Unconventional Water Resources (pp. 111–128). Springer, Cham. https://doi.org/10.1007/978-3-030-90146-2_6
Resourcespolicysys tems	International	Perthuisot, J.-P. (1995). Inland saline lakes with lagoonal biota: Some reflections on the concept and nature of athalassic (non-marine), paralic and marine saline waters. International Journal of Salt Lake Research, 4(2), 79–94. https://doi.org/10.1007/bf01990797
Resourcespolicysys tems	International	Qadir, M., Sharma, B. R., Bruggeman, A., Choukr-Allah, R., & Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agricultural Water Management, 87(1), 2–22. https://doi.org/10.1016/j.agwat.2006.03.018
Algae seaweed	International	Ragaza, J. A., Hossain, Md. S., Meiler, K. A., Velasquez, S. F., & Kumar, V. (2020). A review on Spirulina: Alternative media for cultivation and nutritive value as an aquafeed. Reviews in Aquaculture, 12(4), 2371–2395. https://doi.org/10.1111/raq.12439
Economics	International	Robertson, S. M., Lyra, D. A., Mateo-Sagasta, J., Ismail, S., & Akhtar, M. J. U. (2019). Financial analysis of halophyte cultivation in a desert environment using different saline water resources for irrigation. In M. Hasanuzzaman, K. Nahar, & M. Öztürk (Eds.), Ecophysiology, Abiotic Stress Responses and Utilization of Halophytes (pp. 347–364). Springer. https://doi.org/10.1007/978-981-13-3762-8_17
General status and opportunities	International	Saoud, I. P. (2017). Ensuring food security by improving "freshwater use efficiency" or by farming the seas. In S. Murad, E. Baydoun, & N. Daghir (Eds.), Water, Energy & Food Sustainability in the Middle East (pp. 341–360). Springer, Champ. https://doi.org/10.1007/978-3-319-48920-9_15

Resourcespolicysys tems	International	Shadrin, N., Anufriieva, E., & Gajardo, G. (2023). Ecosystems of inland saline waters in the world of change. Water, 15(1), 52. https://doi.org/10.3390/w15010052
General status and opportunities	International	Shearer, T., Wagstaff, S., Calow, R., Stewart, J., Muir, J., Haylor, G., & Brooks, A. (1997). The potential for aquaculture using saline groundwater. BGS Technical Report WC/97/58. https://nora.nerc.ac.uk/id/eprint/505138/1/WC_97_58.pdf
Resourcespolicysys tems	International	Thangarajan, M., & Singh, V. P. (Eds.). (2016). Groundwater assessment, modeling, and management. CRC Press. https://doi.org/10.1201/9781315369044
Crustaceans (not penaeids)	International	Van Stappen, G., Sui, L., Hoa, V. N., Tamtin, M., Nyonje, B., Medeiros Rocha, R., Sorgeloos, P., & Gajardo, G. (2019). Review on integrated production of the brine shrimp Artemia in solar salt ponds. Reviews in Aquaculture, 12(2), 1054–1071. http://dx.doi.org/10.1111/raq.12371
WaterResources	International	Van Weert, F., Van Der Gun, J., & Utrecht, J. (2009). Global overview of saline groundwater occurrence and genesis. http://www.indiaenvironmentportal.org.in/files/salineground water.pdf
General status and opportunities	International	Vo, T. T. E., Je, S.-M., Jung, S.-H., Choi, J., Huh, J.-H., & Ko, H.-J. (2022). Review of photovoltaic power and aquaculture in desert. Energies, 15(9), 3288. https://doi.org/10.3390/en15093288
Integrated ISA Agriculture	International	Webb, J. M., Quintã, R., Papadimitriou, S., Norman, L., Rigby, M., Thomas, D. N., & Le Vay, L. (2012). Halophyte filter beds for treatment of saline wastewater from aquaculture. Water Research, 46(16), 5102–5114. https://doi.org/10.1016/j.watres.2012.06.034
General status and opportunities	International	Williams, W. D. (1981). Problems in the management of inland saline lakes. SIL Proceedings, 1922-2010, 21(1), 688–692. https://doi.org/10.1080/03680770.1980.11897069
Resourcespolicysys tems	International	Williams, W. D. (1981a). Problems in the management of inland saline lakes. SIL Proceedings, 1922-2010, 21(1), 688–692. https://doi.org/10.1080/03680770.1980.11897069
Resourcespolicysys tems	International	Williams, W. D. (1981b). Problems in the management of inland saline lakes. SIL Proceedings, 1922-2010, 21(1), 688–692. https://doi.org/10.1080/03680770.1980.11897069
Environmental	International	Yavuzcan Yıldız, H., & Pulatsü, S. (2022). Towards zero waste: Sustainable waste management in aquaculture. Ege Journal of Fisheries and Aquatic Sciences, 39(4), 341–348. https://doi.org/10.12714/egejfas.39.4.11
General status and opportunities	International	Zhou, X. (2017). An overview of recently published global aquaculture statistics. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/bs235e/bs235e.pdf
Freshwater fish (not carp)	Iran	Alizadeh, M. (2010). A review on research achievements of rainbow trout (Oncorhynchus mykiss) aquaculture in inland brackish water in central area of Iran. Journal of Animal Environment, 1(4), 57–70. http://www.aejournal.ir/m/article_103107.html?lang=en
Freshwater fish (not carp)	Iran	Alizadeh, M., Dadgar, S., & Hafezieh, M. (2016). Review on rainbow trout (Oncorhynchus mykiss) farming in desert underground brackish water in Iran. Journal of Survey in Fisheries Sciences, 3(1), 21–35. http://www.sifisheriessciences.com/index.php/journal/article/view/94

Freshwater fish (not carp)	Iran	Alizadeh, M., Dadgar, S., & Masaeli, S. (2017). Review on rainbow trout desert farming using underground brackish water. In P. Berillis (Ed.), Trends in Fisheries and Aquatic Animal Health. Bentham Science Publishers. https://books.google.com.au/books?hl=en&lr=&id=G4xCDwAAQBAJ&oi=fnd&pg=PA227&dq=inland+saline+water+aquaculture&ots=0gcirPsR6N&sig=wXnx4D2dEybfETaGb1aoZYkjMQ0#v=onepage&q=inland%20saline%20water%20aquaculture&f=false
Resourcespolicysys tems	Iran	Bemani, A., Alizadeh, M., Rahimian, M. H., & Nowrouzi, M. (2021). Site selection for agri-aquaculture in the arid area using GIS techniques based on groundwater quality (case study: Yazd-Ardakan plain, Iran). Iranian Journal of Fisheries Sciences, 20(3), 710–730. https://jifro.ir/browse.php?a_id=4362&slc_lang=en&sid=1&printcase=1&hbnr=1&hmb=1
Crustaceans (not penaeids)	Iran	Keshtkar, A. R., Oros, Z., Mohammadkhan, Sh., Eagdari, S., & Paktinat, H. (2016). Multi-criteria analysis in Artemia farming site selection for sustainable desert ecosystems planning and management (case study: Siahkouh Playa, Iran). Environmental Earth Sciences, 75(16). https://doi.org/10.1007/s12665-016-5998-2
Integrated ISA Agriculture	Iran	Khorsandi, F. (2016). Haloculture: Strategy for sustainable utilization of saline land and water resources. Khorsandi / Iranian Journal of Earth Sciences, 8, 164–172. https://www.researchgate.net/profile/Anoop-Srivastava/post/Why-do-salt-affected-soils-continue-to-pose-potential-threats-to-food-security/attachment/59d64ef479197b80779a833d/AS%3A495299148107776%401495099927491/download/Haloculture-+Strategy+for+Sustainable+Utilization+of+Saline+Land+and+Water+Resources+-+2016+-+IJES.pdf
Resourcespolicysys tems	Iran	Khorsandi, F. (2016). Haloculture: Strategy for sustainable utilization of saline land and water resources. Khorsandi / Iranian Journal of Earth Sciences, 8, 164–172. https://www.researchgate.net/publication/316961316_Haloculture_Strategy_for_sustainable_utilization_of_saline_land_and_water_resources?enrichId=rgreq-31199c2636e7f882a242823d8f669f97-XXX&enrichSource=Y292ZXJQYWdlOzMxNjk2MTMxNjtBUzo0OTQ5NjQ4Nzg4NTYxOTJAMTQ5NTAyMDIzMTE0NA%3D%3D&el=1_x_2&_esc=publicationCoverPdf
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Tilapia	Iran	Mohammadi, M., Sarsangi Aliabad, H, Mashaii, N., Bitaraf, A., Haghighi, T., Rajabipour, F., & Hafeziyeh, M. (2013). Determine optimal diet for rearing black tilapia (Oreochromis niloticus) in Bafgh brackish water. Iranian Fisheries Science Research Institute, 54. http://hdl.handle.net/1834/14040

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Marine finfish	Israel	Appelbaum, S., & Jesuarockiaraj, A. (2009). Salt incorporated diets for enhancing growth performance and survival in gilthead sea bream Sparus aurata L. juveniles reared in low

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Marine finfish	Israel	Appelbaum, S., & Raj, A. S. J. A. (2009). Salt incorporated diets for enhancing growth performance and survival in gilthead sea bream Sparus aurata L. juveniles reared in low saline brackish water. Sci. Mar., 73S1, 213–217. doi: 10.3989/scimar.2009.73sl213
Marine finfish	Israel	Appelbaum, S., Raj, A. J. A., & Raj, C. I. (2008). Promoting the culture of gilthead sea bream (Sparus auratus L.) in low saline inland water: A novel way to farm saltwater fish in freshwater. Secretariat, Southeast Asian Fisheries Development Center. https://www.researchgate.net/profile/Jesu-Arockiaraj/publication/277667632_Promoting_the_culture_of_gilthead_Fish_for_the_People/links/556feaf208aec226830ab989/Promoting-the-culture-of-gilthead-Fish-for-the-People.pdf
General research	Israel	Applebaum, S. (2011). Aquaculture experiences in the Negev Desert in Israel. In V. Crespi & A. Lovatelli (Eds.), Aquaculture in desert and arid lands: development constraints and opportunities. FAO Technical Workshop. 6–9 July 2010, Hermosillo, Mexico. FAO Fisheries and Aquaculture Proceedings No. 20. Rome, FAO. 2011. pp. 113–118. https://www.academia.edu/download/31569880/aquaculture.pdf#page=125
Marine finfish	Israel	Cnaani, A., Stavi, A., Smirnov, M., & Harpaz, S. (2012). Rearing white grouper (Epinephelus aeneus) in low salinity water: Effects of dietary salt supplementation. The Israeli Journal of Aquaculture - Bamidgeh, IJA, 64. http://hdl.handle.net/10524/23300
General research	Israel	Gross, A., Nemirovsky, A., Zilberg, D., Khaimov, A., Brenner, A., Snir, E., Ronen, Z., & Nejidat, A. (2003). Soil nitrifying enrichments as biofilter starters in intensive recirculating saline water aquaculture. Aquaculture, 223(1-4), 51–62. https://doi.org/10.1016/s0044-8486(03)00067-x
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Marine finfish	Lebanon	Mourad, N., S. Kreydiyyeh, & J. Ghanawi. (2012). Aquaculture of marine fish in inland low salinity well water: potassium is not the only limiting element. Fisheries and Aquaculture Journal, 16–28. https://www.longdom.org/open-access/aquaculture-of-marine-fish-in-inland-low-salinity-well-water-potassium-is-not-the-only-limiting-element-43057.html
Crustaceans (not penaeids)	Lebanon	Rida, R., Zein-Eddine, R., Kreydiyyeh, S., Garza de Yta, A., & Saoud, I. P. (2021). Influence of salinity on survival, growth, hemolymph osmolality, gill sodium potassium ATPase activity, and sodium potassium chloride co-transporter expression in the redclaw crayfish Cherax quadricarinatus. Journal of the World Aquaculture Society, 52, 466–474. https://doi.org/10.1111/jwas.12762
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Penaieds (not vannamei)	Mexico	Gullian, M., Aramburu, C., Sanders, B., & Lope, R. (2010). Viability of culturing pink shrimp Farfantepenaeus duorarum in low-salinity groundwater from the Yucatán Peninsula (SE, México). Aquaculture, 302(3-4), 202–207. https://doi.org/10.1016/j.aquaculture.2010.02.019
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General status and opportunities	Mexico	Llanes-Cárdenas, O., Campos, M. N., Sevilla, P. M., & Guerrero, R. R. (2016). Groundwater: Alternative aquaculture in Northwest Mexico. Revista AquaTIC, 38, 10–20. http://www.revistaaquatic.com/ojs/index.php/aquatic/article/view/83/72

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Integrated ISA Agriculture	Mexico	Mariscal-Lagarda, M. M., Páez-Osuna, F., Esquer-Méndez, J. L., Guerrero-Monroy, I., del Vivar, A. R., & Félix-Gastelum, R. (2012). Integrated culture of white shrimp (Litopenaeus vannamei) and tomato (Lycopersicon esculentum Mill) with low salinity groundwater: Management and production. Aquaculture, 366-367, 76–84. https://doi.org/10.1016/j.aquaculture.2012.09.003
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Integrated ISA Agriculture	Mexico	Sijtsma, L., Boedijn, A., & Appelman, W. (2020). Stimulating the circular economy for food production in central Mexico: Integration of greenhouse cultivation, land-based aquaculture and microalgae production systems (p. 38). Wageningen University & Research. https://doi.org/10.18174/544656
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Crustaceans (not penaeids)	Mexico	Walsh, E. J., Schröder, T., Wallace, R. L., Ríos-Arana, J. V., & Rico-Martínez, R. (2008). Rotifers from selected inland saline waters in the Chihuahuan Desert of México. Saline Systems, 4(1), 7. https://doi.org/10.1186/1746-1448-4-7
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Integrated ISA Agriculture	Netherlands	Wolters, W., Sadek, S., Van Der Heijden, P., Roest, K., Wagieh, H., & Schram, E. (2014). Preparations for a community for development and exchange of knowledge (CDEK) on integrated agriculture – aquaculture (IAA) with brackish water; report of the workshop on 30 November 2014. Wageningen, Alterra Wageningen UR (University & Research centre), Alterra report 2625. 34 pp. https://library.wur.nl/WebQuery/wurpubs/fulltext/338145
Environmental	Norway	Soldal, O., & Rye, N. (1995). Hydrogeology of a fjord delta aquifer, Sunndalsøra, Norway. Norsk Geologisk Tidsskrift, 75, 169–178. https://foreninger.uio.no/ngf/ngt/pdfs/NGT_75_2&3_169-178.pdf
Environmental	Oman	Ahmed, M., Hussain, N., & Al-Rawahy, S. A. (2012). Management of saline lands in Oman: Learning to live with salinity. In S. Shahid, M. Abdelfattah, & F. Taha (Eds.), Developments in Soil Salinity Assessment and Reclamation (pp. 265–281). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-5684-7_17
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Marine finfish	Pakistan	Hassan, H. U., Ali, Q. M., Ahmed, A. E., Gabol, K., Swelum, A. A., Masood, Z., Mushtaq, S., Saeed, Gul, Y., Rizwan, S., Zulfiqar, T., & Siddique, M. a. M. (2022). Growth performance and survivability of the Asian seabass Lates calcarifer (Bloch, 1790) reared under hyper-saline, hypo-saline and freshwater environments in a closed aquaculture system. Brazilian Journal of Biology, 84. https://doi.org/10.1590/1519-6984.254161
Economics	Pakistan	Haylor, G., & Bhutta, M. S. (1997). The role of aquaculture in the sustainable development of irrigated farming systems in Punjab, Pakistan. Aquaculture Research, 28(9), 691–705. https://doi.org/10.1046/j.1365-2109.1997.00912.x
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Integrated ISA Agriculture	Pakistan	Yasin Ashraf, M., Awan, A. R., Anwar, S., Khaliq, B., Malik, A., & Ozturk, M. (2020). Economic utilization of salt-affected wasteland for plant production. In M. Grigore (Ed.), Handbook of Halophytes (pp. 1–24). Springer, Cham. https://doi.org/10.1007/978-3-030-17854-3_87-1
Vannamei	Philippines	Cuvin-Aralar, M. L. A., Lazartigue, A. G., & Aralar, E. V. (2009). Cage culture of the Pacific white shrimp Litopenaeus vannamei (Boone, 1931) at different stocking densities in a shallow eutrophic lake. Aquaculture Research, 40(2), 181–187. https://doi.org/10.1111/j.1365-2109.2008.02081.x
Tilapia	Philippines	Watanabe, W., Ellingson, L., Wicklund, R., & Olla, B. (1988). The effects of salinity on growth, food consumption and conversion in juvenile, monosex male Florida red tilapia. In R. Pullin, T. Bhukaswan, K. Tonguthai, & J. Mclean (Eds.), The Second International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings 15, 623 p (pp. 515–523). Department of Fisheries, Bangkok, Thailand, and International Centre for Living Aquatic Resources Management, Manila, Philippines. https://www.sciencedirect.com/science/article/pii/004484869390392C
Algae seaweed	Portugal	Araujo, G. S., Cotas, J., Morais, T., Leandro, A., García-Poza, S., Gonçalves, A. M. M., & Pereira, L. (2020). Calliblepharis jubata cultivation potential—a comparative study between controlled and semi-controlled aquaculture. Applied Sciences, 10(21), 7553. https://doi.org/10.3390/app10217553
Integrated ISA Agriculture	Portugal	Jerónimo, D., Lillebø, A. I., Cremades, J., Cartaxana, P., & Calado, R. (2021). Recovering wasted nutrients from shrimp farming through the combined culture of polychaetes and halophytes. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-85922-y
General status and opportunities	Portugal	Rosa, R., Marques, A., & Nunes, M. L. (2013). Mediterranean aquaculture in a changing climate. In S. Goffredo & Z. Dubinsky (Eds.), The Mediterranean Sea (pp. 605–616). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6704-1_37
General research	Saudi Arabia	Al Asgah, N. A., & Bedawi, R. M. (1984). Preliminary investigations on the suitability of ground water for aquaculture in Saudi Arabia. Aquaculture, 36(4), 387–390. https://doi.org/10.1016/0044-8486(84)90331-4

Economics	Taiwan	Chou, P.-Y., & Ting, C.-S. (2007). Feasible groundwater allocation scenarios for land subsidence area of Pingtung Plain, Taiwan. Water Resources, 34(3), 259–267. https://doi.org/10.1134/s0097807807030037
Molluscs Echinoderms	Taiwan	Lee, A.-C., Lin, Y.-H., Lin, C.-R., Lee, M.-C., & Chen, Y.-P. (2007). Effects of components in seawater on the digging behavior of the hard clam (Meretrix lusoria). Aquaculture, 272(1-4), 636–643. https://doi.org/10.1016/j.aquaculture.2007.06.013
Marine finfish	Taiwan	Lin, M. C., & Liao, C. M. (2008). Assessing the risks on human health associated with inorganic arsenic intake from groundwater-cultured milkfish in southwestern Taiwan. Food and Chemical Toxicology, 46(2), 701–709. https://doi.org/10.1016/j.fct.2007.09.098
Integrated ISA Agriculture	Taiwan	Lin, Y.-F., Jing, S.-R., Lee, D.-Y., & Wang, T.-W. (2002). Nutrient removal from aquaculture wastewater using a constructed wetlands system. Aquaculture, 209(1-4), 169–184. https://doi.org/10.1016/s0044-8486(01)00801-8
Vannamei	Taiwan	Lin, Y.-F., Jing, S.-R., Lee, D.-Y., Chang, Y.-F., Chen, Y.-M., & Shih, K.-C. (2005). Performance of a constructed wetland treating intensive shrimp aquaculture wastewater under high hydraulic loading rate. Environmental Pollution, 134(3), 411–421. https://doi.org/10.1016/j.envpol.2004.09.015
Crustaceans (not penaeids)	Taiwan	Pan, Y.-J., Souissi, A., Souissi, S., & Hwang, J.-S. (2016). Effects of salinity on the reproductive performance of Apocyclops royi (Copepoda, Cyclopoida). Journal of Experimental Marine Biology and Ecology, 475, 108–113. https://doi.org/10.1016/j.jembe.2015.11.011
Environmental	Taiwan	Wang, S.-W., Kuo, Y.-M., Kao, Y.-H., Jang, C.-S., Maji, S. K., Chang, F.-J., & Liu, C.-W. (2011). Influence of hydrological and hydrogeochemical parameters on arsenic variation in shallow groundwater of southwestern Taiwan. Journal of Hydrology, 408(3), 286–295. https://doi.org/10.1016/j.jhydrol.2011.08.017
Crustaceans (not penaeids)	Tanzania	Mlingi, F. T., Lamtane, H. A., Chenyambuga, S. W., & Lund, I. (2019). First biogeographical survey of Artemia in Tanzania. Journal of Applied Aquaculture, 32(3), 278–290. https://doi.org/10.1080/10454438.2019.1660753
Vannamei	Thailand	Wudtisin, I., & Boyd, C. E. (2011). Possible potassium and magnesium limitations for shrimp survival and production in low-salinity, pond waters in Thailand. Journal of the World Aquaculture Society, 42(6), 766–777. https://doi.org/10.1111/j.1749-7345.2011.00530.x
Vannamei	Thailand	Yano, Y., Hamano, K., Tsutsui, I., Aue-umneoy, D., Ban, M., & Satomi, M. (2015). Occurrence, molecular characterization, and antimicrobial susceptibility of Aeromonas spp. in marine species of shrimps cultured at inland low salinity ponds. Food Microbiology, 47, 21–27. https://doi.org/10.1016/j.fm.2014.11.003
General research	Turkey	Çanak, Ö., & Timur, G. (2020). An initial survey on the occurrence of staphylococcal infections in Turkish marine aquaculture (2013–1014). Journal of Applied Ichthyology, 36(6), 932–941. https://doi.org/10.1111/jai.14141
Marine finfish	Turkey	Hamzaçebi, S. (2018). Embryonic development stages of pink Dentex dentex gibbosus (Rafinesque, 1810) eggs in aquaculture conditions. Turkish Journal of Fisheries and Aquatic Sciences, 19(4), 297–303. https://www.trjfas.org/abstract.php?lang=en&id=1334
Crustaceans (not penaeids)	Uganda	Sserwadda, M., Kagambe, E., & Van Stappen, G. (2018). The brine shrimp Artemia survives in diluted water of Lake

		Bunyampaka, an inland saline lake in Uganda. Water, 10(2), 189. https://doi.org/10.3390/w10020189
Integrated ISA Agriculture	United Arab Emirates	Lyra, D.-A., Lampakis, E., Al Muhairi, M., Mohammed, F., Tarsh, B., Abdel, M., Dawoud, H., Al Khawaldeh, B., Moukayed, M., Plewa, J., Cobre, L., Saleh, O., Masjedi, A., Mohammed, K., Marzouqi, A., Ahmadzai, H., Khamees, M., Tamimi, A., Abdelwahid, W., & Dahr, A. (2021). From desert farm to fork value chain development for innovative Salicornia- based food products in the United Arab Emirates. In K. Negacz, P. Vellinga, E. Barrett-Lennard, R. Choukr-Allah, & T. Elzenga (Eds.), Future of Sustainable Agriculture in Saline Environments. CRC Press. https://doi.org/10.1201/9781003112327-11
Vannamei	USA	Abdelrahman, H. A., Abebe, A., & Boyd, C. E. (2018). Influence of variation in water temperature on survival, growth and yield of Pacific white shrimp Litopenaeus vannamei in inland ponds for low-salinity culture. Aquaculture Research, 50(2), 658–672. https://doi.org/10.1111/are.13943
Vannamei	USA	Atwood, H. L., Young, S. P., Tomasso, J. R., & Browdy, C. L. (2003). Survival and growth of Pacific white shrimp Litopenaeus vannamei postlarvae in low-salinity and mixed-salt environments. Journal of the World Aquaculture Society, 34(4), 518–523. https://doi.org/10.1111/j.1749-7345.2003.tb00091.x
Algae seaweed	USA	Barclay, W. R., Terry, K. L., Nagle, N. J., Weissman, J. C., & Goebel, R. P. (1987). Potential of new strains of marine and inland saline-adapted microalgae for aquaculture. Journal of the World Aquaculture Society, 18(4), 218–228. https://doi.org/10.1111/j.1749-7345.1987.tb01031.x
Vannamei	USA	Boyd, C. (2006). Investigations of water supply and water quality issues related to inland shrimp farming in western Alabama - ProQuest [PhD Thesis]. In www.proquest.com. https://www.proquest.com/openview/7267bef7607ce63c1488c11e59731b79/1?pq-origsite=gscholar&cbl=18750&diss=y
General research	USA	Boyd, C. (2018). Aquaculture pond fertilization. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 13(002). https://doi.org/10.1079/pavsnnr201813002
Vannamei	USA	Boyd, C. A., Boyd, C. E., & Rouse, D. B. (2007). Potassium budget for inland, saline water shrimp ponds in Alabama. Aquacultural Engineering, 36(1), 45–50. https://doi.org/10.1016/j.aquaeng.2006.06.002
Vannamei	USA	Boyd, C. A., Boyd, C. E., McNevin, A. A., & Rouse, D. B. (2006). Salt discharge from an inland farm for marine shrimp in Alabama. Journal of the World Aquaculture Society, 37(4), 345–355. https://doi.org/10.1111/j.1749-7345.2006.00047.x
Resourcespolicysystems	USA	Boyd, C. A., Chaney, P. L., Boyd, C. E., & Rouse, D. B. (2009). Distribution of ground water suitable for use in saline-water aquaculture in Central and West-Central Alabama. Journal of Applied Aquaculture, 21(4), 228–240. https://doi.org/10.1080/10454430903114048
Vannamei	USA	Boyd, C. E. (2009). Better management practices for marine shrimp aquaculture. In C. S. Tucker & J. A. Hargreaves (Eds.), Environmental Best Management Practices for Aquaculture. John Wiley & Sons. https://books.google.com.au/books?hl=en&lr=&id=q0GUV4TemgcC&oi=fnd&pg=PA227&dq=saline+groundwater+aquaculture&ots=d5qNHhf3K8&sig=4Ic6DIpFGvIc6h2MGyOKsU1_RSI#v=onepage&q=saline%20groundwater%20aquaculture&f=false

General research	USA	Boyd, C. E. (2017). General relationship between water quality and aquaculture performance in ponds. In G. Jeney (Ed.), Fish Diseases: Prevention and Control Strategies (pp. 147–166). Academic Press. https://www.sciencedirect.com/science/article/pii/B9780128045640000065
Vannamei	USA	Boyd, C. E., & Jescovitch, L. N. (2020). Penaeid shrimp aquaculture. In G. Lovrich & M. Thiel (Eds.), Fisheries and Aquaculture: Volume 9. Oxford University Press. https://books.google.com.au/books?hl=en&lr=&id=yvPuDwAAQBAJ&oi=fnd&pg=PA233&dq=inland+saline+water+aquaculture&ots=Us-0NJhHIv&sig=4dEXXOSbqi6vSzxH0g8-HkeL8AE#v=onepage&q=inland%20saline%20water%20aquaculture&f=false
Marine finfish	USA	Brown, B. (2007). Evaluation of three fish species for culture using low salinity groundwater in the black belt region of Alabama [Master of Science Thesis]. In etd.auburn.edu. https://etd.auburn.edu/handle/10415/169
General research	USA	Chainark, S., & Boyd, C. E. (2010). Evaluation of a meter for testing potassium concentration in low-salinity aquaculture ponds. Journal of the World Aquaculture Society, 41(s1), 102–106. https://doi.org/10.1111/j.1749-7345.2009.00338.x
Vannamei	USA	Clark, J. L., Weldon, R. N., Adams, C. M., & Wirth, F. F. (2010). Risk assessment of a shrimp aquaculture investment in Florida. Aquaculture Economics & Management, 14(4), 332–357. https://doi.org/10.1080/13657305.2010.526023
Vannamei	USA	Davis, D. A., Boyd, C. E., Rouse, D. B., & Saoud, I. P. (2007). Effects of potassium, magnesium and age on growth and survival of Litopenaeus vannamei post-larvae reared in inland low salinity well waters in west Alabama. Journal of the World Aquaculture Society, 36(3), 416–419. https://doi.org/10.1111/j.1749-7345.2005.tb00346.x
Vannamei	USA	Davis, D. A., Samocha, T. M., & Boyd, C. (2004). Acclimating Pacific white shrimp, Litopenaeus vannamei, to inland, low-salinity waters. Southern Region Aquaculture Centre, Publication 2601, 1–8. http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-2601-Acclimating-Pacific-White-Shrimp-Litopenaeus-vannamei-to-Inland-Low-Salinity-Waters.pdf
Vannamei	USA	Davis, D., Saoud, I., Mcgraw, W., & Rouse, D. (2002a). Considerations for Litopenaeus vannamei reared in inland low salinity waters. In L. Cruz-Suárez, D. Ricque-Marie, M. Tapia-Salazar, M. Gaxiola-Cortés, & N. Simoes (Eds.), Avances en Nutrición Acuícola VI. Memorias del VI Simposium Internacional de Nutrición Acuícola. 3 al 6 de Septiembre del 2002. Cancún, Quintana Roo, México. https://nutricionacuicola.uanl.mx/index.php/acu/article/download/229/227
Vannamei	USA	Davis, D., Saoud, I., Mcgraw, W., & Rouse, D. (2002b). Considerations for Litopenaeus vannamei reared in inland low salinity waters. In L. Cruz-Suárez, D. Ricque-Marie, M. Tapia-Salaza, M. Gaxiola-Cortés, & N. Simoes (Eds.), Avances en Nutrición Acuícola VI. Memorias del VI Simposium Internacional de Nutrición Acuícola. 3 al 6 de Septiembre del 2002. Cancún, Quintana Roo, México. https://scholar.google.com.au/scholar?start=190&q=inland+saline+aquaculture&hl=en&as_sdt=0,5

General status and opportunities	USA	Enciso-López, A. R., & García-Trejo, J. F. (2019). Challenges of inland finfish aquaculture in arid regions in North America. Coniin XV International Engineering Congress. https://www.researchgate.net/profile/Auryn-Enciso/publication/335524555_Challenges_of_inland_finfish_aquaculture_in_arid_regions_in_North_America/links/5d6a9f7192851c8538833d35/Challenges-of-inland-finfish-aquaculture-in-arid-regions-in-North-America.pdf
Tilapia	USA	Ernst, D. H., Watanabe, W. O., Ellingson, L. J., Wicklund, R. I., & Olla, B. L. (1991). Commercial-scale production of Florida red tilapia seed in low- and brackish-salinity tanks. Journal of the World Aquaculture Society, 22(1), 36–44. https://doi.org/10.1111/j.1749-7345.1991.tb00714.x
Marine finfish	USA	Forsberg, J. A., & Neill, W. H. (1997). Saline groundwater as an aquaculture medium: physiological studies on the red drum, Sciaenops ocellatus. Environmental Biology of Fishes, 49(1), 119–128. https://doi.org/10.1023/a:1007350726184
Marine finfish	USA	Forsberg, J. A., Dorsett, P. W., & Neill, W. H. (1996). Survival and growth of red drum Sciaenops ocellatus in saline groundwaters of west Texas, USA. Journal of the World Aquaculture Society, 27(4), 462–474. https://doi.org/10.1111/j.1749-7345.1996.tb00631.x
Vannamei	USA	Galkanda-Arachchige, H. S. C., Roy, L. A., & Davis, D. A. (2020a). Evaluation of an alternative salt mixture to culture Pacific white shrimp (Litopenaeus vannamei) in inland aquaculture. Aquaculture Research, 51(9), 3540–3550. https://doi.org/10.1111/are.14691
Vannamei	USA	Galkanda-Arachchige, H. S. C., Roy, L. A., & Davis, D. A. (2020b). The effects of magnesium concentration in low-salinity water on growth of Pacific white shrimp (Litopenaeus vannamei). Aquaculture Research, 52(2), 589–597. https://doi.org/10.1111/are.14916
Economics	USA	Ganguly, S., Quagrainie, K., Rajagopalan, N., & Small, B. (2013). Feasibility study: Establishing a saline aquaculture industry in Illinois. Illinois Indiana Sea Grant. https://iiseagrant.org/wp-content/uploads/2019/01/Rajagopalan2013.pdf
Vannamei	USA	Gong, H., Jiang, D.-H. ., Lightner, D. V., Collins, C., & Brock, D. (2004). A dietary modification approach to improve the osmoregulatory capacity of Litopenaeus vannamei cultured in the Arizona desert. Aquaculture Nutrition, 10(4), 227–236. https://doi.org/10.1111/j.1365-2095.2004.00294.x
Marine finfish	USA	Gorman, J., Adrian, J., & Chappell, J. (2009). Economic feasibility of utilizing west Alabama saline groundwater to produce Florida pompano and hybrid striped bass in a recirculating aquaculture system (p. 19). Alabama Agricultural Experiment Station Auburn University Special Report No 8. http://aurora.auburn.edu/bitstream/handle/11200/3950/SPEC0008.pdf?sequence=1
Vannamei	USA	Green, B. W. (2007). Stocking strategies for production of Litopenaeus vannamei (Boone) in amended freshwater in inland ponds. Aquaculture Research, 39(1), 10–17. https://doi.org/10.1111/j.1365-2109.2007.01849.x
Vannamei	USA	Hernández, D. P., Abdelrahman, H. A., Galkanda-Arachchige, H. S. C., Kelly, A. M., Butts, I. A. E., Davis, D. A., Beck, B. H., & Roy, L. A. (2023). Evaluation of aqueous magnesium concentration on performance of Pacific white shrimp (Litopenaeus vannamei) cultured in low salinity water of West Alabama, USA. Aquaculture, 565, 739133. https://doi.org/10.1016/j.aquaculture.2022.739133

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Vannamei	USA	Jayasankar, V., Jasmani, S., Nomura, T., Nohara, S., Huong, D. T. T., & Wilder, M. N. (2009). Low salinity rearing of the Pacific white shrimp Litopenaeus vannamei: Acclimation, survival and growth of postlarvae and juveniles. Japan Agricultural Research Quarterly: JARQ, 43(4), 345–350. https://doi.org/10.6090/jarq.43.345
Resourcespolicysys tems	USA	Jensen, R. (1993). Can aquaculture thrive in Texas? Texas Water Resources Institute Spring 1993 19(1). http://riogrande.tamu.edu/newsletters/texaswaterresources/twr-v19n1.pdf
Integrated ISA Agriculture	USA	King, C. E. (2005). Integrated agriculture and aquaculture for sustainable food production [PhD Thesis]. In www.proquest.com. https://www.proquest.com/openview/71e3a72a14db8b6a426a6e3ac057712f/1?cbl=18750&diss=y&pq-origsite=gscholar&parentSessionId=sN41gtMgVvHZdpTUNjj%2FuTHCRoINB%2Fcc%2FsZ98F4atSE%3D
Vannamei	USA	Kuhn, D. D., Smith, S. A., Boardman, G. D., Angier, M. W., Marsh, L., & Flick, G. J. (2010). Chronic toxicity of nitrate to Pacific white shrimp, Litopenaeus vannamei: Impacts on survival, growth, antennae length, and pathology. Aquaculture, 309(1-4), 109–114. https://doi.org/10.1016/j.aquaculture.2010.09.014
Vannamei	USA	Laramore, S., Laramore, C. R., & Scarpa, J. (2001). Effect of low salinity on growth and survival of postlarvae and juvenile Litopenaeus vannamei. Journal of the World Aquaculture Society, 32(4), 385–392. https://doi.org/10.1111/j.1749-7345.2001.tb00464.x
Vannamei	USA	Le, P. T. (2011). Evaluation of flavor of Pacific white shrimp Penaeus vannamei cultured in low salinity water [Master of Science]. In etd.auburn.edu. https://etd.auburn.edu/handle/10415/2791
Integrated ISA Agriculture	USA	Martizez-Gomez, R. (2010). Physiological studies of the halophyte Salicornia bigelovii: A potential food and biofuel crop for integrated aquaculture-agriculture systems [PhD Thesis]. https://books.google.com.au/books/about/Physiological_Studies_of_the_Halophyte_S.html?id=NhgjnQAACAAJ&redir_esc=y
Resourcespolicysys tems	USA	Maupin, M. A., Ivahnenko, T. I., & Bruce, B. (2018). Estimates of water use and trends in the Colorado River Basin, southwestern United States, 1985–2010. In U.S. Geological Survey Scientific Investigations Report 2018–5049, (p. 75). https://pubs.er.usgs.gov/publication/sir20185049?utm_source=WRRC+Summer+Wave%2C+Vol.+6%2C+Issue+6+%287%2F27%2F18%29+&utm_campaign=WW-7-27-18&utm_medium=email
General status and opportunities	USA	Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. (2014). Estimated use of water in the United States in 2010. US Geological Survey Circular 1405, 56. https://doi.org/10.3133/cir1405

Vannamei	USA	McGraw, W. J., & Scarpa, J. (2003). Minimum environmental potassium for survival of Pacific white shrimp Litopenaeus vannamei (Boone) in freshwater. Article in Journal of Shellfish Research, 55(1), 893. https://www.researchgate.net/profile/John-Scarpa/publication/287486764
Vannamei	USA	McGraw, W. J., Davis, D. A., Teichert-Coddington, D., & Rouse, D. B. (2002). Acclimation of Litopenaeus vannamei postlarvae to low salinity: Influence of age, salinity endpoint, and rate of salinity reduction. Journal of the World Aquaculture Society, 33(1), 78–84. https://doi.org/10.1111/j.1749-7345.2002.tb00481.x
Environmental	USA	McIntosh, D. M. (2002). Reducing the environmental impact of aquaculture [PhD Thesis]. In https://www.proquest.com/openview/ee35c63fb95c99cecbb00e65cce39147/1?cbl=18750&diss=y&pq-origsite=gscholar&parentSessionId=yUUByq25%2Fj37YKbOCDuI3qAiMyoCSuUAc9QXs27aaSA%3D
Resourcespolicysys tems	USA	McIntosh, D. M. (2002). Reducing the environmental impact of aquaculture [PhD Thesis]. In www.proquest.com. https://www.proquest.com/openview/ee35c63fb95c99cecbb00e65cce39147/1?cbl=18750&diss=y&pq-origsite=gscholar&parentSessionId=rtCSb9msaeF026OzOeP73ekyPoGnhjwAImaApgqQzUM%3D
Vannamei	USA	McIntosh, D., & Fitzsimmons, K. (2003). Characterization of effluent from an inland, low-salinity shrimp farm: what contribution could this water make if used for irrigation. Aquacultural Engineering, 27(2), 147–156. https://doi.org/10.1016/s0144-8609(02)00054-7
Integrated ISA Agriculture	USA	Mcintosh, D., & Fitzsimmons, K. (n.d.). Shrimp aquaculture & olive production -sustainable integration. Retrieved February 27, 2023, from https://www.researchgate.net/profile/Kevin-Fitzsimmons-4/publication/266465969_SHRIMP_AQUACULTURE_OLIVE_PRODUCTION_-SUSTAINABLE_INTEGRATION/links/54c626920cf219bbe4f68488/SHRIMP-AQUACULTURE-OLIVE-PRODUCTION-SUSTAINABLE-INTEGRATION.pdf
Vannamei	USA	McIntosh, D., Fitzsimmons, K., Collins, C., & Stephens, C. (2006). Phytoplankton community composition and chlorophyll-a levels of inland, low salinity shrimp ponds. World Aquaculture. https://agris.fao.org/agris-search/search.do?recordID=US201301073790
Vannamei	USA	McNevin, A. A., Boyd, C. E., Silapajarn, O., & Silapajarn, K. (2004). Ionic supplementation of pond waters for inland culture of marine shrimp. Journal of the World Aquaculture Society, 35(4), 460–467. https://doi.org/10.1111/j.1749-7345.2004.tb00111.x
Resourcespolicysys tems	USA	Miyamoto, S. (1993). Potentially beneficial uses of inland saline waters in the southwestern USA. In H. Lieth & A. Al Masoom (Eds.), Towards the Rational Use of High Salinity Tolerant Plants (Vol. 2, pp. 407–422). Kluwer Academic Publishers. https://doi.org/10.1007/978-94-011-1860-6_47
Integrated ISA Agriculture	USA	Miyamoto, S. (1996). Growth, water use and salt uptake of four halophytes irrigated with highly saline water. Journal of Arid Environments, 32(2), 141–159. https://doi.org/10.1006/jare.1996.0013

Molluscs Echinoderms	USA	Nelson, S. M., & Flickinger, S. A. (1992). Effects of geothermal saline spring water on white shrimp, eastern oyster, and freshwater prawn. The Progressive Fish-Culturist, 54(1), 28–34. https://doi.org/10.1577/1548-8640(1992)054%3C0028:EOGSSW%3E2.3.CO;2
Freshwater fish (not carp)	USA	O'Neal, C. C., & Weirich, C. R. (2001). Effects of low levels of salinity on production characteristics of fingerling channel catfish reared from fry. North American Journal of Aquaculture, 63(2), 156–160. https://doi.org/10.1577/1548-8454(2001)063%3C0156:eollos%3E2.0.co;2
Freshwater fish (not carp)	USA	O'Neal, C., & Weirich, C. (2004). Effect of low levels of salinity on production characteristics of channel catfish Ictalurus punctatus reared in multiple-crop ponds. Journal of the World Aquaculture Society, 35(2), 284–290. https://www.ars.usda.gov/research/publications/publication/?seqNo115=161257
Vannamei	USA	Parmenter, K. J., Bisesi, J. H., Young, S. P., Klaine, S. J., Atwood, H. L., Browdy, C. L., & Tomasso, J. R. (2009). Culture of Pacific white shrimp Litopenaeus vannamei in a mixed-ion solution. North American Journal of Aquaculture, 71(2), 134–137. https://doi.org/10.1577/a08-015.1
Vannamei	USA	Perez-Velazquez, M., Davis, D. A., Roy, L. A., & González-Félix, M. L. (2012). Effects of water temperature and Na+:K+ ratio on physiological and production parameters of Litopenaeus vannamei reared in low salinity water. Aquaculture, 342-343, 13–17. https://doi.org/10.1016/j.aquaculture.2012.02.008
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Vannamei	USA	Pine, H. J., & Boyd, C. E. (2010). Adsorption of magnesium by bottom soils in inland brackish water shrimp ponds in Alabama. Journal of the World Aquaculture Society, 41(4), 603–609. https://doi.org/10.1111/j.1749-7345.2010.00400.x
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Vannamei	USA	Prapaiwong, N., & Boyd, C. E. (2012d). Water temperature in inland, low-salinity shrimp ponds in Alabama. Journal of Applied Aquaculture, 24(4), 334–341. https://doi.org/10.1080/10454438.2012.731479
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General status and opportunities	USA	Riche, M. A., Pfeiffer, T. J., Wills, P. S., Amberg, J. J., & Sepulveda, M. S. (2012). Inland marine fish culture in low salinity recirculating aquaculture systems. Bull. Fish. Res. Agen., 35, 65–75. https://www.fra.affrc.go.jp/bulletin/bull/bull35/35-8.pdf
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Vannamei	USA	Roy, L. A., Davis, D. A., & Whitis, G. N. (2009). Pond-to-pond variability in post-larval shrimp, Litopenaeus vannamei, survival and growth in inland low-salinity waters of west Alabama. Aquaculture Research, 40(16), 1823–1829. https://doi.org/10.1111/j.1365-2109.2009.02287.x
Vannamei	USA	Roy, L. A., Davis, D. A., & Whitis, G. N. (2012). Effect of feeding rate and pond primary productivity on growth of Litopenaeus vannamei reared in inland saline waters of west Alabama. North American Journal of Aquaculture, 74(1), 20–26. https://doi.org/10.1080/15222055.2011.638416
Vannamei	USA	Roy, L. A., Davis, D. A., Nguyen, T. N., & Saoud, I. P. (2009). Supplementation of chelated magnesium to diets of the Pacific white shrimp, Litopenaeus vannamei, reared in low-salinity waters of west Alabama. Journal of the World Aquaculture Society, 40(2), 248–254. https://doi.org/10.1111/j.1749-7345.2009.00247.x
Vannamei	USA	Roy, L. A., Davis, D. A., Saoud, I. P., & Henry, R. P. (2007a). Effects of varying levels of aqueous potassium and magnesium on survival, growth, and respiration of the Pacific white shrimp, Litopenaeus vannamei, reared in low salinity waters. Aquaculture, 262(2-4), 461–469. https://doi.org/10.1016/j.aquaculture.2006.10.011

Vannamei	USA	Roy, L. A., Davis, D. A., Saoud, I. P., & Henry, R. P. (2007b). Supplementation of potassium, magnesium and sodium chloride in practical diets for the Pacific white shrimp, Litopenaeus vannamei, reared in low salinity waters. Aquaculture Nutrition, 13(2), 104–113. https://doi.org/10.1111/j.1365-2095.2007.00460.x
Vannamei	USA	Roy, L. A., Davis, D. A., Saoud, I. P., Boyd, C. A., Pine, H. J., & Boyd, C. E. (2010). Shrimp culture in inland low salinity waters. Reviews in Aquaculture, 2(4), 191–208. https://doi.org/10.1111/j.1753-5131.2010.01036.x
Vannamei	USA	Roy, L. A., Teichert-Coddington, D., Beck, B. H., Dahl, S., James, J., Guo, J., & Davis, D. A. (2020). Evaluation of stocking density and dietary fish meal inclusion for intensive tank production of Pacific white shrimp Litopenaeus vannamei cultured in low-salinity waters of western Alabama. North American Journal of Aquaculture, 82(3), 345–353. https://doi.org/10.1002/naaq.10150
Vannamei	USA	Roy, L. A., Teichert-Coddington, D., Dahl, S., Beck, B. H., Shoemaker, C. A., Whitis, G. N., & James, J. (2019). On-farm evaluation of three different hatchery sources of Pacific white shrimp (Litopenaeus vannamei) cultured in on-levee tanks in low-salinity waters of west Alabama. Journal of Applied Aquaculture, 32(3), 193–204. https://doi.org/10.1080/10454438.2019.1614510
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Vannamei	USA	Roy, L., & Davis, D. (2020). Tank systems on shrimp farms are effective for extension demonstrations in aquaculture. The Journal of Extension, 58(6). https://tigerprints.clemson.edu/joe/vol58/iss6/29/
Vannamei	USA	Samocha, T. M., Hamper, L., Emberson, C. R., Davis, A. D., McIntosh, D., Lawrence, A. L., & Van Wyk, P. M. (2002). Review of some recent developments in sustainable shrimp farming practices in Texas, Arizona, and Florida. Journal of Applied Aquaculture, 12(1), 1–42. https://doi.org/10.1300/j028v12n01_01
Vannamei	USA	Samocha, T. M., Lawrence, A. L., & Pooser, D. (n.d.). Growth and survival of juvenile Penaeus vannamei in low salinity water in a semi-closed recirculating system. The Israeli Journal of Aquaculture - Bamidgeh, 50(2), 55–59. https://www.academia.edu/download/7406468/37563.pdf
Vannamei	USA	Samocha, T. M., Lawrence, A. L., Collins, C. A., Castille, F. L., Bray, W. A., Davies, C. J., Lee, P. G., & Wood, G. F. (2004). Production of the Pacific white shrimp,litopenaeus vannamei, in high-density greenhouse-enclosed raceways using low salinity groundwater. Journal of Applied Aquaculture, 15(3-4), 1–19. https://doi.org/10.1300/j028v15n03_01
Vannamei	USA	Saoud, I. P., Davis, D. Allen., & Rouse, D. B. (2003). Suitability studies of inland well waters for Litopenaeus vannamei culture. Aquaculture, 217(1-4), 373–383. https://doi.org/10.1016/s0044-8486(02)00418-0
Vannamei	USA	Saoud, I. P., Roy, L. A., & Davis, D. A. (2007). Chelated potassium and arginine supplementation in diets of Pacific white shrimp reared in low-salinity waters of west Alabama. North American Journal of Aquaculture, 69(3), 265–270. https://doi.org/10.1577/a06-045.1

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Vannamei	USA	Sun, W. (2012). Phosphorus and nitrogen budget for inland, saline water shrimp ponds in Alabama. [MSc Thesis.]. http://etd.auburn.edu/handle/10415/3397
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Vannamei	USA	Whetstone, J. M., Treece, G. D., Browdy, C. L., & Stokes, A. D. (2002). Opportunities and Constraints in Marine Shrimp Farming. Southern Regional Aquculture Centre. SRAC Publication No. 2600. https://www.researchgate.net/publication/242488906_Opportunities_and_Constraints_in_Marine_Shrimp_Farming
Vannamei	USA	Yao, S. Q. (2018). Assessment and modeling of whiteleg shrimp production in a low-salinity recirculating aquaculture system [Master of Science Thesis]. In deepblue.lib.umich.edu. https://deepblue.lib.umich.edu/handle/2027.42/145428
Integrated ISA Agriculture	USA, Canada	de Dezsery, A. S. (2010). Commercial integrated farming of aquaculture and horticulture (p. 62). International Specialised Skills Institute. http://byap.backyardmagazines.com/Travis/ISSI%20-%20REPORT.pdf
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Resourcespolicysystems	Uzbekistan	Crootof, A., Mullabaev, N., Saito, L., Atwell, L., Rosen, M. R., Bekchonova, M., Ginatullina, E., Scott, J., Chandra, S., Nishonov, B., Lamers, J. P. A., & Fayzieva, D. (2015). Hydroecological condition and potential for aquaculture in lakes of the arid region of Khorezm, Uzbekistan. Journal of Arid Environments, 117, 37–46. https://doi.org/10.1016/j.jaridenv.2015.02.012
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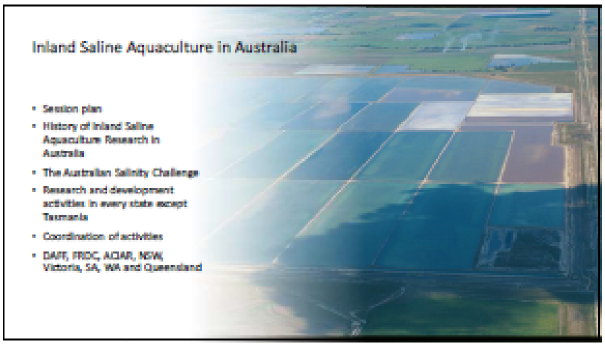
Appendix 2. Presentations -Inland Saline Aquaculture Session WA23

Inland Saline Aquaculture Session, World Aquaculture 2023, Darwin May/June 2023			
INLAND SALINE AQUACULTURE IN AUSTRALIA: PAST PROGRESS CHALLENGES AND OPPORTUUNITIES	Geoff	Allan	NSW DPI
TWO DECADES OF RESEARCH AND DEVELOPMENT IN INLAND SALINE AQUACULTURE IN INDIA: PRESENT STATUS AND PROSPECTS	Tincy	Varghese	CIFI, India
INLAND SALINE AQUACULTURE IN NSW: 10 YEARS OF RESEARCH & DEVELOPMENT	Stewart	Fielder	NSW DPI
PAST RESEARCH AND BARRIERS TO COMMERCIAL AQUACULTURE UTILISING SALINE GROUNDWATER FROM SALT INTERCEPTIONS SCHEMES IN SOUTH AUSTRALIA	Wayne	Hutchinson	FRDC (ex SARDI, SA)
INLAND SALINE AQUACULTURE IN VICTORIA – A RETROSPECTIVE VIEW AND FUTURE OPPORTUNITIES	Brett	Ingram	VFA, Victoria
INLAND SALINE AQUACUTLURE IN WESTERN AUSTRALIA; PAST, PRESENT AND FUTURE?	Gavin	Partridge	Harvest Road (ex-Challenger TAFE, WA)
INLAND SALINE AQUACULTURE - USA AND ISRAEL PERSPECTIVES	Kevin	Fitzsimmons	University Arizona USA)
INLAND SALINE AQUACULTURE IN AUSTRALIA: PANEL DISCUSSION	Geoff	Allan	NSW DPI

INLAND SALINE AQUACULTURE IN AUSTRALIA: PAST PROGRESS, CHALLENGES AND OPPORTUNITIES. Geoff Allan, NSW DPI.

1



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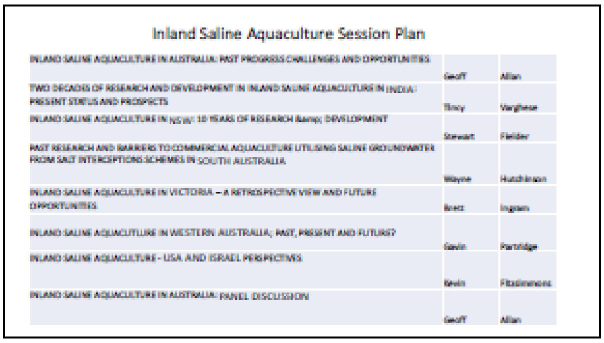

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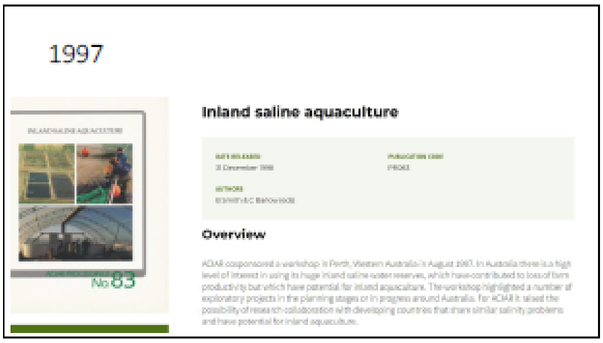

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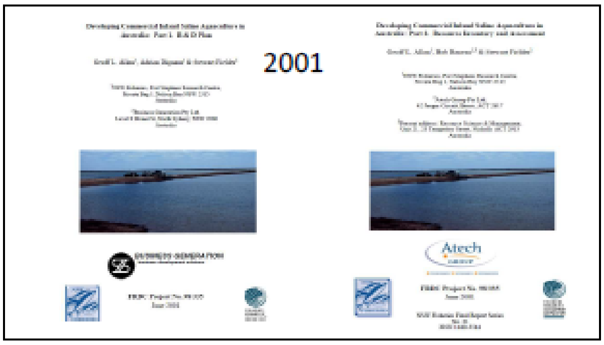

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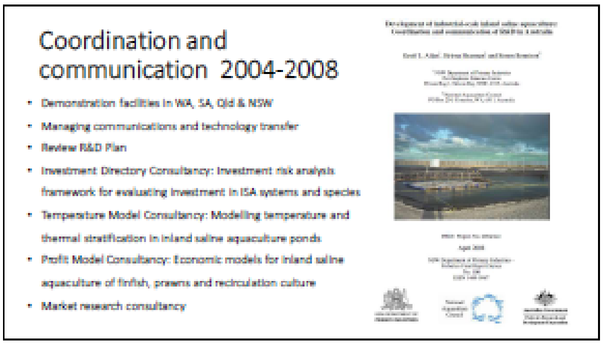


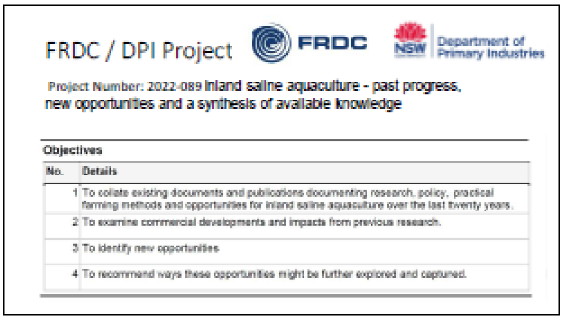
6


Economic analysis
Inland Saline
Recirculation Culture
Decision Tool
Investment opportunity – NSW (trout in saline evaporation ponds)
Investment opportunity – SA (marine fish, etc)
Coal Seam gas opportunity – Qld (use of saline evaporation ponds)
Data Entry Cell
Potential Cell

7


Why hasn't commercial inland saline aquaculture in Australia developed?
There is some new interest in commercial development but potential investors claim they are unaware of previous work
Are there new opportunities for commercial inland saline aquaculture in Australia and what more is needed to help realise them?

8


FRDC / DPI Project
FRDC
NSW Department of Primary Industries
Project Number: 2022-089 Inland saline aquaculture - past progress, new opportunities and a synthesis of available knowledge
Objectives
No.
Details
1 To collate existing documents and publications documenting research, policy, practical farming methods and opportunities for inland saline aquaculture over the last twenty years.
2 To examine commercial developments and impacts from previous research.
3 To identify new opportunities
4 To recommend ways these opportunities might be further explored and captured.

9


Challenges and opportunities
The compilation of references, in both published and grey literature, is growing
There is no shortage of information on inland saline aquaculture from Australia and overseas.
Other challenges to commercial development will be discussed in the next presentations
We will examine them during the panel discussion
We will also try to identify new opportunities
>414 references

10

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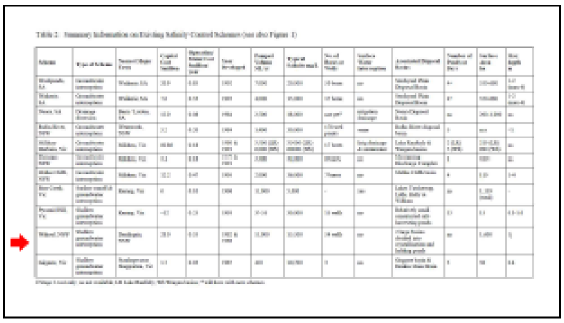

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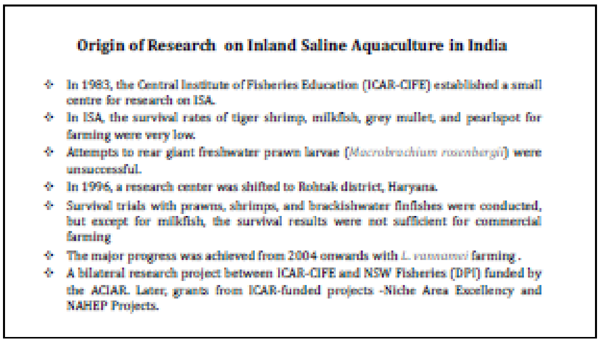
TWO DECADES OF RESEARCH AND DEVELOPMENT IN INLAND SALINE AQUACULTURE IN INDIA: PRESENT STATUS AND PROSPECTS. Tincy Varghese. CIFI, India.

1



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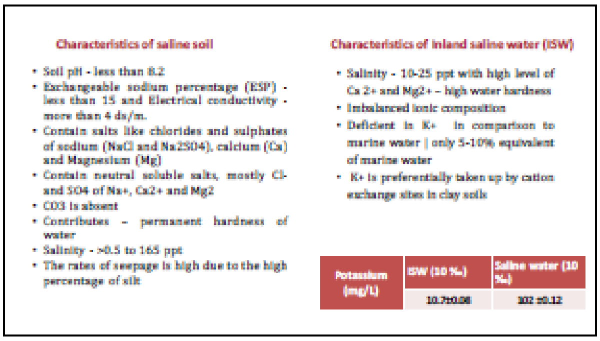

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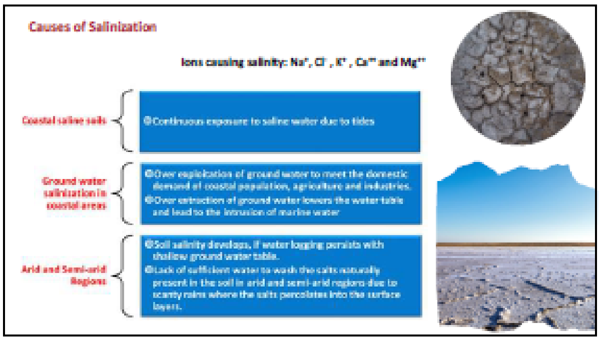

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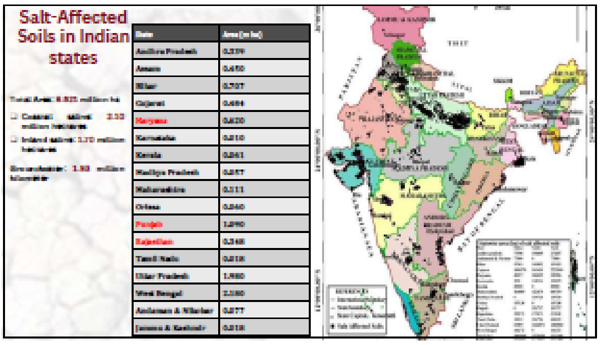

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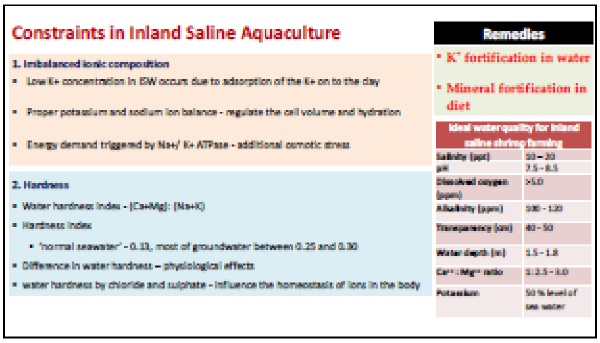


6

Ionic composition of Inland saline waters (ISW) in comparison to the seawater (SW)

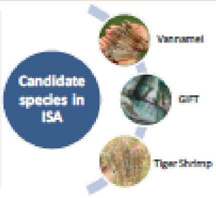
Ions (mg/l)	15 ppt ISW	15 PPT SW	10ppt ISW	10 PPT SW	5 PPT ISW	5 PPT SW
Na^+	4450	4567	3290	3045	1900	1523
K^+	23	160.5	17.2	107	7	53.5
Ca^{2+}	220	174	144	116	104	58
Mg^{2+}	352	593	244	395	140	195
Na^+/K^+	193:1	28:1	192:1	28:1	271:1	28:1
Ca^{2+}/Mg^{2+}	1:1.6	1:3.4	1: 1.69	1:3.4	1:1.34	1:3.4

7

Species Recognized for ISA on a Global Scale

- Species selected on the basis of their **salinity tolerance** and **commercial importance**
- The best candidate species for inland saline waters is *Penaeus vannamei*
- Also a number of brackish water and marine species are cultured

1. *Mugil cephalus*
2. *Lates calcarifer*
3. *Chanos chanos*
4. *Etroplus suratensis*
5. *Oreochromis niloticus*
6. *Argyrosomus japonicus*
7. *Pagrus auratus*
8. *Penaeus vannamei*
9. *Sciaenops ocellatus*
10. *Penaeus latisulcatus*
11. *Penaeus monodon*



12. *Macrobrachium rosenbergii*
13. *Oncorhynchus mykiss*
14. Major Carps
15. *Sparus aurata*
16. Red Tilapia
17. *Pangasiandon spp*
18. Spirulina
19. Rotifers
20. Molluscs
21. Algae
22. Green Lip Abalone

8

Technologies developed by ICAR-CIFE for ISW

- Seed production and culture of Scampi (*M. rosenbergii*) using ISW
- Culture of Tiger shrimp (*P. monodon*) in moderate salinity inland ground saline waters
- Industrial production of vannamei shrimp (*Penaeus vannamei*)
- Culture of milkfish (*Chanos chanos*) in low salinity water
- Culture of GIFT tilapia in low and high inland ground saline waters
- Culture of striped catfish (*Pangasianodon hypophthalmus*) in low salinity water
- Experimental Culture of Indian pompano, Asian seabass and Amur carp in ISW

9

PRODUCTION OF HATCHERY SEED OF SCAMPI USING INLAND GROUND SALINE WATER

- ISW was found unfit for larval survival due to high calcium and low level of potassium.
- Quality of ISW was modified with a cost-effective methodology for commercial production of scampi seed.
- A hatchery with a production capacity of 1.5 million PL was developed

Parameter	CSW	IGSW
pH	7.5	8.2
Alkalinity (mg/l)	121	172
Total Hardness (mg/l)	2330	3600
Chloride (mg/l)	6590	6420
Sodium (mg/l)	3700	4600
Potassium (mg/l)	121	[illegible]
Calcium (mg/l)	144	448
Magnesium (mg/l)	484	[illegible]
Mg^{2+}/Ca^{2+}	[illegible]	1.4

Parameter	Values
Salinity (ppt)	[illegible]
pH	[illegible]
Total alkalinity (mg/l)	[illegible]
Total Hardness (mg/l)	[illegible]
Chlorides (mg/l)	[illegible]
Sodium (mg/l)	[illegible]
Potassium (mg/l)	[illegible]
Calcium (mg/l)	[illegible]
Magnesium (mg/l)	[illegible]
Mg^{2+}/Ca^{2+}	[illegible]

10

First Scampi Hatchery with a Production Capacity of 1.6 million PL Using ISW (amended) Established at Rohtak (Haryana)

Rohtak hatchery commenced prawn seed supply in 2008 and distributed seed to the farmers of Haryana, Punjab, Uttar Pradesh, Bihar, Mizoram, Jammu & Kashmir and Himachal Pradesh. Conducted trainings for researchers, teachers and state officials on prawn breeding and grow-out productions.

11

Grow-out Production of Scampi (*M. rosenbergii*) in ISW

- Suitable for culture in different salinities of ISW (0-10 ppt).
- Commercially farmed up to 5 ppt salinity in saline bore-well water under experimental and farmer's ponds.
- Suitable for culture in mono and polyculture systems.
- High demand in domestic and export markets.
- Production of 1250 kg/ha/6 months in monoculture.
- Production of 350 kg/ha/6-7 months of scampi and 3000 kg/ha/yr IMC under polyculture system

12

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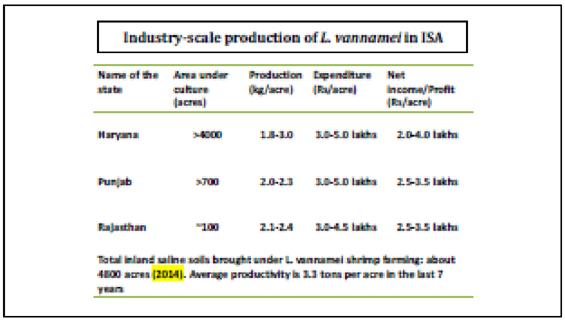

Name of the state	Area under culture (acres)	Production (kg/acre)	Expenditure (Rs/acre)	Net Income/Profit (Rs/acre)
Haryana	>4000	1.8-3.0	3.0-5.0 lakhs	2.0-4.0 lakhs
Punjab	>700	2.0-2.3	3.0-5.0 lakhs	2.5-3.5 lakhs
Rajasthan	~100	2.1-2.4	3.0-4.5 lakhs	2.5-3.5 lakhs

Total inland saline soils brought under L. vannamei shrimp farming: about 4800 acres (2014). Average productivity is 3.3 tons per acre in the last 7 years

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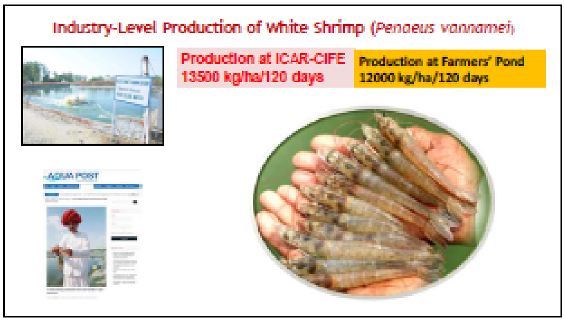

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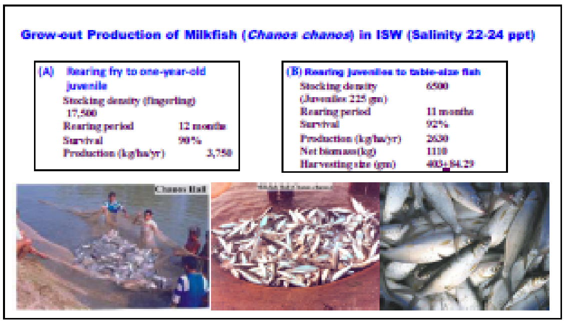

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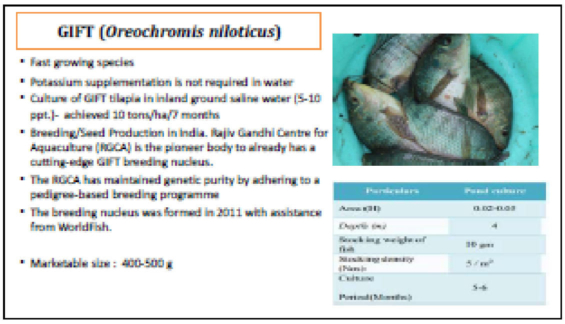

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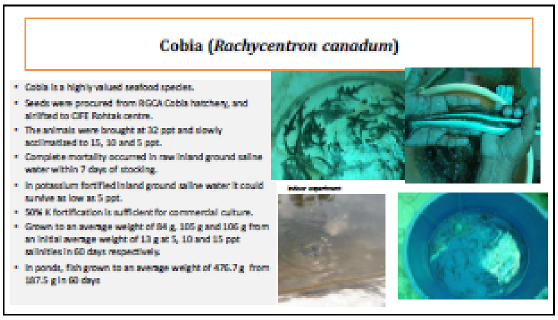

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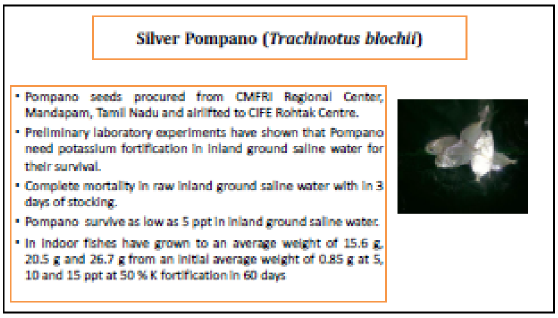

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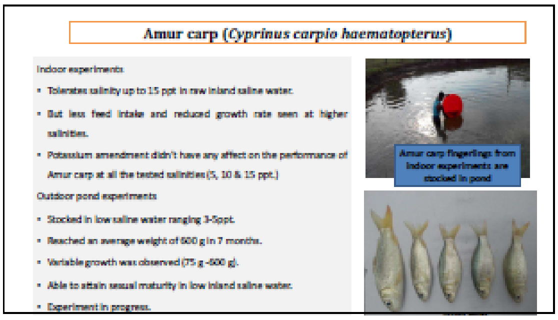

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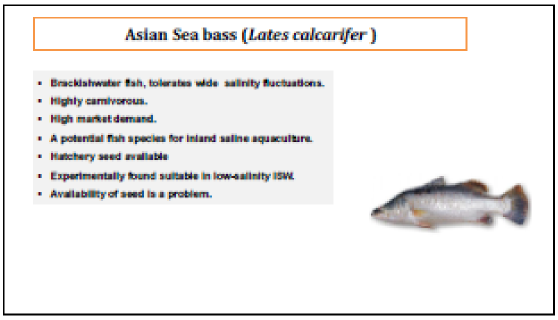

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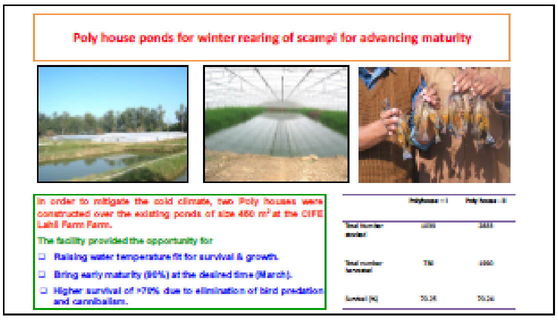

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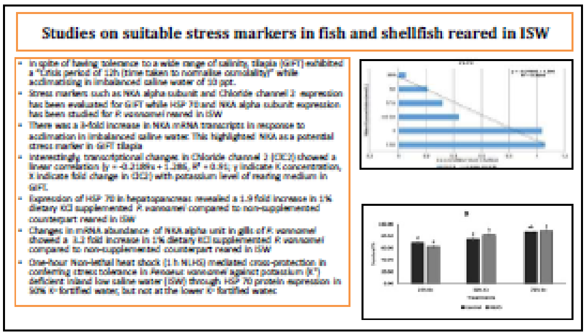

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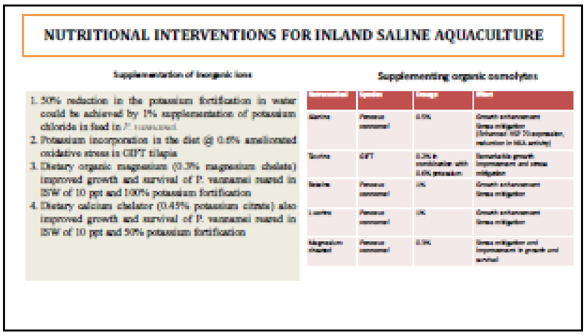

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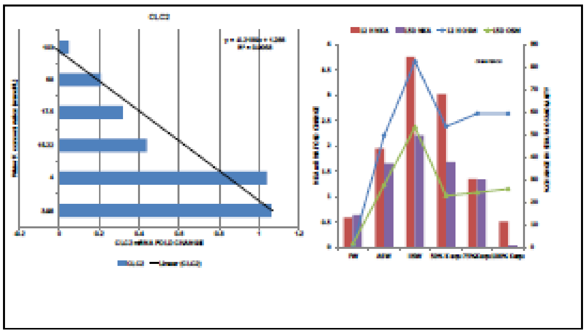

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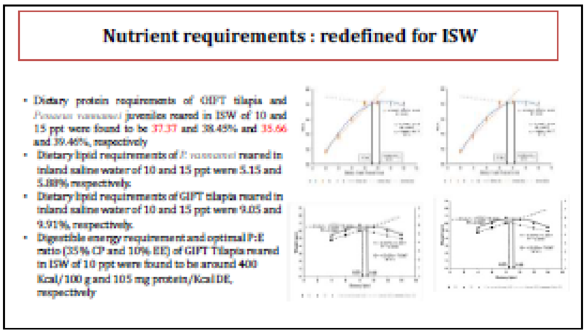

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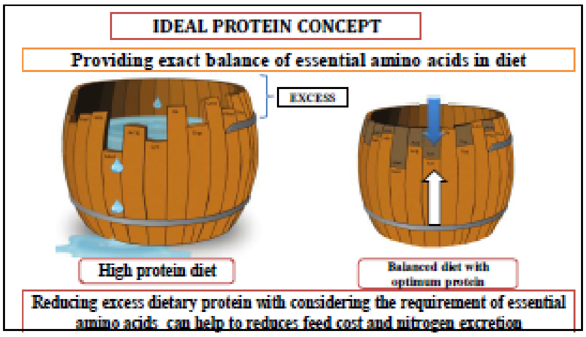

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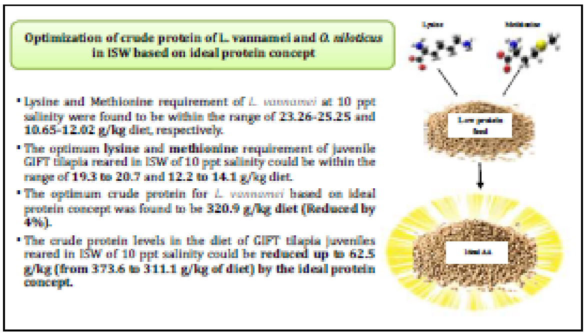


30

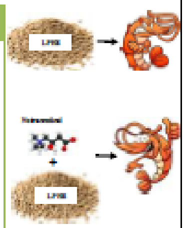
Organic osmolytes supplementation with ISW

Nutraceutical	Species	Dosage	Effect
Alanine	Penaeus vannamei	0.5%	Growth enhancement Stress mitigation (Enhanced HSP 70 expression, reduction in NKA activity)
Taurine	GIFT	0.2% in combination with 0.6% potassium	Remarkable growth improvement and stress mitigation
Betaine	Penaeus vannamei	1%	Growth enhancement Stress mitigation
L-serine	Penaeus vannamei	1%	Growth enhancement Stress mitigation
Magnesium chelator (potassium citrate)	Penaeus vannamei	0.3%	Stress mitigation and improvement in growth and survival

31

Low protein high energy diets supplemented with different nutraceuticals

Additives	Best performing dose	Protein and lipid levels	Authors
L-carnitine	0.05%	33% CP, 8% EE	Raghuvaran, 2021
Taurine	0.5%	33% CP, 8% EE	Bhavatharaniya, 2021
Berberine	0.005%	33% CP, 7% EE	Nanda, 2023
Quercetin	0.025%	33% CP, 7% EE	Nanda, 2023
Glycerol Monolaurate	0.1%	33% CP, 7% EE	Das, 2023
Leonardite	0.12%	33% CP, 7% EE	Das, 2023



32

Government support for the ISA

- Blue Revolution Scheme (2015-16 to 2019-20)
  - An area of 391 ha was covered under the grant (40-60% subsidy on DPR)
- PMMSY (Prime Minister Fisheries Resource Scheme) (2020-21 to 2024-25)
  - Total investment on ISA Rs. 5260 million
  - 1025 new ponds are approved in 2020-21 & 2021-22 with a grant of Rs 217 million (40-60% subsidy on DPR)
  - Grants for RAS/Biofloc; cold-chain & processing included to boost intensification, water conservation, and better marketing.
  - Generation of 0.3 million livelihoods.
- Planning to create an ISA Hub in the saline-affected areas for assured storage and marketing

PMMSY envisages an investment target of Rs. 526 Crore during 2020-21 to 2024-25 for development of saline water aquaculture while generating 3 lakh employment opportunities

33

Conclusion and Way forward

- Hatchery seed production of suitable species for ISA to increase availability and cut down input costs.
- Development of feed mills in the vicinity using locally available feed ingredients to cut down input costs.
- Research on to minimize potassium addition in water
- Research on minimizing temperature and salinity variation stress on species to be farmed in ISA.
- Expansion of exclusive research facilities for the ISA sector
- Organized marketing for a stable price
- Development of value-addition and cold chain facilities nearby for local consumption and export.
- Referral lab for disease monitoring
- Regular monitoring of secondary salinization in non-affected areas

34

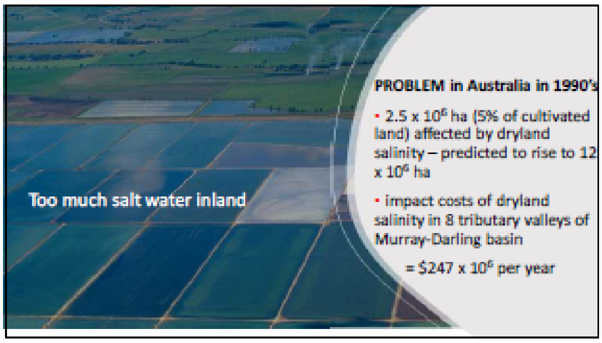
Thank you

Do Have Any Questions?

35

INLAND SALINE AQUACULTURE IN NSW: 10 YEARS OF RESEARCH & DEVELOPMENT. Stewart Fielder, NSW DPI.

1



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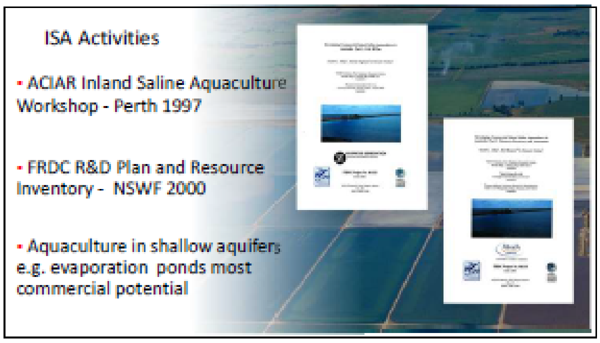

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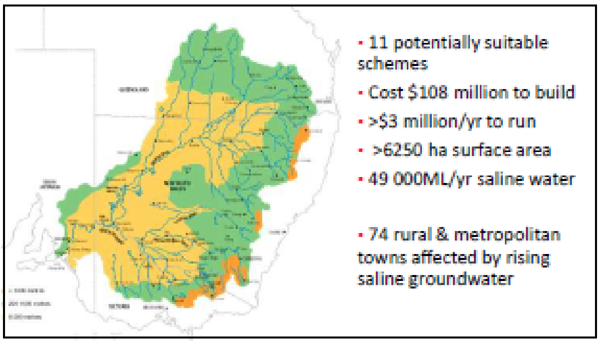

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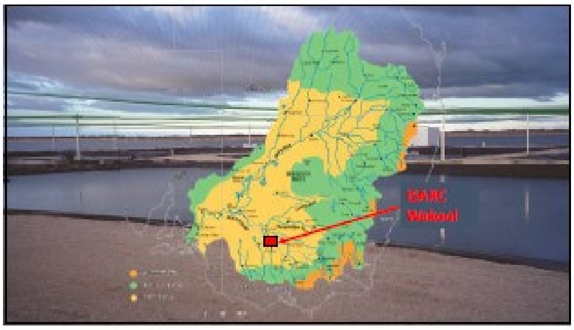
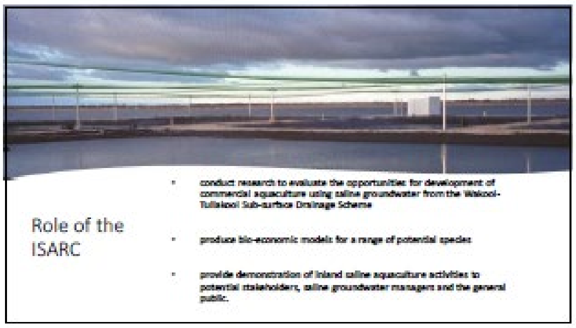

ISARC
Wakool

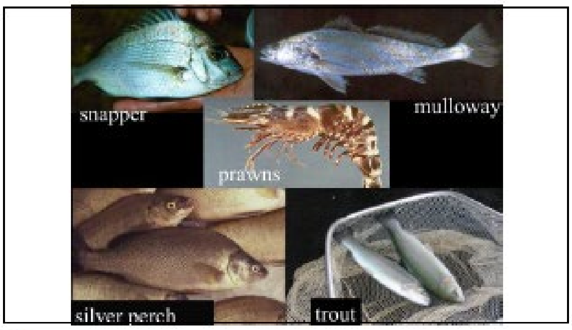
7


Inland Saline Aquaculture Research Centre

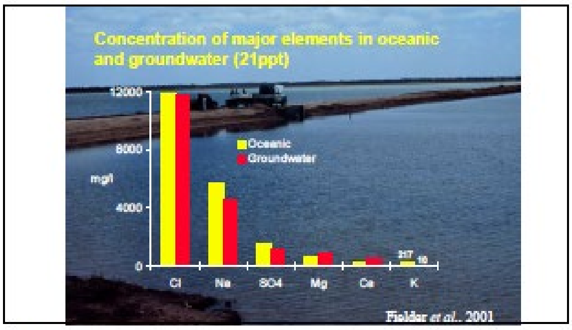
8


Role of the ISARC
conduct research to evaluate the opportunities for development of commercial aquaculture using saline groundwater from the Wakool-Tullakool Sub-surface Drainage Scheme
produce bio-economic models for a range of potential species
provide demonstration of inland saline aquaculture activities to potential stakeholders, saline groundwater managers and the general public.

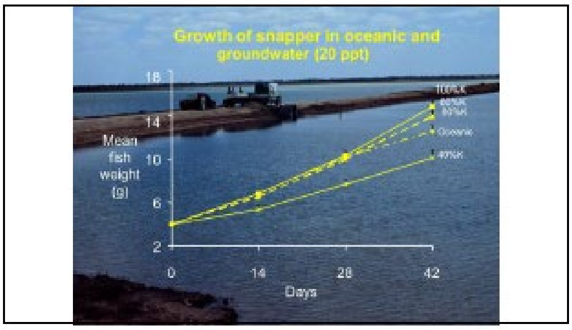
9


snapper
mulloway
prawns
silver perch
trout

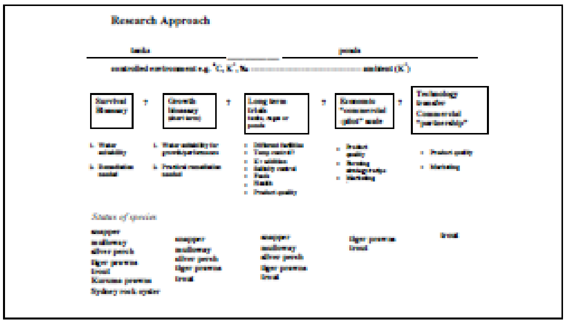
10


Concentration of major elements in oceanic and groundwater (21ppt)
12000
8000
4000
0
mg/l
Oceanic
Groundwater
Cl
Na
SO4
Mg
Ca
K
Fielder et al., 2001

11


Growth of snapper in oceanic and groundwater (20 ppt)
Mean fish weight (g)
18
14
10
6
2
Oceanic
0
14
28
42
Days

12



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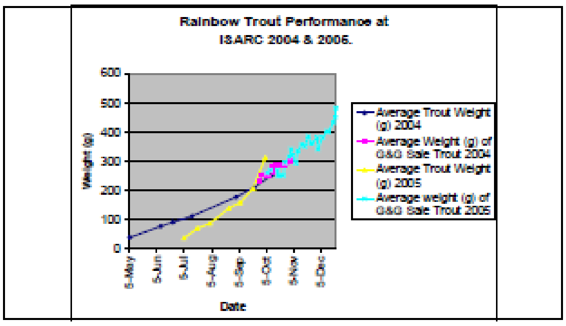

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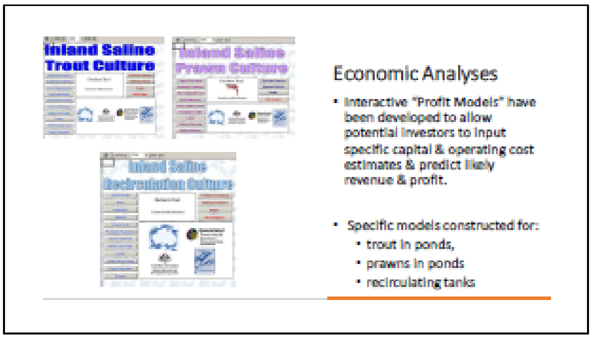

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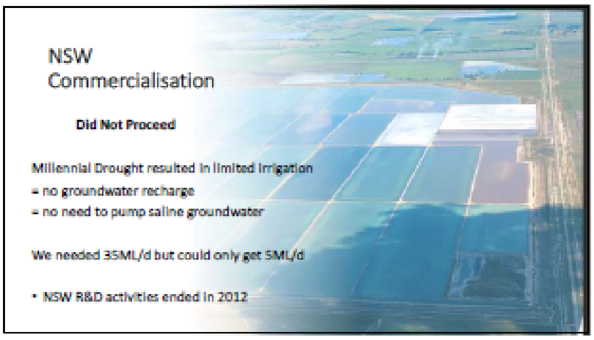

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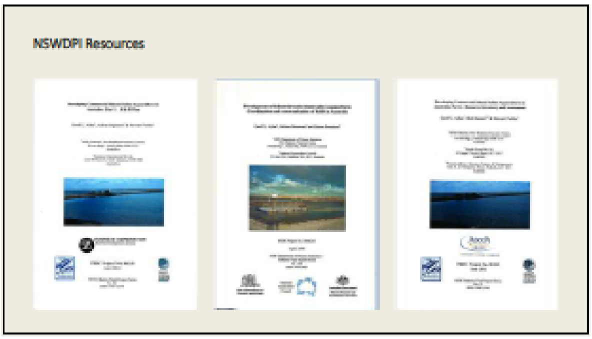

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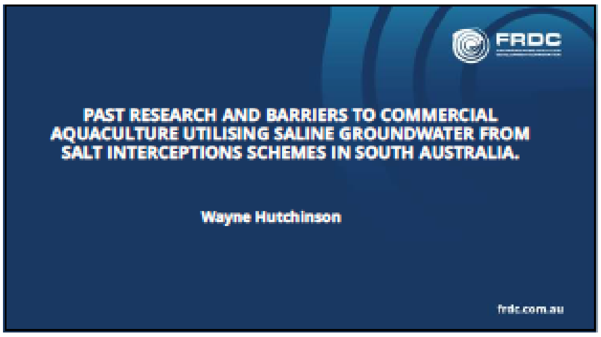
24

PAST RESEARCH AND BARRIERS TO COMMERCIAL AQUACULTURE UTILISING SALINE GROUNDWATER FROM SALT INTERCEPTIONS SCHEMES IN SOUTH AUSTRALIA. Wayne Hutchinson. FRDC (ex SARDI, SA).



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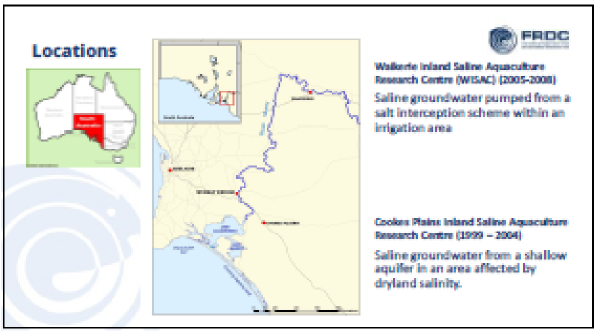

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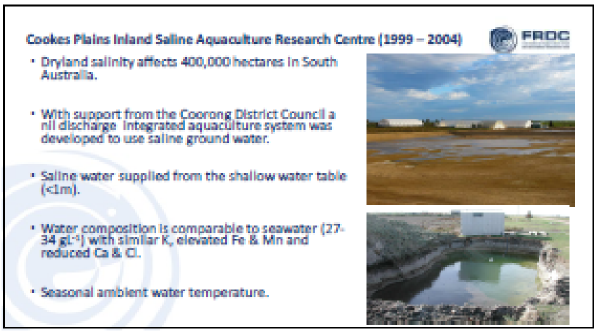

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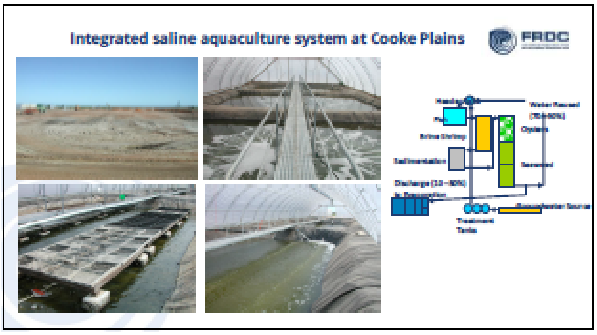

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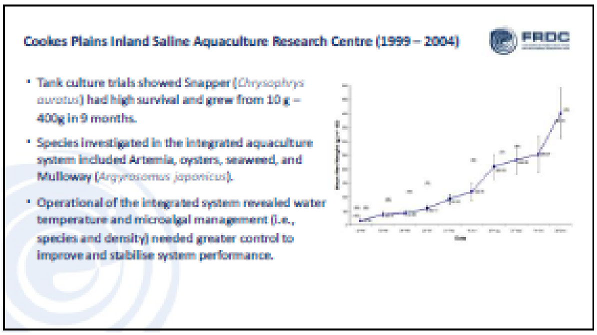

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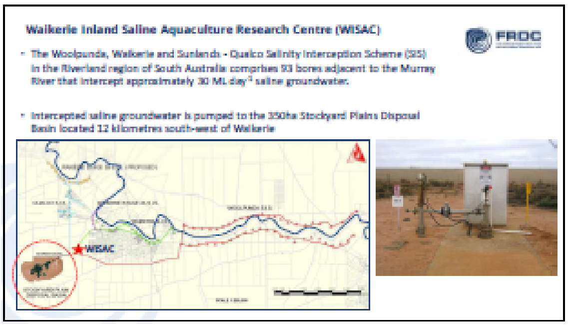
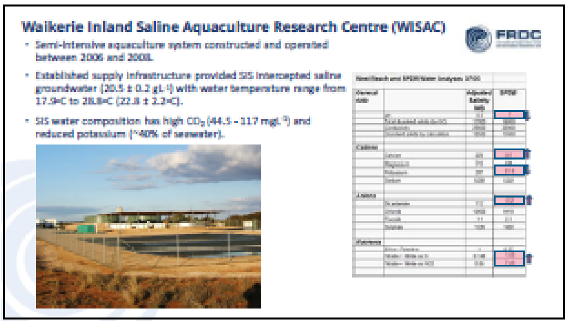

Waikerie Inland Saline Aquaculture Research Centre (WISAC)
FRDC
The Woolpunda, Waikerie and Sunlands - Qualco Salinity Interception Scheme (SIS) in the Riverland region of South Australia comprises 93 bores adjacent to the Murray River that intercept approximately 30 ML day-1 saline groundwater.
Intercepted saline groundwater is pumped to the 350ha Stockyard Plains Disposal Basin located 12 kilometres south-west of Waikerie
WISAC

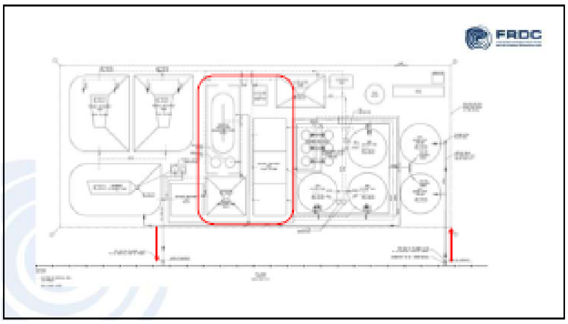
7


Stockyard Plains Disposal Basin
FRDC

8


Waikerie Inland Saline Aquaculture Research Centre (WISAC)
FRDC
Semi-intensive aquaculture system constructed and operated between 2006 and 2008.
Established supply infrastructure provided SIS intercepted saline groundwater (20.5 ± 0.2 gL-1) with water temperature range from 17.9ºC to 28.8ºC (22.8 ± 2.2ºC).
SIS water composition has high CO3 (44.5 - 117 mgL-1) and reduced potassium (~40% of seawater).

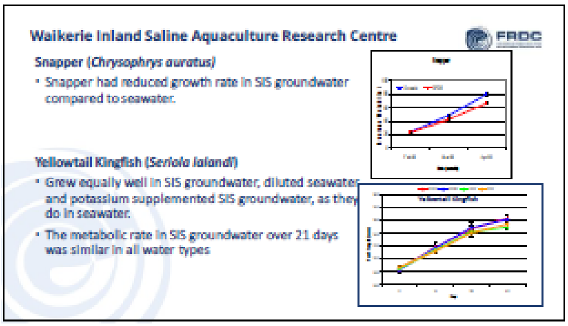
9


FRDC

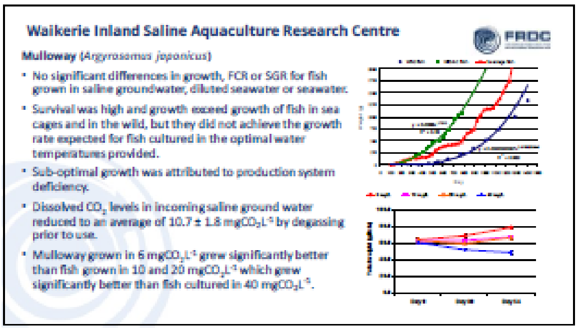
10


Waikerie Inland Saline Aquaculture Research Centre (WISAC)
FRDC

11


Waikerie Inland Saline Aquaculture Research Centre
FRDC
Snapper (Chrysophrys auratus)
Snapper had reduced growth rate in SIS groundwater compared to seawater.
Yellowtail Kingfish (Seriola lalandi)
Grew equally well in SIS groundwater, diluted seawater and potassium supplemented SIS groundwater, as they do in seawater.
The metabolic rate in SIS groundwater over 21 days was similar in all water types

12



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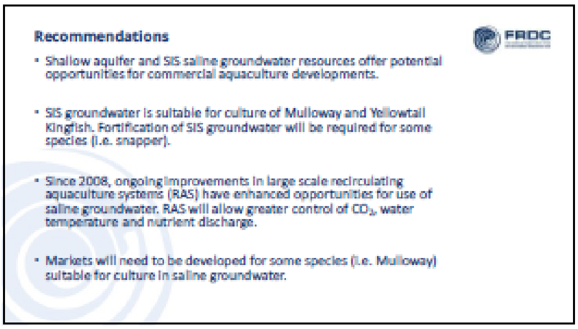

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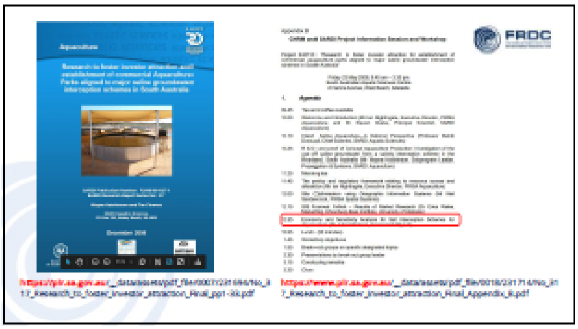

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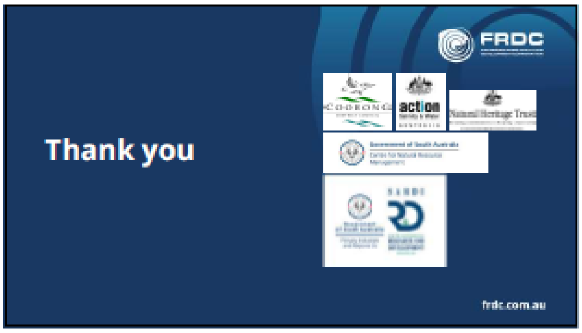
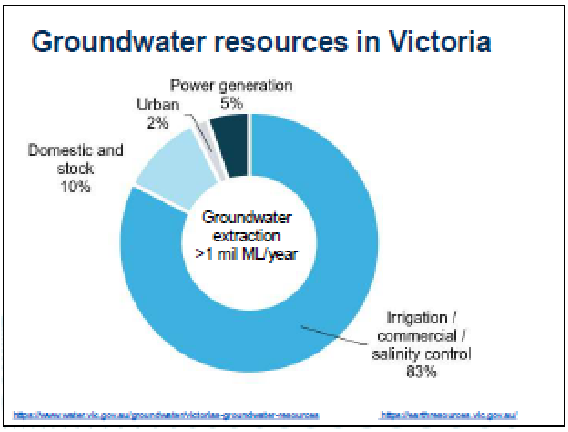


18

INLAND SALINE AQUACULTURE IN VICTORIA – A RETROSPECTIVE VIEW AND FUTURE OPPORTUNITIES. Brett Ingram, VFA, Victoria.

1



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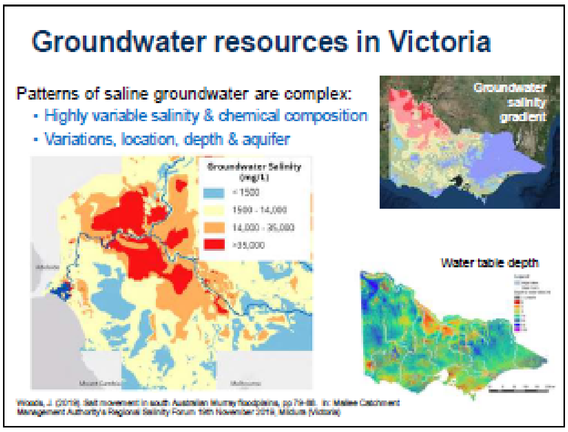

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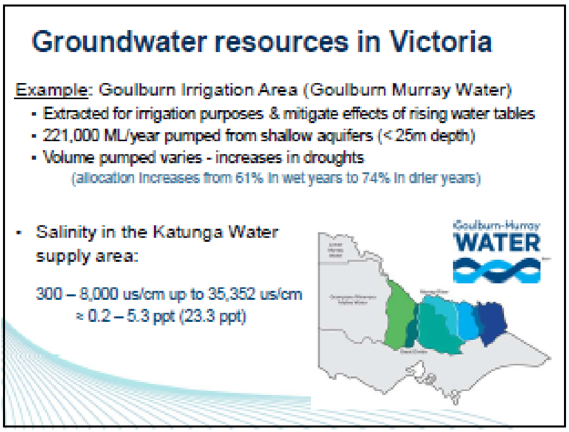

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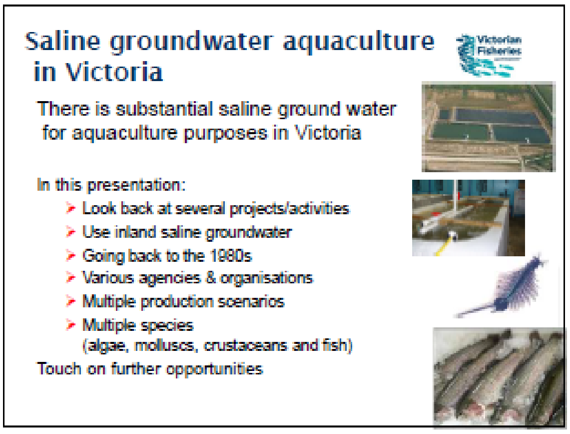

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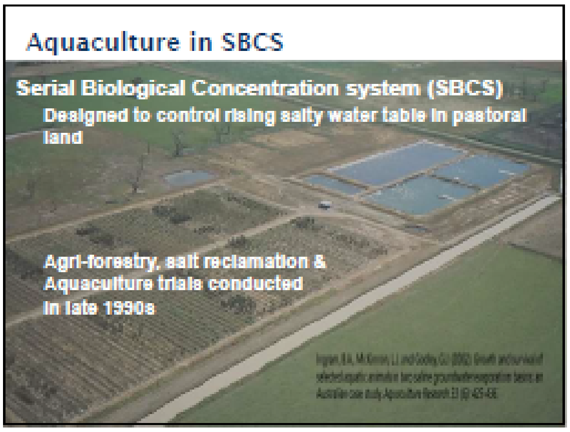
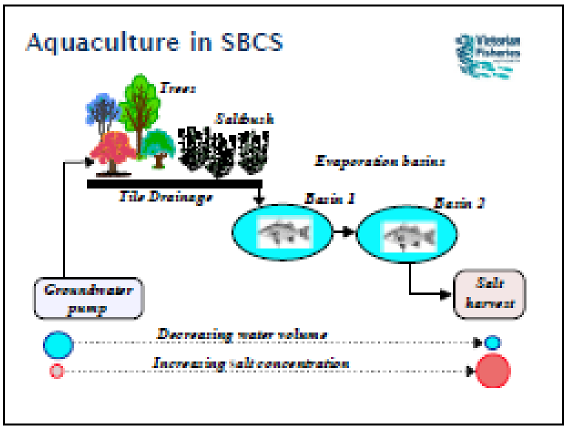
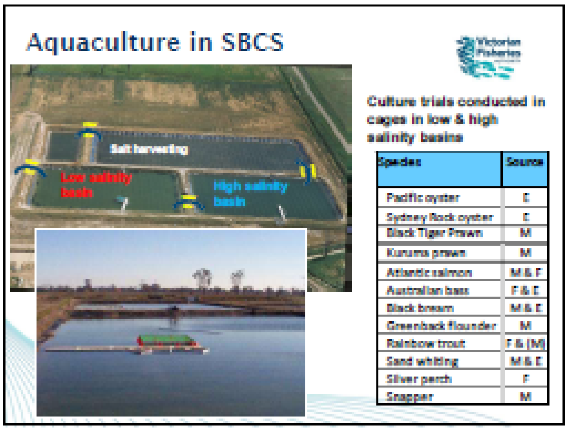

Aquaculture in SBCS
Serial Biological Concentration system (SBCS)
Designed to control rising salty water table in pastoral land
Agri-forestry, salt reclamation & Aquaculture trials conducted in late 1990s

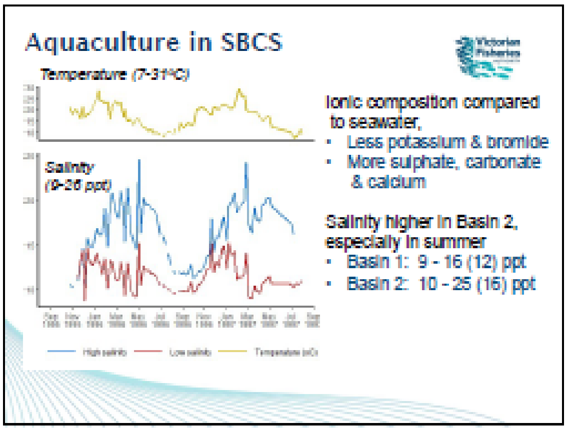
7


Aquaculture in SBCS
Victorian Fisheries
Trees
Saltbush
Evaporation basins
Tile Drainage
Basin 1
Basin 2
Groundwater pump
Salt harvest
Decreasing water volume
Increasing salt concentration

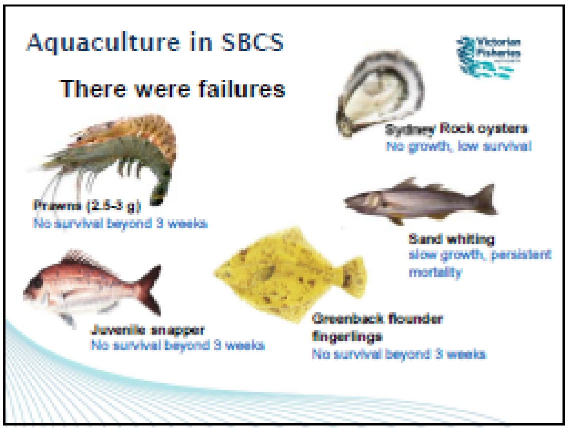
8


Aquaculture in SBCS
Victorian Fisheries
Salt harvesting
Low salinity basin
High salinity basin
Culture trials conducted in cages in low & high salinity basins
Species | Source
Pacific oyster | E
Sydney Rock oyster | E
Black Tiger Prawn | M
Kuruma prawn | M
Atlantic salmon | M & F
Australian bass | F & E
Black bream | M & E
Greenback flounder | M
Rainbow trout | F & (M)
Sand whiting | M & E
Silver perch | F
Snapper | M

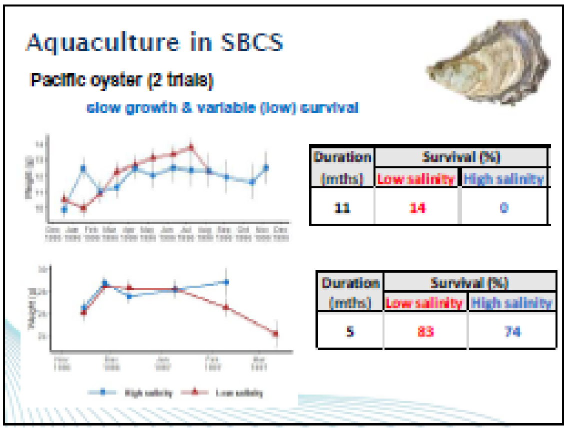
9


Aquaculture in SBCS
Victorian Fisheries
Temperature (7-31ºC)
Salinity (9-26 ppt)
Ionic composition compared to seawater,
• Less potassium & bromide
• More sulphate, carbonate & calcium
Salinity higher in Basin 2, especially in summer
• Basin 1: 9 - 16 (12) ppt
• Basin 2: 10 - 25 (16) ppt

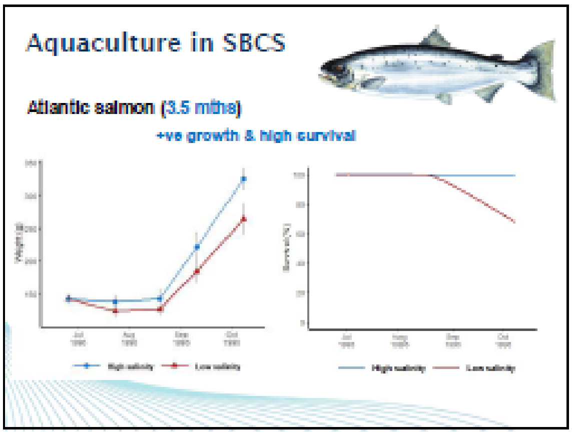
10


Aquaculture in SBCS
Victorian Fisheries
There were failures
Sydney Rock oysters
No growth, low survival
Prawns (2.5-3 g)
No survival beyond 3 weeks
Sand whiting
slow growth, persistent mortality
Juvenile snapper
No survival beyond 3 weeks
Greenback flounder fingerlings
No survival beyond 3 weeks

11


Aquaculture in SBCS
Pacific oyster (2 trials)
slow growth & variable (low) survival
Duration (mths) | Survival (%) Low salinity | High salinity
11 | 14 | 0
Duration (mths) | Survival (%) Low salinity | High salinity
5 | 83 | 74

12



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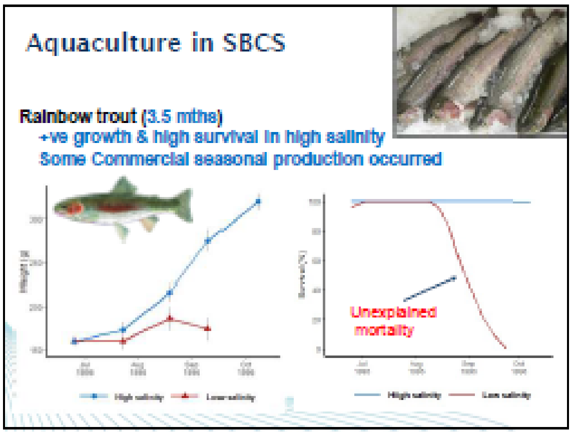

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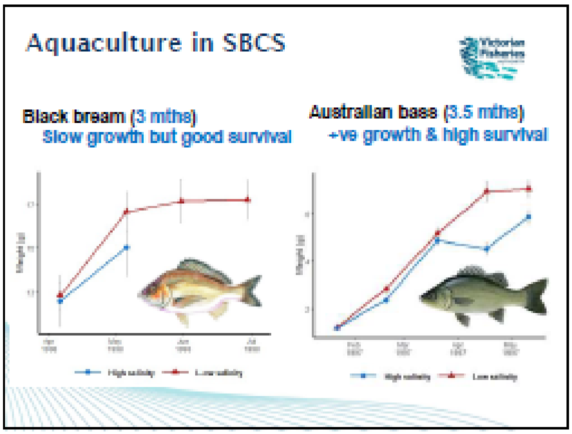

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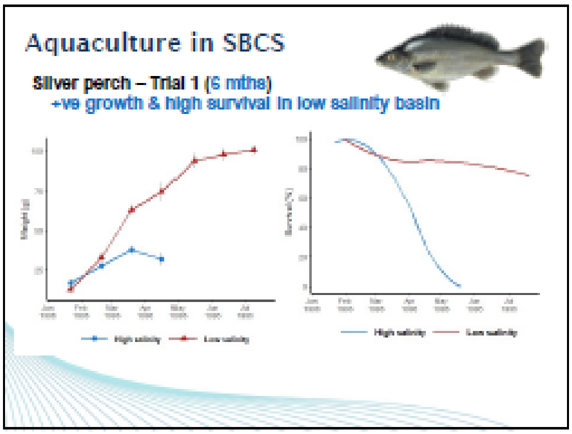

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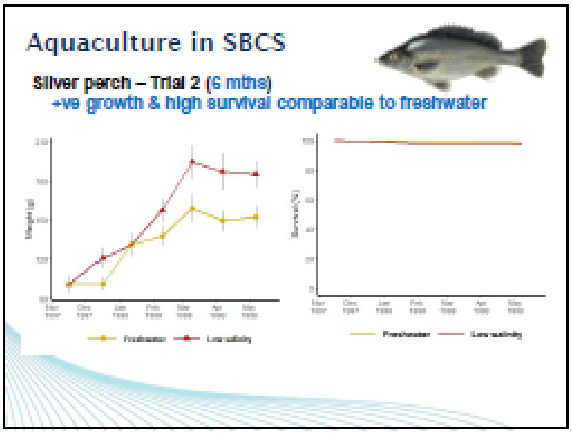

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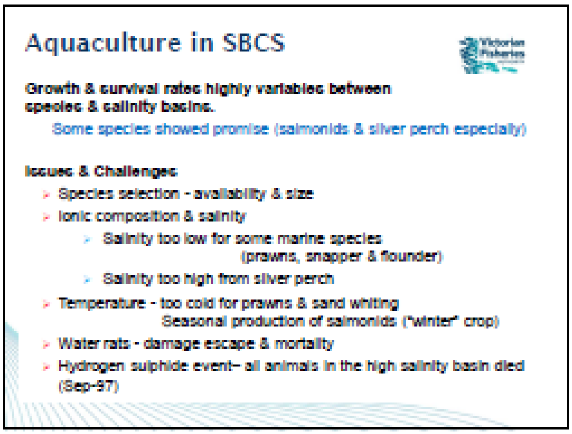

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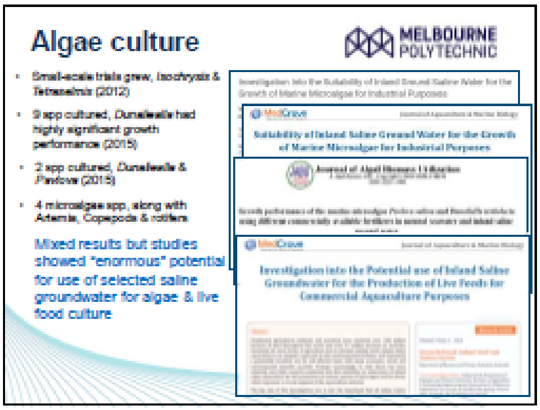

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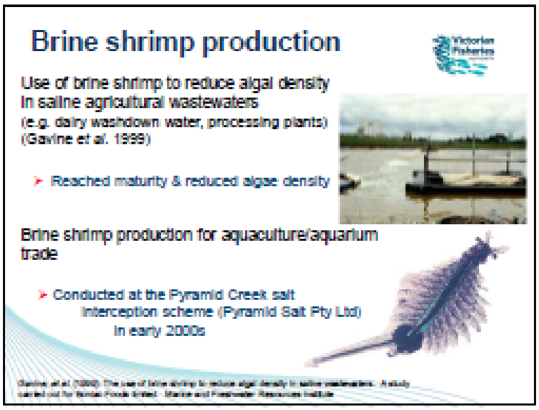

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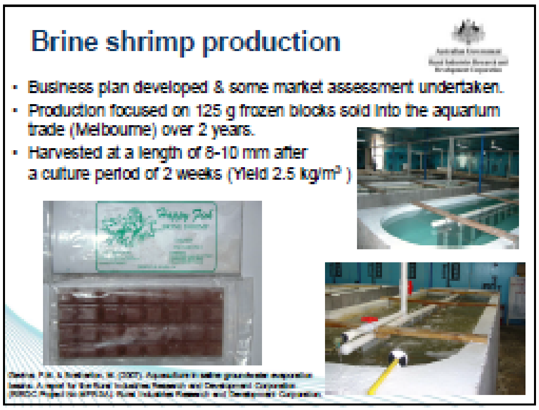

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Barramundi in geothermal water

Commercial production started in mid-2000s:

Mainstream Aquaculture, Werribee (*https://www.mainstreamaquaculture.com*)

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Where to from here

Agricultural water is becoming a more valuable & limited resource.

In the face of an increasingly variable climate,
Long-term resilience of farming industries & communities will need to become more dependent on more diversified & complementary production strategies, which ~~could~~ should include aquaculture.

The historic “proof-of-concept” projects conducted in Victoria highlight opportunities.

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Where to from here

Further R&D for Victoria may focus on, for example,

- Matching saline groundwater resources (salinity, ionic composition) to potential species
- Evaluating new & emerging species (especially euryhaline spp.)
- Seasonal production (e.g. coldwater species)
- The species – finfish, crustaceans, gastropods, algae
- The products – think beyond food consumption (live foods for aquaculture, feed ingredients, biofuels, nutraceuticals, bioremediation, biofuels)

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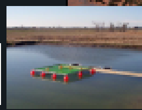
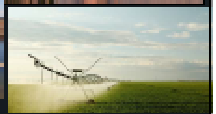
Acknowledgements

Many agencies, institutions & companies have supported research into saline aquaculture development & production in Victoria.

A few are listed below





The authors acknowledge the Traditional Owners of Country throughout Victoria and pay respect to their cultures and Elders past, present and emerging

We're hooked on SAFETY

28

INLAND SALINE AQUACUTLURE IN WESTERN AUSTRALIA; PAST, PRESENT AND FUTURE? Gavin Partridge, Harvest Road and Challenger TAFE, WA.

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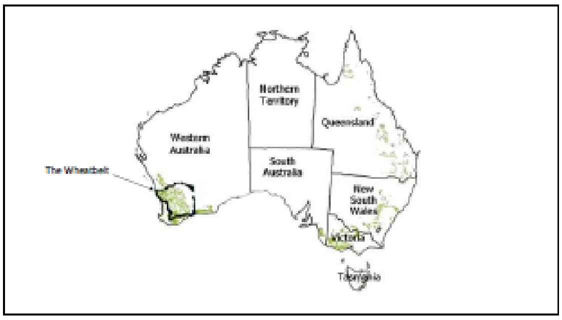

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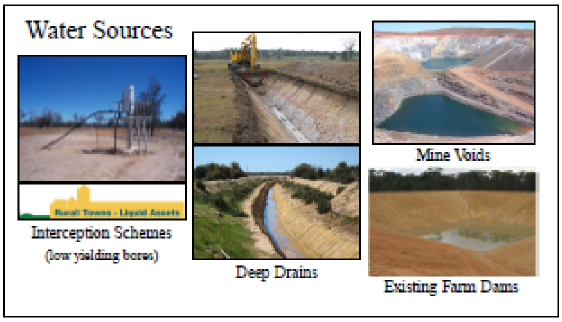

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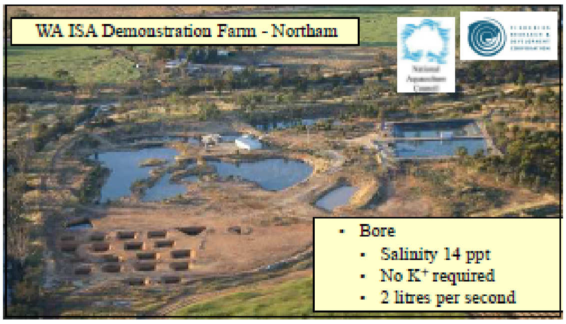

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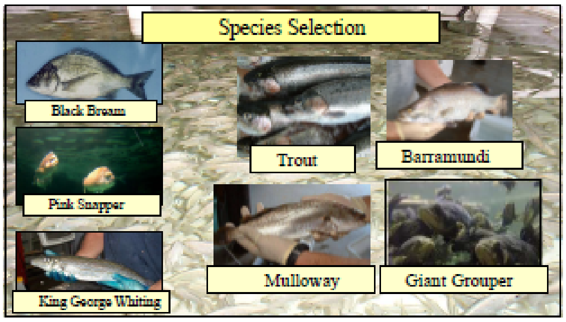
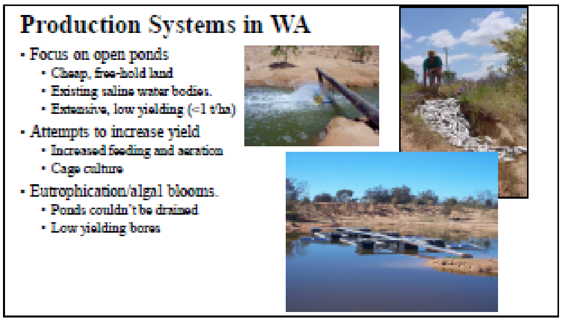

Species Selection
Black Bream
Trout
Barramundi
Pink Snapper
Mulloway
Giant Grouper
King George Whiting

7


Production Systems in WA
• Focus on open ponds
• Cheap, free-hold land
• Existing saline water bodies.
• Extensive, low yielding (<1 t/ha)
• Attempts to increase yield
• Increased feeding and aeration
• Cage culture
• Eutrophication/algal blooms.
• Ponds couldn't be drained
• Low yielding bores

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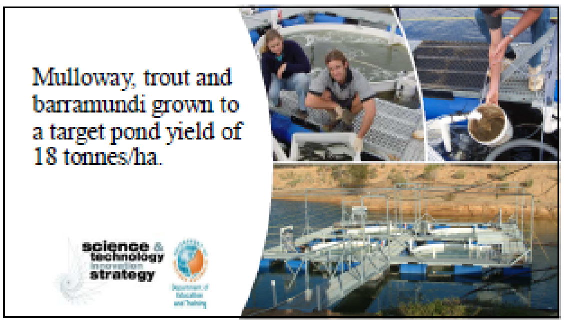
McROBERT
Semi Intensive Floating Tank System

9


Mulloway, trout and barramundi grown to a target pond yield of 18 tonnes/ha.
science & technology innovation strategy

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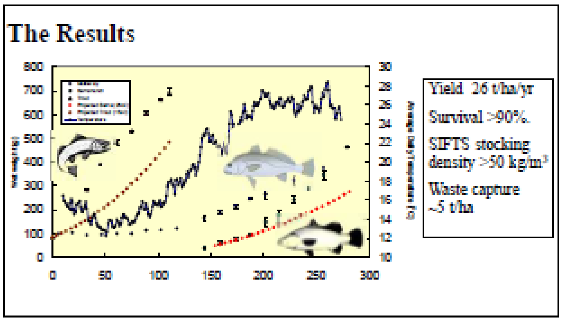
The Results
Yield 26 t/ha/yr
Survival >90%.
SIFTS stocking density >50 kg/m³
Waste capture ~5 t/ha
0
50
100
150
200
250
300

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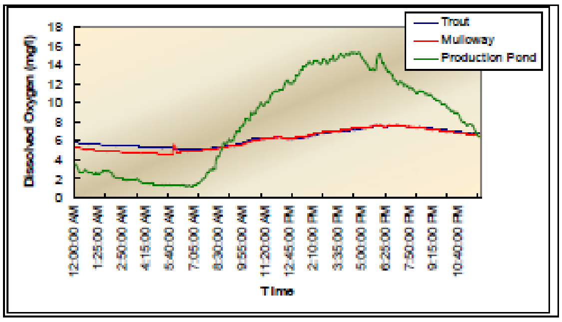
Trout
Mulloway
Production Pond
Dissolved Oxygen (mg/l)
Time
12:00:00 AM
1:25:00 AM
2:50:00 AM
4:15:00 AM
5:40:00 AM
7:05:00 AM
8:30:00 AM
9:55:00 AM
11:20:00 AM
12:45:00 PM
2:10:00 PM
3:35:00 PM
5:00:00 PM
6:25:00 PM
7:50:00 PM
9:15:00 PM
10:40:00 PM

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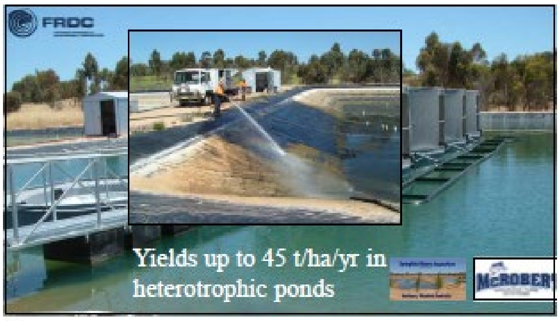

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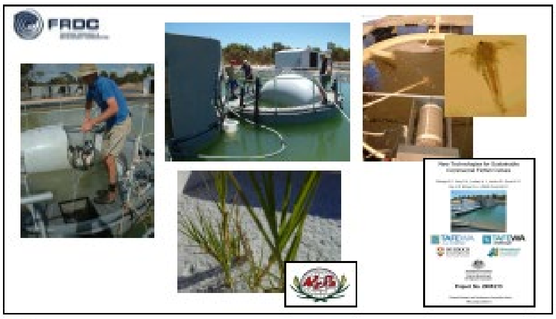

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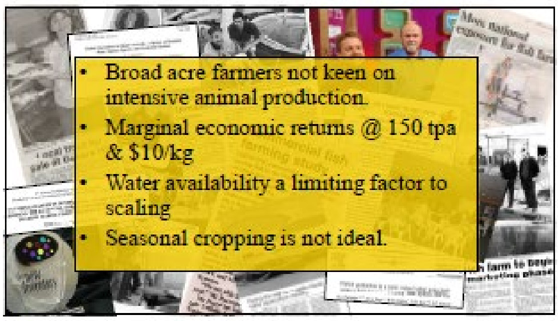

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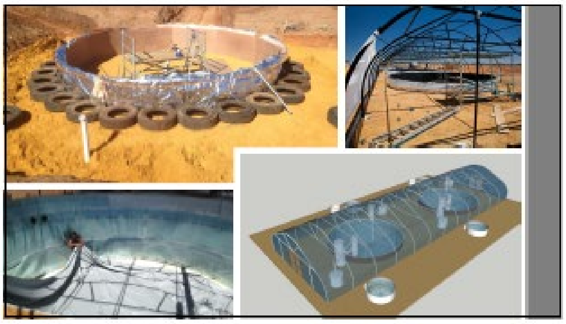
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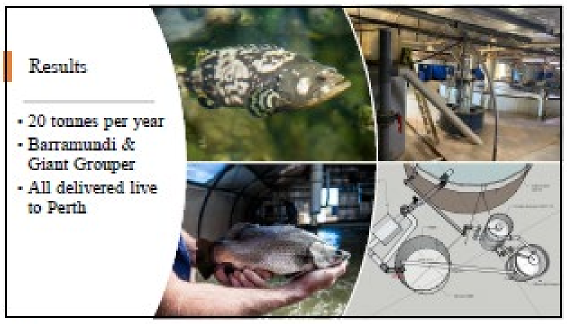

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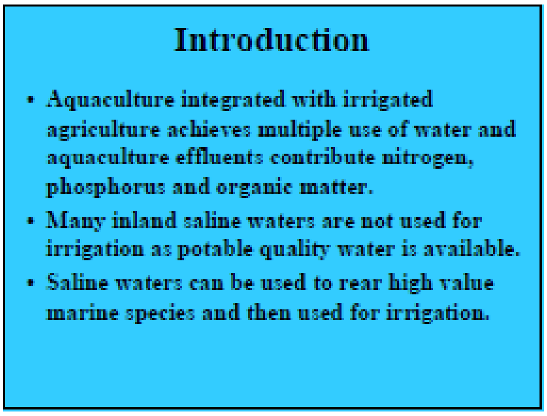
Acknowledgements

- Gavin Sarre
- Greg Jenkins
- Bruce Ginbey
- Ian McRobert
- Rob Michael
- Gavin Kay
- Stan Malinowski
- David Coaker
- Alan Lymbery

25

INLAND SALINE AQUACULTURE: USA AND ISRAEL PERSPECTIVES. Kevin Fitzsimmons. University of Arizona USA.

1



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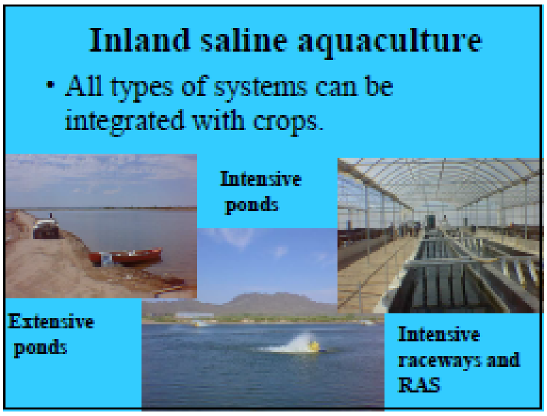

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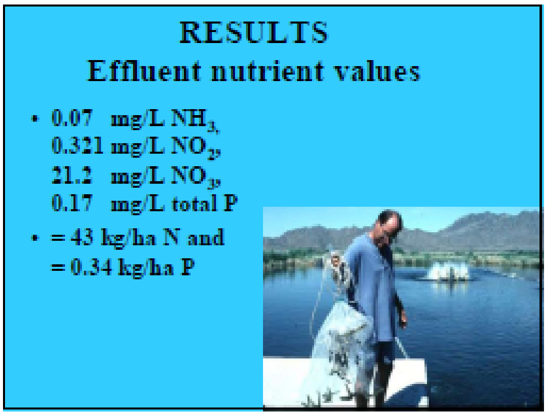

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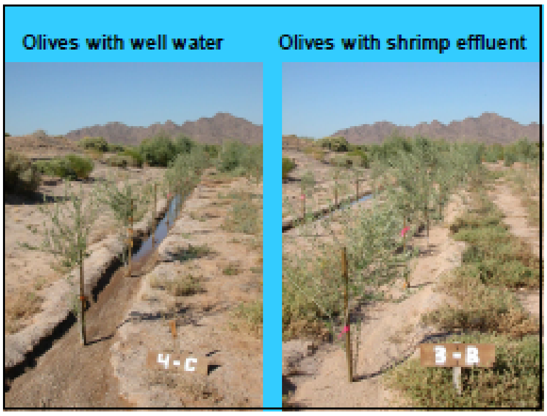

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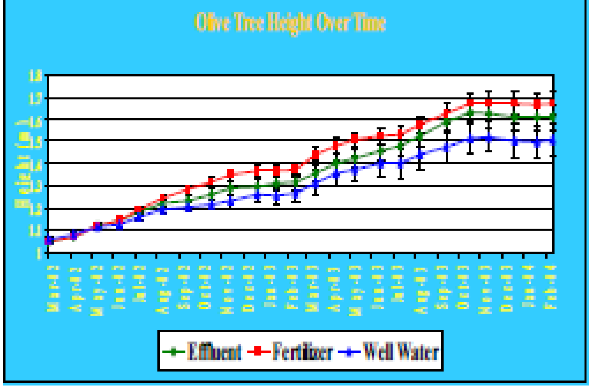
Olives irrigated with shrimp effluent



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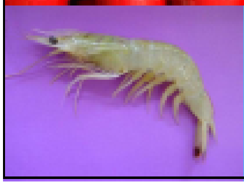
Use of Shrimp Sludge as a Soil Amendment for Tomatoes



Chad King
University of Arizona

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Shrimp Sludge Characteristics

Sample	*Total N* % dry matter	*Total PO_4-P* % dry matter	*Total K* % dry matter	*NO_3-N* µg/g	*Olsen P* µg/g	*Soluble K* µg/g	*EC* dS/m
1	0.13	0.10	0.23	1497.4	22.60	27.3	
2	0.48	0.21	0.20	4.36	73.50	53.6	8.5

Total N, PO_4-P and K show total plant macronutrients

NO_3-N, Olsen P and soluble K show plant available nutrients

EC provides a measurement of soil salinity

10

Research Design

- Treatments of 5, 10 and 20% sludge application by volume, 402, 805 and 1,610 g/plant
- Mechanically mixed shrimp sludge and potting soil mix (concrete sand, mulch, vermiculite)
- Randomly transplanted and arranged 28 'Roma' tomato starts in a greenhouse, one plant per pot
- Each plant received 4 L of water daily, over four applications by drip irrigation
- Response measured in mass of tomatoes produced

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Tomato Production Results

Treatment	Tomato Mass (g/plant)	SEM
0% (Control)	39.2^{a}	11.54
5% Sludge/potting mix	65.1^{a}	11.14
10% Sludge/potting mix	141.1^{b}	20.73
20% Sludge/potting mix	113.6^{b}	19.9

Different superscripts indicate a significant difference, $p<0.05$

13

Conclusions

- Applications of 10% and 20% increased plant production
- Suggests land application will benefit crop production while providing a disposal mechanism
- Large, field scale application experiment suggested to verify results
- Soil salinity must also be monitored, given high evaporation rates
- Sludge is highly variable, depending on pond management

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Shrimp and irrigation of Halophytes

- Many families of plants have halophytic representatives.
- Grasses, bushes, trees
- Many are from arid regions
- Native species are usually available
- Some have edible portions or can be used for forage, biomass, habitat, landscaping, and dust control

15

Shrimp and halophytes

16

Saline Aquaculture in Israel

- Use of saline aquifers for extensive culture of euryhaline species including tilapia, carp, flathead mullet (*Mugil cephalus*) and to a lesser extent: European seabass, red drum barramundi and gilthead sea bream (*Sparus aurata*) have operated for many years.

17

- Most of these operations use extensive methods such as earthen or cement ponds with paddle wheels for aeration but some have been using intensive methods (RAS) with variable degrees of success.

18

Fish Pond System in Israel

19

Inland RAS Aquaculture

- The largest RAS facility in Israel is capable of producing around 1000 tons of barramundi per year.

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Microalgae production

Several inland facilities, especially in the Southern Arava desert, produce microalgae for food supplements using either sea or saline water.

21

Research

- Current research is focused on development of species specific diets, acclimation of high value marine species to saline water, aquaculture wastewater treatment, trials to utilize in-pond raceways and split pond designs, and integrated aquaculture.
- high value broodstock and hatchery for ocean spawners are planned or underway.

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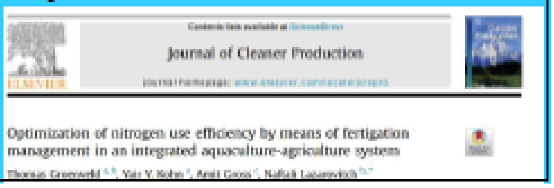
Integrated Aquaculture

- Various applications for use of aquaculture effluent are being researched including aquaponics and larger scale irrigation of plantations.



Journal of Cleaner Production

Optimization of nitrogen use efficiency by means of fertigation management in an integrated aquaculture-agriculture system

23

Conclusions

- Inland saline production has grown slowly but steadily in Israel.
- In Arizona, many of the initial farms have closed as the prices of farmed shrimp from Northern Mexico were lower with only a few more hours for delivery
- One Arizona farm switched from shrimp to tilapia and then to barramundi

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Conclusions

Barramundi have been produced and sold at much higher prices in California than shrimp or tilapia

MAINSTREAM PURCHASES ARIZONA FISH FARM July 2022

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