STATE OF STORM BAY, TASMANIA

An Overview of Current Information and Values

Version 3 – 5 August 2019

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Environment Tasmania

OVERVIEW

This report has been prepared in response to a planned expansion of salmon farming into Storm Bay, which seeks to more than double Tasmania's current production (@55,000 tonnes per year) by another 40,000 to 80,000 tpa. As of August 2019, three new farming areas have been approved (North Bruny, West of Wedge, Betsey Island). Numerous concerns have been raised about the potential impacts of these developments, including how the planned expansion may impact on the natural, community and economic values of the region.

While there is a considerable body of information in the public domain, this is widely dispersed and difficult to access at short notice. A 'State of the Bay' report is urgently needed to collect, compile and document existing values and scientific information about Storm Bay and associated areas (including Frederick Henry Bay, Norfolk Bay and the east coast of Bruny Island). This document would benefit the community (as well as research scientists, regulators and a range of relevant industries) by providing an unbiased and independent source of information, as well as by identifying key gaps and uncertainties. Without this information, it is difficult to engage in meaningful debate in a scientific manner. Information about the Derwent estuary is not included here, as there is a considerable body of information available through regularly published *State of the Derwent* reports.

This report consists of three main elements:

- A brief summary of the key natural, community and economic values of Storm Bay along with associated 'values maps', as a basis for further consultation. (Appendix A)
- A draft Table of Contents for a comprehensive 'State of Storm Bay' report (Appendix B)
- A compilation of existing reports and other relevant references for Storm Bay, with some annotations (Appendix C)

Based on a review of available reports, key information gaps include:

- Regional marine habitat mapping is over 20 years old, is at a relatively coarse scale, and does not include areas of Storm Bay deeper than the 40m contour
- Seagrass/*Caulerpa* algae beds have not been assessed in any detail
- Giant kelp forest (EPBC-listed) mapping is out of date, currently being updated
- Baseline surveys of rocky reef communities are spatially and temporally limited, do not include many vulnerable areas, and the most recent studies have not yet been published (e.g. FRDC 2015-024)
- Baseline water quality monitoring has not been carried out in sheltered embayments such as Frederick Henry Bay and Norfolk Bay, which are more susceptible to problems; there is also limited information about water quality responses during and immediately after storm events;
- Lack of recent recreational fishing report (due out soon)
- Risks to biosecurity and fish health have not been fully addressed, and information on this is not readily available
- Toxic algae and jellyfish risks have not been fully assessed
- Information on net-cleaning methods and risks is very limited
- Information on shark and seal populations/interactions is very limited.

In conclusion, there would be considerable merit in producing an independent *State of Storm Bay Report*, to ensure that existing information is readily available, major gaps can be highlighted, and a case made to address these as a prerequisite to full expansion.

The estimated cost to produce this report would be in the order of $30,000 to 40,000, not including graphic design or printing.

APPENDIX A

THE NATURAL, COMMUNITY AND ECONOMIC VALUES OF STORM BAY

Storm Bay covers an area of approximately 1000 km^2 and is bordered by Bruny Island to the west, the Tasman Peninsula to the east and the sheltered coastal waters of the Derwent estuary, Frederick Henry Bay and Norfolk Bay to the north. Weather patterns are variable and frequently extreme, with prevailing winds generally from the west/southwest and prevailing waves from the south. Coastal currents and water masses also have a major influence, with East Australian Current water (warm, low nutrients) prevailing in summer, and Southern Ocean water (cold, high nutrients) in winter. This region is characterised by its variability and diversity – weather, coastal currents, landscapes, biota, etc – and the values described below reflect this. Storm Bay is also a climate change hotspot, and is increasingly being affected by invasive species including nuisance and toxic algal blooms, jellyfish, fish/shellfish diseases and sea urchins.

NATURAL VALUES

Storm Bay falls within the Bruny Bioregion, which is particularly noted for its biodiversity and endemism. There are a number of useful reports on the natural values of the Storm Bay region – in particular, Barrett et al, 2001 mapped the key habitats within the region, including important seagrass/*Caulerpa* algae beds in Norfolk Bay, and extensive fringing reef communities across the region. Unfortunately, this mapping is now over 20 years old and does not extend beyond the 40m contour. This urgently needs to be updated.

Storm Bay is a biodiversity hotspot for the <u>spotted and red handfish</u>, <u>endemic seastars</u>, rare <u>saltmarsh moths</u>, a variety of <u>protected birds</u> (both resident and migratory), <u>southern right whale</u> (nursery), and numerous species of <u>rare algae and protected coastal plants</u>. Important seagrass habitat and <u>giant kelp</u> forests are also found here, as is the internationally significant Ramsar wetlands at Pittwater. There is also a Marine Reserve at Tinderbox, and two Marine Conservation Areas at Sloping Island and Monk Bay (Tasman Peninsula).

While there have been a number of studies of <u>reef and intertidal communities</u>, including assessment of impacts associated with salmon aquaculture (see Appendix C), these have been largely focussed on the Channel area, or have not yet been finalised (e.g. FRDC-024), and findings have not been conclusive (e.g. Oh et al, 2016; Valentine et al, 2016; Crawford and Harwin, 2018).

Of particular value are the extensive <u>seagrass and *Caulerpa* algae beds</u> found in Norfolk Bay and to a lesser extent in other areas (e.g. Nubeena, White Beach, Adventure Bay). These habitats provide essential shelter, spawning and nursery areas for many fish, calamari and invertebrates, and have been shown to be sensitive to high nutrient loads. These seagrass/*Caulerpa* habitats are not well documented and no local studies were identified. The sheltered waters of Frederick Henry Bay, Norfolk Bay and the Derwent estuary are also protected as shark nurseries, and sharks are regular visitors/residents in the Bay.

Storm Bay is an important migration pathway for <u>whales</u> (southern right and humpback), with increasing numbers spotted here each year. The associated sheltered bays were historically an important nursery area for southern right whales, and it appears the whales may be returning with births and/or very young whales recorded in recent years.

The extensive <u>sandy beaches, tidal flats and saltmarshes</u> around Storm Bay also provide valuable habitat for a variety of species – including protected resident and migratory birds and rare saltmarsh moths.

Finally, Storm Bay sets the <u>background water quality</u> for the Derwent estuary, Frederick Henry Bay and Norfolk Bay, and as such a decline in offshore water quality could have far-reaching effects. An increase in nutrient levels – particularly during summer months and/or following storm events – could stimulate planktonic or filamentous algal blooms, leading to impaired water quality (e.g. water clarity) and degradation/loss of seagrass and reef communities (caused by overgrowth/shading). Where algae sink and decompose, low oxygen levels at depth can displace or kill benthic organisms. In the Derwent, this is further exacerbated by potential remobilisation of heavy metals from contaminated sediments (Coughanowr et al, 2015). While water quality has been monitored at a number of sites in Storm Bay (e.g. Swadling et al, 2017), monitoring sites have generally been located in well-mixed areas of the bay, and more sheltered areas of Frederick Henry Bay and Norfolk Bay have not been included. Further, very little monitoring has been undertaken during or immediately after major storm events, when sediment and organic matter at depth is resuspended.

Figure 1 highlights some of the key natural values of the region.

COMMUNITY AND RECREATIONAL VALUES

Over 40% of Tasmania's population (>210,000) live in the Storm Bay region (including the associated Derwent, Frederick Henry Bay and Norfolk Bay) and this is the State's most densely populated and fastest growing region. Most live in the Hobart metropolitan area, but approximately 11,000 people live in the nearby towns bordering on Storm Bay, with the majority in the Dodges Ferry/Carlton/Primrose Sands area (>4600), Cremorne/ Lauderdale/Seven Mile Beach area (>4200) and Nubeena/White Beach (>750) (ABS Census, 2016). Many more regularly use holiday homes in the region or visit for recreational purposes. This region is also increasingly popular with residents who commute to Hobart, as well as 'seachange' and retired residents. The demand for, and value of coastal properties is rising quickly – driven in large part by the region's varied and wild coast and multiple recreational opportunities, combined with proximity to Hobart and its airport. A visual scan of land tenure maps indicates that well over 50% of the immediate shoreline is in some form of public ownership, either as national parks, Crown land, state or council reserves.

Recreational activities include boating, fishing, swimming and surfing, and enjoyment of the many beaches and coastal reserves that border on the Bay. Recreational boating and fishing are particularly popular in the region, due to a combination of diverse habitats, sheltered waterways and over 16 boat ramps. This region has the highest level of boat ownership in Tasmania, as well as the greatest participation in recreational fishing, particularly for rock lobster, abalone and flathead (Lyle et al, 2014). These recreational fisheries provide important social, cultural and economic values to the region.

Storm Bay occupies the heart of the southeast recreational fishing region (Area 1), and accounted for 45% of the state-wide recreational harvest of crayfish and 58% of the total effort in 2017/18. For abalone, Area 1 accounted for 61% of the recreational harvest, and 49% of the total effort. (Lyle, 2018). The latest 5-year recreational fishing survey has not yet been released, but the previous report (2013/14) highlighted a number of features of the Storm Bay region, specifically (Lyle et al, 2014):

- Highest level of participation (27% of population, as compared with 22% state-wide)
- General decline in recreational fishing across the state, but this is less pronounced in the southeast region
- Flathead is the primary scalefish target, particularly in sheltered waters of Frederick Henry Bay and Norfolk Bay, where catches are large and account for >80% of species caught. In 2013/14 the state-wide recreational catch of flathead was estimated at 236 tonnes, almost six times the commercial catch. While the recreational catch of most species has declined over the years, that of calamari and squid has increased.
- High economic value of goods and services associated with recreational fishing, as well as boats (see next section for details)
- Perceptions that the recreational fishery has declined, with Frederick Henry/Norfolk Bay and D'Entrecasteaux/Channel areas rated as among the poorest performing

The Storm Bay region has some of the most diverse and spectacular beaches in Tasmania, some with associated tidal flats and dunes. These include both open ocean beaches such as those along the Bruny Island Neck, Clifton Beach, South Arm, Seven Mile Beach and Roaring Beach, as well as more sheltered beaches (e.g. Lauderdale, Primrose Sands, Norfolk Bay beaches, Lime Bay, Slopen Main and White Beach). There are also a number of popular and iconic surfing sites (e.g. Shipstern Bluff, Roaring Beach, Clifton Beach, Carlton, South Arm).

Finally, there are numerous coastal walks throughout the region, many with spectacular views of Tasmania's ocean wilderness. These include those within national parks (e.g. Cape Raoul, Fluted Cape), as well as numerous state and council reserves.

Figure 2 highlights some of the key community and recreational values of the region.

ECONOMIC VALUES

Economic activities associated with Storm Bay, the Derwent estuary, Frederick Henry Bay and Norfolk Bay are highly diverse and include the general commerce and services of the growing Hobart metropolitan area, commercial fisheries, aquaculture and tourism. Economic values of the Bay also include those associated with recreational activities (e.g. boating and fishing) and other 'lifestyle' values. Recent studies have documented the high values associated with coastal real estate, particularly the premium placed on sites with unimpeded views, as well as the less tangible values or 'environmental services' that healthy coastal ecosystems provide, such as fish nurseries, erosion control and water quality protection. It is difficult to place a dollar on these less tangible values and we tend to take them for granted. This is an important area for further investigation, for example along the lines of recent studies of Sydney Harbour (Hoisington, 2015). This summary report attempts to roughly estimate the dollar values of various activities in Storm Bay based on existing reports, however these values should be considered as indicative and require further assessment.

Commercial fishing in Storm Bay is predominantly focused on abalone, rock lobster and some scale-fishing. The bay is also an important transit area for fishing boats en route to southeastern and southwestern fishing grounds.

Storm Bay falls within the Eastern Zone of the abalone fishery, and there are five designated fishing blocks in the Storm Bay/Frederick Henry/Derwent area (Blocks 16 through 20); of these, blocks 16 and 20 are most productive. Total catch over the past 3 seasons has ranged from 40 to 81 tonnes, which is about 2 to 4% of the total landings for the state. The Eastern zone has been doing poorly in recent years – particularly along the east coast – due to a combination of previous overfishing, marine heat waves, predation by urchins and a major storm in 2017. The Total Allowable Catch for the Eastern Zone was further reduced for 2018, from 446t to 294t. (Mundy & McAllister, 2018). Based on a statewide value of $79.7M for the abalone fishery (ABARES, 2017 cited Browne, 2018) and assuming the Storm Bay fishery accounts for 3% of this – the value of the Storm Bay abalone fishery would be worth about $2.4M.

Storm Bay falls within Area 1 of the commercial rock lobster fishing zone, and is further subdivided into about a dozen smaller blocks. Of these, block 7G2G at the southern end of the Tasman Peninsula is the most productive (Tassal, 2018). The most recent rock lobster fisheries assessment report (Hartman et al, 2018) found that Area 1 comprised approximately 80t or about 8% of the total commercial catch for the state (1051t), and notes the general decline of this fishery. In terms of economic value, based on a statewide value of $92.9M for the abalone fishery (ABARES, 2017 cited Browne, 2018) and assuming the Storm Bay fishery accounts for 8% of this – the value of the Storm Bay rock lobster fishery would be worth about $7.4M.

The scalefish fishery is managed at a national level by AFMA and at a state level by DPIPWE, and limits are set by through e.g. quotas, capped license numbers, closed areas/seasons and gear restrictions. For the state as a whole, there has been a general decline in production, from a high of >1100 t in the mid-1990s to about 300 t in recent years (Moore et al, 2018). Commercially-targeted species of scalefish in the region include blue grenadier, tiger flathead, school whiting, silver warehou, gummy shark, pink ling, calamari, garfish, Australian salmon, banded morwong, squid, southern calamari, octopus, wrasse, flounder (Tassal, 2018; Petuna, 2018; Moore et al, 2018). Two Danish seine net trawlers operate in Storm Bay and parts of the lower Derwent and Frederick Henry Bay, primarily targeting school whiting and tiger flathead.

There is limited information for the Storm Bay fishing blocks in the most recent 2017/18 Scalefish Fishery Assessment Report (Moore et al, 2018), with the exception of the three estuarine areas. These areas have had highly variable landings since the mid-1990s, with significant declines in Frederick Henry Bay and Norfolk Bay. In 2016/17, 26 t of fish were taken from the Derwent estuary (predominately whiting), 4 t from Norfolk Bay (mostly octopus and some calamari) and 4 t from Frederick Henry Bay (mostly calamari). These three blocks alone account for more than 10% of the state total. If the 17t from the two eastern Storm Bay blocks is included (Tassal, 2017), Storm Bay would account for at least 17%. Further work is needed to compile the regional scalefish harvest for Storm Bay. Based on a statewide value of $9.7M for the 'other wild-caught species' (ABARES, 2017 cited Browne, 2018) and assuming the Storm Bay fishery accounts for 20% of this – the value of the Storm Bay scalefish fishery would be worth about $1.9M.

Marine farming activities in the Storm Bay region include both shellfish (oysters and mussels) and finfish (Atlantic salmon). There are three Marine Farming Development Plans for this region: Storm Bay - Trumpeter Bay/North Bruny; Storm Bay North; and Norfolk Bay/Tasman Peninsula). According to these plans there are currently 30 areas zoned marine farming across the Storm Bay Region, of which 20 allow for finfish production. There are also over 30 additional zones, primarily for shellfish, in the sheltered waters of Pipeclay Lagoon, Pittwater and Blackman Bay. It is difficult to determine which of these zones are currently under production.

The current harvest from existing finfish leases in Storm Bay is approximately 4000 to 4500t for those in the Nubeena area (Tassal Public Information Meeting, Feb 2019), and 8000 to 12,000t for those in the Trumpeter Bay region (HAC, 2017). Based on a value of $704M for 55,000t (ABARES, 2017 cited Browne, 2018), this would suggest a current value of $154M to $211M. Projected tonnage for the approved expansion is likely to be in the order of 30,000t in the short term and could expand to 40,000 to 80,000 t in the longer term, which - using the values above – would yield values of $384M, $512M and $1.02B, respectively.

Values associated with oyster and mussel aquaculture are more difficult to estimate, without a regional breakdown on the location of these leases. There are, however, significant numbers of leases in the sheltered waters of Frederick Henry & Norfolk Bay, Pittwater and Blackmans Bay, and recent studies suggest that oyster aquaculture in the Hobart and Southeast ABS regions account for 25% and 24% of employment in these sectors, respectively (Brown, 2018). Based on a statewide value of $23.5M for oyster and blue mussel aquaculture (ABARES, 2017 cited Browne, 2018) and assuming the Storm Bay fishery accounts for at least 25% of this – the value of Storm Bay shellfish aquaculture would be worth at least $5.9M.

The value of recreational fishing in southeastern Tasmania is estimated to generate $20M/year, while the value of recreational boats is estimated at $170M (replacement value) (Lyle et al, 2014). Assuming a 10-year depreciation period, this would amount to $17M/year, for a total combined value of $37M/year.

It is difficult to estimate the value of Storm Bay-associated tourism, events and other recreational activities, and particularly how a loss of environmental quality/amenity might affect these. Activities most directly affected could include major yacht races, boat tours (e.g. Hobart to Betsey Island, Port Arthur, Bruny Island), fishing charters, scuba and snorkel tours, and coastal walks. Further analysis is recommended.

Coastal real estate values are increasing rapidly in southeastern Tasmania, with a premium placed on unobstructed ocean views. A recent study of Sydney Harbour found that coastal real estate accounted for by far the largest proportion of economic values in dollar terms (Hoisington, 2015). This also merits further consideration, as does how the installation large and visually prominent coastal infrastructure may influence property values (e.g. Jensen et al, 2018).

Finally, the value of 'ecosystem services' provided by healthy coastal habitats also requires further consideration, as well as the estimated losses associated with varying levels of impairment. In particular, the value of healthy reef communities and seagrass beds should be considered, together with the services they provide, such as:

- Water quality improvement
- Shoreline protection/sediment stabilisation
- Habitat, shelter and spawning/nursery areas for commercial and recreational species
- Habitat, shelter and spawning/nursery areas for protected and threatened species

Figure 3 highlights some of the key economic values of the Storm Bay region.

Summary of economic values of Storm Bay (*indicative – requires further analyses*)

Activity/Value	**Estimated value**
Commercial fishing	
• Abalone	2.4
• Rock lobster	7.4
• Scalefish	1.9
Marine Farming	
• Salmon	$154 to $211M
• Oysters & mussels	$5.9M
Recreational fishing	$37M
Other	
• Swimming, surfing, walking	??
• Tourism and events	??
• Real estate	??
Ecosystem services	??
• Seagrass & Caulerpa beds	??
• Temperate reefs & kelp	??
Total	**$209 to $266M**

APPENDIX B

STATE OF STORM BAY: DRAFT TABLE OF CONTENTS

APPENDIX C

STATE OF STORM BAY: REFERENCES, LINKS & NOTES (as of 27/7/19)

The following list of references has been compiled from a variety of sources and include IMAS scientific and fisheries reports, FRDC reports, State government planning documents, environmental impact assessments and associated reportd, various websites as well as more traditional peer-reviewed journals. References are broadly grouped into topics, with the most recent and relevant references first. Some references include abstracts or key figures, and some include annotated comments in italics (which reflect the views of this author). There is a considerable body of work on Storm Bay that is still in progress, and additional references should be added to this list as they become available.

STORM BAY MARINE FARM DEVELOPMENT PLANS, ENVIRONMENTAL LICENSES AND ENVIRONMENTAL IMPACT ASSESSMENTS

DPIPWE, 2018. Tasman Peninsula and Norfolk Bay Marine Farming Development Plan – September 2018
https://dpipwe.tas.gov.au/Documents/Tasman%20Peninsula%20and%20Norfolk%20Bay%20MFDP%20September%202018.pdf
Sets out marine farming zones and allowable uses in Norfolk Bay, eastern Storm Bay and Long Bay. There are currently 26 designated zones in this region, including 2 in Long Bay. Excluding Long Bay, 10 zones are designated for shellfish and seaweed only and 14 for finfish, shellfish and seaweed. The total zoned area within the Storm Bay region (excluding Long Bay) is 1657 ha, while the maximum leasable area is 828 ha. See table below for details. Of these areas, the area zoned for finfish is 426 ha, with a maximum leasable area of 238 ha.

Table 2.1 - Summary of Zones

Zone	Location	Category of Fish	Zone Area (ha)	Maximum Leasable Area (ha)
1	at Boxall Rock	Shellfish, seaweeds	5.07	5.00
2	at Breaknock Bay	Finfish, shellfish, seaweeds	9.10	9.10
3	west of Fulham Island	Finfish, shellfish, seaweeds	26.95	20.00
4	at Dunalley Bay	Finfish, shellfish, seaweeds	22.28	20.01
5	at Dunalley Bay	Shellfish, seaweeds	15.00	15.00
6A	west of Smooth Island	Finfish, shellfish, seaweeds	63.91	40.00
6B	north of Smooth Island	Shellfish, seaweeds	5.52	5.00
7A	east of King George Island	Finfish, shellfish, seaweeds	34.51	24.02
7B	north of Chronicle Point	Finfish, shellfish, seaweeds	19.54	14.00
7C	south of Chronicle Point	Finfish, shellfish, seaweeds	25.22	20.00
8	at Flinders Reef	Shellfish, seaweeds	58.04	50.00
9A	at Eaglehawk Bay	Shellfish, seaweeds	49.59	32.50
9B	at Boxall Bay	Shellfish, seaweeds	41.05	32.50
10A	south of Dart Island	Shellfish, seaweeds	6.18	5.00
10B	at Garfish Bay	Shellfish, seaweeds	21.55	20.00
10C	at Little Norfolk Bay	Shellfish, seaweeds	5.01	5.00
11	north of Eli Point	Shellfish, seaweeds	132.80	40.00
12	south-east of Ironstone Point	Shellfish, seaweeds	29.51	20.00
13	east of Green Head	Finfish, shellfish, seaweeds	59.23	27.01
14A	south-west of Creeses Mistake	Finfish, shellfish, seaweeds	143.10	48.50
14B	Billy Blue	Finfish, shellfish, seaweeds	3.95	3.00
14C	at Parsons Bay	Finfish, shellfish, seaweeds	17.21	12.00
14D	at Badger Cove	Finfish, shellfish, seaweeds	0.45	0.43
15A	at Long Bay	Shellfish, seaweeds	17.95	17.26
15B	at Long Bay	Finfish, shellfish, seaweeds	24.91	15.01
16	West of Wedge Island	Finfish, shellfish, seaweeds	863.00	360.00
Total			**1700.63**	**860.34**

DPIPWE, 2018. Storm Bay off Trumpeter Bay North Bruny Island Marine Farming Development Plan- Aug 2018
https://dpipwe.tas.gov.au/Documents/Storm%20Bay%20off%20Trumpeter%20Bay%20North%20Bruny%20Island%20MFDP%20August%202018.pdf
Sets out marine farming zones and allowable uses for the North Bruny area. There are currently 5 zones in this region, designated for finfish. The total zoned are within this region is 973 ha, while the maximum leasable area is 530 ha.

DPIPWE, 2017. Storm Bay North Marine Farming Development Plan – November 2017
https://dpipwe.tas.gov.au/Documents/FINAL%20-%20Storm%20Bay%20North%20MFDP%20November%202017.pdf
Sets out marine farming zone and allowable uses for Storm Bay North (SW of Betsey Island). There is one designated zone in this region with an area of 430 ha, with a maximum leasable area is 273 ha. Allowable uses include finfish, shellfish and seaweed.

Huon Aquaculture, 2017. Environmental impact statement to accompany the Draft Amendment No. 3 to the Storm Bay off Trumpeter Bay North Bruny Island, Marine Farming Development Plan, July 1998.
https://dpipwe.tas.gov.au/sea-fishing-aquaculture/marine-farming-aquaculture/marine-farming-development-plans/marine-farm-planning-proposals/storm-bay-off-trumpeter-bay

Petuna Environmental Impact Statement, 2017. Draft Storm Bay North Marine Farming Development Plan.
https://dpipwe.tas.gov.au/sea-fishing-aquaculture/marine-farming-aquaculture/marine-farming-development-plans/marine-farm-planning-proposals/storm-bay-north

Tassal, 2017. Environmental Impact Statement to accompany Draft Amendment No. 5 to the Tasman Peninsula and Norfolk Bay Marine Farming Development Plan, November 2005.
https://dpipwe.tas.gov.au/sea-fishing-aquaculture/marine-farming-aquaculture/marine-farming-development-plans/marine-farm-planning-proposals/tasman-peninsula-and-norfolk-bay

HYDRODYNAMICS, MODELLING & RISK ASSESSMENT

Karen Wild-Allen et al (in progress). Storm Bay biogeochemical model. FRDC 2017-215.
This $1.65M, 3-year project in progress commenced in late 2018. Key objectives are:

- To evaluate the performance of the existing hydrodynamic model of Storm Bay
- To characterise the primary sources of nutrients into Storm Bay from ocean currents, sediment resuspension, river inputs.
- To deliver a validated model of water quality in Storm Bay suitable for assessing future salmon farm expansion.
- To provide an information system comprising model results, observations and synthesis analyses, with links to parallel projects (e.g. monitoring program, decision support tools, seasonal predictions).

See FRDC website: http://www.frdc.com.au/project/2017-215 for further details and updates.

Hadley S, C Mcleod & J Ross (2017). Nutrient dispersion modelling for proposed marine finfish farming zones in Storm Bay. Report prepared for DPIPWE; selected sections provided as Appendix M within Huon Aquaculture EIS.

https://dpipwe.tas.gov.au/Documents/Appendix%20M%20-%20Overview%20Modelled%20Outputs%20for%20Storm%20Bay.pdf
Nutrient dispersion modelling was carried out (using CONNIE) for proposed marine finfish farming zones in Storm Bay. This involved single and combined farm dispersion modelling using particle tracking plus decay rates. Assumptions (Table 1) include a release period of 14 days and decay rate of 4 days. Six figures are provided in this report that integrate nutrient loads from the 3 farming areas based on a 40,000t biomass. These plots show modelled output for nutrients at surface and at depth, both seasonally and for the full year. Figures 2 & 3 show ammonia-N released from the 3 farms as a proportion of the TDN released (surface and depth). Figures 4 & 5 show ammonia-N released from the 3 farms superimposed on background ammonia-N levels. Figures 6 & 7 show ammonia-N released from the 3 farms superimposed on background DIN levels (ammonia + nitrate). There are many caveats around the use of this modelling outlined in Appendix 1 (p 14), including that the intent was to 'inform the design of a monitoring program' and cautionary statements about using results for assessment ('this early stage modelling is only indicative and results should be interpreted with caution'). *I think this model needs to be run using a much wider range of assumptions, and that the full range of outputs should be provided (e.g. sensitivity analyses). Without this, the presentation of selected scenarios and optimistic assumptions could be interpreted as cherry-picking those outcomes that appear to be of minor concern.*

Condie, S.A., R. Gorton, S. Hadley, R. Little, C. MacLeod, E. Ogier, W. Proctor, J. Ross, M. Sporcic and K. Wild-Allen (2017). INFORMD-2. Risk-based tools supporting consultation, planning and adaptive management for aquaculture and other multiple-uses of the coastal waters of southern Tasmania. FRDC 2012-024
http://frdc.com.au/Archived-Reports/FRDC%20Projects/2012-024-DLD.pdf
This project (4-yr, $750,000) developed four new products to assist in planning and ongoing management of aquaculture leases with a focus on the Derwent, Huon and D'Entrecasteaux regions:

(i) A new approach to identifying community, government and industry values (Your Marines Values – YMV) that has facilitated a more informed engagement processes and greater trust between participants. *How effective has this been? Seems like there are still high levels of continuing concern/mistrust across the region.*

(ii) A new biogeochemical model for the waters of the Derwent Estuary, Huon River and D'Entrecasteaux Channel. This model has been validated in detail and is now being used by stakeholders to test scenarios for planning and water quality impact assessment.

(iii) A publicly accessible online decision support tool (CONNIE) that can be used to identify waterborne interactions between aquaculture and other marine activities and assets. This facility is now being used extensively to identify impact zones and quantify pathogen risks.

(iv) A new online decision support tool (MAREE) to be used by government and industry for rapid assessment of the impacts of marine and coastal activities on local water quality. Examples include the impacts of nutrient and sediment loads associated with stocking of salmon leases; sewage treatment plants, other industrial discharges; and altered land-use in local catchments.

Buchanan PJ, KM Swadling, RE Eriksen, K Wild-Allen, 2014. New evidence links changing shelf phytoplankton communities to boundary currents in SE Tas. Reviews in Fish Biology and Fisheries vol 24(2), 427-442.
Storm Bay is affected by the seasonal interplay between the East Australian Current (EAC) and Leeuwin Current (LC). Intensifying EAC current has resulted in seasonal increase in southward penetration, beginning in October. However, tends to be erratic; may still have LC present on shelf in summer (as per HAC EIS, p83).

Herzfeld, 2008. Connectivity in Storm Bay. CSIRO Tech Report (19pp).
Internal report – commissioned by DPIPWE; this does not appear to be a public document, though it is cited in the EIS.

WATER QUALITY & MONITORING
Swadling KM, RS Eriksen, JM Beard and CM Crawford (2017). Marine currents, nutrients & plankton in the coastal waters off SE Tasmania and responses to changing weather patterns (FRDC 2014-31)
http://www.frdc.com.au/Archived-Reports/FRDC%20Projects/2014-031-DLD.pdf

Good overview of various coastal water masses, and increasing influence of EAC.

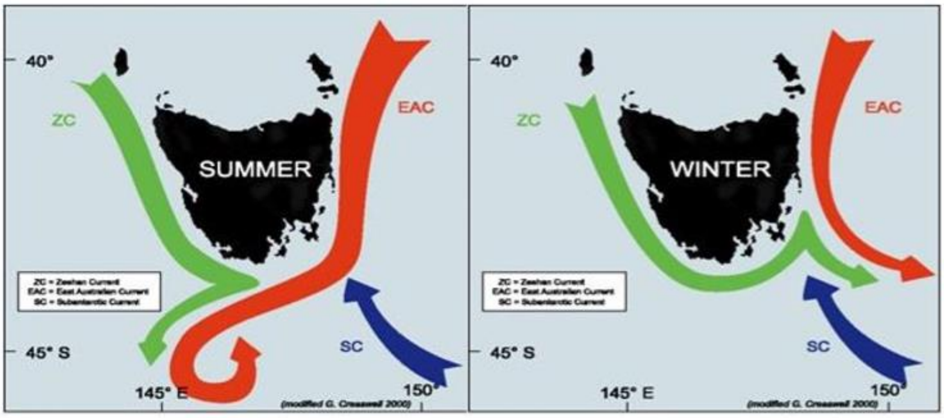

Figure 2.1 Major currents and water masses influencing the east coast of Tasmania, including Storm Bay; ZC = Zeehan Current, EAC = East Australian Current, SC = Subantarctic Current (from Cresswell 2000).

Report on results of 5-year monthly sampling (Nov2009 - Apr2015) at six sites in Storm Bay:

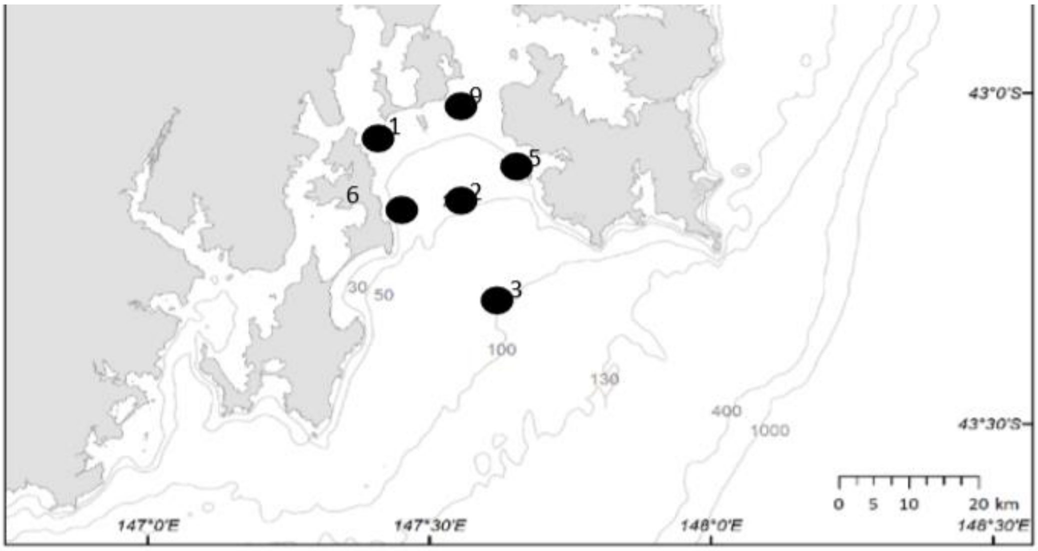

Figure 2.5 Map of Storm Bay showing site locations, and bathymetry (m).

Collected sensor data (temp, salinity, dissolved oxygen, fluorescence) as well as surface, mid (10m) and bottom samples for dissolved nutrients, chlorophyll a, phytoplankton and zooplankton. Data presented as time series and box & whisker plots. Some inclusion of CSIRO glider data as well. Compared 10m results at S2 with CSIRO data collected in 1985-89. During final 12 months also trialled Fast Repetition Rate Fluorometer (rates of primary production) and screened water samples for amoebic gill disease (AGD). Found high level of seasonal and interannual variability, depending on which water body dominates, La Nina vs El Nino conditions, and river flows. Comparison of two data sets indicates increasing water temperature and decreasing NOx and particularly PO4, and overall decline in chla. Found low levels of AGD agent, however this was sufficient to induce AGD under suitable conditions.

- Site 9 (FHB) had lowest NOx and highest chla
- Ammonia values at S6 (Trumpeter Bay) increased from Aug 2011, *presumably due to fishfarm expansion?*
- Response to storm conditions not really explored; did not sample during extreme weather
- Excerpt from page 64:

Low nutrients, especially at the surface in summer and autumn, along with lowest dissolved oxygen concentrations in summer – autumn when the temperatures and biological activity are highest, suggest that a significant increase in nutrients, especially available N, from salmon aquaculture over this period could have a significant effect on the ecology of the system. On the other hand, these increased nutrients could potentially help mitigate the effect of increased penetration of nutrient-poor EAC waters in the region. This is a major factor in the demise of giant kelp (*Macrocystis pyrifera*) beds on the east coast of Tasmania (Johnson et al. 2011). The consistently higher ammonium concentration in bottom waters at site 6 from 2011 also requires further observation as this site is close to a salmon farm that has been in commercial production for around two years.

Crawford C , K Swadling, P Thompson, L Clementson , T Schroeder, K Wild-Allen (2011). Nutrient and phytoplankton data from Storm Bay to support sustainable resource planning. FRDC 2009-067
http://www.frdc.com.au/Archived-Reports/FRDC%20Projects/2009-067-DLD.pdf
Summarises 12 months of monthly monitoring data for six sampling sites in SB: 1 through 4 in a line from Iron Pot to offshore; 5 to N of Wedge Island; 6 off North Bruny. This data is included in FRDC 2014 – 31 (above)

Harris GP, FB Griffiths, LA Clementson, V Lyne and H Van der Doe, 1991. Seasonal and interannual variability in physical processes, nutrient cycling and the structure of the food chain in Tasmanian shelf waters. Journal of Plankton Research 13:109-131.

FISH HEALTH, ANTIBIOTICS AND ANTIFOULANTS
Key issues/diseases include AGD and pilchard orthomyxovirus (POMV). AGD is caused by a parasitic amoeba; thickens gill epithelium, which reduces oxygen diffusion – fish basically suffocates. Fish in first year at sea are the most susceptible. AGD becomes more prevalent with increasing water temperature and when fish are stressed.

Adams M, A Bridle, C Norte Dos Santos, Y Pennachi and B Nowak, 2016. Comparative susceptibility and host responses of endemic fishes and salmonids to amoebic gill disease in Tasmania. FRDC Project No 2011/070
http://www.frdc.com.au/project/2011-070
Series of experiments whereby endemic fish and Atlantic salmon were infected with AGD. Experiments 1-4 involved 4 species of Tasmanian endemic fish with different life histories (Australian salmon, yellow eye mullet, purple wrasse, sand flathead; collected from Tamar in 2012) – 10-day exposure to relatively high levels of AGD, and compared to parallel experiments on Atlantic salmon. While the endemic fish were variously infected, all showed innate capacity to resist, defend, or tolerate experimental challenge with AGD. Experiment 5 compared responses of cohabiting Atl salmon and YE mullet over 28 days, and found that mullet were able to recover from AGD infection. Second series of experiments studied response of Atl salmon, rainbow and brown trout (incl hybrids) to repeated infections. Rainbows could not acclimatise to marine conditions. Brown trout and hybrids generally more robust. Atl salm tend to build up resistance when re-infected.

Good discussion of other studies of AGD on endemic species both globally and in Tassie on p 16. Globally, AGD has been reported in other salmonid and non-salmonid species including Chinook salmon, Coho salmon, rainbow trout, brown trout, turbot, sea bass, sea bream, ballan wrasse, olive flounder, etc. In Tassie, AGD-like lesions have been observed on couta, bastard trumpeter and mullet (Jones, 88). However, a survey of 12 spp/325 fish caught in vicinity of salmon cages did not find AGD; also were not able to induce AGD in seahorses

McLeod C & R Eriksen, 2009. A review of the ecological impacts of selected antibiotics and antifoulants currently used in the Tasmanian salmonid farming industry (marine farming phase) FRDC 2007-246
http://www.frdc.com.au/Archived-Reports/FRDC%20Projects/2007-246-DLD.pdf

HABITAT MAPPING

The LIST: SE Tas Marine Habitat Map (1:25,000)
https://www.thelist.tas.gov.au/app/content/data/geo-meta-data-record?detailRecordUID=392697df-2ccc-4fc7-ba38-eb24a97c803c
Produced by TAFI based on surveys undertaken from June to Dec 2000. Ran zig-zag transects from 40m contour at 200m intervals. Eleven habitat classifications, including rocky reefs and seagrass beds. See full report below for details.

Barrett N, J.C. Sanderson, M. Lawler, V. Halley and A. Jordan, 2001. Mapping of Inshore Marine Habitats in South -eastern Tasmania for Marine Protected Area Planning and Marine Management. TAFI Technical Report Series #7. Produced for NHT
https://eprints.utas.edu.au/9087/1/Mapping_of_Inshore_Marine_Habitats_Nov2001.pdf
Inventory of habitat types of the shallow coastal zone (to 40m depth) in Bruny Bioregion, as a basis for identifying potential Marine Protected Areas. Started with Bruny Bioregion because of high level of diversity, endemism and relatively high risk due to proximity to Hobart. Includes detailed series of 1:25,000 maps with 4 categories of reef, 4 of seagrass/Caulerpa and 4 of unconsolidated substrate. Also includes bathymetry and wave exposure maps. Based on extensive field surveys with position, depth and bottom type continually logged plus regular video drops. Aerial photos scanned/rectified to provide more detail in shallow water (<10m). Nine mapping units described, including 4 relevant to Storm Bay (Norfolk, Frederick Henry, Betsey and Adventure). Of particular note:

- Large Caulerpa beds in Norfolk Bay
- This bioregion has particularly high abundances of two macroalgal species that are endemic to Tasmania (*Lessonia corrugata* and *Xiphophora gladiata*) and one species whose Australian distribution is restricted to the southern half of Tasmanian waters (*Macrocystis pyrifera*). *Lessonia* is particularly common in the region extending from northern Bruny Island to Cape Raoul, where it appears to replace *Phyllospora*. The distribution of *Macrocystis* extended throughout this bioregion, and while its distribution appears highly variable through time, a number of locations appear to consistently have large beds, including north-east Bruny Island.

Barrett N & V Lucieer, 2008. Inshore habitat mapping in the southeast of Tasmania.
www.nespmarine.edu.au/system/files/Barrett%20and%20Lucieer%20inshore%20habitat%20mapping.pdf
Poster illustrating extremely detailed inshore habitat mapping using multibeam profiler at four sites in SE Tas (none in Storm Bay).

Mount R, V Lucieer, M Lawler and A Jordan (2005). Mapping of estuarine and marine habitats in the southern NRM region.
http://www.imas.utas.edu.au/__data/assets/pdf_file/0005/743090/Southern_Estuaries_Final_Report05.pdf
Mapped 11 estuaries in the southeast region, including Pittwater and Pipeclay Lagoon

ROCKY REEFS & INTERTIDAL AREAS
McLeod et al (in progress). Managing ecosystem interactions across differing environments: building flexibility and risk assurance into environmental management strategies. FRDC 2015-024
Four main objectives:

1. Establish key recovery response principles and benthic condition criteria for all areas in which farming currently occurs – building on existing understanding to identify both generic and regionally specific performance criteria.
2. Improve our understanding of sediment process interactions and recovery responses, in order to ensure that monitoring and management strategies are optimised for each growing region – a key objective will be relating the findings to the most important ecological and resource interactions of salmon farming in each region.

3. To evaluate the potential for interactions between local reef systems and salmon farming – determining the main risk factors, recommending risk appropriate monitoring and assessment approaches and identifying risk mitigation strategies where relevant.
4. To improve our understanding of how local scale (site based) environmental condition data, can integrate with local scale modelling to improve management outcomes – a key goal will be identifying how local scale understanding of sediment processes and benthic pelagic interactions can inform and be informed by regional modelling and management approaches.

Several review papers are being/have been produced, including one on international best practice. Final report for this project is now due i@ Aug 2019, and should include much useful new information.

Crawford C and S Harwin (2018). Reassessment of intertidal macroalgal communities near to & distant from salmon farms and an evaluation of using drones to survey macroalgal distribution. FRDC Project 2014-241
http://www.frdc.com.au/project/2014-241
Revisited intertidal sites previously surveyed in 2002/3 (2 surveys) in autumn/spring of 2015/16 (4 surveys). Sixteen sites across Channel/Huon – 5 close to fishfarms (<1km), 6 mid (1-5 km) and 5 far >7 km (refs). Three transects at each site w/replicate quadrats in mid and lower intertidal. Recorded % algal cover, with a focus on two dominant species - *Ulva* and *Hormosira*. *Ulva* (sea lettuce) typically considered to be a nuisance/nutrient indicator species while *Hormosira* (Neptune's Necklace) is an important 'ecosystem engineer' with a low tolerance for nutrients and sediments; also prefers sheltered sites. Results found that abundance of H had declined significantly since previous survey (nearly gone from mid-tide region). Ulva dominated in spring (esp in 2016) and at mid-tide sites, and % cover of Ulva had increased significantly since 2002/3. However, did not find any significant patterns wrt proximity to fish farms, suggesting that other factors may be in play. Suggest that intertidal algae may not be a useful indicator of nutrient impacts from fish farms, as there are too many other factors (e.g. temperature, wave exposure, substrate, other nutrient sources, incl S Ocean). Also note a number of issues with intertidal monitoring, including access/logistics and the difficulty of finding unimpacted reference sites. Stable isotopes in *Ulva* could be a useful tracer of nitrogen sources – some work on this done by Oakes & Eyre, 2015. Other useful refs: Bellegove et al 2017; Hadley et al, 2016 (IMTA) and McLeod et al 2016 (nutrient additions – see below). Drone surveys were not very successful – could not clearly delineated submerged *Macrocystis*, and intertidal surveys also hard to do because even small water depths caused interference (see report for details).

Macleod C, D Ross, S Hadley, L Henriquez and N Barrett (2016). Clarifying the relationship between salmon farm nutrient loads and changes in macroalgal community structure/distribution. FRDC Project 2011-042
https://www.imas.utas.edu.au/__data/assets/pdf_file/0008/905759/2011-042-DLD-Nutrients.pdf

Set of 2 PhD projects on potential for nutrient impacts on macroalgae: one based on field manipulations, the second on modelling of Integrated Multi-trophic Aquaculture (IMTA) potential.

#1 (Henriquez) looked at impact of nutrient additions to three reef communities in the Channel (TB, Green Isl and 9pin). Work done @2012? Three main components: first added nutrients to established reef communities; second added nutrients to cleared patches and tracked succession; third measured physiological responses (PAM and nutrient tissue levels). Did not find major effect on canopy abundance, but some physiological differences. Effect on opportunistic species was variable – proliferated at one site, not at others. Need to consider combined impacts of light, T, S, nutrients and exposure (waves). Lower & mid channel sites may be influenced by Huon River tannins, & less susceptible?

#2 (Hadley) used models to assess potential for IMTA. Found the was good potential, but location of culture depends on whether using IMTA for profit or nutrient mitigation. Desktop project.

Valentine J, M Jensen, D Ross, S Riley and S Ibbott (2016). Understanding broad scale impacts of salmonid farming on rocky reef communities. FRDC 2014-042

http://www.frdc.com.au/project/2014-042
Two-part study of reef communities. Part 1 analysed long-term database for three Marine Protected Areas (MPAs) at Maria, Tinderbox and Ninepin Pt (1992-2015, autumn sampling events only). No consistent pattern of change, except at central Tinderbox (big increase in *Caulerpa*). Nutrient indicator species (NIS) generally low and variable. Part 2 surveyed broader set of reefs (26 sites) including MPAs, Oakhampton Bay, Storm Bay (N Bruny and Nubeena area) and lower Channel. These were also done in autumn. Again no obvious regional impacts from FFs, and low cover of NIS. Did not match findings by Oh. (*Note: sites were somewhat distant from FFs (>2 km) as focus was on regional impacts, and sampling took place in autumn, when NIS are generally low*.) Recommend that future monitoring be designed to include both rapid assessment methods with a focus on NIS (e.g. 6 monthly) as well as more holistic Edgar-Barrett surveys (3-5 yearly). Extra sites included in 2015 could provide useful baseline.

Oh E, G Edgar, J Kirkpatrick, R Stuart-Smith and N Barrett (2015). Broad-scale impacts of salmon farms on temperate macroalgal assemblages on rocky reefs. Marine Pollution Bulletin 98 (1-2)

A B S T R A C T

Intensive fish culture in open sea pens delivers large amounts of nutrients to coastal environments. Relative to particulate waste impacts, the ecological impacts of dissolved wastes are poorly known despite their potential to substantially affect nutrient-assimilating components of surrounding ecosystems. Broad-scale enrichment effects of salmonid farms on Tasmanian reef communities were assessed by comparing macroalgal cover at four fixed distances from active fish farm leases across 44 sites. Macroalgal assemblages differed significantly between sites immediately adjacent (100 m) to fish farms and reference sites at 5 km distance, while sites at 400 m and 1 km exhibited intermediate characteristics. Epiphyte cover varied consistently with fish farm impacts in both sheltered and exposed locations. The green algae *Chaetomorpha* spp. predominated near fish farms at swell-exposed sites, whereas filamentous green algae showed elevated densities near sheltered farms. Cover of canopy-forming perennial algae appeared unaffected by fish farm impacts.

Good review of opportunistic algal growth on temperate reefs @ FFs; often accompanied by loss of diversity & canopy-forming species. Many macroalgal spp have preference for ammonia-N. Transects & photos at 10 reefs which varied in exposure to wind and swell. Surveys conducted in Nov/Dec 2008, primarily in Channel, but one in Nubeena. Lack of impacts on canopy species could be related to general resilience, insufficient nutrients and/or insufficient time for full effects to become apparent. Possibility that reference sites also influenced by regional enrichment noted. Macroalgae is a useful tool for detecting nutrient impacts (possibly more so than direct water quality measures), and suggest that impacts may extend beyond regulatory compliance boundaries. Impacts could be better assessed/modelled with additional info on prevailing current directions. See Oh, 2009 Thesis for further detail.

Fowles et al, 2018.
Series of paper looking at impacts of pollution from sewage, stormwater, marinas and fishfarms using deployment of paver substrates. Study sites in the Channel and Derwent

SOCIO-ECONOMICS

Browne B (2018). Fishing for compliments: fishing in the Tasmanian economy. Report prepared for the Australia Institute/commissioned by the Tasmanian Abalone Council.
Assessment of the economic value and employment figures associated with salmon aquaculture, shellfish aquaculture, commercial fishing and recreational fishing. Includes both sectoral and regional analyses. Results based on ABC census data are quite different than those based on TSGA figures.

Alexander K, (in progress). Determinants of socially supported wild-catch & aquaculture fisheries.
http://www.frdc.com.au/project/2017-158
Objectives (as set out on FRDC website)
1. To provide a nuanced definition of societal support for wild-catch and aquaculture fisheries in Australia

2. To identify determining factors (social, economic, environmental and political) affecting societal support for wild-catch and aquaculture fisheries in Australia
3. To identify means by which to detect, assess and monitor societal support for wild-catch and aquaculture fisheries in Australia using a risk-based approach

Fudge M, M Anderson and T Lewis (2012). Establishing regional indicators of social sustainability in the Tasmanian aquaculture industry - a pilot study. FRDC 2010/219
http://www.frdc.com.au/project/2010-219

Hoisington C (2015). Our Harbour Our Asset: An overview of economic activities and values associated with Australia's most iconic harbour, and its use by the city that surrounds it, Sydney Institute of Marine Science, Sydney, Australia
Interesting economic assessment of Sydney Harbour, including commercial activities, tourism, real estate, recreation. Real estate by far the largest value.

Jensen CU, TE Panduro, TH Lundhede, ASE Nielson, M Dalsgaard and BJ Thorsen, 2018. The impact of onshore and offshore wind turbine farms on property prices. Energy Policy 116, p 50-59.

JELLYFISH AND HARMFUL ALGAL BLOOMS

Crawford C, N Moltschaniwskyj and S Willcox (2011). Size and characteristics of aggregations of moon jellyfish (*Aurelia sp*) in Tasmania, Australia. Papers and Proceedings of the Royal Society of Tasmania, Volume 145

Willcox S, N Moltschaniwskyj, C Crawford (2008). Population dynamics of natural colonies of *Aurelia* sp. scyphistomae in Tasmania, Australia. Marine Biology 154 (4)

Carl C, J Gunther and L Sunde (2011). Larval release and attachment modes of the hydroid *Ectopleura larynx* on aquaculture nets in Norway. Aquaculture Research 42: 1056-60

Guenther J, E Misimi and L Sunde (2010). The development of biofouling particularly the hydroid Ectopleura larynx on commercial cage nets in mid-Norway. Aquaculture 300:120-127

Holst S and G Jarms (2007). Substrate choice and settlement preferences of planula larvae of five Schphozoa (Cnidaria) from German Bight, North Sea. Marine Biology 151: 863-71

Lo W, J Purcell, J Hung, H Su and P Hsu (2008). Enhancement of jellyfish (Aurelia aurita) populations by extensive aquaculture rafts in a coastal lagoon in Taiwan. ICES Journal of Marine Science 65:453-61.

McLeod D, G Hallegraeff, G Hosie and A Richardson, 2012. et al, 2012. Climate change driven expansion of the red tide dinoflagellate *Noctaluca scintillans* into the Southern Ocean. *Journal of Plankton Research*, Volume 34, Issue 4,

FISH & FISHERIES
Lyle (2018). Tasmanian recreational rock lobster and abalone fisheries: 2017-18 Fishing Season. IMAS report.

Lyle J, K Stark and S Tracey (2014). 2012/13 Survey of recreational fishing in Tasmania. IMAS Report
Next one is due out in 2019

Mundy and McAllister (2018). Tasmanian abalone fishery assessment 2017. IMAS Report.
http://www.imas.utas.edu.au/__data/assets/pdf_file/0006/1162518/AbaloneAssessment2017Web-sm.pdf

Moore B, J Lyle and K Hartmann (2018). Tasmanian scalefish fishery assessment 2016/17. IMAS Report.
http://www.imas.utas.edu.au/__data/assets/pdf_file/0004/1227541/Tasmanian-Scalefish-Fishery-Assessment-2017_18.pdf

Hartmann K, C Gardner, R León, J Rizzari (2019). Fisheries assessment: Tasmanian rock lobster 2017/18. IMAS Report
http://www.imas.utas.edu.au/__data/assets/pdf_file/0011/1245458/RL_Stock_Assessment_2017-19_Final_June_2019.pdf

Tracey S, K Hartmann, E Forbes, J Semmens & J Lyle (2011). Movement of recreational fish species in southeast Tasmania. IMAS Report.
Acoustic tagging study of flathead, bream and trout in the Derwent, Frederick Henry and Norfolk Bay

Stehfest K, J Lyle and J Semmens (2015). The use of acoustic accelerometer tags to determine seasonal changes in activity and catchability of a recreationally caught marine teleost.
Flathead behaviour in Frederick Henry, & links to temperature

Barnett A, K Abrantes, J Stevens, B Bruce, J Semmens (2010) Fine-Scale Movements of the Broadnose Sevengill Shark and Its Main Prey, the Gummy Shark.
Tracking tagged sharks in Derwent and Norfolk Bay