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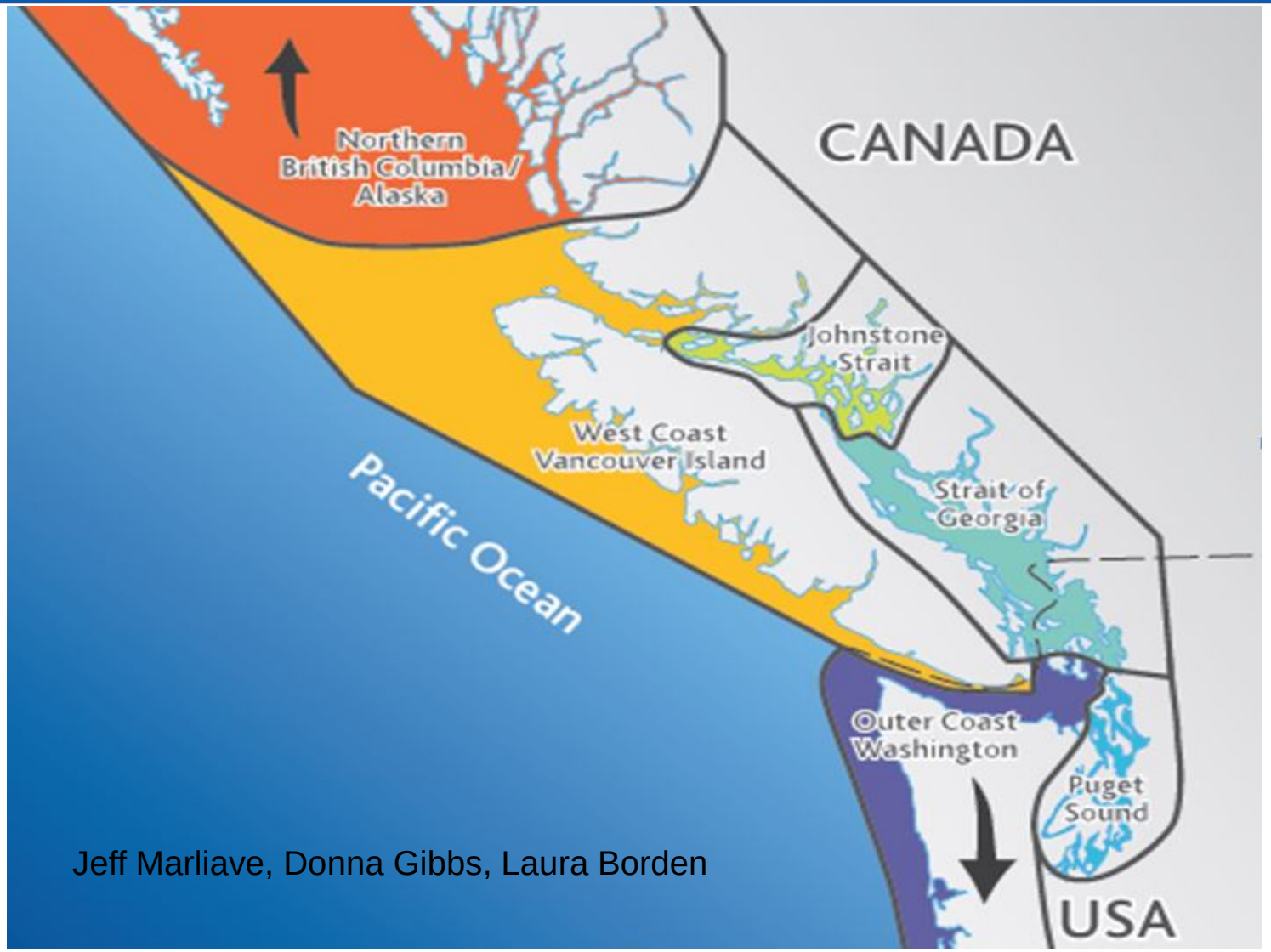
The 2011 climate regime shift: seabed taxon monitoring identifies regimes

Jeff Marliave
Ocean Wise, Canada, jeff.marliave@ocean.org

Donna Gibbs
Ocean Wise, Canada, donna.gibbs@ocean.org

Laura Borden
Ocean Wise, Canada, laura.borden@ocean.org

2011 Climate Regime Shift: Revealed by Seabed Biodiversity



Jeff Marliave, Donna Gibbs, Laura Borden

jeff.marliave@ocean.org

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Climate Regime Shifts according to ONI

ONI – Ocean Niño Index (=ENSO)
N.B. seabed taxa no relation to PDO
(Pacific Decadal Oscillation)

Present 23 spp in 5 phyla for 3 regimes
(from 171 spp in all phyla for 4 regimes)

3865 SCUBA dives
1077 taxa: species abundance by year
Abundance categories:

- none = 0
- few ≤ 10
- some ≤ 25
- many ≤ 50
- very many ≤ 100
- abundant ≤ 1000
- very abundant = thousands (3,000 for calc. avg.)

Ocean Niño Index (temperature anomalies)

1996	-0.9	-0.8	-0.6	-0.4	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5
1997	-0.5	-0.4	-0.1	0.3	0.8	1.2	1.6	1.9	2.1	2.3	2.4	2.4
1998	2.2	1.9	1.4	1.0	0.5	-0.1	-0.8	-1.1	-1.3	-1.4	-1.5	-1.6
1999	-1.5	-1.3	-1.1	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.7
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2000	-1.7	-1.4	-1.1	-0.8	-0.7	-0.6	-0.6	-0.5	-0.5	-0.6	-0.7	-0.7
2001	-0.7	-0.5	-0.4	-0.3	-0.3	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3

Ocean Niño Index (temperature anomalies)

1985	-1.0	-0.8	-0.8	-0.8	-0.8	-0.6	-0.5	-0.5	-0.4	-0.3	-0.3	-0.4
1986	-0.5	-0.5	-0.3	-0.2	-0.1	0.0	0.2	0.4	0.7	0.9	1.1	1.2
1987	1.2	1.2	1.1	0.9	1.0	1.2	1.5	1.7	1.6	1.5	1.3	1.1
1988	0.8	0.5	0.1	-0.3	-0.9	-1.3	-1.3	-1.1	-1.2	-1.5	-1.8	-1.8
1989	-1.7	-1.4	-1.1	-0.8	-0.6	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1990	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.4
1991	0.4	0.3	0.2	0.3	0.5	0.6	0.7	0.6	0.6	0.8	1.2	1.5

Ocean Niño Index (temperature anomalies)

2008	-1.6	-1.4	-1.2	-0.9	-0.8	-0.5	-0.4	-0.3	-0.3	-0.4	-0.6	-0.7
2009	-0.8	-0.7	-0.5	-0.2	0.1	0.4	0.5	0.5	0.7	1.0	1.3	1.6
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2010	1.5	1.3	0.9	0.4	-0.1	-0.6	-1.0	-1.4	-1.6	-1.7	-1.7	-1.6
2011	-1.4	-1.1	-0.8	-0.6	-0.5	-0.4	-0.5	-0.7	-0.9	-1.1	-1.1	-1.0
2012	-0.8	-0.6	-0.5	-0.4	-0.2	0.1	0.3	0.3	0.3	0.2	0.0	-0.2

Ocean Niño Index (temperature anomalies)

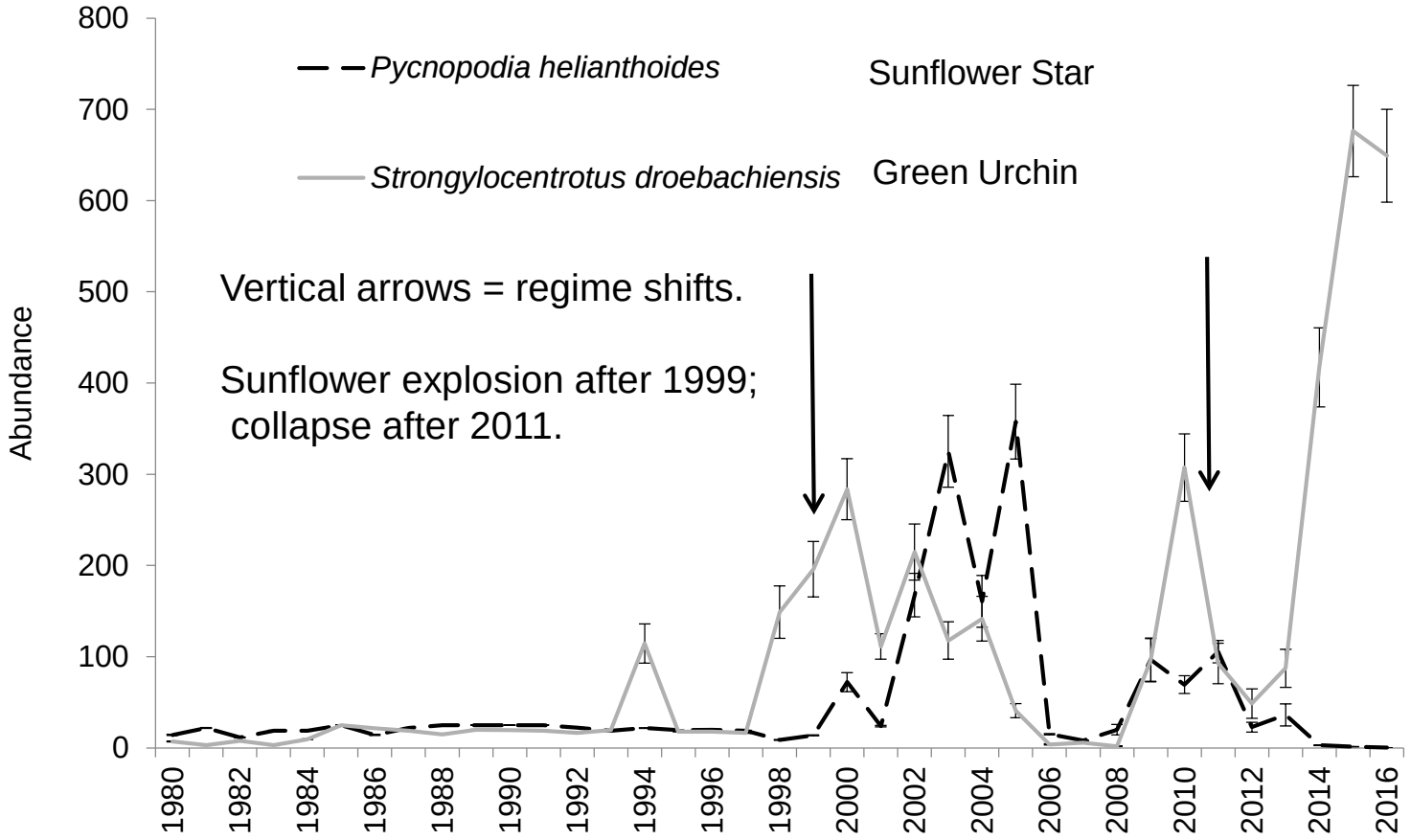
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1970	0.5	0.3	0.3	0.2	0.0	-0.3	-0.6	-0.8	-0.8	-0.7	-0.9	-1.1
1971	-1.4	-1.4	-1.1	-0.8	-0.7	-0.7	-0.8	-0.8	-0.8	-0.9	-1.0	-0.9
1972	-0.7	-0.4	0.1	0.4	0.7	0.9	1.1	1.4	1.6	1.8	2.1	2.1
1973	1.8	1.2	0.5	-0.1	-0.5	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.0
1974	-1.8	-1.6	-1.2	-1.0	-0.9	-0.8	-0.5	-0.4	-0.4	-0.6	-0.8	-0.6
1975	-0.5	-0.6	-0.7	-0.7	-0.8	-1.0	-1.1	-1.2	-1.4	-1.4	-1.6	-1.7
1976	-1.6	-1.2	-0.7	-0.5	-0.3	0.0	0.2	0.4	0.6	0.8	0.9	0.8
1977	0.7	0.6	0.3	0.2	0.2	0.3	0.4	0.4	0.6	0.7	0.8	0.8

Strait of Georgia 2017-11-28	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
No. Dives per Year	52	58	59	56	109	119	102	122	122	115	110	97	93	112	140	126	136	188	99	191	124	105	84	107	171	102	182	134	122
Mollusca																													
Cryptobranchia concentrica	.	.	.	.	.	.	.	.	.	.	.	1	1	*	*	*	*	2	11	6	*	*	*	*	*	*	*	1	1
Epitonium indianorum	.	.	.	*	*	*	.	*	.	*	*	*	*	*	*	.	.	*	*	*	*	*	.	.	.	.	.	.	.
Trichotropsis cancellata	*	2	2	5	32	11	12	10	1	1	2	4	1	2	8	*	2	2	1	*	*	*	*	1	1	*	1	1	*
Janolus fuscus	*	52	1	2	1	1	*	*	*	*	1	1	1	*	1	1	*	.	*	*	*	*	*	*	*	*	*	*	*
Hermissenda crassicornis	*	17	3	1	4	5	11	10	*	1	1	14	1	10	2	25	8	12	15	13	49	1	2	39	2	2	1	23	2
Flabellina verrucosa	.	1	34	.	13	29	13	*	9	*	2	32	11	*	1	*	*	*	*	17	6	2	.	*	1	.	*	*	*
Arthropoda																													
Heptacarpus kincaidi	*	*	.	.	*	*	*	*	*	1	1	2	2	1	1	2	1	1	*	1	1	1	*	*	1	.	*	1	*
Heptacarpus sitchensis	.	.	.	.	*	*	*	*	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hippolyte clarki	.	.	51	.	2	1	*	.	.	.	*	*	*	.	.	.	7	*	.	.	*	.	.	.	.	.	.	.	.
Pandalus stenolepis	*	1	1	*	2	10	1	10	10	20	4	24	15	2	1	2	42	3	5	12	3	14	4	1	7	.	2	3	11
Echinodermata																													
Dermasterias imbricata	*	3	21	9	4	7	25	6	3	2	6	7	8	9	5	14	4	22	11	16	21	12	15	11	11	20	32	19	8
Pycnopodia helianthoides	5	23	6	5	34	8	16	15	7	7	27	45	84	114	142	110	262	32	25	45	56	48	60	53	37	9	2	1	1
Ophiura luetkenii	.	18	17	*	42	30	2	2	19	3	23	58	62	115	113	182	221	193	216	187	327	190	44	40	39	90	35	11	38
Florometra serratissima	.	1	.	1	39	2	4	34	4	4	49	45	16	51	118	32	55	75	191	179	91	139	56	16	18	37	45	27	6
Strongylocentrotus droebachiensis	3	21	21	20	53	37	12	28	119	150	85	184	82	159	92	136	56	20	33	78	197	293	97	82	134	347	581	599	462

Strait of Georgia 2017-11-28	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
No. Dives per Year	52	58	59	56	109	119	102	122	122	115	110	97	93	112	140	126	136	188	99	191	124	105	84	107	171	102	182	134	122
Urochordata																													
Styela gibbsii	*	21	2	4	30	19	11	2	9	1	65	4	38	39	5	28	1	2	64	38	1	24	5	1	2	1	1	1	2
Boltenia villosa	*	3	2	4	15	21	34	29	37	30	42	19	42	53	40	22	5	7	60	27	5	10	6	5	9	4	2	5	2
Metandrocarpa taylori	19	210	20	204	133	33	86	29	19	19	58	97	35	12	31	2	17	29	13	36	37	3	4	13	3	1	1	1	*
Didemnum/Tridemnum complex	.	.	.	.	.	.	*	25	.	.	10	12	1	9	15	8	1	8	52	22	37	25	5	3	1	*	*	2	*
Chordata																													
Sebastes maliger	25	3	4	26	23	3	6	4	4	2	7	7	11	6	30	27	59	20	33	30	43	32	13	18	8	3	12	3	4
Sebastes emphaeus	59	1	107	94	107	30	2	92	11	11	3	53	23	11	17	20	5	19	15	20	18	2	27	4	2	*	1	2	2
Hexagrammos decagrammus	*	4	7	6	8	6	6	5	6	2	6	10	16	12	10	9	10	9	9	15	27	30	15	19	8	5	4	3	1
Jordania zonope	22	8	27	14	29	60	4	3	1	1	4	5	6	14	5	4	12	5	6	17	24	31	7	10	7	2	3	3	2

No overall pattern between different species, regarding increase versus decrease at regime shifts.

Eleven species winked out in 2011; all at center of zoogeographic range (none at S limit).


Pycnopodia helianthoides
Sunflower Star
Strongylocentrotus droebachiensis
Green Urchin
Vertical arrows = regime shifts.
Sunflower explosion after 1999;
collapse after 2011.
Abundance
800
700
600
500
400
300
200
100
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

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Seabed Biodiversity Shifts Identify Climate Regimes: the 2011 Climate Regime Shift

Jeffrey B. Marliave, Donna M. Gibbs, Laura A. Borden & Charles J. Gibbs

jeff.marliave@ocean.org

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