19 May 2020

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Dear Ali

Cumulative effects of the Pareora discharge

Purpose

As requested in your email of 28 April 2020, this letter provides my response to Canterbury Regional Council's s92 request for an assessment of the cumulative effects of Silver Fern Farms Ltd's Pareora ocean outfall with regard to other nearby potential coastal discharges (Timaru municipal wastewater treatment plant, Fonterra Clandeboye, Fonterra Studholme and Oceania Dairy Glenavy).

Assessment of cumulative effects

Local effects of the Pareora outfall

The discharge from the Pareora outfall is one of several sources of nutrients, particulate matter and other inputs to the coast of South Canterbury, including other outfalls, rivers and streams (Figure 1 and Table 1). Monitoring data collected around the Pareora outfall under the existing consent[1] has not shown any effect of the discharge on pH, salinity, colour or concentrations of total suspended solids, total phosphorus, total nitrogen, chlorophyll-*a* or dissolved oxygen in surface waters adjacent to the discharge (Morrisey et al. 2016). Dissolved reactive phosphorus, total Kjeldahl nitrogen and ammoniacal nitrogen have shown irregular increases in concentrations within the mixing zone, but effects on surface-water concentrations of contaminants from the outfall were at most local. Ranges of nutrient and chlorophyll-*a* concentrations from consent monitoring of the Pareora outfall are comparable to those measured along a 200 km stretch of the adjacent coast in 2004 (Bolton-Ritchie 2006).

Combined effects with other inputs

Although increases in concentrations may be undetectable or local in extent, there are still net inputs of contaminants to the coastal zone from the Pareora outfall. In combination with other sources, these may have a cumulative effect on the coastal environment, particularly the water column. Given the distance of the Pareora outfall from other contaminant sources (the closest major source being the Timaru wastewater treatment plant outfall 16 km to the north) and the strong water movements in the shallow coastal waters around the outfall,

[1] Data are collected monthly at near-shore stations and annually at off-shore stations.

cumulative effects on the seabed are unlikely because particulate and dissolved contaminants are unlikely to accumulate.

Loads of suspended solids from the Pareora outfall (and their effects on turbidity and water colour and clarity) will be small relative to those from rivers, particularly when they are in flood. Consequently, the discharge plume will only be detectable at a local scale (if at all). Dispersion and dilution by water movement will further reduce the already low concentrations of metals and persistent organic contaminants in the wastewater. The fractions of these contaminants that are associated with particulate matter will also be dispersed by water movement and these are therefore unlikely to accumulate on the seabed. Cumulative effects on temperature, pH and dissolved oxygen (and biochemical oxygen demand) are unlikely because of the substantial buffering capacity of the ocean and reoxygenation of the water column by diffusion and wave action as it travels along the coast from one point source input to the next.

Cumulative effects of nutrients on phytoplankton

The fact that monitoring has not shown any local effect of the outfall on concentrations of chlorophyll-*a* is not surprising because phytoplankton may take several days to respond to an increase in nutrient availability. By this time, currents would have relocated (and presumably also diluted) the affected water. However, cumulative effects may occur if the combined sources of nutrients enrich the waters along the South Canterbury coast to a sufficient degree. Coastal marine phytoplankton are typically limited and regulated by the supply of nitrogen, rather than that of other nutrients such as phosphorus and silicate (Howarth 1988). In contrast, phosphorus is usually quite abundant in most temperate coastal systems but is often limiting in freshwater environments.

Nitrogen in seawater is mainly present as nitrate and, in some inshore coastal areas, as ammonia. Together with nitrite these forms comprise dissolved inorganic nitrogen (DIN), representing the nitrogen fraction which is most readily taken up by primary producers. Total nitrogen (TN) is the sum of DIN and the fraction represented by organic forms of nitrogen. DIN concentrations in coastal waters are modified by phytoplankton metabolism and growth. Concentrations are typically low in summer and higher in winter, and they tend to be low and variable at the sea surface and increase with depth. The low surface concentrations in summer reflect stimulation of the phytoplankton by peak light conditions.

In the present context, nitrogen is likely to be the contaminant most likely to produce cumulative effects, namely stimulation of phytoplankton growth, particularly in summer when nitrogen-limitation is most pronounced. Phytoplankton blooms (defined as chlorophyll-*a* concentrations above 5 µg/L) have been reported along the South Canterbury coast from Canterbury Regional Council monitoring, mainly during spring and summer when light availability is highest (Bolton-Ritchie undated). Estimates of the relative contributions of various forms of nitrogen from the Pareora discharge, other discharges along the South Canterbury coast, and the rivers are constrained by the available information (not all forms are measured for all sources: Tables 1–3). The Pareora assessment of environmental effects only provided expected concentrations of TN (not DIN) and dissolved reactive phosphate (DRP) in the wastewater from Pareora after the upgrade of the treatment system (Table 2).

The expected daily TN load from the Pareora discharge after the upgrade[2] will represent 5–6% of the load from the rivers (Table 3). The DRP load, in contrast, will represent 76%, which is perhaps to be expected given the relatively low (i.e. limiting to primary producers) concentrations in fresh water. The expected TN load from Pareora (post-upgrade) is higher than those derived from proposed consent conditions for the dairy factory discharges at Studholme and Glenavy (Table 3) but smaller than those from the Clandeboye dairy factory and Timaru wastewater treatment discharges (based on consent monitoring median values for nitrate-nitrite or consent conditions for ammonia, respectively, because TN values are not available—these values will underestimate the TN load from these discharges). The combined TN contribution from the anthropogenic sources listed in consent conditions for the various outfalls represents c. 30% of the input from rivers. The Pareora (post-upgrade) discharge represents 15% of the total anthropogenic TN load as shown in Table 3.

The contribution of the (post-upgrade) Pareora discharge to the total input of TN from rivers and outfalls is relatively small but clearly does add to the anthropogenic loading to this coastal area and, potentially, to the frequency and scale of phytoplankton blooms. It is important to note, however, that this is an existing discharge and the proposed upgrade will not increase the contribution. Furthermore, the estimates in Table 3 do not consider what is perhaps the overwhelming driver of coastal nutrient concentrations, namely the input of nutrients from offshore waters (for example, by upwelling under northerly winds: Heath (1972)). Nutrients derived from the land via rivers and diffuse sources will also be dispersed and diluted in these waters.

Summary

In summary, there is a significant contribution from anthropogenic discharges to the terrestrial nitrogen (and phosphorus) loads to the adjacent coast. Phytoplankton blooms have been observed in this area and may be stimulated by the availability of nitrogen derived partly from these sources (blooms can also occur under natural conditions). The main sources of nitrogen, however, are the rivers and possibly adjacent offshore waters. Cumulative effects on pH, dissolved oxygen, temperature, suspended solids, water colour and clarity are expected to be insignificant relative to other sources or to the buffering and assimilative capacity of coastal waters.

[2] Based on the expected quality of the treated effluent after upgrade of the treatment process: see Table 4.3 of SFF (2019).

Yours sincerely

Scientist

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Reviewed by

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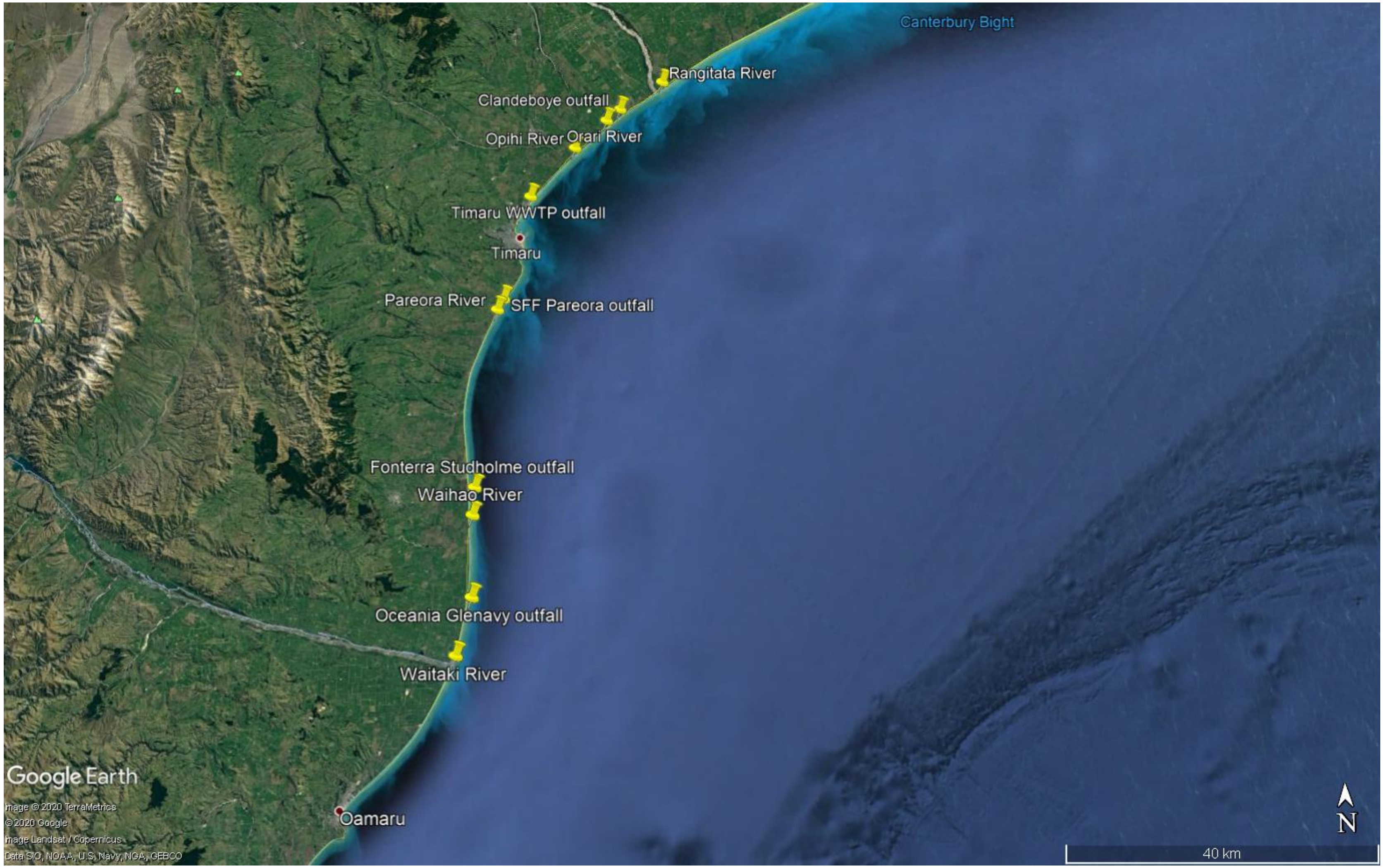

Figure 1. Coast of South Canterbury, showing the SFF Pareora outfall, other outfalls and larger rivers.

Table 1. Summary of information on flow rates from outfalls and larger rivers entering the coastal area of South Canterbury. 'WWTP' wastewater treatment plant. Average flows for rivers are derived from NZ River Maps (https://shiny.niwa.co.nz/nzrivermaps/, accessed 14/05/2020).

	Distance from Pareora outfall (km)	**Ave flow (cumec)**	**Daily discharge (m^3)**	**Source** of information
OUTFALLS				
Fonterra Clandeboye	34.2	0.20	24,153	Sneddon et al. 2015
Timaru WWTP 2011	16.2	2.20	40,000	CRC 2011 consent conditions trigger values for post-2013 combined industrial and domestic treatment plant (median (90%ile)
SFF Pareora 2019	**Not applicable**		**8,300**	**SFF 2019 Consent renewal application proposed consent limit**
Fonterra Studholme	27.6	0.28	24,000	CRC 2016 consent limit (max)
Oceania Glenavy	42.5	0.16 (max)	4,000 (10 k max)	Babbage 2019 proposed consent limits (max)
RIVERS				
Rangitata	41.2	114.00	9,849,600	
Orari	31.6	7.50	648,000	
Opihi	25.5	26.70	2,306,880	
Pareora	2.0	4.10	354,240	
Waihao	31.5	3.70	319,680	
Waitaki	50.1	627.00	54,172,800	

Table 2. Summary of information on nutrient concentrations from outfalls and larger rivers entering the coastal area of South Canterbury. Empty cells indicate no data available.

	NH_3N (g/m^3)	**NO_x (g/m^3)**	**DIN (g/m^3)**	**TN (g/m^3)**	**DRP (g/m^3)**	**TP (g/m^3)**	**Source of information**
OUTFALLS							
Fonterra Clandeboye	0.465	48	51				Monthly monitoring medians
Timaru WWTP 2002							Bolton-Ritchie 2006
Timaru WWTP 2011	42 (55)						CRC 2011 consent conditions trigger values for post-2013 combined industrial and domestic treatment plant (median (90%ile))
SFF Pareora 2012-2018	**20 (438)**			**69 (199)**	**9 (36)**	**13 (82)**	**Consent monitoring (med(max)) 2012-2018**
SFF Pareora 2019				**< 70 (< 90)**	**<10 (< 10)**		**SFF 2019 Consent renewal application - expected quality of DAF-treated wastewater (Table 4.3 of SFF 2019)**
Fonterra Studholme	< 2 (4)	10 (15)	12 (15)	15 (20)	2 (4)	2 (4)	Consent limit (median (95%ile))
Oceania Glenavy	2 (4)	10 (15)	12 (15)	15 (20)	2 (4)	2 (4)	Proposed consent limits (median (95%ile)
RIVERS							
Rangitata	0.011	0.19	0.201	0.32	0.003	0.012	Bolton-Ritchie 2006
Orari	0.01	1.45	1.46	1.45	0.0045	0.0065	Bolton-Ritchie 2006
Opihi	0.026	0.54	0.566	0.76	0.0075	0.019	Bolton-Ritchie 2006
Pareora	0.018	0.18	0.198	0.3	0.006	0.001	Bolton-Ritchie 2006
Waihao	0.042	0.51	0.552	0.77	0.012	0.038	Bolton-Ritchie 2006
Waitaki	0.005			0.12	0.001	0.015	Bolton-Ritchie 2006

Table 3. Summary of information on nutrient loads from outfalls and larger rivers entering the coastal area of South Canterbury. Average flows for rivers were derived from NZ River Maps (https://shiny.niwa.co.nz/nzrivermaps/, accessed 14/05/2020). * values for DIN and NH_3 were used for Fonterra Clandeboye and Timaru WWTP, respectively, in the absence of information on TN. Empty cells indicate no data available.

	NH_3N (kg/d)	**NO_x (kg/d)**	**DIN (kg/d)**	**TN (kg/d)**	**DRP (kg/d)**	**TP (kg/d)**	**Source** of information
OUTFALLS							
Fonterra Clandeboye	11	1159	1232				Sneddon et al. 2016
Timaru WWTP 2002		841			167		CH2M Beca 2002 (cited in Bolton-Ritchie 2006)
Timaru WWTP 2011	1680						CRC 2011 consent conditions trigger values for post-2013 combined industrial and domestic treatment plant (median)
SFF Pareora 2019				**581 (747)**	**83 (83)**		**SFF 2019 (mean(max))**
Fonterra Studholme	48		288	360	48	48	Sneddon et al. 2015 and CRC 2016 consent conditions trigger values (median)
Oceania Glenavy	8	40	48	60	8	8	Babbage 2019 (expected concentration (95%ile))
OUTFALLS							
Rangitata	108	1,871	1,980	3,152	30	118	
Orari	6	940	946	940	3	4	
Opihi	60	1,246	1,306	1,753	17	44	
Pareora	6	64	70	106	2	0	
Waihao	13	163	176	246	4	12	
Waitaki	271			6,501	54	813	
Rivers total	**465**			**12,698**	**110**	**991**	
Expected mean (max) for SFF Pareora as % of rivers total				4.6 (5.9)	75.5 (75.5)		
Outfalls total (including SFF Pareora expected mean) as % of rivers total*	375			31			
Pareora as a % of all outfalls				15			