Outputs from OTOT and Related Mahi*, at Sept 2019

Journal articles

- Berthelsen, A., Atalah, J., Clark, D., Goodwin, E., Sinner, J., & Patterson, M. (2019). New Zealand estuary benthic health indicators summarised nationally and by estuary type. *New Zealand Journal of Marine and Freshwater Research*, 1-21. doi:10.1080/00288330.2019.1652658
- Berthelsen A, Atalah J, Clark D, Goodwin E, Patterson M, Sinner J. 2018. Relationships between biotic indices, multiple stressors and natural variability in New Zealand estuaries. *Ecological Indicators*, 85:634-643.
- * Bollen M, Battershill CN, Pilditch CA, Bischof K. 2017. Desiccation tolerance of different life stages of the invasive marine kelp Undaria pinnatifida: Potential for overland transport as invasion vector. Journal of Experimental Marine Biology and Ecology, 496, 8 pages. doi:10.1016/j.jembe.2017.07.005
- Clark DE, Hewitt JE, Pilditch CA, Ellis JI (accepted). The development of a national approach to monitoring estuarine health based on multivariate analysis. *Marine Pollution Bulletin*.
- *Cussioli MC, KR Bryan, CA Pilditch, WP de Lange, K Bischof. 2019. Light penetration in a terperate meso-tidal lagoon: Implications for seagrass growth and dredging in Tauranga Harbour, New Zealand. *Ocean Coast Manag*. https://doi.org/10.1016/j.ocecoaman.2019.01.014
- Ellis J, Clark D, Atalah J, Jiang W, Taiapa C, Patterson M, Sinner J, Hewitt J. 2017. Multiple stressor effects on marine infauna: responses of estuarine taxa and functional traits to sedimentation, nutrient and metal loading. *Scientific Reports*, 7(1):12013. DOI:10.1038/s41598-017-12323-5
- * Kulgemeyer T, Müller H, Dobeneck TV, Bryan KR, de Lange WP, Battershill CN. 2017. Magnetic mineral and sediment porosity distribution on a storm-dominated shelf investigated by benthic electromagnetic profiling (Bay of Plenty, New Zealand). *Marine Geology*, 383, 78-98. doi:10.1016/j.margeo.2016.11.014
- *Norris BK, JC Mullarney KR Bryan SM Henderson. 2019. Turbulence Within Natural Mangrove Pneumatophore Canopies. *Journal of Geophysical Research* https://doi.org/10.1029/2018JC014562
- *Patterson MG, Hardy DJ, McDonald GM. 2017. Is there more in common than we think? Convergence of ecological footprinting, emergy analysis, life cycle assessment and other methods of environmental accounting. Ecological Modelling, 362(C), 19-36. doi:10.1016/j.ecolmodel.2017.07.022
- *Ruiter Peter J, Mullarney Julia C, Bryan Karin R, Winter Christian. 2019. The links between entrance geometry, hypsometry and hydrodynamics in shallow tidally dominated basins. *Earth Surface Processes and Landforms*, August 2019, Vol. 44(10), pp.1957-1972. https://doi.org/10.1002/esp.4622
- Smith NJ, McDonald GW, Patterson MG. 2019. Biogeochemical Cycling in the Anthropocene: Quantifying Environment-Economy Exchanges. *Ecological Modelling*. (In Press).
- *Staudt F, Mullarney JC, CA Pilditch, K Huhn. 2019. Effects of grain-size distribution and shape on sediment bed stability, near-bed flow and bed micro-structure. *Ear. Sur. Proc. Land*. https://doi.org/10.1002/esp.4559
- *Stewart, Benjamin; Bryan, Karin; Pilditch, Conrad; Santos, Isaac. 2018. Submarine Groundwater Discharge Estimates Using Radium Isotopes and Related Nutrient Inputs into Tauranga Harbour (New Zealand). *Estuaries and Coasts*, Vol. 41(2), pp.384-403

• Tremblay LA, Clark D, Sinner J, Ellis JI. 2017. Integration of community structure data reveals observable effects below sediment guideline thresholds in a large estuary. *Environ. Sci.: Processes Impacts* 19, 1134–1141.

In prep:

• Battershill C, Kellett M, Cadwallader H, Francis M. (In prep). A trophic cascade for Tauranga Harbour.
• Berthelsen et al. (In prep). Relationships between freshwater and estuarine benthic ecological health.
•* Cadwallader H, Fernihough G, Ross P, Francis M, Battershill C. (In prep). The role of mesopredators in maintenance of ecosystems services in estuaries 2019. PlosONE.
• Clark et al. (in prep). Species turnover thresholds in response to sedimentation and nutrient loading.
• Harvey EP *et al.* (In prep). Demonstration of the Integrated Spatial Planning Tool (ISPT) for chosen scenarios.
• Harvey EP *et al.* (In prep). Testing intervention options and modelling extrema to ascertain potential pathways for the Tauranga Harbour.
•* Kellett M, Ross P, Francis M, Battershill C. (In prep). The importance of estuaries as nursery grounds for Bronze Whaler sharks and other elasmobranchs. In preparation for publication in PlosONE.
• McDonald GW *et al.* (In prep). Policy implications from the Integrated Spatial Planning Tool (ISPT) modelling.
• McDonald G, Patterson MG, Battershill C. (In prep). Ecopath modelling for the Tauranga Harbour.

Books, book chapters, technical reports and monographs

• Berthelsen A, Atalah J, Clark D. (2017). *National Estuary Dataset: inconsistencies in survey data*. Prepared for Northland Regional Council. Cawthron Report No. 3107
• Berthelsen A, Clark D, Goodwin E, Atalah J, Patterson M. 2018b. *National Estuary Dataset: User Manual*. OTOT Research Report No 5. Cawthron Report No 3152. Massey University, Palmerston North.
•* Cadwallader H, Fernihough G, Ross P, Francis M, Battershill C. 2019. The role of mangrove fringe areas in providing feeding habitat for the New Zealand eagle ray (Myliobatis tenuicaudatus). Environmental Research Institute, The University of Waikato, Hamilton, New Zealand (Peer reviewed Report ERI.12, 25pp.).
• Clark D, Taiapa C, Sinner J, Taikato V, Culliford D, Battershill C, Ellis J, Hewitt J, Gower F, Borges H, Patterson M. 2018. *2016 Subtidal Ecological Survey of Tauranga Harbour and Development of Benthic Health Models*. OTOT Research Report No. 4. Massey University, Palmerston North.
• Hardy D, Patterson M, Smith H, Taiapa, C. 2015. Cross Cultural environmental research processes, principles, and methods: coastal examples from Aotearoa/New Zealand. In M. Ruth (Ed.), Handbook of Research methods and Applications in Environmental Studies (pp. 44-80). Edward Elgar. doi:10.4337/9781783474646
• *Horstman, Erik M.; Bryan, Karin R.; Mullarney, Julia C.; Pilditch, Conrad A.; Eager, Christopher Andrews. 2018 Are flow-vegetation interactions well represented by mimics? A case study of mangrove pneumatophores. Elsevier.
• *Mullarney, Julia C.; de Lange, Willem P. 2018. Hydrodynamic modelling of proposed expansion of the Port of Tauranga shipping channels and wharves. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato.

- *Norris, Benjamin Mullarney, Julia C.; Bryan, Karin R.; Henderson, Stephen M. 2019. Small-scale Turbulence and its Influence on Forest-scale Morphodynamics within a Coastal Mangrove Forest. ERI Report. The University of Waikato.
- Patterson MG, Gledhill L, Hardy DJ, Love A, Kim J-H, McDonald GW, McCallion AC. 2017. Performance of Sectors and Markets in the Tauranga Economy. OTOT Research Report No. 1. Massey University, Palmerston North. https://www.mtm.ac.nz/
- *Tangatatai, T., Patterson, M.G., Hardy, D.J. 2017. Cost Benefit Analysis of Riparian Planting of Waiwiri Stream, Horowhenua. MTM Research Report No. 15. Massey University, Palmerston North.

In prep/review for OTOT Report Series, Massey University:

- Cole AO me ōna tūpuna, McCallion A. Special issue on information technology and systems: Towards an understanding of barriers to the Māori cultural adoption and use of information technology and systems in the expression of kaitiakitanga.
- Cole AO et al. (Under review). Enhancing the expression of kaitiakitanga with the aid of information technology and systems.
- Cole A. (in peer review). Whakatupu mātauranga, co-governance and co-management engagement with hapū.
- Cole A. (in peer review). Literature review method as an instrument of Māori knowledge development.
- Cole A. (in peer review). Characterisation of the landscape of Māori knowledge development.
- Cole A. (in peer review). Whakatupu mātauranga in a mixed market economic world, the commodification of kawa, kaupapa and tikanga.
- Cole A. (in peer review). Te wānanga o kaupapa Māori.
- Cole A. (in peer review). Te whāriki o kaupapa Māori.
- Cole A. (in peer review). Engaging with hapū in creative, co-governance and co-management activities, the role of kawa, kaupapa and tikanga.
- Hardy DJ et al. (in development). Integrated Spatial Planning Tool for Estuaries and their Catchments – its Heritage in Coastal Planning, Coastal Management and Spatial-Dynamic Modelling Literature.
- Harvey EP et al. (in preparation) ISPT technical report.
- Harvey EP et al. (in preparation) ISPT metadata report.
- Harvey EP et al. (in preparation) ISPT scenario document.
- Harvey EP et al. (in preparation) ISPT overview/summary pamphlet.
- Knight B. (in prep) Estuary transport model for Tauranga Harbour.

PhD or Masters Theses in Development or Completed

- * Aroha Spinks graduated with a PhD in Environmental and Resource Planning at Massey University in 2019: Restoring the Mauri of Coastal Dune Lake Ecosystems: The case study of Lake Waiorongomai, Otaki, Aotearoa/New Zealand, published in 2018.
- * Mahina-a-Rangi Baker's PhD in Environmental and Resource Planning at Massey University, is currently being examined: Te Kete Tua-ātea, Māori modelling of the future and the kaitiakitanga of water.
- * A Waikato University PhD Thesis on mesopredators informing the food web modelling input to the ISTP has been submitted (August 2019) – H Cadwallader, The Ecology of the New Zealand Eagle Ray (Myliobatis tenuicaudatus) in an Urbanised Estuary: Seasonality, Habitat use and Pollutant Exposure in Tauranga Harbour.

- * A Waikato University MSc thesis will be submitted by the end of September 2019 – M Kellett, Ontogeneic phase and seasonal habitat partitioning of bronze whaler sharks in the Bay of Plenty.
- Dana Clark, from our research team, is completing a PhD on drivers of change in estuarine benthic communities.
- * Other PhD research related to the OTOT programme being undertaken with Prof Chris Battershill at Waikato University includes: Stine Sorensen - seagrass health; Anja Singer - Biogenic habitat; Merle Bollen - invasive species; Manuela Biondo - sedimentary stability in subtidal estuaries; and Caine Taiapa - Kukuroa/ureroa atrina beds bioremediation programme.
- * MSc research related to the OTOT programme being undertaken at Waikato University under supervision of OTOT researchers includes: Fenna Beets - Metazoan and benthic community respiration of sediments; and Regan Fairlie – Environmental history of Tauranga moana.

Conference presentations or proceedings

- Battershill CN. (2017). Marine biotechnology in Aotearoa: just the beginning. In Blue2Green Marine Biotechnology Convention 2017. Conference held in Tauranga, New Zealand.
- Harvey E, Gordon M, Smith N, McDonald G, Patterson M. (2017). Developing a spatially explicit dynamic rural land use change model for the Tauranga Harbour catchment, 22nd International Congress on Modelling and Simulation (MODSIM2017), 3-8 December 2017.
- Smith N, McDonald G, Harvey E, Kim J. (2017). Introducing the MERIT economic model: a dynamic general equilibrium-seeking model to support decision analysis when out-of-equilibrium dynamics are important, 22nd International Congress on Modelling and Simulation (MODSIM2017), 3-8 December 2017.
- Paper presented at the New Zealand Marine Science Society conference in Dunedin. A national approach to monitoring estuarine health based on multivariate analysis. Dana Clark. Co-authors: Judi Hewitt, Joanne Ellis, Conrad Pilditch (3-5 July 2019).
- Paper presented at the Estuarine and Coastal Shelf Science (ECSA) conference in Perth, Australia. The multivariate Benthic Health Model: a standardised and sensitive approach to assessing estuary health. Dana Clark. Co-authors: Judi Hewitt, Joanne Ellis, Conrad Pilditch, Anastasija Zaiko (3-6 September 2018).
- Paper presented at the New Zealand Marine Science Society conference in Napier. The multivariate Benthic Health Model: a standardised and sensitive approach to assessing estuary health in New Zealand. Dana Clark. Co-authors: Hewitt, Ellis, Pilditch, Zaiko (3-5 July September 2018).
- Paper presented at the 4th World Conference on Marine Biodiversity in Montreal. Multiple stressor effects in marine ecosystems: responses of estuarine species and functions under stress. Dana Clark. Co-authors: Joanne Ellis, Javier Atalah, Weimin Jiang, Caine Taiapa, Murray Patterson, Jim Sinner, Judi Hewitt) (13-16 May 2018).
- Paper presented at the New Zealand Marine Science Society conference in Christchurch. Testing the ability of biotic indices to track environmental stressor gradients using a national estuarine dataset. Anna Berthelsen. Co-authors: Javier Atalah, Dana Clark, Eric Goodwin, Jim Sinner (4-6 July 2017).
- Paper presented at Sea Week, introducing ISPT and other OTOT tools, 2-10 March 2019.
- Paper presented at NZ Planning Institute Special Session, 2-3 April 2019.
- Paper presented at NZ Marine Sciences Conference, Special Session on Managing Estuarine Health, Dunedin, July 2019.

- Papers presented and/or lectures are provided on OTOT at all the major New Zealand meetings and internationally, including: Sustainable Seas National Science Challenge, New Zealand Association of Resource Management (NZARM) Conference, New Zealand Coastal Society's Sustainability Conference, Australasian Molluscs Society Conference and Australia New Zealand Marine Biotech Society Conference), involvement of Māori BOP Regional Council planning/policy staff in project Wānanga; regular hui with local kaitiaki and staff from the Waikato University Marine Field station in Tauranga.
- Monthly OTOT presentations to groups such as Rotary, University of the Third Age, Probis.
- *Curiosity Minds Symposium, 14th June 2019, Waikato University student, Yanika Reiter, gave a presentation on her research of comparing the competitive between native and introduced byrozoan species within Bay of Plenty and the importance of the study.
- New Zealand Marine Science Society Conference, 2-5th July 2019. A mixed group of staff and students presented at the NZMSS conference in July. Battershill, Cadwallader, Kellett, McCormack, Taiapa, Taikato, Bennion, Ross.
- *NZ Coastal Society Public Series Tauranga. Marine Student Talk Evening, 24th July 2019, Three student presentations in regards to research occurring in the Tauranga Harbour greater area. Topics included seagrass and sediment to nutrients in the harbour waste.
- *McCormack S, Battershill C, Ross P, Kelly M. 2018. A biogeographic baseline of Taranaki sponge communities: assessing the effects of catchment runoff and reviewing stability of species assemblages NZ Marine Sciences Society Conference: Weaving The Strands, Conference held at Napier Conference Centre, Napier, New Zealand, 03 Jul 2018 - 05 Jul 2018.
- *Taikato V, Battershill CN, Ross P.2018. Ancient aquaculture and the translocation of toheroa - it's not just bull kelp! NZ Marine Sciences Society Conference: Weaving The Strands, Conference held at Napier Conference Centre, Napier, New Zealand, 03 Jul 2018 - 05 Jul 2018.
- *Cadwallader H, Fernihough G, Ross P, Francis M, Battershill CN. 2018. Feeding on the fringe! The implications of mangrove removal for eagle rays NZ Marine Sciences Society Conference: Weaving The Strands, Conference held at Napier Conference Centre, Napier, New Zealand, 03 Jul 2018 - 05 Jul 2018.
- *Fothergill N, Battershill CN, Boren L. 2018. Health and demographics of the New Zealand fur seal (Arctocephalus forsteri) in the Western Bay of Plenty NZ Marine Sciences Society Conference: Weaving The Strands, Conference held at Napier Conference Centre, Napier, New Zealand, 03 Jul 2018 - 05 Jul 2018.
- *Battershill CN. 2018. Rocky Reef community ecology: Is there a paradigm for the paradigms explaining pattern? Insight from Poor Knights Islands' marine caves NZ Marine Sciences Society Conference: Weaving The Strands, Conference held at Napier Conference Centre, Napier, New Zealand, 03 Jul 2018 - 05 Jul 2018.
- *Hudson M, Mika J, Wilcox P, Ruru J, Brooks R, Thompson A, Stott M, Battershill C, Nikora T. 2018. Te nohonga kaitiaki: Developing guidelines for genomic research on taonga species 8th Biennial International Indigenous Research Conference (IIRC18), Conference held at Auckland, New Zealand, 13 Nov 2018 - 16 Nov 2018.
- *Café Scientifique Tauranga, 16th April 2019, Presentation by Kevin Johnson (sabbatical academic) – "Invasive Species: The Second Greatest Global Environmental Threat". School of Science, University of Waikato Hamilton Presentation, 16th May 2019 Kevin Johnson (sabbatical academic) gave a presentation on "Ecological Responses to Estuarine Eutrophication and Restoration".
- *SCIEN301 Capstone Project, Maketu Marae, 29th May 2019 Student presentations of research conducted by students that undertook the SCIEN301 Capstone paper Semester A. 43 students

spent 8,000 hours on this project comparing Tauranga Moana with Maketu Estuary with individual research projects based on MtM and OTOT research methods and finding. Dissertations are being published with BoPRC.
- *Genomics Aotearoa Wananga – 23rd July Chris Battershill attended and presented to this wananga. The relevance is discussion about the importance of Taonga species and maintenance of natural biodiversity.
- *Battershill C. (2017) Keynote presentations during 2017 at: Ocean University Tauranga Workshop 14-15 August; -Qing Dao Ocean University Blue Carbon 20-22 June; Toi Oho Mai Annual Conference 8 June; China Delegation University Overview 8-9 May; Rangatahi Me Taiao; University of Waikato Open Day 16 March; Harbour Forum 3 March; NZ Coastal Conference 16 Nov ; NZ German 40yr celebration MBIE 6 Nov; TEDx 7 October 2017; Aquaculture Conf 20 Sept; INTERCOAST 28 August; Blue2 Green Convention 8 August.
- NZ Marine Sciences Association conference, 2016. Presented 10 papers on Tauranga Moana related research. Matuaranga workshop with Caine Taiapa.
- Māori Water conference Te Mauri o te Wai, Rotorua. Invited keynote on Matauranga and Western Science fusion, 27 July 2016, FoMA and BoPRC Matauranga leaders.

Anticipated:
- *Kaeden Leonard: 13 – 23 October 2019. International Conference on Marine Bioinvasions (ICMB) Puerto Madryn, Patagonia, Argentina.
- OTOT presentations to NZ Marine Sciences Society Conference in 2020, 2021
- OTOT presentations to NZ Coastal Society Conferences in 2019, 2020, 2021
- OTOT presentations to Iwi Leaders Forum and Maori Fisheries Conferences in 2020

OTOT Research Team Science Achievement Awards

- Dana Clark, Coastal Special Interest Group Award for Best Applied Environmental Science student presentation at the New Zealand Marine Science Society conference, Napier (3-5 July 2018).
- Dana Clark, 2nd prize for best student paper at the 4th World Conference on Marine Biodiversity, Montreal (2018).
- New Zealand Coastal Society's Sustainability Award presented to Caine Taiapa & Kelly Ratana (Manaaki Te Awanui) in November 2018 for presenting on kaupapa from OTOT and their work in the Sustainable Sea NSC Project, which is believed to be extremely important to the future work of the society. This work which is engaging discussion about how to support hapū kaitiaki in their work as co-managers of Tauranga Moana.
- Battershill, C. TEDx Invitation and recognition of international perspective in marine biotechnology and conservation. https://www.youtube.com/watch?v=MPR-FoIns-U&feature=youtu.be
- Claude McCarthy fellowship for Dana Clark to attend the Estuarine and Coastal Shelf Science (ECSA) conference in Perth, 2018.

Main Toolsets Produced

• *Integrated Spatial Planning Tool (and modules)*
This decision-making tool integrates economic, demographic, land use, pollutant transfer and ecological data, for the entire Tauranga harbour and its catchment – which is a very challenging task, but potentially very beneficial in supporting the decision making and co-management of the harbour. The ISPT thereby enables decision-makers to understand impacts of proposed interventions, on the whole of the catchment, the harbour itself, as well as the economy (23 industry sectors). Although other 'integrated' modelling tools developed overseas have combined such data and terrestrial models, this is believed to be the first such dynamic model to integrate spatially referenced data for terrestrial and coastal ecosystems linked to a detailed model of the economy.

The ISPT includes the following modules: economic, land use, pollutant transfer, hydrodynamic, and harbour ecology. In validating and calibrating the integrated modules, 'extreme' future land use scenarios were developed to test what impact pollutant loadings can potentially have on species distribution in the Tauranga harbour. Following this validation step, the tool has been further developed, including generating external 'reference modes' (trajectories based on external conditions), to specifically assess the ecological and economic impact of a selected number of policy actions. For example, assessing the impact of introducing nitrogen caps on agricultural activity.

• *National Estuary Dataset (NED) and National Benthic Health models*
The National Estuary Dataset is New Zealand's first comprehensive national estuary dataset and represents a significant resource for estuary management and research, containing information from 815 sampling events over 15 years, across 70 estuaries and 14 councils. We have summarised the information contained in this dataset to provide estuary managers with an idea of where their estuaries sit in a national context. We have also identified inconsistencies in the methods that councils currently use to monitor their estuaries so that they can better align methods and get the most out of their monitoring data going forward. Access to this large dataset also facilitated the development of National Benthic Health Models (BHMs). The National BHMs provide a consistent approach to estuary health monitoring, which can be applied in estuaries across New Zealand to indicate estuary health in response to sedimentation and heavy metal loading. A number of councils have shown interest in this tool and we hope that it will provide a standardised approach to estuary health monitoring across the country. The dataset also allowed us to investigate the suitability of various biotic indices for reporting on the ecological status of New Zealand's estuaries; and we are currently looking at relationships between freshwater and estuary health. This dataset will be open access and a dataset User Manual has been produced to facilitate national uptake.

• *Tauranga Harbour intertidal survey*
A comprehensive survey of Tauranga Harbour's intertidal environment was carried out as part of OTOT's predecessor programme Manaaki Taha Moana (MTM). Physico-chemical and macrofaunal information was collected from 75 sites across the harbour. This data was used in OTOT to develop models that predict how estuarine taxa and traits will change over increasing stressor gradients and how key stressors interact. This research has informed the cockle and pipi species distribution models used in the ISPT. Data from the intertidal survey was also used to demonstrate that observable effects on estuarine benthic communities are detected below sediment guideline values.

- *Tauranga Harbour subtidal survey*

We carried out the first comprehensive quantitative survey of Tauranga Harbour's subtidal environment since 1990/91. This survey provides information on spatial patterns in water and sediment physico-chemical variables across the harbour as well as on subtidal biological communities[1]. Models were developed to classify subtidal sites according to categories of relative ecosystem health, based on community structure and predicted responses to environmental gradients. Information from this survey has been used to inform the harbour ecology module of the ISPT.

• *Pataka Korero*

In parallel with fundamental Māturanga Māori research to be published in a report series by Cole, the 'Pātaka Korero' process and conceptual framework has been developed, with funding from OTOT and Sustainable Seas NSC, for organising and storing knowledge on holistic estuarine health that is specific to the Mātauranga Māori, tikanga and values of the hapū and kaitiaki who develop it for their rohe. The 'Pātaka Korero' framework consists of six pou:

-Whakahua (expression of kaupapa/tikanga),
-Kohikohi (establishment of tikanga to collect information),
-Whakarite (process of collecting raw data),
-Pātaka (establishment of tikanga to store processed data for access by kaitiaki),
-Wānanga (information in the pātaka is investigated, reflected and adapted to create links and cross-validate with other information), and
-Whangai (dissemination of information internally to whānau/hapū, and externally to iwi and co-management/co-governance groups).

The Pātaka Korero has been disseminated outside the OTOT case study area in a project co-funded by the Parliamentary Commission for the Environment. See https://sustainableseaschallenge.co.nz/sites/default/files/2019-08/TAIPIRI-Report-web.pdf

• *Estuarine Cultural Health Index (eCHI) – Maatai*

A prototype cloud-based eCHI has been published online with user access enabled for the 11 Iwi affiliates of Te Pumautangata o Te Arawa. The eCHi, named Maatai, will be released nationally in 2020 once the software has been further adapted and amended by the participating Hapū. Accompanying educational resources are scheduled to be completed by the end of 2019.

[1] Repeated sampling of key MTM/OTOT intertidal stations for infaunal species abundance has also been conducted, including a further full seasonal cycle (summer/winter 2018/2019) to provide extended continuity for examining intertidal ecology in areas of significant urban influence. This data is now to be combined with a subtidal survey of biogenic reef stability and abundance of fish populations (BRUVS). There are now two years of data available.