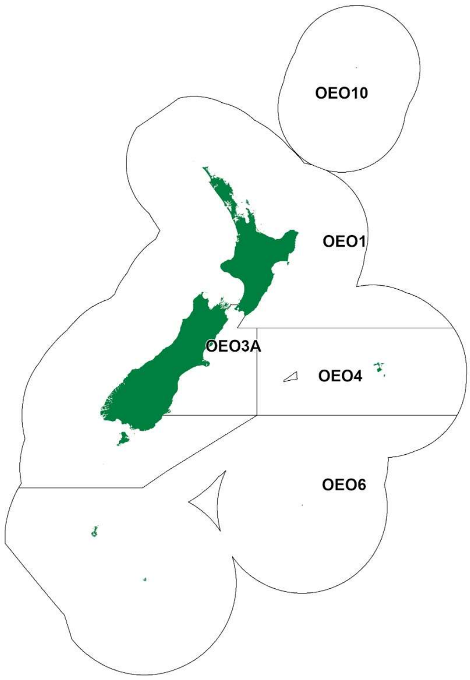
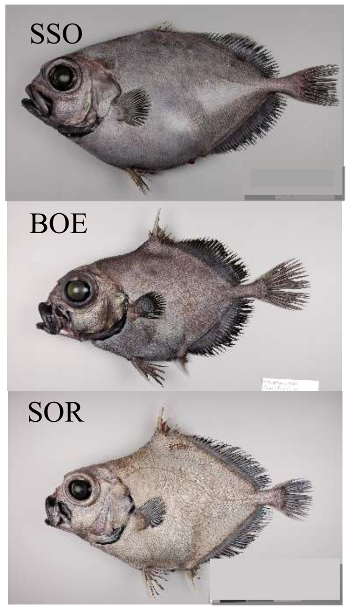
INTRODUCTION – OREOS (OEO)

(*Pseudocyttus maculatus, Allocyttus niger*, *Neocyttus rhomboidalis*, and *Allocyttus verucosus*)





1. INTRODUCTION

The oreo (OEO) complex consists of four species: smooth oreo (*Pseudocyttus maculatus*, SSO)*,* black oreo (*Allocyttus niger*, BOE), spiky oreo (*Neocyttus rhomboidalis*, SOR), and warty oreo (*Allocyttus verucosus,* WOE). The species most commonly caught are smooth oreo and black oreo.

The main black oreo and smooth oreo fisheries have been assessed separately and individual reports produced for each as follows:

1. OEO 3A black oreo and smooth oreo
2. OEO 4 black oreo and smooth oreo
3. OEO 1 and OEO 6 black oreo and smooth oreo

2. BIOLOGY

2.1 Black oreo

Black oreo have been found within a 600 m to 1300 m depth range. The geographical distribution south of about 45° S is not well known. It is a southern species and is abundant on the south Chatham Rise, along the east coast of the South Island, the north and east slope of Pukaki Rise, the Bounty Plateau, the Snares slope, Puysegur Bank, and the northern end of the Macquarie Ridge. They most likely occur all around the slope of the Campbell Plateau.

Spawning occurs from late October to at least December and is widespread on the south Chatham Rise. Mean length at maturity for females, estimated from Chatham Rise trawl surveys (1986–87, 1990, 1991–93) using macroscopic gonad staging, is 34 cm total length (TL).

They appear to have a pelagic juvenile phase, but little is known about this phase because only about 12 fish less than 21 cm TL have been caught and measured. The pelagic phase may last for 4–5 years with lengths of up to 21–26 cm TL.

Unvalidated age estimates were obtained for Chatham Rise and Puysegur-Snares samples in 1995 and 1997, respectively, using counts of the zones (assumed to be annual) observed in thin sections of otoliths. These estimates indicate that black oreo is slow growing and long lived. The maximum estimated age was 153 years (45.5 cm TL fish). Australian workers used the same methods, i.e., sections of otoliths, and reported similar results. A von Bertalanffy growth curve was fitted to the Puysegur samples only (Table 1). Estimated age at maturity for females was 27 years.

Table 1: Biological parameters for black oreo and smooth oreo stock assessments. Values not estimated are indicated by –. Some parameters may be estimated in specific stock assessments.

Fishstock			Estimate
1. Natural Mortality - *M* (y^{-1})	Females	Males	Unsexed
Black oreo (McMillan et al 1997)	0.044 (0.028–0.075)	0.044 (0.028–0.075)	0.044
Smooth oreo (Doonan et al 1997)	0.063 (0.042–0.099)	0.063 (0.042–0.099	
2. Age at recruitment - A_r (y)			
Black oreo	–	–	–
Smooth oreo	21	21	
3. Age at maturity A_M (y)			
Black oreo	27	–	–
Smooth oreo	31	–	

4. von Bertalanffy parameters

	Females			Males			Unsexed		
	L_∞ (cm, TL)	k(y^1)	t_0 (y)	L_∞ (cm, TL)	k(y^1)	t_0 (y)	L_∞ (cm, TL)	k(y^1)	t_0 (y)
Black oreo	39.9	0.043	-17.6	37.2	0.056	-16.4	38.2	0.05	-17.0
Smooth oreo	50.8	0.047	-2.9	43.6	0.067	-1.6	–	–	–

5. Length-weight parameters (Weight = *a*(length)^b (Weight in g, length in cm fork length))

	Females		Males		Unsexed	
	a	*b*	*a*	*b*	*a*	*b*
Black oreo	0.008	3.28	0.016	3.06	0.0078	3.27
Smooth oreo	0.029	2.90	0.032	2.87	–	–

	Females	Males	Unsexed
6. Length at recruitment (cm, TL)			
Black oreo	–	–	–
Smooth oreo	34	–	–
7. Length at maturity (cm, TL)			
Black oreo	34	–	–
Smooth oreo	40	–	–
8. Recruitment variability (σ_R)			
Black oreo	0.65	0.65	0.65
Smooth oreo	0.65	0.65	–
9. Recruitment steepness			
Black oreo	0.75	0.75	0.75
Smooth oreo	0.75	0.75	–

A first estimate of natural mortality (*M*), 0.044 (y^{-1}), was made in 1997 using the Puysegur growth data only. This estimate is uncertain because it appeared that the otolith samples were taken from a well fished part of the Puysegur area.

Black oreo appear to settle over a wide range of depths on the south Chatham Rise but appear to prefer to live in the depth interval 600–800 m that is often dominated by individuals with a modal size of 28 cm TL.

2.2 Smooth oreo

Smooth oreo occur from 650 m to about 1500 m depth. It is a southern species and is abundant on the south Chatham Rise, along the east coast of the South Island, the north and east slope of Pukaki Rise, the Bounty Plateau, the Snares slope, Puysegur Bank, and the northern end of the Macquarie Ridge. They most likely occur all around the slope of the Campbell Plateau, but the geographical distribution south of about 45° S is not well known.

Spawning occurs from late October to at least December and is widespread on the south Chatham Rise in small aggregations. Mean length at maturity for females, estimated from Chatham Rise trawl surveys (1986–87, 1990, 1991–93) using macroscopic gonad staging, is 40 cm TL.

They appear to have a pelagic juvenile phase, but little is known about this phase because only about six fish less than 16 cm TL have ever been caught. The pelagic phase may last for 5–6 years with lengths of up to 16–19 cm TL.

Unvalidated age estimates were obtained for Chatham Rise and Puysegur-Snares fish in 1995 and 1997, respectively, using counts of the zones (assumed to be annual) observed in thin sections of otoliths. These estimates indicate that smooth oreo is slow growing and long lived. The maximum estimated age was 86 years (51.3 cm TL fish). Australian workers used the same methods, i.e., sections of otoliths, and reported similar results. A von Bertalanffy growth curve was fitted to the age estimates from Chatham Rise and Puysegur-Snares fish combined and the parameters estimated for the growth curve are in Table 1. Estimated age at maturity for females was 31 years.

An estimate of natural mortality, 0.063 (y^{-1}), was made in 1997 (Doonan et al 1997). The estimate was from a moderately exploited population of fish from the Puysegur region.

There are concentrations of recently settled smooth oreo south and southwest of Chatham Island, although small individuals (16–19 cm TL) occur widely over the south Chatham Rise at depths of 650–800 m.

3. STOCKS AND AREAS

3.1 Black oreo

The stock structure of Australian and New Zealand samples was examined using genetic (allozyme and mitochondrial DNA) and morphological counts (fin rays, etc.). It was concluded that the New Zealand samples constituted a stock distinct from the Australian sample based on "small but significant difference in mtDNA haplotype frequencies (with no detected allozyme differences), supported by differences in pyloric caeca and lateral line counts". The genetic methods used may not be suitable tools for stock discrimination around New Zealand.

A New Zealand pilot study examined stock relationships using samples from four management areas (OEO 1, OEO 3A, OEO 4, and OEO 6) of the New Zealand EEZ. Techniques used included genetic (nuclear and mitochondrial DNA), lateral line scale counts, settlement zone counts, parasites, otolith microchemistry, and otolith shape. Lateral line scale and pyloric caeca counts were different between samples from OEO 6 and the other three areas. The relative abundance of three parasites differed significantly between all areas. Otolith shape from OEO 3A samples was different to that from OEO 1 and OEO 4, but OEO 1, OEO 4, and OEO 6 otolith samples were not morphologically different. Genetic, otolith microchemistry, and settlement zone analyses showed no regional differences.

3.2 Smooth oreo

Stock structure of Australian and New Zealand samples was examined using genetic (allozyme and mitochondrial DNA) and morphological counts (fin rays, etc.). No differences between New Zealand and Australian samples were found using the above techniques. A broad scale stock is suggested by these results, but this seems unlikely given the large distances between New Zealand and Australia. The genetic methods used may not be suitable tools for stock discrimination around New Zealand.

A New Zealand pilot study examined stock relationships using samples from four management areas (OEO 1, OEO 3A, OEO 4, and OEO 6) of the New Zealand EEZ. Techniques used included genetic (nuclear and mitochondrial DNA), lateral line scale counts, settlement zone counts, parasites, otolith microchemistry, and otolith shape. Otolith shape from OEO 1 and OEO 6 was different to that from OEO 3A and OEO 4 samples. Weak evidence from parasite data, one gene locus, and otolith microchemistry suggested that northern OEO 3A samples were different from other areas. Lateral line scale and otolith settlement zone counts showed no differences between areas.

These data suggest that the stock boundaries given in previous assessment documents should be retained until more definitive evidence for stock relationships is obtained, i.e., retain the existing areas OEO 1, OEO 3A, OEO 4, and OEO 6.

The four species of oreos (black oreo, smooth oreo, spiky oreo, and warty oreo) are managed with separate catch limits for black and smooth in some areas. Each species could be managed separately. They have different depth and geographical distributions, different stock sizes, rates of growth, and productivity.

4. FISHERY SUMMARY

4.1 Commercial fisheries

Commercial fisheries occur for black oreo (BOE) and smooth oreo (SSO). Oreos are managed as a species group, which also includes warty and spiky oreo (SOR). The Chatham Rise (OEO 3A and OEO 4) is the main fishing area, but other fisheries occur off Southland on the east coast of the South Island (OEO 1/OEO 3A) and on the Pukaki Rise, Macquarie Ridge, and Bounty Plateau (OEO 6). In the past, oreo catch has been taken as bycatch of the more valuable orange roughy fisheries but target fisheries for smooth or black oreo are now much more common in most areas.

Total reported landings and TACCs are shown in Table 2, and Figure 1 depicts the historical landings and TACC values for the main OEO stocks. OEO 3A and OEO 4 were introduced into the QMS in 1982–83, and OEO 1 and OEO 6 were introduced later in 1986–87. Reported estimated catches by species from tow-by-tow data recorded in catch and effort logbooks and electronic reporting forms, and the ratio of estimated to landed catch reported, are given in Table 3.

OEO 1 was fished under the adaptive management programme up to the end of 1997–98. The OEO 1 TACC reverted back to pre-adaptive management levels from 1998–99. Landings have declined since then, and from 1 October 2007 the TACC was reduced to 2500 t; other sources of mortality were allocated 168 t.

Oreo landings from OEO 3A were less than the TACC from 1992–93 to 1995–96, substantially so in 1994–95 and 1995–96. The OEO 3A TACC was reduced from 10 106 t to 6600 t in 1996–97. A voluntary agreement between the fishing industry and the Minister of Fisheries to limit catch of smooth oreo from OEO 3A to 1400 t of the total oreo TACC of 6600 t was implemented in 1998–99. Subsequently the total OEO 3A TACC was reduced to 5900 t in 1999–00, 4400 in 2000–01, 4095 in 2001–02, and 3100 t in 2002–03. In 2009–10 the OREO 3A TACC was increased slightly to 3350 t and landings have been close to the TACC since then, averaging 3340 t between 2009–10 and 2018–19, although landings reduced to 2731 t in 2019–20 and increased to 3095 in 2020–21.

Total oreo landings from OEO 4 exceeded the TACC from 1991–92 to 1994–95 and were close to the TACC from 1995–96 to 2000–01 (Table 2). Landings remained high in OEO 4, whereas the orange roughy fishery declined. The OEO 4 TACC was reduced from 7000 t to 5460 t in 2001–02 but was restored to 7000 t in 2003–04. In 2015–16, following an assessment of SSO 4, the OEO 4 TACC was reduced to 3000 t and the landings of smooth oreo were approximately 2000 t. The OEO 4 TACC was increased to 3600 t for the fishing year 2018–19, and just under 3300 t of all oreo species combined were landed, but landings reduced again to 2951 t in 2019–20 and increased to 3542 in 2020–21.

Landings from the Sub-Antarctic area (OEO 6) increased substantially in 1994–95 and exceeded the TACC in 1995–96. The OEO 6 TACC was increased from 3000 t to 6000 t in 1996–97. Landings exceeded the TACC slightly in 2002–03 and in 2005–06 but dropped substantially after 2009–10. Following a period of very low landings ranging from just 136 t to 367 t in 2012–13 to 2014–15, landings recovered slightly, averaging just over 1575 t between 2015–16 and 2020–21. There was also a voluntary agreement in 1998–99 not to fish for oreo in the Puysegur area. More recently there was a voluntary agreement not to fish parts of the Pukaki and Bounty areas to allow fish to increase in size. This agreement was initially for 3 years starting 1 October 2012. It was reinstated on 1 October 2015 for a further 2 years until 1 October 2017.

Table 2: Total reported landings (t) for all oreo species combined by Fishstock from 1978–79 to present and TACCs (t) from 1982–83 to present.

Fishing	OEO 1		OEO 3A		OEO 4		OEO 6		Totals	
year	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1978–79*	2 808	–	1 366	–	8 041	–	17	–	12 231	–
1979–80*	143	–	10 958	–	680	–	18	–	11 791	–
1980–81*	467	–	14 832	–	10 269	–	283	–	25 851	–
1981–82*	21	–	12 750	–	9 296	–	4 380	–	26 514	–
1982–83*	162	–	8 576	10 000	3 927	6 750	765	–	13 680	17 000
1983–83#	39	–	4 409	#	3 209	#	354	–	8 015	#
1983–84†	3 241	–	9 190	10 000	6 104	6 750	3 568	–	22 111	17 000
1984–85†	1480	–	8 284	10 000	6 390	6 750	2 044	–	18 204	17 000
1985–86†	5 390	–	5 331	10 000	5 883	6 750	126	–	16 820	17 000
1986–87†	532	4 000	7 222	10 000	6 830	6 750	0	3 000	15 093	24 000
1987–88†	1 193	4 000	9 049	10 000	8 674	7 000	197	3 000	19 159	24 000
1988–89†	432	4 233	10 191	10 000	8 447	7 000	7	3 000	19 077	24 233
1989–90†	2 069	5 033	9 286	10 106	7 348	7 000	0	3 000	18 703	25 139
1990–91†	4 563	5 033	9 827	10 106	6 936	7 000	288	3 000	21 614	25 139
1991–92†	4 156	5 033	10 072	10 106	7 457	7 000	33	3 000	21 718	25 139
1992–93†	5 739	6 044	9 290	10 106	7 976	7 000	815	3 000	23 820	26 160
1993–94†	4 910	6 044	9 106	10 106	8 319	7 000	983	3 000	23 318	26 160
1994–95†	1 483	6 044	6 600	10 106	7 680	7 000	2 528	3 000	18 291	26 160
1995–96†	4 783	6 044	7 786	10 106	6 806	7 000	4 435	3 000	23 810	26 160
1996–97†	5 181	6 044	6 991	6 600	6 962	7 000	5 645	6 000	24 779	25 644
1997–98†	2 681	6 044	6 336	6 600	7 010	7 000	5 222	6 000	21 249	25 644
1998–99†	4 102	5 033	5 763	6 600	6 931	7 000	5 287	6 000	22 083	24 633
1999–00†	3 711	5 033	5 859	5 900	7 034	7 000	5 914	6 000	22 518	23 933
2000–01†	4 852	5 033	4 577	4 400	7 358	7 000	5 932	6 000	22 719	22 433
2001–02†	4 197	5 033	3 923	4 095	4 864	5 460	5 737	6 000	18 721	20 588
2002–03†	3 034	5 033	3 070	3 100	5 402	5 460	6 115	6 000	17 621	19 593
2003–04†	1 703	5 033	2 856	3 100	6 735	7 000	5 811	6 000	17 105	21 133
2004–05†	1 025	5 033	3 061	3 100	7 390	7 000	5 744	6 000	17 220	21 133
2005–06†	850	5 033	3 333	3 100	6 829	7 000	6 463	6 000	17 475	21 133
2006–07†	903	5 033	3 073	3 100	7 211	7 000	5 926	6 000	17 113	21 133
2007–08†	947	2 500	3 092	3 100	7 038	7 000	5 902	6 000	16 979	18 600
2008–09†	582	2 500	2 848	3 100	6 907	7 000	5 540	6 000	15 877	18 600
2009–10†	464	2 500	3 550	3 350	7 047	7 000	5 730	6 000	16 791	18 850
2010–11†	381	2 500	3 370	3 350	7 061	7 000	3 610	6 000	14 422	18 860
2011–12†	581	2 500	3 324	3 350	6 858	7 000	2 325	6 000	13 088	18 860
2012–13†	652	2 500	3 245	3 350	6 944	7 000	136	6 000	10 977	18 860
2013–14†	386	2 500	3 473	3 350	7 024	7 000	367	6 000	11 251	18 860
2014–15†	277	2 500	3 352	3 350	7 274	7 000	156	6 000	11 059	18 860
2015–16†	523	2 500	3 334	3 350	2 898	3 000	1 357	6 000	8 111	14 860
2016–17†	603	2 500	3 206	3 350	3 011	3 000	1 200	6 000	8 020	14 860
2017–18†	601	2 500	3 177	3 350	2 867	3 000	2 138	6 000	8 783	14 860
2018–19†	689	2 500	3 365	3 350	3 283	3 600	1 613	6 000	8 950	15 460
2019–20†	604	2 500	2 731	3 350	2 951	3 600	1 446	6 000	7 733	15 460
2020–21†	357	2 500	3 095	3 350	3 542	3 600	1 711	6 000	8 705	15 460

Source: FSU from 1978–79 to 1987–88; QMS/MFish/MPI from 1988–89 to 2013–14. *, 1 April to 31 March. #, 1 April to 30 September. Interim TACs applied. †, 1 October to 30 September. Data prior to 1983 were adjusted up due to a conversion factor change.

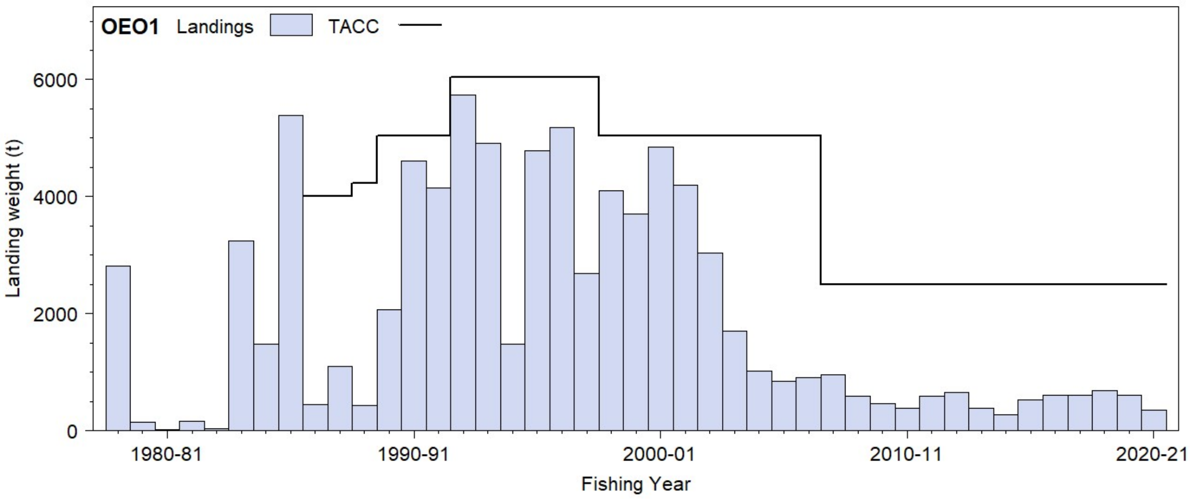
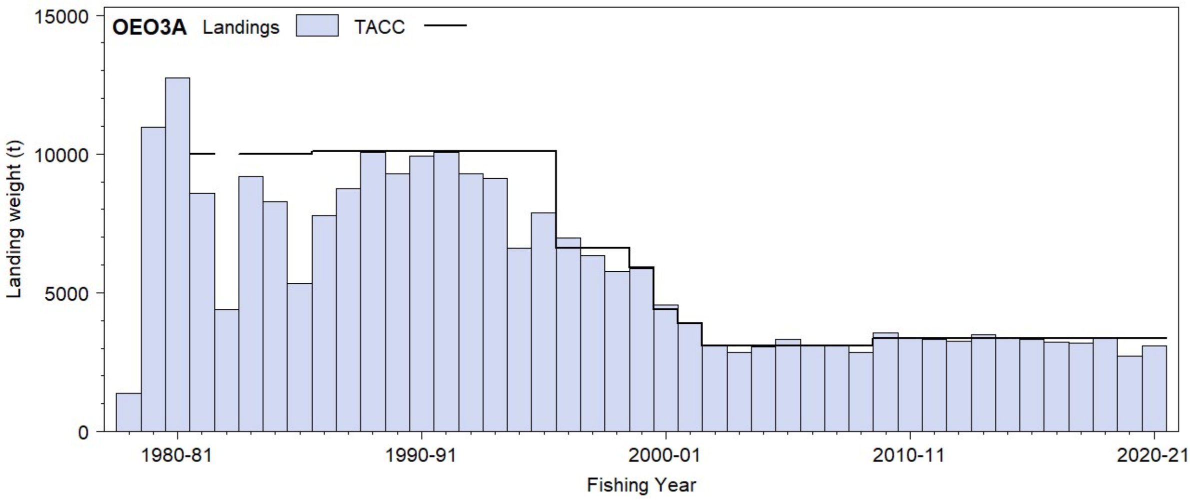
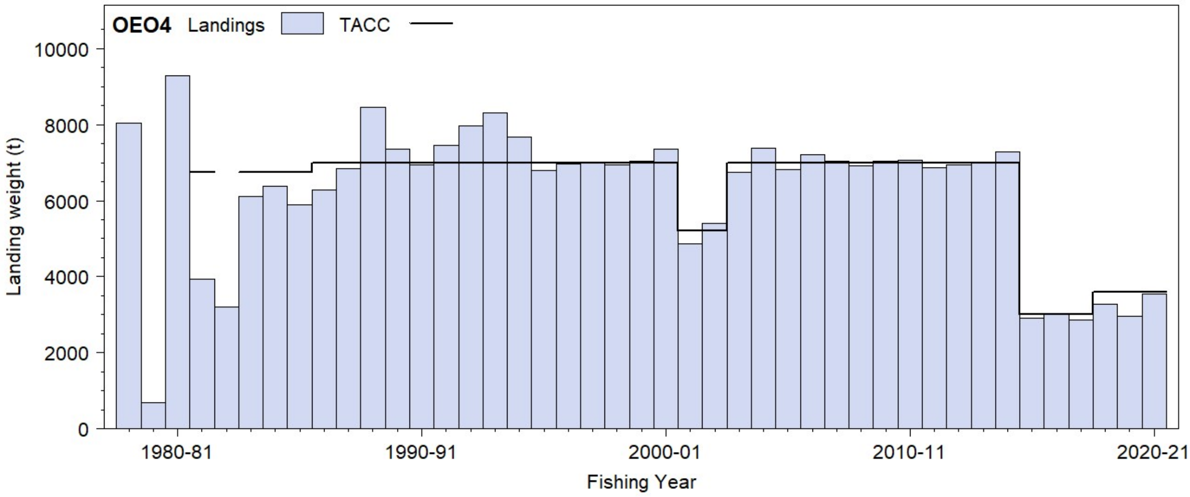


Figure 1: Reported commercial landings and TACC for the four main OEO stocks. OEO 1 (Central East - Wairarapa, Auckland, Central Egmont, Challenger, Southland, South East Catlin Coast). [Continued on next page]





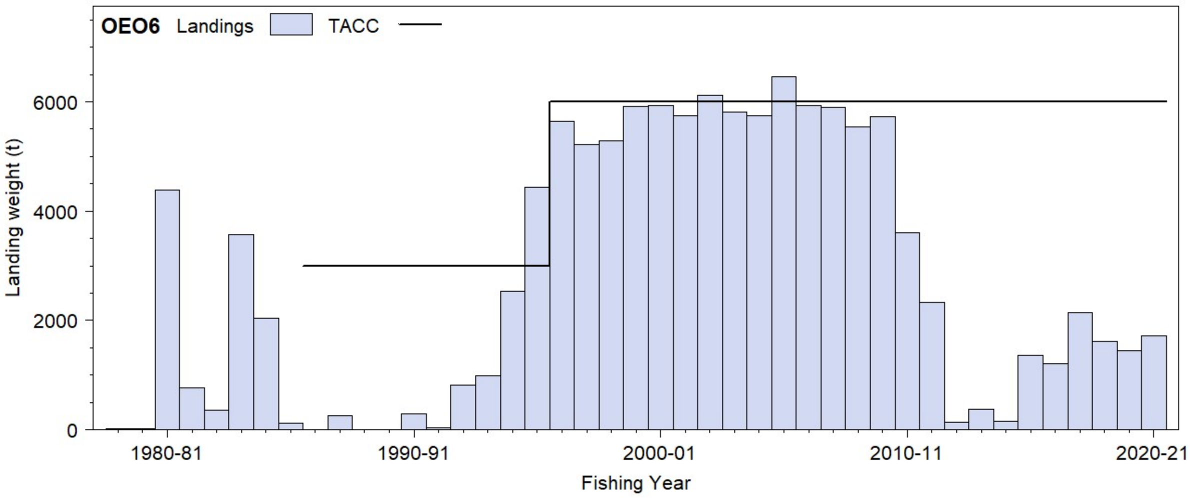


Figure 1: [Continued] Reported commercial landings and TACC for the four main OEO stocks. From top: OEO 3A (South East Cook Strait/Kaikōura/Strathallan), OEO 4 (South East Chatham Rise), and OEO 6 (Sub-Antarctic).

Table 3: Reported estimated catch (t) by species (smooth oreo (SSO), black oreo (BOE)) by Fishstock from 1978–79 to present and the ratio (percentage) of the total estimated SSO plus BOE, to the total reported landings (from Table 2). –, less than 1 t.

				SSO				BOE	Total	Estimated
Year	OEO 1	OEO 3A	OEO 4	OEO 6	OEO 1	OEO 3A	OEO 4	OEO 6	estimated	landings (%)
1978–79*	0	0	0	0	9	0	0	0	9	–
1979–80*	16	5 075	114	0	118	5 588	566	18	11 495	98
1980–81*	1	1 522	849	2	66	8 758	5 224	215	16 637	64
1981–82*	21	1 283	3 352	2	0	11 419	5 641	4 378	26 096	98
1982–83*	28	2 138	2 796	60	6	6 438	1 088	705	13 259	97
1983–83#	9	713	1 861	0	1	3 693	1 340	354	7 971	100
1983–84†	1 246	3 594	4 871	1 315	1 751	5 524	1 214	2 254	21 769	99
1984–85†	828	4 311	4 729	472	544	3 897	1 651	1 572	18 004	99
1985–86†	4 257	3 135	4 921	72	1 060	2 184	961	54	16 644	99
1986–87†	326	3 186	5 670	0	163	4 026	1 160	0	14 531	96
1987–88†	1 050	5 897	7 771	197	114	3 140	903	0	19 072	100
1988–89†	261	5 864	6 427	–	86	2 719	1 087	0	16 444	86
1989–90†	1 141	5 355	5 320	–	872	2 344	439	–	15 471	83
1990–91†	1 437	4 422	5 262	81	2 314	4 177	793	222	18 708	87
1991–92†	1 008	6 096	4 797	2	2 384	3 176	1 702	15	19 180	88
1992–93†	1 716	3 461	3 814	529	3 768	3 957	1 326	69	18 640	78
1993–94†	2 000	4 767	4 805	808	2 615	4 016	1 553	35	20 599	88
1994–95†	835	3 589	5 272	1 811	385	2 052	545	230	14 719	81
1995–96†	2 517	3 591	5 236	2 562	1 296	3 361	364	1 166	20 093	84
1996–97†	2 203	3 063	5 390	2 492	2 578	3 549	530	1 950	21 755	88
1997–98†	1 510	4 790	5 868	2 531	1 027	1 623	811	1 982	20 142	95
1998–99†	2 958	2367	5 613	3 462	820	3 147	844	1 231	20 442	93
1999–00†	2 487	1 230	5 879	4 427	953	2 773	627	1 036	19 412	86
2000–01†	4 117	1 288	6 009	4 241	316	2 423	803	1 128	20 325	89
2001–02†	3 135	1 272	3 860	4 471	709	1 906	515	983	16 851	90
2002–03†	2 402	1 025	4 090	3 952	470	1 144	862	1 642	15 587	88
2003–04†	958	884	5 098	3 771	457	1 095	973	1 496	14 732	86
2004–05†	622	1 150	6 013	3 863	209	1 163	852	1 618	15 490	90
2005–06†	412	1 005	5 202	3 292	218	1 336	763	2 633	14 861	85
2006–07†	509	989	5 978	2 214	262	1 223	796	3 071	15 042	88
2007–08†	414	1 402	6 171	2 182	429	1 469	592	3 022	15 681	92
2008–09†	435	1 258	5 703	2 703	143	1 388	766	2 832	15 228	96
2009–10†	319	1 581	6 204	2 487	67	1 781	942	3 032	16 413	98
2010–11†	107	1 558	6 472	1 672	235	1 563	539	1 501	13 647	95
2011–12†	210	1 442	6 183	562	326	1 620	487	1 540	12 370	95
2012–13†	319	1 408	5 920	104	224	1 582	973	31	10 561	96
2013–14†	214	1 391	6 000	286	114	1 722	988	50	10 765	96
2014–15†	75	1 369	6 447	119	170	1 783	961	16	10 940	99
2015–16†	248	1 480	1 948	583	259	1 782	858	809	7 967	98
2016–17†	367	1 520	2 357	1 000	182	1 727	678	156	7 987	100
2017–18†	363	1 539	2 095	1 123	130	1 550	758	850	8 408	96
2018–19†	400	1 522	2 479	908	199	1 737	671	586	8 502	95
2019–20†	272	1 394	2 327	824	221	1 326	538	430	7 332	95
2020–21†	200	1 566	2 565	878	136	1 212	793	745	8 096	93

Source: FSU from 1978–79 to 1987–88 and MFish from 1988–89 to 2006–07. *, 1 April to 31 March. #, 1 April to 30 September. †, 1 October to 30 September.

4.2 Recreational fisheries

There are no known recreational fisheries for black oreo and smooth oreo.

4.3 Customary non-commercial fisheries

There is no known customary non-commercial fishing for black oreo and smooth oreo.

4.4 Illegal catch

Estimates of illegal catch are not available.

4.5 Other sources of mortality

Dumping of unwanted or small fish and accidental loss of fish (lost codends, ripped codends, etc.) were features of oreo fisheries in the early years. These sources of mortality were probably substantial in those early years but are now thought to be relatively small. No estimate of mortality from these sources has been made because of the lack of hard data and because mortality now appears to be small. Estimates of discards of oreos were made for 1994–95 and 1995–96 from MFish observer data. This involved calculating the ratio of discarded oreo catch to retained oreo catch and then multiplying the annual total oreo catch from the New Zealand EEZ by this ratio. Estimates were 207 t and 270 t for 1994–95 and 1995–96, respectively.

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the 2020 Fishery Assessment Plenary (Fisheries New Zealand 2020). A more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021), available online at https://www.mpi.govt.nz/dmsdocument/51472-Aquatic-Environment-and-Biodiversity-Annual-Review-AEBAR-2021-A-summary-of-environmental-interactions-between-the-seafood-sector-and-the-aquatic-environment. Some tables in this section have not been updated because the data were unavailable at the time of publication.

5.1 Role in the ecosystem

Smooth and black oreo dominate trawl survey relative abundance estimates of demersal fish species at 650–1200 m on the south and southwest slope of the Chatham Rise (e.g., Hart & McMillan 1998). They are probably also dominant at those depths on the southeast slope of the South Island and other southern New Zealand slope areas including Bounty Plateau and Pukaki Rise. They are replaced at depths of about 700–1200 m on the east and northern slope of Chatham Rise by orange roughy. The south Chatham Rise oreo fisheries are relatively long-standing, dating from Soviet fishing in the 1970s, but the effects of extracting approximately 6000 t per year of smooth oreo from the south Chatham Rise (OEO 4) ecosystem between 1983–84 and 2012–13 are unknown.

5.1.1 Trophic interactions

Smooth oreo feed mainly on salps (80%), molluscs (9%, of which 8% are squids but also including octopods), and teleosts (5%) (percentage frequency of occurrence in stomachs with food, Stevens et al 2011). Black oreo feed on teleosts (48%), crustaceans (36%), salps (24%), and cephalopods (mainly squid, 6%) (Stevens et al 2011). Diet varies with fish size but salps remained the main prey for smooth oreo in the largest fish with small numbers of Scyphozoa, fish, and squids. Salps were the main prey for smaller black oreo, but amphipods and natant decapod crustaceans were important for intermediate sized fish (Clark et al 1989). Smooth oreo and black oreo occur with orange roughy at times. Orange roughy diet was mainly crustaceans (58%), teleosts (41%), and molluscs (10%, particularly squids) (frequency of occurrence, Stevens et al 2011) suggesting little overlap with the salp-dominated diet of smooth oreo. Where they co-occur, orange roughy and black oreo may compete for teleost and crustacean prey.

Predators of oreos probably change with fish size. Larger smooth oreo, black oreo, and orange roughy were observed with healed soft flesh wounds, typically in the dorso-posterior region. Wound shape and size suggest they may be caused by one of the deepwater dogfishes (Dunn et al 2010).

5.1.2 Ecosystem indicators

Tuck et al (2009, 2014) used data from the Sub-Antarctic and Chatham Rise middle-depth trawl surveys to derive indicators of fish diversity, size, and trophic level. However, fishing for oreos occurs mostly deeper than the depth range of these surveys and is only a small component of fishing in the areas considered by Tuck et al (2009, 2014).

5.2 Non-target fish and invertebrate catch

Anderson & Finucci (2022) summarised the bycatch of oreo trawl fisheries from 2002–03 to 2019–20. Since 2002–03, oreo species (five species, mainly smooth oreo and black oreo) accounted for about 95% of the total estimated catch from all observed trawls targeting oreos. In total, over 500 species or species groups were identified by observers in the target fishery. Total annual fish bycatch in the oreo fishery ranged from a low of 135 t in 2019–20 to a high of 1457 t in 2002–03, with a general declining trend through time and the five lowest values in the last seven years. Orange roughy (2.3%) was the main bycatch species, with no other species or group of species accounting for more than 0.5% of the total catch. Other recorded bycatch species included Baxter's lantern dogfish (*Etmopterus granulosus*, 0.49%), hoki (0.37%), and rattails (0.27%), all of which were usually discarded. Estimated annual bycatch of non-QMS species was roughly equal to that of QMS species. From 2002–03 to 2019–20, the overall discard fraction value was 0.014 kg (range of 0.01–0.05 kg) and tended to be lower after 2005–06 (Anderson & Finucci 2022).

Non-QMS invertebrate bycatch made up a very small fraction of the overall catch (0.3%) and included warty squid (0.07%), and bushy hard coral (0.07%, Anderson & Finucci 2022). Other observed species or species groups each accounted for less than 0.01% of the observed catch. Tracey et al (2011) analysed the distribution of nine groups of protected corals based on bycatch records from observed trawl effort from 2007–08 to 2009–10, primarily from 800–1000 m depth. For the oreo target fishery, the highest catches were reported from the north and south slopes of the Chatham Rise, east of the Pukaki Rise, and on the Macquarie Ridge.

Finucci et al (2019) analysed bycatch trends in deepwater fisheries, including oreo trawl, from 1990–91 until 2016–17. They found that the most common bycatch species by weight (t) were orange roughy (ORH), unspecified sharks (SHA), and Baxter's dogfish (ETB). Moreover, among the 228 bycatch species examined, 40 showed a decrease in catch over time (7 were statistically significant) and 44 showed an increase (9 were significant). The species showing the greatest decline were dark ghost shark (*Hydrolagus novaezealandiae*, GSH), unspecified shark (SHA), and lanternshark (*Etmopterus* sp., ETM), whereas the greatest increases were found for longnose velvet dogfish (*Centroscymnus crepidater*, CYP), ridge scaled rattail (*Macrourus carinatus*, MCA), and Baxter's dogfish (*Etmopterus granulosus*, ETB). The decline in unspecified shark could be linked to better identification of specimens through time, which would match the increases seen in other deepwater shark bycatch.

5.3 Incidental capture of Protected Species (seabirds, mammals, and protected fish)

For protected species, capture estimates presented here include all animals recovered to the deck of fishing vessels (alive, injured, or dead), but do not include any cryptic mortality (e.g., a seabird struck by a warp but not brought on board the vessel, Middleton & Abraham 2007, Brothers et al 2010). Ramm (2011, 2012a, 2012b) summarised observer data for combined bottom trawl fisheries for orange roughy, oreos, and cardinalfish and listed annual captures of seabirds and mammals from 2008–09 to 2010–11.

5.3.1 Marine mammal captures

Trawlers targeting orange roughy, oreo, and black cardinalfish occasionally catch New Zealand fur seal (which were classified as 'Not Threatened' under the New Zealand Threat Classification System in 2009, Baker et al 2010). Between 2002–03 and 2007–08, there were 14 observed captures of New Zealand fur seal in orange roughy, oreo, and black cardinalfish trawl fisheries. There have been two observed captures in the period between 2008–09 and 2019–20, during which time the average level of annual observer coverage was 26.2% (Table 4). Corresponding annual estimated captures between 2008–09 and 2015–16 ranged 0–4 (mean 1.75) based on statistical capture models (Thompson et al 2013, Abraham et al 2016). All observed fur seal captures occurred in the Sub-Antarctic region.

Table 4: Number of tows by fishing year and observed and model-estimated total New Zealand fur seal captures in orange roughy, oreo, and cardinalfish trawl fisheries, 2002–03 to 2019–20. Annual fishing effort (tows), and observer coverage (%) in deepwater trawl fisheries; number of observed captures and observed capture rate (captures per hundred tows) of New Zealand fur seal; estimated captures and capture rate of New Zealand fur seal (mean and 95% credible interval). Estimates are based on methods described by Abraham et al (2021), available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in these tables derive from the PSC database version PSCV6. [Continued on next page]

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 871	1 384	15.6	0	0	4	0–12	0.04	0.00–0.14
2003–04	8 007	1 262	15.8	2	0.16	9	3–23	0.12	0.04–0.29
2004–05	8 420	1 619	19.2	4	0.25	14	6–28	0.16	0.07–0.33
2005–06	8 292	1 359	16.4	2	0.15	10	3–23	0.13	0.04–0.28
2006–07	7 365	2 324	31.6	2	0.09	3	2–7	0.05	0.03–0.10
2007–08	6 731	2 811	41.8	5	0.18	8	5–13	0.12	0.07–0.19
2008–09	6 130	2 372	38.7	0	0	2	0–7	0.03	0.00–0.11
2009–10	6 008	2 133	35.5	0	0	3	0–8	0.05	0.00–0.13
2010–11	4 178	1 205	28.8	0	0	3	0–10	0.08	0.00–0.24
2011–12	3 655	923	25.3	0	0	1	0–5	0.04	0.00–0.14
2012–13	3 098	346	11.2	0	0	0	0–2	0.02	0.00–0.06
2013–14	3 606	434	12.0	0	0	1	0–3	0.02	0.00–0.08
2014–15	3 814	978	25.6	1	0.1	2	1–4	0.04	0.03–0.10
2015–16	4 088	1 421	34.8	0	0	1	0–3	0.01	0.00–0.07
2016–17	3 962	1 226	30.9	0	0	0	0–2	0.01	0.00–0.05
2017–18	3 753	903	24.1	0	0	1	0–3	0.01	0.00–0.08

Table 4 [continued]

Fishing year	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2018–19	3 906	1 190	30.5	1	0.1				
2019–20	3 952	1 171	29.6	0	0				

5.3.2 Seabird captures

Annual observed seabird capture rates ranged from 0 to 0.9 per 100 tows in orange roughy, oreo, and cardinalfish trawl fisheries between 2002–03 and 2019–20 (Table 5). Capture rates have fluctuated without obvious trend at this low level. The average capture rate in deepwater trawl fisheries (including orange roughy, oreo, and cardinalfish) for the period from 2002–03 to 2019–20 is about 0.33 birds per 100 tows, a very low rate relative to other New Zealand trawl fisheries, e.g., for scampi (3.8 birds per 100 tows) and squid (12.9 birds per 100 tows) over the same years.

Table 5: Number of tows by fishing year and observed seabird captures in orange roughy, oreo, and cardinalfish trawl fisheries, 2002–03 to 2019–20. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Estimates are based on methods described by Abraham & Richard (2020) and are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6.

Fishing year	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	8 871	1 384	15.6	0	0.00	36	17-60	0.40	0.19-0.68
2003–04	8 007	1 262	15.8	3	0.24	33	17-54	0.41	0.21-0.67
2004–05	8 420	1 619	19.2	7	0.43	44	25-68	0.52	0.3-0.81
2005–06	8 292	1 359	16.4	8	0.59	42	25-66	0.51	0.3-0.8
2006–07	7 365	2 324	31.6	2	0.09	22	10-40	0.30	0.14-0.54
2007–08	6 731	2 811	41.8	7	0.25	24	13-40	0.35	0.19-0.59
2008–09	6 130	2 372	38.7	8	0.34	26	15-42	0.42	0.24-0.69
2009–10	6 008	2 133	35.5	19	0.89	36	25-51	0.60	0.42-0.85
2010–11	4 178	1 205	28.8	1	0.08	17	7-33	0.42	0.17-0.79
2011–12	3 655	923	25.3	2	0.22	13	5-26	0.37	0.14-0.71
2012–13	3 098	346	11.2	2	0.58	15	6-30	0.50	0.19-0.97
2013–14	3 606	434	12.0	2	0.46	18	7-33	0.49	0.19-0.92
2014–15	3 814	978	25.6	0	0.00	15	5-30	0.40	0.13-0.79
2015–16	4 088	1 421	34.8	4	0.28	15	7-28	0.38	0.17-0.68
2016–17	3 962	1 226	30.9	2	0.16	14	5-26	0.35	0.13-0.66
2017–18	3 753	903	24.1	4	0.44	17	8-29	0.44	0.21-0.77
2018–19	3 906	1 190	30.5	9	0.76	21	13-34	0.55	0.33-0.87
2019–20	3 952	1 171	29.6	2	0.17	13	5-25	0.34	0.13-0.63

Table 6: Number of observed seabird captures in orange roughy, oreo, and cardinalfish fisheries, 2002–03 to 2019–20, by species and area. The risk category is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Thresholds, PST (from Richard et al 2017, where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for black cardinalfish. Observed protected species captures in this table derive from the PSC database version PSCV6. [Continued on next page]

Species	Risk Category	Chatham Rise	East coast South Island	Fiordland	Sub-Antarctic	Stewart-Snares shelf	West coast South Island	West coast North Island	Total
Salvin's albatross	High	12	4	0	3	0	0	0	19
Southern Buller's albatross	High	3	0	1	0	0	0	0	4
Chatham Island albatross	Medium	11	0	0	1	0	0	0	12
New Zealand white-capped albatross	Medium	4	0	0	0	0	2	0	6
Gibson's albatross	High	1	0	0	0	0	0	0	1
Antipodean albatross	Medium	1	0	0	0	0	0	0	1
Northern royal albatross	Low	1	0	0	0	0	0	0	1
Southern royal albatross	Negligible	2	1	0	1	0	0	0	4
Albatrosses	–	2	1	0	0	0	0	0	3
Total albatrosses	–	37	6	1	5	0	2	0	51
Black petrel	Very High	0	0	0	0	0	0	1	1
Northern giant petrel	Medium	1	0	0	0	0	0	0	1
White-chinned petrel	Low	3	2	0	0	1	0	0	6
Grey petrel	Negligible	1	0	0	1	0	0	0	2

Table 6 [continued]

Species	Risk Category	Chatham Rise	East coast South Island	Fiordland	Sub-Antarctic	Stewart-Snares shelf	West coast South Island	West coast North Island	Total
Sooty shearwater	Negligible	1	3	0	0	0	1	0	5
Common diving petrel	Negligible	3	0	0	0	0	0	0	3
White-faced storm petrels	Negligible	3	0	0	0	0	0	0	3
Cape petrel	–	8	1	0	0	0	0	0	9
Petrels, prions, and shearwaters	–	0	0	0	1	0	0	0	1
Total other birds	–	20	6	0	2	1	1	1	31

Salvin’s albatross was the most frequently captured albatross (38% of observed albatross captures), but eight different species have been observed captured since 2002–03. Cape petrels were the most frequently captured other taxon (29%, Table 6). Seabird captures in the orange roughy, oreo, and cardinalfish fisheries have been observed mostly around the Chatham Rise and off the east coast South Island. These numbers should be regarded as only a general guide on the distribution of captures because the observer coverage is not uniform across areas and may not be representative.

The deepwater trawl fisheries (including the cardinalfish target fishery) contributes to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). The two species to which the fishery poses the most risk are Chatham Island albatross and Salvin’s albatross, with this suite of fisheries posing 0.06 and 0.022 of Population Sustainability Threshold (PST) (Table 7). Chatham Island albatross and Salvin’s albatross were assessed as high risk (Richard et al 2020).

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the oreo and all fisheries included in the level two risk assessment, 2006–07 to 2016–17, showing seabird species with a risk ratio of at least 0.001 of PST (from Richard et al 2017 and Richard et al 2020, where full details of the risk assessment approach can be found). The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the PST. The Department of Conservation threat classifications are shown (Robertson et al 2017 at http://www.doc.govt.nz/documents/science-and-technical/nztcs19entire.pdf).

		Risk ratio			
Species name	PST (mean)	OEO, ORH, CDL target trawl*	TOTAL	Risk category	DOC Threat Classification
Chatham Island albatross	428	0.060	0.28	High	At Risk: Naturally Uncommon
Salvin's albatross	3 460	0.022	0.65	High	Threatened: Nationally Critical
Northern giant petrel	337	0.005	0.15	Medium	At Risk: Naturally Uncommon
Northern Buller's albatross	1 640	0.002	0.26	Medium	At Risk: Naturally Uncommon
Black petrel	447	0.002	1.23	Very high	Threatened: Nationally Vulnerable
Antipodean albatross	369	0.002	0.17	Medium	Threatened: Nationally Critical
Gibson's albatross	497	0.002	0.31	High	Threatened: Nationally Critical
Northern royal albatross	723	0.001	0.05	Low	At Risk: Naturally Uncommon

* OEO, ORH, CDL target trawl from Richard et al 2017.

Mitigation methods such as streamer (tori) lines, Brady bird bafflers, warp deflectors, and offal management are used in the orange roughy, oreo, and cardinalfish trawl fisheries. Warp mitigation was voluntarily introduced from about 2004 and made mandatory in April 2006 (Department of Internal Affairs 2006). The 2006 notice mandated that all trawlers over 28 m in length use a seabird scaring device while trawling (being “paired streamer lines”, “bird baffler” or “warp deflector” as defined in the Notice).

5.4 Benthic interactions

The spatial extent of seabed contact by trawl fishing gear in New Zealand’s EEZ and Territorial Sea has been estimated and mapped in numerous studies for trawl fisheries targeting deepwater species (Baird et al 2011, Black et al 2013, Black & Tilney 2015, Black & Tilney 2017, Baird & Wood 2018, and Baird & Mules 2019, 2021a, b), species in waters shallower than 250 m (Baird et al 2015, Baird & Mules 2021a, b), and all trawl fisheries combined (Baird & Mules 2021a, b). The most recent assessment of the deepwater trawl footprint was for the period 1989–90 to 2018–19 (Baird & Mules 2021b).

Orange roughy, oreo, and cardinalfish are taken using bottom trawls and accounted for about 15% of all tows reported on TCEPR forms that fished on or close to the bottom between 1989–90 and 2018–19 (Baird & Mules 2021b). From 1989–90 to 2018–19, about 62 900 bottom trawls targeting oreo species were reported on TCEPRs and ERS (Baird & Mules 2021b): between 1600–2500 tows were reported a year during 1989–90 to 1994–95; 2000–3300 tows between 1995–96 and 2009–10; and annual tows decreased from almost 2000 tows in 2010–11 to under 800 tows in 2018–19. The total footprint generated from these tows was estimated at about 17 480 km^2. This footprint represented coverage of 0.4% of the seafloor of the combined EEZ and the Territorial Sea areas; 1.3% of the 'fishable area', that is, the seafloor area open to trawling, in depths of less than 1600 m. For the 2018–19 fishing year, 796 oreo bottom tows had an estimated footprint of 300 km^2 which represented coverage of less than 0.1% of the EEZ and Territorial Sea and less than 0.1% of the fishable area (Baird & Mules 2021b).

The overall trawl footprint for oreo (1989–90 to 2018–19) covered 5% of the seafloor in 800–1000 m, 3% of 1000–1200 m seafloor, and 0.8% of the 1200–1600 m seafloor (Baird & Mules 2021b). The oreo footprint contacted 0.1%, less than 0.1%, and less than 0.1% of those depth ranges in 2018–19, respectively (Baird & Mules 2021b). The BOMEC areas with the highest proportion of area covered by the oreo footprint were classes J (comprising mainly the Challenger Plateau and northern and southern slopes of the Chatham Rise) and M (shallower waters of the Southern Plateau). In 2018–19, the oreo footprint covered about 0.04% of the 311 360 km^2 of class J and 0.04% of the 233 825 km^2 of class M (Baird & Mules 2021b).

Trawling for orange roughy, oreo, and cardinalfish, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings et al 2001, Hermsen et al 2003, Hiddink et al 2006, Reiss et al 2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021).

The New Zealand EEZ contains Benthic Protection Areas (BPAs) and seamount closures that are closed to bottom trawl fishing for the protection of benthic biodiversity. These combined areas include 28% of underwater topographic features (including seamounts), 52% of all seamounts over 1000 m elevation, and 88% of identified hydrothermal vents.

5.5 Other considerations

5.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. Morgan et al (1999) concluded that Atlantic cod (*Gadus morhua*) "exposed to a chronic stressor are able to spawn successfully, but there appears to be a negative impact of this stress on their reproductive output, particularly through the production of abnormal larvae". Morgan et al (1997) also reported that "Following passage of the trawl, a 300-m-wide "hole" in the [cod spawning] aggregation spanned the trawl track. Disturbance was detected for 77 min after passage of the trawl." There is no research on the disruption of spawning smooth oreo and black oreo by fishing in New Zealand, but spawning of both species appears to be over a protracted period (October to February) and over a wide area (O'Driscoll et al 2003). Fishing continues during the spawning period, possibly because localised spawning schools of smooth oreo, in particular, may provide good catch rates.

5.5.2 Genetic effects

Fishing and environmental changes, including those caused by climate change or pollution, could alter the genetic composition or diversity of a species. There are no known studies of the genetic diversity of smooth or black oreo from New Zealand. Genetic studies for stock discrimination are reported under Section 3.

5.5.3 Habitat of particular significance to fisheries management

Habitat of particular significance for fisheries management does not have a policy definition. O'Driscoll et al (2003) identified the south Chatham Rise as important for smooth oreo spawning, and the north, east, and south slopes as important for juveniles. The south Chatham Rise is also important for black oreo spawning and juveniles. Deepsea corals such as the reef-forming scleractinian corals and gorgonian sea fan corals are thought to provide prey and refuge for deep-sea fish (Fosså et al 2002, Stone 2006, Mortensen et al 2008). Large aggregations of deepwater species like orange roughy, oreos, and cardinalfish occur above seamounts with high densities of such 'reef-like' taxa, but it is not known if there are any direct linkages between the fish and corals. Bottom trawling for orange roughy, oreos, and cardinalfish has the potential to affect features of the habitat that could qualify as habitat of particular significance to fisheries management.

6. FOR FURTHER INFORMATION

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