APPENDIX 1

Detail on year quality assessment

Researchers have often used a combination of large scale, remotely sensed oceanographic indices in combination with localized measures to characterize year quality (Ainley & Hyrenbach 2010, Schrimpf *et al*. 2012, Betts *et al*. 2020). Here we sought to evaluate year quality in terms of seabird prey availability without using seabird metrics (as this would be a circular argument). We found the Multivariate ENSO Index (MEI) effective in characterizing ENSO years as provided by https://psl.noaa.gov/enso/mei/. Specifically, after reviewing multiple indices and indicators, the sum of two-month MEI means during spring (February – May) gave values of >+ 1.0 during ENSO and marine heat wave years, and this appeared to be an appropriate dividing point between the two-year quality categories (Tables 1, A1). However, there were exceptions in years 1992, 1996 (Zone 3), and 2015, and these are discussed further. There was a lag time in the 1992–93 ENSO in that warm water and poor productivity did not reach Oregon until 1993 (Carter *et al*. 2001, Strong *et al*. 1995). Our *in-situ* temperature readings supported this: cold nearshore waters were seen in 1992 and unusually warm waters were recorded in 1993. There was also a lag time of effect of the marine heat wave of 2014–2016 on upper trophic near-shore species, at least in Zone 4. Though ecosystem effects from the marine heat wave were very evident by early 2015, a cold-water refugium was described for Northern California in this time (Friedman *et al.* 2018; graphic displays of this refugium at https://www.nnvl.noaa.gov/view/globaldata.html#SSTA). This was further supported by a normally timed spring transition, a typical suite of prey species, and near average reproduction of murres at Castle Rock NWR (Lat. 41.7^{o}N; Schneider 2018). The categorically poor conditions in 1996 were not explained by Basin-wide indices or by lag time effects, however it certainly was a poor year in Zone 3. This is evident in a surge of emaciated beach-cast adult murres (Lowe & Pitman 1996), an exodus of thousands of murres flying north into Washington from northern Oregon (Strong 1997, M. Patterson, pers. comm) and a very atypical, offshore distribution of murrelets in 1996 (Strong 1997). Subsequent annual abundance surveys of murrelets indicate that approximately 50% of the central Oregon murrelet population disappeared in 1996 and numbers have never returned to previous levels (Strong 2003).

The year 2010 qualified as a poor year using the MEI metric. However, there are indications that 2010 was a better season than 2011, based on an analysis of prey and murre nesting success by Gladics *et al*. (2015). In this case we simply relied on the standard used in our categorical assessment rather than trying to interpret these conflicting assessments.

Appendix Additional References

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TABLE A1

Year quality assessment based on the sum of spring Multivariate Enso Index (MEI)[a] values and exceptions to the MEI assessment for the two study regions on the Oregon coast

Year	Feb – May Sum MEI	Zone 3 Year Quality	Zone 4 Year Quality	Explanation
1992	**5.39**	Good	Good	Delay in ENSO effect in Oregon
1993	**3.24**	Bad	Bad	ENSO
1994	-0.18	Good	Good	
1995	0.48	Good	Good	
1996	-2.16	Bad	Good	Adult dieoff, relocation out of Zone 3
1997	0.56	Good	Good	
1998	**7.08**	Bad	Bad	ENSO
1999	-3.64	Good	Good	
2000	-3.26	Good	Good	
2001	-1.98	Good	Good	
2002	-0.66	Good	Good	
2003	-0.12	Good	Good	
2004	-1.11	Good	Good	
2005	**1.13**	Bad	Bad	ENSO
2006	-1.88	Good	Good	
2007	-1.02	Good	Good	
2008	-3.65	Good	Good	
2009	-2.47	Good	Good	
2010	**1.63**	Bad	Bad	ENSO
2011	-4.82	Good?	Good	
2012	-1.37	Good	Good	
2013	-1.22	Good	Good	
2014	-0.42	Good	Good	
2015	**1.44**	?	Good	Delayed Marine Heat Wave (Zone 4)
2016	**3.90**	Bad	Bad	Marine Heat Wave / ENSO
2017	-0.62	Bad	Bad	Marine Heat Wave - Delayed
2018	-2.99	Good	Good	
2019	**1.36**	?	Bad	ENSO
2020	-0.2	Good	Good	

[a] Data source: https://psl.noaa.gov/enso/mei/.