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Submission on South Island Marine Protected Area

Thank you for the opportunity to comment on the proposed Marine Protected Area (MPA) plan for the Otago coast, as recommended by The South-East Marine Protection Forum (SEMP) – Te Roopu Manaaki ki te Toka (the Forum). My submission here is as a local Otago-based marine scientist and member of the community.

As mandated by the Department of Conservation (DOC) and Ministry of Fisheries policy and implementation plan (2005), the recommended network aims to protect a range of unique coastal and estuarine habitats on the Otago coast. In the call for submissions, DOC enlists feedback on how to "progress the network of marine protected areas to best protect our environment and valuable marine biodiversity." In the SEMP Forum recommendations (2018), two possible networks are proposed. Network 1 covers six marine reserves, four Type 2 MPAs, and one kelp protection area, covering a total of 1267 km^2 from Timaru in South Canterbury to Waipapa Point in Southland. Network 2 covers three marine reserves and two Type 2 MPAs totalling 366 km^2.

In this submission, I express support for the following:

1. **Marine reserve designations in both governmental MPA and traditional (Mātaitai, Taiāpure) frameworks**. Marine reserves, the selection of locations with enforced restrictions on marine activity, is an effective strategy to protect marine biodiversity, habitat restoration, and recovery of fish stocks. Global evidence of their success is abundant. We support both frameworks that offer this protection.
2. **A more expansive Network 1 for the SEMP region.** I recognize the sensitivity and effort needed to plan for Marine reserves as they must fairly accommodate a multitude of ecological, socio-economic, cultural, and scientific perspectives. Habitat diversity and replication of environments in Network 1 is more consistent with best practices compared to the Network 2 alternative.
3. **The protection of a southern site increases the likelihood of success.** Although I do not support the Long Point site proposal as it is opposed by Kāi Tahu, a site designation in the southern part of the forum region is potentially crucial to successful protection. Below, this is supported with historical data from interdisciplinary science publications and example numerical model analysis. I support in addition to Network 1, either an alternate reserve site is considered or Mātaitai designation is approved for the Long Point site in accord with Fisheries (South Island Customary Fishing) Regulations, 1999. Crucially, adequate resources for Mātaitai management and monitoring should also be provided.

Further comments here centre on the following themes: the overall collaborative approach undertaken to propose the SEMPA, habitat-type representation and future monitoring efforts, and connectivity from an oceanographic and ecological perspective.

The collaborative process

Although the call for submissions does not request feedback on the socio-cultural-economic perspectives for Marine Reserve design, the long-term success of any network requires support and buy-in from a wide range of ocean users. The design process, including a delegation of a Forum with stakeholders from a variety of perspectives, Kāi Tahu, science, tourism, and recreational and commercial fisheries is impressive and I express support for this overall approach. I hope that the collaborative approach to the Otago region MPA design continues to the establishment and implementation phases. In particular, the consideration of the Irihuka (Long Point) site O1. SEMPF Recommendations (2018) note that the site is an important customary and commercial fishery resource for Kāi Tahu, and there has been a desire by Te Rūnaka o Awarua to establish mātaitai reserves at this location. It further notes that a no-take MPA and the associated fishing prohibitions is a significant negative factor towards Kāi Tahu rūnaka to agree to the establishment of MPAs in their rohe. The report recommends that agencies continue to work with Kāi Tahu to explore their aspirations for establishing and managing Marine Protected Areas in the region, including co-management of the proposed Marine Protected Area. In the spirit of good faith collaboration and shared conservation goals, I express support for customary protection areas such as mātaitai reserves. If co-management were approved by all parties, inclusion of mātaitai reserves as part of the network of marine protected areas would be a preferred outcome. I believe that there is sufficient evidence a protected Southern site would act as a nursery and serve as a significant larval source to downstream populations.

Importance of representative habitats

To function as a viable reserve, two levels of representativeness are captured in Network 1: physical habitat environment (estuarine, substrate type, water depth) and variation in community composition (fish, shellfish, etc.). As in Forum Recommendations (Table 2.1, SEMPF, 2018), 27 of 37 habitats are represented in Network 1, compared to 12 of 37 in Network 2. Habitat diversity and replication of environments in Network 1 are consistent with best practices, subject to sufficient connectivity (e.g., Carr et a., 2019). I note that there is a disagreement about spill-over effects in the Network (Section 5.2, SEMPF, 2018), but also note evidence from worldwide MPAs to suggest fish biomass that accumulates inside MPAs can spill-over into adjacent fished areas (e.g., White et al., 2013).

Connectivity

As acknowledged in the Forum Recommendations (2018) and scientific literature, marine population connectivity is difficult to assess. With a range of life histories, evolutionary strategies, and complexity of ocean currents, connectivity is difficult to measure and quantifiable estimates depend heavily on what is measured and how the data are interpreted. However, connectivity is an essential component of Marine Reserve planning (e.g., Carr et al., 2019) and inherent in the philosophical approach of designing a *network* of protection in favour of a standalone reserve.

For many invertebrate species whose adult stage is largely sessile, dispersal occurs during a pelagic larval stage (e.g., Pineda et al. 2007; Cowen and Sponaugle 2009) where larvae are carried passively by horizontal currents (e. g., Genin et al 2005). This leads to asymmetric gene flow, with upstream populations driving population structure (Pringle et al. 2011). Therefore, the conservation and health of upstream source populations is crucial to

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ensure ongoing recruitment and long-term protection of downstream populations (Roberts 1997, Lundberg and Jonzen 1999). A marine reserve that does not adequately include source populations runs the risk of negatively effecting the entire network (Crowder et al. 2000).

Many tools exist for evaluating marine connectivity and we recommend that *multiple* estimates of connectivity be included in any future monitoring plan. Below, we illustrate a few regional applications of connectivity to the Otago area specifically commenting on two aspects of the SEMP proposal:

1. The baseline connectivity represented in the coloured blue diagrams in the proposal (e.g., Figure 2-5, SEMPF, 2018) *overestimates* southward connectivity.
2. With a predominant northward-flowing current to carry planktonic larvae, a high density of subtidal reef habitats, and a healthy fishery, the area between Waipapa and Nugget Point likely serves as a source population for sites downstream. We strongly encourage a form of marine protection in this southern region to help conserve source populations.

Physical Oceanographic connectivity

Physical oceanographic connectivity concerns the influence of ocean currents to the transport and dispersal of marine larvae. In the context of the Otago region, we recognize the relative lack of direct current observations and therefore some limitations to any description of connectivity. However, available historical observations of the predominantly *northward* flowing Southland Current can, and should, be interpreted to provide baseline connectivity estimates. Direct ocean current observations from 2 locations (Nugget Point and Oamaru) were maintained for 7 months in 100 m water depth (Chiswell, 1996). A remarkable aspect of these measurements was a northward flow (Southland Current) persistently to the north (i.e., rarely directed to the south) that was coherent between the two locations. This indicates a limited pathway for freely-drifting material to transit from north to south in this region. Chiswell (1996), notes that measurements in 100 m depth are *onshore* of the core of the Southland Current where flow is strongest and even more northward-trending. Subsequent research suggested that the flow “may be the least variable and most predictable of New Zealand’s currents (Chiswell and Rickard, 2011).”

Nearshore current measurements are also few, with more complicated dynamics driven by the combination of winds, tides, waves, and freshwater discharge. However, observations from Russell and Vennell around Cape Saunders indicates that, “the currents around the Cape are dominated by the Southland current which is generally stronger than tidal flows making the current flow in a northeastward direction at most states of the tide (Russell and Vennell, 2017).” This further supports the idea that there is a relative boundary for southward movement of water around the Otago Peninsula. To the north of the peninsula, flow is weaker (Chiswell, 1996) and the nearshore currents are susceptible to retention, recirculation, and even reverse flow that can cause remarkable DNA diversity within short distances (e.g., Jeunen et al., 2019).

For the SEMPA planning, connectivity estimates are drawn as concentric distance markers (e.g., Figure 2-5, SEMPF, 2018), suggesting equal spreading in both directions. The assumption would be that the dispersal is equally probable to the north and south, as would be indicated by a predominantly *diffusive* dispersion regime (e.g., Drake et al., 2011). Because the Southland Current is persistently northward, this flow qualifies instead as being *advective*. In regions of highly variable currents, the diffusive effect can counteract mean advection. However, *particularly south of the Otago Peninsula*, the evidence above suggests a mostly advective region that creates net downstream dispersal northward. Baseline connectivity estimates are therefore more likely shifted northward as seen in Figure 6 of

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Chiswell and Rickard (2011). In this numerical model study, rapid northward transport of material along the Otago coast was such that after 10 days, the mean dispersal distance was 177 km to the North (Chiswell and Rickard, 2011).

These inferences from observations can be further evaluated with Lagrangian particle tracking in physical oceanographic models forced with realistic wind and large-scale current mechanisms. An example is illustrated here, where passive drifting particles (n = 50,000) are released at Long Point and the Otago Peninsula every day for 1 year (2017) within a 4-km resolution, 25-year simulation of New-Zealand wide ocean circulation (Figure 1). These model outputs are publicly available through the MOANA project website, https://www.moanaproject.org/data, and a wide range of drift experiments and particle releases can be conducted. In this experiment, 10 days after release particles originating near Long Point are distributed predominantly to the North of the release location (left panel). Particles are found throughout the Otago coastline, remain somewhat close to shore, and are concentrated around the recirculation area of the Blueskin Bay eddy north of the Otago Peninsula (e.g., Murdoch et al., 1990). Few particles transit to the south of the Long Point release location. Particles released from the Otago Peninsula (right panel) similarly transit to the north. Although some particles are retained nearshore, relative to the Long Point release, particles are spread more across the shelf and are exported to offshore regions following the curvature of the depth contours (not shown). In this release, few particles move to the south indicating again the net northward dispersal and a downstream connectivity pattern.

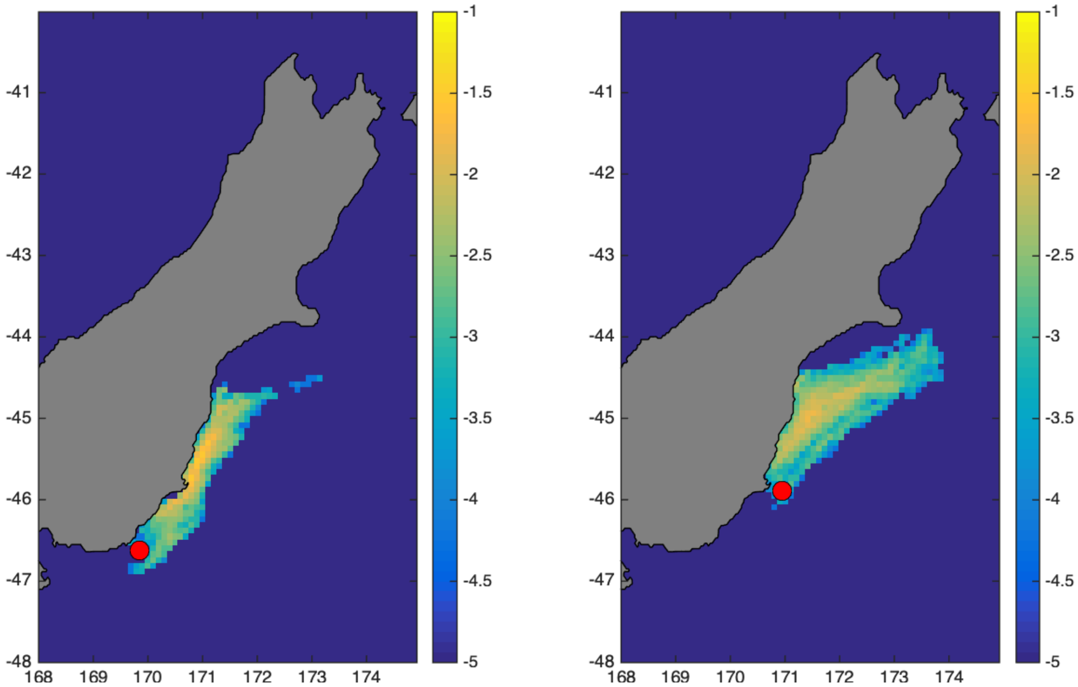

Figure 1: Example physical oceanographic model output used to aid connectivity estimates. Colour is the Log distribution of the probability that a particle lands in a 10 km x 10 km grid around the South Island, 10 days after release. Release locations Long Point (left panel) and Otago Peninsula (right panel) are denoted by the red circles.

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Genetic Connectivity

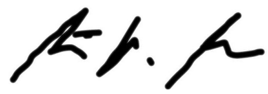
For the South Island, there have been few molecular studies with sufficiently concentrated sampling to provide genetic evidence that southern coastal populations act as a regional source. However, published genetic connectivity data for offshore sites (e.g., Zeng et al. 2019) clearly shows sites to the south and southeast of the Otago coastline contribute offspring to sites further north, including the Chatham Rise. This is interpreted as deep ocean currents promoting the south to north movement of larvae in deep water, in a similar manner as described above for the coastal situation.

Similarly, there are limited analyses and measurements of life history and larval behaviour in the taonga species protected in SEMPA. However, work on blue cod larvae by Robertson (1973) suggests that blue cod eggs are positively buoyant and can be passively transported by prevailing currents for 6 days. Together with the prevailing northward flow of the Southland Current, this supports the hypothesis that southern populations can act as important genetic sources within the consultation area.

These combined considerations lead me to comment on the potential for site Irihuka, Long Point site O1. I note the opposition to O1 due to cultural significance and economic value of this location, but believe that protection in this area is crucial to the Marine Reserve network success. Figure 2-7 of the 2018 forum report indicates a region of high catch intensity of trawled fishery running from Long Point, past the Clutha River. If an alternate location cannot be considered, I recommend customary protection should be approved and implemented as part of the regional network (an expansion of Network 1). If included in the network as a mātaitai reserve, the Irihuka reefs have the clear potential to continue to be a healthy source population feeding important harvesting sites to the north. Representation of these southern populations in the reserve network will help ensure continuous fishery yields throughout the region, as well as promote genetic connectivity through the system.

My best wishes to DOC and MPI towards the implementation of this network of protected areas that will be a benefit for New Zealand oceanic ecosystems for decades to come.

Sincerely,



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References

Department of Conservation and Ministry of Fisheries. 2005. Marine Protected Areas Policy and implementation plan. Wellington. 25 p.

South-East Marine Protection Forum. 2018. Recommendations to the Minister of Conservation and the Minister of Fisheries: Recommendations towards implementation of the Marine Protected Areas Policy on the South Island's south-east coast of New Zealand. Department of Conservation. Wellington. 314 p.

Carr, Mark H. et al. 2019. "Marine Protected Areas Exemplify the Evolution of Science and Policy." *Oceanography* 32(3): 94–103.

Chiswell, Stephen M. 1996. "Variability in the Southland Current, New Zealand." *New Zealand Journal of Marine and Freshwater Research* 30(1): 1–17.

Chiswell, Stephen M., and Graham J. Rickard. 2011. "Larval Connectivity of Harbours via Ocean Currents: A New Zealand Study." *Continental Shelf Research* 31(10): 1057–74.

Cowen, R. K., and Sponaugle, S. 2009. Larval Dispersal and Marine Population Connectivity. *Annual Review of Marine Science*, 1, 443-466.

Crowder, L. B., Lyman, S. J., Figueira, W. F., and Priddy, J. 2000. Source-sink population dynamics and the problem of siting marine reserves. *Bulletin of Marine Science,* 66(3), 799-820.

Drake, Patrick T., Christopher A. Edwards, and John A. Barth. 2011. "Dispersion and Connectivity Estimates along the U.S. West Coast from a Realistic Numerical Model." *Journal of Marine Research* 69(1): 1–37.

Fisheries (South Island Customary Fishing) Regulations, 1999.

Genin, A., Jaffe, J., Reef, R., Richter, C., and Franks, Peter. 2005. Swimming Against the Flow: A Mechanism of Zooplankton Aggregation. *Science* (New York, N.Y.). 308. 860-2. 10.1126/science.1107834.

Jeunen, Gert-Jan et al. 2019. "Environmental DNA (EDNA) Metabarcoding Reveals Strong Discrimination among Diverse Marine Habitats Connected by Water Movement." *Molecular Ecology Resources* 19(2): 426–38.

Lundberg, P., and Jonzen, N. 1999. Optimal population harvesting in a source-sink environment. *Evolutionary Ecology Research*, 1(6), 719-729.

Murdoch, R. C., R. Proctor, J. B. Jillett, and J. R. Zeldis. 1990. "Evidence for an Eddy over the Continental Shelf in the Downstream Lee of Otago Peninsula, New Zealand." *Estuarine, Coastal and Shelf Science* 30(5): 489–507.

Pineda, J., Hare, J. A., and Sponaugle, S. 2007. Larval Transport and Dispersal in the Coastal Ocean and Consequences for Population Connectivity. *Oceanography*, 20(3), 22-39.

Pringle, J. M., Blakeslee, A. M., Byers, J. E., and Roman J. 2011. Asymmetric dispersal allows an upstream region to control population structure throughout a species? *Range. Proc. Natl Acad. Sci*. USA 108:15288–15293.

Robertson DA 1973. Planktonic eggs and larvae of some New Zealand marine teleosts. University of Otago Unpublished Ph.D. Thesis, Dunedin. pp 350+.

Roberts, C. M. 1997. Connectivity and management of Caribbean coral reefs. *Science*, 278(5342), 1454-1457.

Russell, P., and R. Vennell. 2017. "High-Resolution Observations of Secondary Circulation and Tidally Synchronized Upwelling around a Coastal Headland." *Journal of Geophysical Research: Oceans* 122(2): 890–913. 74–79.

White, Crow et al. 2010. "Ocean Currents Help Explain Population Genetic Structure." *Proceedings of the Royal Society B: Biological Sciences*: rspb20092214.

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White, J. Wilson et al. 2013. “A Comparison of Approaches Used for Economic Analysis in Marine Protected Area Network Planning in California.” *Ocean & Coastal Management* 74: 77–89.

———. 2019. “Connectivity, Dispersal, and Recruitment: CONNECTING BENTHIC COMMUNITIES AND THE COASTAL OCEAN.” *Oceanography* 32(3): 50–59.

Zeng C, Clark MR, Rowden AA, Kelly M, Gardner JPA. 2019. The use of spatially explicit genetic variation data from four deep-sea sponges to inform the protection of Vulnerable Marine Ecosystems. *Scientific Reports* 9:5482 | https://doi.org/10.1038/s41598-019-41877-9

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