

The following supplements accompany the article

Ecosystem attributes of trophic models before and after construction of artificial oyster reefs using Ecopath

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Supplement 1. Descriptions of functional groups

Phytoplankton

Phytoplankton biomass in terms of chlorophyll-a was measured using a Turner fluorometer according to standard procedures (Parsons *et al.*, 1984). The mean chlorophyll-a concentration observed was 3.93 mg m⁻³ in 2010 (**Table S-1**). Phytoplankton biomass was estimated to be 1.572 g m⁻³ using the conversion factor of 1 mg chlorophyll-a per 400 mg phytoplankton biomass (Jones, 1979). Using a mean depth of 6 m in Blue Ocean marine ranching area, we estimated the phytoplankton biomass of **9.432 g m⁻²** in 2010. Phytoplankton biomass was estimated to be **5.562 g m⁻²** in 2015-2016 (**Table S-2**). Unassimilation parts were set to **0.4**. P/B ranges of phytoplankton was 63-410 (**Table S-3**).

Table S-1 Ranges and mean of chlorophyll-a concentration in 2010 in this study.

Month	Lowest (mg m ⁻³)	Highest (mg m ⁻³)	Mean (mg m ⁻³)
May 2010	3.22	6.62	4.36
October 2010	0.718	8.33	3.50
Mean in 2010			3.93

Table S-2 Ranges and mean of chlorophyll-a concentration in 2015-2016 in this study.

Month	Lowest (mg m ⁻³)	Highest (mg m ⁻³)	Mean (mg m ⁻³)
October 2015	1.18	8.67	3.12
April 2016	0.38	0.69	0.52
June 2016	1.32	3.66	1.97
August 2016	2.43	5.62	3.66
Mean in 2015-16			2.3175

Table S-3 P/B of phytoplankton in references.

Group name	B	P/B	References
Phytoplankton		75	Whitehouse, 2013
Phytoplankton		69.03	Coll <i>et al.</i> , 2007
Phytoplankton		71.2	Wu et al., 2016
Phytoplankton		71.2	Lin et al., 2015
Phytoplankton		71.2	Guan et al., 2016
Phytoplankton		70	Crisp 1975; Parsons and Takahashi, 1973
Phytoplankton	18.763	71.2	Wu et al., 2013
Phytoplankton		180	Zhang et al., 2013
Phytoplankton	16.3	63	Yang et al., 2016
Phytoplankton	45.86	410	Li et al., 2014
Phytoplankton	15.7		Tong et al., 2000
Phytoplankton	31.0	106.52	Wang et al., 2016
Phytoplankton	28.0		Su 2016
Phytoplankton 2010		132.1	Xu et al., 2016
Phytoplankton 2011		105.0	Xu et al., 2016
Phytoplankton 2012		105.0	Xu et al., 2016
Phytoplankton June	23.862		Lin et al., 2015
Phytoplankton August	14.454		Lin et al., 2015
Phytoplankton October	18.721		Lin et al., 2015
Phytoplankton 1982	6.676	380	Lin et al., 2009
Phytoplankton 1992	3.935	398	Lin et al., 2009

Octopodidae

Fishing area in artificial reefs is 30.665 km^2 . *Octopus variabilis* and *Octopus ocellatus* biomass B in 2010 are **0.00392 t km⁻²**. P/B and Q/B ranges of *Octopodidae* were 2-4.58 and 7-15.6(**Table S-5**). *Octopodidae* biomass B in 2016 was estimated to be **0.08488 t km⁻²**.

Table S-4. Fishing landings (t km^{-2}) of *Octopodidae* in 2014-2016.

Year	Landing (ton)	Landing (t km^{-2})
2014	22.119	0.7213
2015	8.056	0.2627
2016	6	0.1957

Table S-5. B, P/B, Q/B of *Octopodidae* in references.

Group name	B	P/B	Q/B	References
Large cephalopods		2.0	7.0	Tong and Tange, 1999
<i>Octopus variabilis</i> , <i>Octopus ocellatus</i>	3.3	11.0		Wu <i>et al.</i> , 2012
<i>O. variabilis</i> , <i>O. ocellatus</i>	0.25	2.94	11.97	Wu <i>et al.</i> , 2013
Cephalopods	0.074	3.1	15.5	Zhang <i>et al.</i> , 2013
Cephalopods	0.07	4.58	15.6	Yang <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i>	0.24	2.0	7.0	Tong <i>et al.</i> , 2000
<i>O. variabilis</i> , <i>O. ocellatus</i>	0.3	3.0	9.75	Wang <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i>	3.6	2.8	8.9	Su, 2016
<i>O. variabilis</i> , <i>O. ocellatus</i>	9.23	4.5	11	Xu <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i> 2011	11.23	3.3	11	Xu <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i> 2012	17.13	3.3	11	Xu <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i>	0.189	3.0	9.75	Zhang <i>et al.</i> , 2016
<i>O. variabilis</i> , <i>O. ocellatus</i>	0.0298	3.3	8.0	Lin <i>et al.</i> , 2013
<i>O. variabilis</i> , <i>O. ocellatus</i> June	0.019	3.3	8.0	Lin <i>et al.</i> , 2015
<i>O. variabilis</i> , <i>O. ocellatus</i> August	0.011	3.3	8.0	Lin <i>et al.</i> , 2015
<i>O. variabilis</i> , <i>O. ocellatus</i> October	0.0049	3.3	8.0	Lin <i>et al.</i> , 2015
Cephalopods 1982	0.156	3.1	15.5	Lin <i>et al.</i> , 2009
Cephalopods 1992	0.0594	3.7	15.5	Lin <i>et al.</i> , 2009

Mesopelagic fishes

Fishing area in artificial reefs is 30.665 km². Mesopelagic fishes biomass B in 2010 are **0.03114 t km⁻²** (**Table S-6**). *Sardinella zunasi*, *Scomberomorus niphonius*, *Konosirus punctatus* rank the first three in biomass B (Proportion in total biomass = 69.61%) to calculate P/B and Q/B (**Table S-7**, **Table S-8**). P/B and Q/B ranges of mesopelagic fishes were 0.65-5.57 and 5.98-9.7 (**Table S-9**). Biomass B of mesopelagic fishes in 2016 were estimated to be **0.01275 t km⁻²**.

Table S-6. Biomass B (kg km⁻²) and proportion in total biomass for mesopelagic fishes.

Species	Biomass B (kg km ⁻²)	Proportion in total biomass
<i>Thryssa kammalensis</i>	1.92	6.17%
<i>Scomberomorus niphonius</i>	3.99	12.81%
<i>Konosirus punctatus</i>	2.86	9.18%
<i>Sardinella zunasi</i>	14.83	47.62%
<i>Sillago sihama</i>	1	3.21%
<i>Setipinna tenuifilis</i>	0.86	2.76%
<i>Argyrosomus argentatus</i>	0.77	2.47%
<i>Johnius belangerii</i>	0.54	1.73%
<i>Pampus argenteus</i>	0.44	1.41%
<i>Eupleurogrammus muticus</i>	1.13	3.63%
<i>Takifugu pseudommus</i>	2.8	8.99%
Sum of biomass B	31.14	

Table S-7. VBGF parameters, P/B and Q/B for *Scomberomorus niphonius*, *Konosirus punctatus*, *Sardinella zunasi*. VBGF means Von Bertalanffy growth equation as the following. $L_t = L_\infty(1 - e^{-K(t-t_0)})$ or $W_t = W_\infty(1 - e^{-K(t-t_0)})$. The parameters included L_∞ , W_∞ , K , t_0 .

Species	VBGF parameters	P/B	Q/B	References
<i>Scomberomorus niphonius</i>	$L_\infty=746$ mm $K=0.4606$ $W_\infty=2825.4$ g	0.7128	12.6	Sun, 2009
<i>Konosirus punctatus</i>	$L_\infty=248$ mm $K=0.1828$ $W_\infty=246.7$ g	0.2785	18.8	Jiao <i>et al.</i> , 2001
<i>Sardinella zunasi</i>	$L_\infty=165.3$ mm $K=0.4698$ $W_\infty=57.6$ g	0.5783	25.3	Jiao <i>et al.</i> , 2001

Table S-8. Biomass B (kg km^{-2}) and biomass proportion for *Scomberomorus niphonius*, *Konosirus punctatus*, *Sardinella zunasi*.

Species	Biomass B (kg km^{-2})	Biomass proportion in these 3 species
<i>Scomberomorus niphonius</i>	3.99	18.4%
<i>Konosirus punctatus</i>	2.86	13.2%
<i>Sardinella zunasi</i>	14.83	68.40%
Sum of biomass B	21.68	

$$\sum_{i=1}^3 (P_i / B_i) \times B_i \%$$

$$P/B = (0.7128 \times 18.4\%) + (0.2785 \times 13.2\%) + (0.5783 \times 68.40\%) = \mathbf{0.5635}$$

$$Q/B = (12.6 \times 18.4\%) + (18.8 \times 13.2\%) + (25.3 \times 68.40\%) = \mathbf{22.1052}$$

Table S-9. B, P/B and Q/B for mesopelagic fishes in references

Group names	B	P/B	Q/B	References
Mesopelagic fishes	2.6	2.37	7.9	Wu <i>et al.</i> , 2013
<i>Lateolabrax maculatus</i>	0.003	1.058		Zhang <i>et al.</i> , 2013
<i>Scomberomorus niphonius</i>	0.043	0.65		Zhang <i>et al.</i> , 2013
<i>Platycephalus indicus</i>	0.012	1.112		Zhang <i>et al.</i> , 2013
<i>Thryssa kammalensis</i>	0.051	3.26		Zhang <i>et al.</i> , 2013
<i>Sardinella zunasi</i>	0.159	2		Zhang <i>et al.</i> , 2013
<i>Konosirus punctatus</i>	0.226	3.5		Zhang <i>et al.</i> , 2013
Mesopelagic fishes	0.02	0.808		Zhang <i>et al.</i> , 2013
Mesopelagic fishes	1.58	2.44		Yang <i>et al.</i> , 2016
Mesopelagic fishes	2.14	2.37	7.9	Tong <i>et al.</i> , 2000
Mesopelagic fishes	0.25	1.80	5.98	Wang <i>et al.</i> , 2016
<i>Engraulis japonicus</i>	0.45	3.01	9.70	Wang <i>et al.</i> , 2016
Mesopelagic fishes	3.50	3	9.1	Su, 2016
Mesopelagic fishes 2010	0.73	0.84	6.35	Xu <i>et al.</i> , 2016
Mesopelagic fishes 2011	0.53	0.84	6.35	Xu <i>et al.</i> , 2016
Mesopelagic fishes 2012	0.51	0.84	6.35	Xu <i>et al.</i> , 2016
Mesopelagic fishes 2010	3.83	5.57	7.9	Xu <i>et al.</i> , 2016
Mesopelagic fishes 2011	2.73	4.5	7.9	Xu <i>et al.</i> , 2016
Mesopelagic fishes 2012	4.41	4.5	7.9	Xu <i>et al.</i> , 2016

Demersal fishes

Liza haematocheila, *Platycephalus indicus*, *Saurida elongata* rank the first three in biomass B (Proportion in total biomass = 89.1%) to calculate P/B and Q/B (**Table S-10**, **Table S-11**, **Table S-12**). P/B and Q/B ranges of demersal fishes were 0.52-6.85 and 3.6-27.4 (**Table S-13**). Biomass B of demersal fishes in 2010 was estimated to be **0.142785 t km⁻²**. Biomass B of demersal fishes in 2016 was estimated to be **0.02877 t km⁻²**.

Table S-10. Biomass B (kg km⁻²) and proportion in total biomass for demersal fishes.

Species	Biomass B (kg km ⁻²)	Proportion of total biomass
<i>Liza haematocheila</i>	99.55	69.72%
<i>Platycephalus indicus</i>	16.7	11.70%
<i>Saurida elongata</i>	10.96	7.68%
<i>Kareius bicoloratus</i>	7.15	5.00%
<i>Cynoglossus joyneri</i>	4.98	3.49%
<i>Callionymus kitaharae</i>	1.28	0.90%
<i>Paralichthys olivaceus</i>	1.13	0.79%
<i>Enerias fangi</i>	0.53	0.37%
<i>Cottiusculus gonez</i>	0.34	0.24%
<i>Sparus macrocephalus</i>	0.15	0.1%
<i>Hippocampus fasciatus</i>	0.015	0.01%
Sum of biomass B	142.785	

Table S-11. VBGF parameters, P/B and Q/B for *Liza haematocheila*, *Platycephalus indicus*, *Saurida elongate*.

Species	VBGF parameters	P/B	Q/B	References
<i>Liza haematocheila</i>	$L_{\infty}=67.9$ cm K=0.23 $W_{\infty}=2790.2$ g	0.4646	15.8	Fishbase
<i>Platycephalus indicus</i>	$L_{\infty}=459$ mm K=0.3848 $W_{\infty}=797.7$ g	0.7256	6.0	Chen and Zhao, 1986
<i>Saurida elongate</i>	$L_{\infty}=42.4$ cm K=1.2 $W_{\infty}=742$ g	1.5615	6.8	Fishbase

Table S-12. Biomass B (kg km^{-2}) and biomass proportion for *Liza haematocheila*, *Platycephalus indicus*, *Saurida elongate*.

Species	Biomass B (kg km^{-2})	Biomass proportion in these 3 species
<i>Liza haematocheila</i>	99.55	78.26%
<i>Platycephalus indicus</i>	16.7	13.12%
<i>Saurida elongate</i>	10.96	8.62%

$$\sum_{i=1}^3 (P_i / B_i) \times B_i \%$$

$$P/B = (0.4646 * 78.26\% + 0.7256 * 13.12\% + 1.5615 * 8.62\%) = \mathbf{0.5934}$$

$$Q/B = (15.8 * 78.26\% + 6 * 13.12\% + 6.8 * 8.62\%) = \mathbf{13.7384}$$

Table S-13. B, P/B and Q/B for demersal fishes in references.

Group name	B	P/B	Q/B	References
<i>Platycephalus indicus</i>	0.0034	0.72	3.6	Lin <i>et al.</i> , 2013
<i>Saurida elongate</i>	0.0012	0.52	5.0	Lin <i>et al.</i> , 2013
Bottom fishes	0.0078	1.4791	4.95	Lin <i>et al.</i> , 2013
Demersal fishes	0.0094	1.5922	4.7	Lin <i>et al.</i> , 2013
Bottom fishes, June	0.004	1.479	4.95	Lin <i>et al.</i> , 2015
Demersal fishes, June	0.008	0.958	4.93	Lin <i>et al.</i> , 2015
Bottom fishes, August	0.007	1.479	4.95	Lin <i>et al.</i> , 2015
Demersal fishes, August	0.003	0.958	4.93	Lin <i>et al.</i> , 2015
Bottom fishes, October	0.003	1.479	4.95	Lin <i>et al.</i> , 2015
Demersal fishes, October	0.0003	0.958	4.93	Lin <i>et al.</i> , 2015
<i>Platycephalus indicus</i>	0.012	1.112	4.12	Zhang <i>et al.</i> , 2013
Demersal fishes	0.024	1.05	4.95	Zhang <i>et al.</i> , 2013
Demersal fishes	2.18	2.61	8.93	Yang <i>et al.</i> , 2016
Demersal fishes	0.3	1.46	5.6	Wang <i>et al.</i> , 2016
Bottom fishes 2010	2.37	5.36	26.1	Xu <i>et al.</i> , 2016
Bottom fishes 2011	3.38	4.56	26.1	Xu <i>et al.</i> , 2016
Bottom fishes 2012	2.91	4.76	26.1	Xu <i>et al.</i> , 2016
Small mollusca	2.76	6.85	27.4	Tong <i>et al.</i> , 2000
Demersal fishes 1982	0.4916	0.9578	4.933	Lin <i>et al.</i> , 2009
Bottom fishes 1982	0.3946	0.8791	4.95	Lin <i>et al.</i> , 2009
Demersal fishes 1992	0.2937	0.9456	4.933	Lin <i>et al.</i> , 2009
Bottom fishes 1992	0.3056	1.05	4.95	Lin <i>et al.</i> , 2009

Sebastes schlegeli

Fishing area in artificial reefs is 30.665 km^2 . *Sebastes schlegeli* biomass B in 2010 is **0.00028 t km⁻²** (**Table S-15**). P/B and Q/B ranges of *Sebastes schlegeli* were 1.32-6.3 and 4.7-8.3 (**Table S-16**). *Sebastes schlegeli* biomass B in 2016 is **0.1505755 t km⁻²**.

Table S-14. Fishing landings (t km^{-2}) of *Sebastes schlegeli* in 2014-2016.

Year	Landing (ton)	Landing (t km^{-2})
2014	1.7	0.0554
2015	1.903	0.0621
2016	0.2	0.006522

Table S-15. VBGF parameters, P/B and Q/B for *Sebastes schlegeli*.

Species	VBGF parameters	P/B	Q/B	References
<i>Sebastes schlegeli</i>	$L_{\infty}=367.2 \text{ mm}$ $K=0.576$ $W_{\infty}=1423 \text{ g}$	1.0056	5.3	Zhuang <i>et al.</i> 2015

Table S-16. B, P/B and Q/B for *Sebastes schlegeli*.

Functional group	B	P/B	Q/B	References
<i>Sebastes schlegeli</i>	1.126	1.42	5.8	Wu et al., 2013
<i>Sebastes schlegeli</i>	1.89	1.32	4.7	Yang et al., 2016
<i>Sebastes schlegeli</i> 2010	2.31	6.30	8.30	Xu et al., 2016
<i>Sebastes schlegeli</i> 2011	4.21	5.70	8.30	Xu et al., 2016
<i>Sebastes schlegeli</i> 2012	7.59	5.70	8.30	Xu et al., 2016

Hexagrammos otakii

Fishing area in artificial reefs is 30.665 km^2 . No records about *Hexagrammos otakii* in bottom trawling were written, so *Hexagrammos otakii* biomass B in 2010 is 0 t km^{-2} . P/B and Q/B ranges of *Hexagrammos otakii* were 1.24-4.3 and 4.3-8.3 (Table S-18, Table S-19). In 2016 *Hexagrammos otakii* biomass B was estimated to be 0.05 t km^{-2} .

Table S-17. Fishing landings (t km^{-2}) of *Hexagrammos otakii* in 2014-2016.

Year	Landing (ton)	Landing (t km^{-2})
2014	1.154	0.03763248
2015	2.255	0.13875754
2016	1	0.0326105

Table S-18. VBGF parameters, P/B and Q/B for *Hexagrammos otakii*.

Species	VBGF parameters	P/B	Q/B	Reference
<i>Hexagrammos otakii</i>	$L_\infty=250.5 \text{ mm}$ $K=0.43$ $W_\infty=302.7 \text{ g}$	0.9245	7.3	Ji (2014)

Table S-19. B, P/B and Q/B for *Hexagrammos otakii* in references.

Group	B	P/B	Q/B	References
Demersal fishes	0.0078	1.4791	4.95	Lin et al., 2013
Bottom fishes, June	0.004	1.479	4.95	Lin et al., 2015
Bottom fishes, August	0.007	1.479	4.95	Lin et al., 2015
Bottom fishes, October	0.003	1.479	4.95	Lin et al., 2015
<i>Hexagrammos otakii</i>	0.583	1.24	8.3	Wu et al., 2013
<i>Hexagrammos otakii</i>	1.62	1.24	4.3	Yang et al., 2016
<i>Hexagrammos otakii</i> 2010	3.71	4.3	8.3	Xu et al., 2016
<i>Hexagrammos otakii</i> 2011	9.4	4.3	8.3	Xu et al., 2016
<i>Hexagrammos otakii</i> 2012	10.13	4.3	8.3	Xu et al., 2016

Gobiidae

Fishing area in artificial reefs is 30.665 km^2 . *Gobiidae* biomass B in 2010 is $0.109468 \text{ t km}^{-2}$ (Table S-21). P/B and Q/B ranges of *gobiidae* were 1.46-5.36 and 4.7-26.1 (Table S-22, Table S-23, Table S-24). *Gobiidae* biomass B in 2016 is $0.068871 \text{ t km}^{-2}$.

Table S-20. Fishing landings ($t km^{-2}$) of *Gobiidae* in 2014-2016.

Year	Landing (ton)	Landing ($t km^{-2}$)
2014	0.569	0.0186
2015	2	0.0652
2016	1	0.0326

Table S-21. Biomass B ($kg km^{-2}$) for *Gobiidae*.

Species	Biomass B ($kg km^{-2}$) in 2010
<i>Acanthogobius ommaturus</i>	61.32
<i>Chaeturichthys stigmatias</i>	48.09
<i>Ctenotrypauchen chinensis</i>	0.048
<i>Tridentiger trigonocephalus</i>	0.01

Table S-22. VBGF parameters, P/B and Q/B for *Acanthogobius ommaturus*, *Chaeturichthys stigmatias*.

Species	VBGF parameters	P/B	Q/B	References
<i>Acanthogobius ommaturus</i>	$L_{\infty}=464.5$ mm $K=0.2$ $W_{\infty}=473.3$ g	0.4714	6.7	Fan <i>et al.</i> (2005)
<i>Chaeturichthys stigmatias</i>	$L_{\infty}^{female}=207.5$ mm $L_{\infty}^{male}=255$ mm $K^{female}=2.4$ $K^{male}=2.0$ $W_{\infty}^{female}=103.39$ g $W_{\infty}^{male}=198.2$ g	2.7568	8.55	Zhao <i>et al.</i> (2012) Meng <i>et al.</i> (2015) Fishbase

Table S-23. Biomass B ($kg km^{-2}$) and biomass proportion for *Acanthogobius ommaturus*, *Chaeturichthys stigmatias*.

Species	Biomass B ($kg km^{-2}$)	Biomass proportion
<i>Acanthogobius ommaturus</i>	61.32	56.05%
<i>Chaeturichthys stigmatias</i>	48.09	43.95%

$$\sum_{i=1}^2 (P_i / B_i) \times B_i \%$$

$$P/B = (56.05\% * 0.4714 + 43.95\% * 2.7568) = 1.4758;$$

$$Q/B = (56.05\% * 6.7 + 43.95\% * 8.55) = 7.5131;$$

Table S-24. B, P/B and Q/B for *Gobiidae* in references.

Groups	B	P/B	Q/B	References
<i>Chaeturichthys stigmatias</i>	0.098	1.9		Zhang et al., 2013
<i>Acanthogobius ommaturus</i>	0.051	2.435		Zhang et al., 2013
<i>Acanthogobius ommaturus</i>	0.08	1.90	6.5	Yang et al., 2016
<i>Gobiidae</i> 2010	2.37	5.36	26.1	Xu et al., 2016
<i>Gobiidae</i> 2011	3.38	4.56	26.1	Xu et al., 2016
<i>Gobiidae</i> 2012	2.91	4.76	26.1	Xu et al., 2016
<i>Gobiidae</i>	0.0094	1.5922	4.7	Lin et al., 2013
<i>Gobiidae</i> , June	0.025	1.592	4.7	Lin et al., 2015
<i>Gobiidae</i> , August	0.003	1.592	4.7	Lin et al., 2015
<i>Gobiidae</i> , October	0.0049	1.592	4.7	Lin et al., 2015
Demersal fishes	0.3	1.46	5.6	Wang et al., 2016

Charybdis japonica

Fishing area in artificial reefs is 30.665 km^2 . *Charybdis japonica* biomass B in 2010 is **0.01152 t km⁻²**. P/B and Q/B ranges of *Charybdis japonica* were 1.5-8.31 and 11.3-26.9 (**Table S-26**). *Charybdis japonica* biomass B in 2016 is **0.75388 t km⁻²**.

Table S-25. Fishing landings (t km^{-2}) of *Charybdis japonica* in 2014-2016.

Year	Landing (ton)	Landing (t km^{-2})
2014	16.676	0.5438
2015	35.507	1.1578
2016	6.0	0.1957

Table S-26. B, P/B, Q/B of *Charybdis japonica* in references.

Group names	B	P/B	Q/B	References
<i>Charybdis japonica</i>		1.5	11.6	Quan et al. 2000
<i>Charybdis japonica</i>	0.446	3.5	12	Zhang et al., 2016
<i>Charybdis japonica</i>	7.477	5.65	26.9	Lin et al., 2013
Benthic crustaceans June	0.91	5.65	26.9	Lin et al., 2015
Benthic crustaceans August	1.21	5.65	26.9	Lin et al., 2015
Benthic crustaceans October	7.4	5.65	26.9	Lin et al., 2015
Crabs	0.075	3.5	12	Zhang et al., 2013
Crustaceans	11.403	4.8	14.5	Wu et al. 2013
<i>Charybdis japonica</i>	3.92	3.2	11.3	Yang et al., 2016
<i>Charybdis japonica</i>	0.25	3.5	12	Wang et al., 2016
<i>Charybdis japonica</i> 2010	5.91	7.22	24.31	Xu et al., 2016
<i>Charybdis japonica</i> 2011	5.43	7.22	24.31	Xu et al., 2016
<i>Charybdis japonica</i> 2012	6.97	8.31	24.31	Xu et al., 2016
<i>Charybdis japonica</i>	0.45	3.8	11.8	Su, 2016
<i>Charybdis japonica</i>	0.37	1.5	11.6	Tong et al., 2000
<i>Charybdis japonica</i> 1982	0.3493	3.5	12	Lin et al., 2009
<i>Charybdis japonica</i> 1992	0.2221	2.5	11.3	Lin et al., 2009

Oratosquilla oratoria

Fishing area in artificial reefs is 30.665 km². *Oratosquilla oratoria* biomass B in 2010 is **0.03843 t km⁻²**. P/B and Q/B ranges of *Oratosquilla oratoria* were 8-8.7 and 28-30 (**Table S-27**). *Oratosquilla oratoria* biomass B in 2016 is **0.00042 t km⁻²**.

Table S-27. B, P/B, Q/B of *Oratosquilla oratoria* in references.

Group name	B	P/B	Q/B	References
<i>Oratosquilla oratoria</i>		0.8	4.0	Watari <i>et al.</i> , 2011
<i>Oratosquilla oratoria</i>		1.5	4.56	Coll <i>et al.</i> , 2007
<i>Oratosquilla oratoria</i>	0.094	8	28.9	Zhang <i>et al.</i> , 2013
Small crustacean	2.01	8	30	Tong <i>et al.</i> , 2000
<i>Oratosquilla oratoria</i>	0.6	8.7	28.0	Wang <i>et al.</i> , 2016
<i>Oratosquilla oratoria</i>	1.28	8.5	30.0	Su, 2016
<i>Oratosquilla oratoria</i>	0.0385	8	30.0	Lin <i>et al.</i> , 2013
<i>Oratosquilla oratoria</i> June	0.02	8	30	Lin <i>et al.</i> , 2015
<i>Oratosquilla oratoria</i> August	0.015	8	30	Lin <i>et al.</i> , 2015
<i>Oratosquilla oratoria</i> October	0.0121	8	30	Lin <i>et al.</i> , 2015
<i>Oratosquilla oratoria</i> 1982	0.0554	8	28.9	Lin <i>et al.</i> , 2009
<i>Oratosquilla oratoria</i> 1992	0.0329	8.2	28.9	Lin <i>et al.</i> , 2009

Table S-28. Fishing landings (t km⁻²) of *Oratosquilla oratoria* in 2014-2016.

Year	Landing (ton)	Landing (t km ⁻²)
2014	1.151	0.03753465
2015	0.171	0.00557639
2016	0.15	0.0048916

Large crustacean

P/B and Q/B ranges of large crustacean were 1.5-8.7 and 11.3-30 (**Table S-30**). Biomass B of large crustacean in 2010 is estimated to be **0.06114 t km⁻²**. Biomass B of large crustacean in 2016 is estimated to be **0.011162 t km⁻²**.

Table S-29. Gear parameters of trawling net (Ren *et al.*, 2014).

Gear parameters	Value
CPUE	1.91 kg h ⁻¹
Net mouth width	~ 8 m
Towing speed	3 knot
Trawling sweeping area	44448 m ²
Large crustacean B biomass	0.0428 t km ⁻²
q (SC/T 9403-2012)	0.7
Large crustacean B ÷ q	0.0428/0.7= 0.06114 t km⁻²

Table S-30. B, P/B, Q/B of large crustacean in references.

Group names	B	P/B	Q/B	References
Large crustacean		4.0	20	Brey, 1990
Crustacean	11.403	4.8	14.5	Wu et al., 2013
<i>Portunus trituberculatus</i>	0.032	2		Zhang et al., 2013
Crabs	0.075	3.5		Zhang et al., 2013
<i>Penaeus orientalis</i>	0.01	8.2		Zhang et al., 2013
Shrimps	0.014	8.0		Zhang et al., 2013
Benthic crustacean	8.5	6.13	24.11	Yang et al., 2016
Small crustacean	2.01	8	30	Tong et al., 2000
Large crustacean	0.37	1.5	11.6	Tong et al., 2000
<i>Penaeus orientalis</i>	0.04	8.5	25.0	Wang et al., 2016
Crabs	0.25	3.5	12.0	Wang et al., 2016
Shrimp	0.6	8.7	28.0	Wang et al., 2016
Shrimps and crabs	11.1	6.5	20.1	Su, 2016
Shrimp 2010	9.17	5.91	28.0	Xu et al., 2016
Shrimp 2011	17.23	5.91	28.0	Xu et al., 2016
Shrimp 2012	23.13	5.91	28.0	Xu et al., 2016
Crab 2010	5.91	7.22	24.31	Xu et al., 2016
Crab 2011	5.43	7.22	24.31	Xu et al., 2016
Crab 2012	6.97	7.22	24.31	Xu et al., 2016
Shrimp	1.391	8	28	Zhang et al., 2016
Crab	0.446	3.5	12	Zhang et al., 2016
Benthic crustacean	7.477	5.65	26.9	Lin et al., 2013
Crustacean June	0.91	5.65	26.9	Lin et al., 2015
Crustacean August	1.21	5.65	26.9	Lin et al., 2015
Crustacean October	7.4	5.65	26.9	Lin et al., 2015
Shrimp 1982	0.4599	8	28	Lin et al., 2009
Crab 1982	0.3493	3.5	12	Lin et al., 2009
Shrimp 1992	0.0329	8.2	28.9	Lin et al., 2009
Crab 1992	0.2221	2.5	11.3	Lin et al., 2009

Other cephalopods

Loligo chinensis biomass B in 2010 is **0.15605 t km⁻²**. P/B and Q/B ranges of other cephalopods were 2-3.7 and 7-15.5 (Table S-31).

Table S-31. B, P/B, Q/B of large cephalopods in references.

Group name	B	P/B	Q/B	References
Large cephalopods		2.0	7.0	Tong and Tanga 1999
<i>Loligo chinensis</i>	0.0298	3.3	8	Lin et al., 2013
<i>Loligo chinensis</i> June	0.019	3.3	8	Lin et al., 2015
<i>Loligo chinensis</i> August	0.011			Lin et al., 2015
<i>Loligo chinensis</i> October	0.0049			Lin et al., 2015
<i>Loligo chinensis</i>	0.3	3	9.75	Wang et al., 2016
<i>Loligo chinensis</i>	0.24	2.0	7.0	Tong et al., 2000
Cephalopod 1982	0.156	3.1	15.5	Lin et al., 2009
Cephalopod 1992	0.0594	3.7		Lin et al., 2009

Rapana venosa

Weight per each individual of *Rapana venosa* are 50 g. Coefficient of weight per individual against meat is 1/3. In 2015, mean biomass and meat biomass of *Rapana venosa* are **152.5 g m⁻²** and **50.83 t km⁻²** (**Table S-32**). In 2016, mean biomass and meat biomass of *Rapana venosa* are **116.5 g m⁻²** and **38.83 t km⁻²** (**Table S-33**). P/B and Q/B of *Rapana venosa* are **0.26** and **2.82** (Lercari and Bergamino, 2011). Fishing area of diving fishing species *Stichopus japonicas* and *Rapana venosa* in artificial reefs is 5.333 km².

Table S-32. Mean biomass and meat biomass of *Rapana venosa* in 2015-2016.

Time	August 2015	October 2015	Mean biomass	Meat biomass
Biomass	185 g m ⁻²	120 g m ⁻²	152.5 g m⁻²	50.83 t km⁻²

Table S-33. Mean biomass and meat biomass of *Rapana venosa* in 2016.

Time	April 2016	June 2016	August 2016	Mean biomass	Meat biomass
Biomass	128 g m ⁻²	87.5 g m ⁻²	134 g m ⁻²	116.5 g m⁻²	38.83 t km⁻²

Table S-34. Fishing landings (t km⁻²) of *Rapana venosa* in 2014-2016.

Year	Landing (t)	Landing (t km ⁻²)	Landing (t km ⁻²)
2014	25	4.68779299	1.562597663
2015	400	75.0046878	25.0015626
2016	475	89.0680668	29.6893556

Table S-35. B, P/B, Q/B of *Rapana venosa* in references.

Group name	B	P/B	Q/B	References
<i>Rapana venosa</i>	2.41	9.2	30.9	Yang <i>et al.</i> , 2016

Stichopus japonicas

P/B and Q/B of *Stichopus japonicas* are **0.6** and **3.36** (Okey *et al.*, 2004). Unassimilation rate of *Stichopus japonicas* are **0.4** (Brey 1990). Fishing area of diving fishing species *Stichopus japonicas* and *Rapana venosa* in artificial reefs is 5.333 km². Biomass of *Stichopus japonicas* (F., Shi, CEO of Blue Ocean marine ranching L.T.D., personal communication) is estimated to be 2,000,000 jin in 10000 mu, that is **150 t km⁻²**.

Table S-36. Fishing landings (t km⁻²) of *Stichopus japonicas* in 2014-2016.

Year	Landing (t)	Landing (t km ⁻²)
2014	1	0.18751172
2015	150	28.1267579
2016	175	32.8145509

Oyster

Fishing area in artificial reefs is 30.665 km². Mean meat weight per individual is 2 g. Q/B, EE and unassimilation rate of oyster are **10.5**, **0.95** and **0.4** (Rosado-Solórzano and Prío, 1998).

Table S-37. Mean biomass and meat biomass of Oyster in 2015.

Month	August 2015	October 2015	Mean meat biomass in 2015
Biomass	292 g m ⁻²	961 g m ⁻²	626.5 g m⁻²

Table S-38. Mean biomass and meat biomass of Oyster in 2016.

Month	April 2016	June 2016	August 2016	Mean meat biomass in 2016
Biomass	778 g m ⁻²	794 g m ⁻²	1350 g m ⁻²	974 g m⁻²

Zoobenthos

To calculate secondary productivity of zoobenthos following empirical formula (Brey 1990),

$$\lg P = 0.27 \times \lg A + 0.737 \times \lg B - 0.4$$

Where P is annual mean secondary productivity of macrobenthic fauna (g m⁻² a⁻¹), B is annual mean biomass (g m⁻² a⁻¹), A is annual mean number (ind m⁻² a⁻¹), W is annual mean weight per individual (g ind⁻¹ a⁻¹).

Annual mean secondary productivity of Lai-zhou Bay in 2011 was estimated to be $\sim 3.48 \times 10^4$ t a⁻¹ (AFDM), $\sim 1.93 \times 10^5$ t a⁻¹ (wet weight), and the area of Lai-zhou Bay is ~ 6215.40 km². Biomass B of zoobenthos is estimated to be **31.05** t km⁻² (Li *et al.*, 2014). P/B and Q/B of zoobenthos are **1.67** and **8.35** (Li *et al.*, 2014). Biomass B of zoobenthos in 2016 is estimated to be 0.00235 t km⁻².

P/B and Q/B ranges of zoobenthos were 2.0-9.0 and 15-33 (**Table S-40**).

Table S-39. Comparison of secondary productivity of different macrobenthic communities in Bohai and Yellow sea areas.

Sea area	Annual mean secondary productivity (g · m ⁻² · a ⁻¹)	P/B (a ⁻¹)	References
Lai-zhou Wan	5.60	1.59	Li <i>et al.</i> , 2014
Bohai Sea area	6.49	0.82	Yu <i>et al.</i> , 2011
San-gou Wan	4.76	1.45	Wang <i>et al.</i> , 2011
Yellow Sea southern areas	4.98	1.10	Li <i>et al.</i> , 2005
Jiao-zhou Wan	13.41	1.05	Li <i>et al.</i> , 2005

Table S-40. B, P/B, Q/B of zoobenthos in references

Groups	B	P/B	Q/B	References
Zoobenthos	4.605	9	33	Lin et al., 2013
Zoobenthos June	0.821	9	33	Lin et al., 2015
Zoobenthos August	2.07			Lin et al., 2015
Zoobenthos October	2.22			Lin et al., 2015
<i>Polychaeta</i>	5.93	5.8	25.72	Yang et al., 2016
Zoobenthos	9.5	9	33	Wang et al., 2016
<i>Mollusca</i> 2010	15.31	4.73	17.2	Xu et al., 2016
<i>Mollusca</i> 2011	27.23	4.43	17.2	Xu et al., 2016
<i>Mollusca</i> 2012	21.31	4.53	17.2	Xu et al., 2016
Zoobenthos	8.5	3	15	Su, 2016
<i>Polychaeta</i> 1982	1.99	6.75	22.5	Lin et al., 2009
<i>Polychaeta</i> 1992	2.135	2	27.8	Lin et al., 2009

Zooplankton

Zooplankton samples were collected by opening-closing bongo nets (with a diameter of 37 cm and a mesh size of 0.03 mm) through the water column. Biomass of zooplankton was estimated by displaced volume according to Ahlstrom and Thraikill (1960). Daily turnover rate P/B of zooplankton in May and June are 0.2 and 0.16 in Lai-zhou Wan, and the mean of daily turnover rate P/B is 0.18. Annual turnover rate P/B is **65.7**. P/Q is generally 0.2, so Q/B of zooplankton is **328.5** (Jiang *et al.*, 2015). Biomass B in May and October 2010 were 745.0 and 939.9 mg m⁻³, so the mean of biomass B was 842.45 mg m⁻³ in 2010. Using a mean depth of 6 m, we estimated mean zooplankton biomass of **5.0547 g m⁻²**. P/B and Q/B ranges of zooplankton were 12.0-57.0 and 26.0-1140.0 (**Table S-41**). In 2016, the mean of zooplankton biomass B was 233.68228 mg m⁻³ in 2016, using a mean depth of 6 m, we estimated mean zooplankton biomass of **1.402 g m⁻²**.

Table S-41. B, P/B, Q/B for zooplankton in references.

Group	B	P/B	Q/B	References
Zooplankton	10.738	25	122.1	Wu <i>et al.</i> , 2013
Zooplankton	2.91	50	1000	Li <i>et al.</i> , 2014
Cladocera	3.51	57	1140	Li <i>et al.</i> , 2014
Copepoda	4.24	48	960	Li <i>et al.</i> , 2014
Zooplankton	4.4	36	186	Tong <i>et al.</i> , 2000
Zooplankton	18.2	25	180	Wang <i>et al.</i> , 2016
Zooplankton	20	12	26	Su, 2016
Zooplankton		35	122	Xu <i>et al.</i> , 2016

Detritus

Mean depth of artificial reefs area is 6 m. DOC in September in sea surface and sea bottom are 2.212-4.704 mg L⁻¹ and 2.153-4.173 mg L⁻¹, and the mean are 3.458 mg L⁻¹ and 3.163 mg L⁻¹ (Liu, 2006). DOC for 30 cm thick sedimentary layer is 0.9489 g m⁻², and DOC in 6 m deep water body is 20.748 g m⁻². POC in Bohai Sea ranges from 251.47-1268 µg L⁻¹, and the mean is 530.4 µg L⁻¹ (Shang, 2011). Suspension POC in water body is 3.1824 g m⁻². Detritus biomass stock is equivalent to DOC content plus POC content, ~**24.8793 g m⁻²**. Dead animal biomass, dead plankton biomass and benthic diatoms biomass were not considered in the calculations (**Table S-42**).

Scallop raft cultivation areas in Lai-zhou are 187 km^2 , and they produced $4.3384 \times 10^5 \text{ t}$ biological detritus biomass (**Table S-43**). Exploited shallow sea area in Lai-zhou city is 1000 km^2 , so detritus biomass stock input from scallop farming is **433.84 t km^{-2}** .

Table S-42. Detritus biomass stock D in different ecosystems.

Survey place	Detritus biomass stock D	References
Hang-zhou Bay, China	8.43 t km^{-2}	Xu <i>et al.</i> , 2011
Bohai Sea, China	43.00 t km^{-2}	Tong <i>et al.</i> , 1999
Sea areas adjacent to Yellow River in June	30 t km^{-2}	Lin <i>et al.</i> , 2015
Sea areas adjacent to Yellow River in August	45 t km^{-2}	Lin <i>et al.</i> , 2015
Sea areas adjacent to Yellow River in October	28 t km^{-2}	Lin <i>et al.</i> , 2015

Table S-43. Detritus biomass stock D input in scallop farming in Sang-gou Bay (Zhou *et al.*, 2003).

Species	<i>Chlamys (Azumapecten) Farreri</i>
Place	Sang-gou Bay
Cultivation area	75 km^2
Total number of the cultivation	20 billion
Mean biological deposition rate	$2.38 \text{ g ind}^{-1} \text{ d}^{-1}$
Biological sediments per year	$1.74 \times 10^5 \text{ t} / 75 \text{ km}^2 = 2316.53 \text{ t km}^{-2}$

Table S-44. Initial inputs (**Modified inputs**) of B (t km⁻²) in 2010, P/B (year⁻¹), Q/B (year⁻¹) and unassimilation parts of functional groups before artificial reef deployments.

Input (shaded background) and output parameters used to model the trophic functioning before artificial reefs deployments: trophic level (TL); biomass (B; t km⁻²); production/biomass ratio (P/B; yr-1); consumption/biomass ratio (Q/B; yr-1); ecotrophic efficiency (EE; 0.95); unassimilated food (U/Q). Landing and discards are expressed in t km⁻² year⁻¹.

Group name	Trophic level	B (t km ⁻²)	P/B (year ⁻¹)	Q/B (year ⁻¹)	Un	EE
1. Octopodidae	4.94	0.00392	2.0 (2.1)	7.0		0.96
2. Other		0.15605	2.0	7.0		
Cephalopods	3.24					0.29
3. Mesopelagic fishes		0.03114(0.09)	0.5635(3.5)	22.1(9.7)		
4. Demersal fishes	3.46					0.98
5. Gobiidae	2.83	0.142785	0.5934	13.7384		0.33
6. Sebastes schlegelii	3.79	0.109468(0.13)	1.4758(2.2)	7.5131		0.99
7. Charybdis japonica	4.12	0.00028(0.004)	1.0056(1.2)	5.3		
8. Oratosquilla oratoria	3.18					0.88
9. Large crustacean	3.06	0.01152	1.5	11.6		
10. Zoobenthos	3.03					0.28
11. Zooplankton	2.00	31.05	65.7	8.35		0.04
12. Phytoplankton	2.25	5.0547	71.2(135)	328.5(300.0)		0.55
13. Detritus	1.00	9.432			0.4	0.77
	1.00	24.8793		Input: 433.84 t km ⁻²		0.21

Notes: **1. Octopodidae** P/B 2.0→2.1; **3. Mesopelagic fishes** B 0.0311→0.09, P/B 0.563→3.5, mesopelagic fishes item 0.154→0.054 and import item 0→0.1 in mesopelagic fishes diet composition; **5. Gobiidae** B 0.109→0.13, P/B 1.476→2.2, *Gobiidae* item 0.419→0.2 and import item 0→0.219 in *Gobiidae* diet composition; **6. Sebastes schlegelii** B 0.00028→0.004, P/B 1.006→1.2; **8. Oratosquilla oratoria** P/B 0.8→2.1, Q/B 4.0→7.0, *O. oratoria* item 0.00826→0 and import item 0.1→0.10826 in mesopelagic fishes diet composition; **9. Large crustacean** B 0.0611→0.12, P/B 4.0→6.0; **11. Zooplankton** Q/B 328.5→300.0; **12. Phytoplankton** P/B 71.2→135.0.

Table S-45. Initial inputs (**Modified inputs**) of B (t km⁻²) in 2016, P/B (year⁻¹), Q/B (year⁻¹), unassimilation parts and landings in 2016 of functional groups after artificial reef deployments.

Group name	Trophical level	B (t km ⁻²)	P/B (year ⁻¹)	Q/B (year ⁻¹)	Un	EE	Landing
1. Octopodidae	4.517	0.08488(0.3)	2.0(2.1)	7.0		0.952	0.1957
2. Mesopelagic fishes	3.454	0.01275(0.2)	0.5635(3.5)	22.1(9.7)		0.861	
3. Demersal fishes	2.822	0.02877(0.23)	0.5934(1.0)	13.7384		0.970	
4. Sebastes schlegelii	4.066	0.1505755	1.0056	5.3		0.074	0.006522
5. Hexagrammos otakii	3.873	0.05	0.9245	7.3		0.806	0.0326105
6. Gobiidae	3.278	0.068871(0.47)	1.4758(3.6)	7.5131(14)		0.999	0.0326
7. Charybdis japonica	3.128	0.75388	1.5(2)	11.6		0.931	0.1957
8. Oratosquilla oratoria	3.063	0.00042(0.03843)	0.8(8)	4.0(30)		0.855	0.0048916
9. Large crustacean	3.030	0.011162(0.34)	4.0(6.0)	20		0.938	
10. Other Cephalopods	3.237	0.15605(0.21)	2.0(3.0)	7.0(10.0)		0.977	
11. Rapana venosa	3.000	38.83	0.26(0.8)	2.82		0.956	29.6893556
12. Sea cucumber	2.000	150	0.6	3.36		0.365	32.8145509
13. Zoobenthos	2.000	31.05	1.67	8.35		0.294	
14. Oyster	2.000	974(97.4)		10.5	0.4	0.950	
15. Zooplankton	2.250	1.402	65.7	328.5(200)		0.593	
16. Phytoplankton	1.000	5.562	71.2(100)			0.915	
17. Detritus	1.000	24.8793		Input: 433.84 t km ⁻²			

Notes: **1. Octopodidae** B 0.08488→0.3, P/B 2.0→2.1, *Octopodidae* item 0.2875→0.0875 and import item 0→0.2 in *Octopodidae* diet composition; **2. Mesopelagic fishes** B 0.01275→0.2, P/B 0.5635→3.5, mesopelagic fishes item 0.154→0.054 and import item 0→0.1 in mesopelagic fishes diet composition; **3. Demersal fishes** B 0.02877→0.23, P/B 0.593→1.0; **6. Gobiidae** B 0.068871→0.47, P/B 1.4758→3.6, Q/B 7.513→14, *Gobiidae* item 0.45→0.05 and *Charybdis japonica* item 0.175→0.575 in *Octopodidae* diet composition, *Gobiidae* item 0.419→0 and other cephalopods item 0.0439→0.263 and import item 0.45→0.65 in *Gobiidae* diet composition; **7. Charybdis japonica** P/B 1.5→2; **8. Oratosquilla oratoria** B 0.00042→0.03843, P/B 0.8→8, Q/B 4.0→30 ; **9. Large crustacean** B 0.011162→0.34, P/B 4.0→6.0, large crustacean item 0.361→0.111 and import item 0→0.25 in *Gobiidae* diet composition; **10. Other Cephalopods**, B 0.15605→0.21, P/B 2.0→3.0, Q/B 7.0→10.0, Other Cephalopods item 0.263→0.063 and import item 0.25→0.45 in *Gobiidae* diet composition; **11. Rapana venosa**, P/B 0.26→0.8; **14. Oyster** B 974→97.4 (artificial reefs area=10% total area of Blue Ocean marine ranching); **15. Zooplankton** Q/B 328.5→200; **16. Phytoplankton** P/B 71.2→100, zooplankton item 0.5→0, phytoplankton item 0.9→0.3, detritus item 0→0.55 and import item 0→0.15 in oyster diet composition.

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Supplement 2. Given parameters of food web

Zoobenthos

Species composition: *Cypridina, Capitella capitata, Siliqua paulchella, Philine kinglippini* ;

Diet composition: Diatoms, detritus;

Given consumption proportion: detritus 1.0;

Gobiidae

Species composition: *Synechogobius ommaturus* 56.05%, *Chaeturichthys stigmatias* 43.95%

;

Table B-1 Diet composition of main *Gobiidae* species.

Species	Diet composition	References
<i>Chaeturichthys stigmatias</i>	Crustacean, crustacean larvae etc	Deng and Yang, 1997 (1992-1993, Bohai Sea)
<i>Chaeturichthys stigmatias</i>	Benthic decapoda, <i>Stomatopods</i> , Bivalve, <i>Gammaridea</i> , Cephalopod and fishes	Zhang et al., 2012 (2009, Bohai Sea)
<i>Synechogobius ommaturus</i>	Fishes and shrimps, crabs and bivalves, <i>Amblychaeturichthys hexanema</i> (67%), <i>Alpheus japonicas</i> and <i>Alpheus distinguendus</i> (33%)	Han, 2013 (2011, Jiao-zhou)

Given consumption proportion: Large crustacean 0.360765, Zoobenthos 0.1758, *Gobiidae* 0.419485, Other cephalopods 0.04395;

Calculation method:

Prey items percentage of *Chaeturichthys stigmatias*: Large crustacean 0.4, Zoobenthos 0.4, *Gobiidae* 0.1, Other cephalopods 0.1.

Prey items percentage of *Synechogobius ommaturus*: *Gobiidae* 0.67, Large crustacean 0.33.

Large crustacean : $43.95\% * 0.4 + 0.33 * 56.05\% = 0.360765$;

Zoobenthos : $0.4 * 43.95\% = 0.1758$;

Gobiidae : $0.1 * 43.95\% + 0.67 * 56.05\% = 0.419485$;

Other cephalopods : $0.1 * 43.95\% = 0.04395$;

Sebastes schlegelii

Species composition: Single species

Table B-2 Diet composition of *Sebastes schlegeli*.

Species	Diet composition	References
<i>Sebastes schlegeli</i>	54.69% benthic shrimps, 30.76% fishes, crabs, <i>Stomatopods, Cephalopoda</i>	Zhang <i>et al.</i> , 2012
<i>Sebastes schlegeli</i>	<i>Crangon affinis, Alpheus japonicas, Heptacarpus</i>	Zhang <i>et al.</i> , 2011

Given consumption proportion: Large crustacean 0.7, Mesopelagic fishes 0.05, Demersal fishes 0.1, *Gobiidae* 0.1, Other cephalopods 0.05.

Hexagrammos otakii

Species composition: Single species

Table B-3 Diet composition of *Hexagrammos otakii*.

Species	Diet composition	References
<i>Hexagrammos otakii</i>	Benthic shrimp 62.5%, <i>Stomatopods</i> 8.68%	Zhang <i>et al.</i> , 2012 (October 2009)
<i>Hexagrammos otakii</i>	Dominant prey species: Other cephalopods, large crustceans; Occasional prey species: Zooplankton, <i>Oratosquilla oratoria</i>	Deng and Yang, 1997

Given consumption proportion: Large crustacean 0.6, Zoobenthos 0.1, Other cephalopods 0.1, Zooplankton 0.1, *Oratosquilla oratoria* 0.1.

Mesopelagic fishes

Species composition: *Scomberomorus niphonius, Johnius belangerii, Argyrosomus argentatus, Thryssa kammalensis, Sardinella zunasi, Setipinna tenuifilis, Pampus argenteus, Konosirus punctatus, Euplectrogrammus muticus*

Table B-4 Diet composition of mesopelagic fishes group.

Species	Biomass ratio	Diet composition
<i>Scomberomorus niphonius</i>	3.99 kg km^{-2} 14.59%	Mesopelagic fishes : $0.95 * 14.59\% = 0.138605$; Zoobenthos : $0.05 * 14.59\% = 0.007295$;
<i>Johnius belangerii</i>	0.54 kg km^{-2} 1.98%	Large crustacean : $0.65 * 1.98\% = 0.01287$; Other cephalopods : $0.1 * 1.98\% = 0.00198$; Zoobenthos : $0.05 * 1.98\% = 0.00099$; Gobiidae : $0.05 * 1.98\% = 0.00099$; <i>Sebastes schlegeli</i> : $0.05 * 1.98\% = 0.00099$; <i>Hexagrammos otakii</i> : $0.05 * 1.98\% = 0.00099$; Mesopelagic fishes : $0.05 * 1.98\% = 0.00099$; Other cephalopods : $0.05 * 2.82\% = 0.00141$
<i>Argyrosomus argentatus</i>	0.77 kg km^{-2} 2.82%	Large crustacean : $0.65 * 2.82\% = 0.01833$; Gobiidae : $0.15 * 2.82\% = 0.00423$; <i>Sebastes schlegeli</i> : $0.05 * 2.82\% = 0.00141$; <i>Hexagrammos otakii</i> : $0.05 * 2.82\% = 0.00141$; Mesopelagic fishes : $0.05 * 2.82\% = 0.00141$
<i>Thryssa kammalensis</i>	1.92 kg km^{-2} 7.02%	Zooplankton : $0.7 * 7.02\% = 0.04914$; Large crustacean : $0.3 * 7.02\% = 0.02106$;
<i>Sardinella zunasi</i>	14.83 kg km^{-2} 54.24%	Zooplankton = $54.24\% * 1 = 0.5424$;
<i>Setipinna tenuifilis</i>	0.86 kg km^{-2} 3.15%	Zooplankton = $3.15\% * 1 = 0.0315$;
<i>Pampus argenteus</i>	0.44 kg km^{-2} 1.61%	Phytoplankton : $0.5 * 1.61\% = 0.00805$ Zooplankton : $0.5 * 1.61\% = 0.00805$
<i>Konosirus punctatus</i>	2.86 kg km^{-2} 10.46%	Zoobenthos : $0.62 * 10.46\% = 0.064852$ Phytoplankton : $0.19 * 10.46\% = 0.019874$ Zooplankton : $0.19 * 10.46\% = 0.019874$
<i>Eupleurogrammus muticus</i>	1.13 kg km^{-2} 4.13%	Zooplankton : $0.3 * 4.13\% = 0.01239$ Mesopelagic fishes : $0.3 * 4.13\% = 0.01239$ Other cephalopods : $0.2 * 4.13\% = 0.00826$ <i>Oratosquilla oratoria</i> : $0.2 * 4.13\% = 0.00826$

Given consumption proportion: *Hexagrammos otakii* 0.0024, Other cephalopods 0.01165, Phytoplankton 0.027924, *Oratosquilla oratoria* 0.00826, Large crustacean 0.05226, Zoobenthos 0.073137, Gobiidae 0.00522, *Sebastes schlegeli* 0.0024, Zooplankton 0.663354, Mesopelagic fishes 0.153395

Demersal fishes

Species composition: *Cynoglossus joyneri*, *Sphyraenus*, *Callionymus kitaharae*, *Platycephalus indicus* (*Linnaeus*), *Paralichthys olivaceus*, *Platichthys bicoloratus*, *Saurida elongate*, *Pagrosomus major*, *Enedrias fangi*.

Table B-5 Diet composition of demersal fishes group.

Species	Biomass ratio	Diet composition
<i>Cynoglossus joyneri</i>	4.98 kg km ⁻² 3.5%	Zoobenthos : 1 * 3.5% = 0.035
<i>Sphyraenus</i>	99.55 kg km ⁻² 69.89%	Phytoplankton : 0.088 * 69.89% = 0.0615032 Zoobenthos : 0.312 * 69.89% = 0.2180568 Detritus : 0.6 * 69.89% = 0.41934
<i>Callionymus kitaharae</i>	1.28 kg km ⁻² 0.9%	Zoobenthos : 1 * 0.9% = 0.009
<i>Platycephalus indicus</i>	16.7 kg km ⁻² 11.73%	<i>Oratosquilla oratoria</i> 0.338 * 11.73% = 0.0396474 Large crustacean 0.25 * 11.73% = 0.029325 Other cephalopods 0.078 * 11.73% = 0.0091494 Mesopelagic fishes 0.15 * 11.73% = 0.017595 Demersal fishes 0.05 * 11.73% = 0.005865 Gobiidae 0.134 * 11.73% = 0.0157182
<i>Paralichthys olivaceus</i>	1.13 kg km ⁻² 0.79%	Gobiidae 0.3 * 0.79% = 0.00237 Mesopelagic fishes 0.5 * 0.79% = 0.00395 Demersal fishes 0.1 * 0.79% = 0.00079 Other cephalopods 0.05 * 0.79% = 0.000395 <i>Oratosquilla oratoria</i> 0.02 * 0.79% = 0.000158 Large crustacean 0.03 * 0.79% = 0.000237 Other cephalopods 0.269 * 5.02% = 0.0135038
<i>Platichthys bicoloratus</i>	7.15 kg km ⁻² 5.02%	Large crustacean 0.614 * 5.02% = 0.0308228 Zoobenthos 0.117 * 5.02% = 0.0058734 Mesopelagic fishes : 0.88 * 7.7% = 0.06776 Demersal fishes : 0.07 * 7.7% = 0.00539 Gobiidae : 0.05 * 7.7% = 0.00385
<i>Saurida elongata</i>	10.96 kg km ⁻² 7.7%	<i>Oratosquilla oratoria</i> 0.15 * 0.1% = 0.00015 Large crustacean 0.5 * 0.1% = 0.0005 Zoobenthos 0.2 * 0.1% = 0.0002
<i>Pagrosomus major</i>	0.15 kg km ⁻² 0.1%	

		Mesopelagic fishes $0.1 * 0.1\% = 0.0001$
		Demersal fishes $0.05 * 0.1\% = 0.00005$
<i>Enedrias fangi</i>	0.53 kg km^{-2} 0.37%	Zooplankton $1 * 0.37\% = 0.0037$

Given consumption proportion: *Gobiidae* 0.022, Large crustacean 0.0609, Other cephalopods 0.023, Demersal fishes 0.0121, Zoobenthos 0.2681, Zooplankton 0.0037, Phytoplankton 0.0615, *Oratosquilla oratoria* 0.04, Detritus 0.4193, Mesopelagic fishes 0.0894.

Oratosquilla oratoria

Species composition: Single species.

Given consumption proportion: Zooplankton 0.25, Zoobenthos 0.75
 Chen J.S., Zhu J.S. 1997. A study on feeding characteristics and trophic levels of main economic invertebrates in Yellow Sea. *Acta Oceanologica Sinica*, 19(6), 102-108. (In Chinese with English abstract)

Large crustacean

Species composition: *Penaeus orientalis*, *Trachypenaeus curvirostris*, *Crangon affinis*, *Palaemon gravieri*, *Metapenaeopsis dalei*, *Portunus trituberculatus*

Table B-6 Diet composition of large crustacean group.

Species	Biomass ratio	Diet composition
<i>Penaeus orientalis</i>	0.489 kg km ⁻² 3.88%	Zooplankton : 0.25 * 3.88% = 0.0097 Zoobenthos : 0.75 * 3.88% = 0.0291
<i>Trachypenaeus curvirostris</i>	0.074 kg km ⁻² 0.6%	Zooplankton : 0.25 * 0.6% = 0.0015 Zoobenthos : 0.75 * 0.6% = 0.0045
<i>Crangon affinis</i>	0.06 kg km ⁻² 0.48%	Zooplankton : 0.05 * 0.48% = 0.00024 Zoobenthos : 0.95 * 0.48% = 0.00456
<i>Palaemon gravieri</i>	0.863 kg km ⁻² 6.85%	Zooplankton : 0.3 * 6.85% = 0.02055 Zoobenthos : 0.7 * 6.85% = 0.04795
<i>Metapenaeopsis dalei</i>	0.115 kg km ⁻² 0.91%	Zooplankton : 0.3 * 0.91% = 0.00273 Zoobenthos : 0.7 * 0.91% = 0.00637
<i>Portunus trituberculatus</i>	10.99 kg km ⁻² 87.28%	Zooplankton : 0.1 * 87.28% = 0.08728 Zoobenthos : 0.9 * 87.28% = 0.78552

Given consumption proportion: Zooplankton 0.122, Zoobenthos 0.878

Charybdis japonica

Species composition: *Charybdis japonica*

Table B-7 Diet composition of *Charybdis japonica*.

Diet composition	References
Mollusca and Mollusca juveniles, crustacean, fishes, squid, <i>Polychaete</i>	Deng and Yang 1997
Crustaceans, bivalves, fishes, <i>Gastropods</i>	Jiang et al., 1998 August 1992

Given consumption proportion: Zoobenthos 0.9, *Gobiidae* 0.1

Octopodidae

Species composition: *Octopodidae*

Table B-8 Diet composition of *Octopodidae*.

Month	Weight	Prey item percentage	Diet composition
April	0.25	<i>Acanthogobius flavimanus</i> 77.8%, <i>Oratosquilla oratoria</i> 16.67%, <i>Octopodidae</i> 6.56% ;	<i>Gobiidae</i> : 80% * 0.25 = 0.2; <i>Octopodidae</i> : 5% * 0.25 = 0.0125; <i>Oratosquilla oratoria</i> : 15% * 0.25 = 0.0375
May	0.25	<i>Octopus variabilis</i> 27.27%, <i>Acanthogobius flavimanus</i> 27.27%, <i>Charybdis japonica</i> 27.27%, <i>Tridentiger trigonocephalus</i> 18.18%	<i>Octopodidae</i> : 30% * 0.25 = 0.075; <i>Gobiidae</i> : 40% * 0.25 = 0.1 <i>Charybdis japonica</i> : 30% * 0.25 = 0.075;
June	0.25	<i>Octopus variabilis</i> 26.67%, <i>Synechogobius hasta</i> 26.67%, <i>Charybdis japonica</i> 13.33%, <i>Alpheus brevicristatus</i> 6.67%, <i>Diopatra neapolitana</i> 6.67%, <i>Enedrius crassispina</i> 20%	<i>Octopodidae</i> : 30% * 0.25 = 0.075 <i>Gobiidae</i> : 30% * 0.25 = 0.075 <i>Charybdis japonica</i> : 20% * 0.25 = 0.05 Demersal fishes : 20% * 0.25 = 0.05
July	0.25	<i>Octopus variabilis</i> 46.15%, <i>Acanthogobius flavimanus</i> 7.7%, <i>Charybdis japonica</i> 23.08%, <i>Synechogobius hasta</i> 23.08%	<i>Octopodidae</i> : 50% * 0.25 = 0.125 <i>Gobiidae</i> : 30% * 0.25 = 0.075 <i>Charybdis japonica</i> : 20% * 0.25 = 0.05

Given consumption proportion: *Gobiidae* 0.45 ; *Octopodidae* 0.2875 ; *Charybdis japonica* 0.175 ; Demersal fishes 0.05 ; *Oratosquilla oratoria* 0.0375

Other cephalopods

Species composition: *Loligo chinensis*

Table B-9 Diet composition of other cephalopods group.

Species	Diet composition
<i>Loligo beka Sasaki</i>	Zooplankton 41.9%, Zoobenthos 0.6%, fish juveniles 57.5%
<i>Loligo japonica</i>	Zooplankton 38.4%, Zoobenthos 1.7%, fish juveniles 59.9%

Given consumption proportion: Zooplankton 0.95, Zoobenthos 0.05

Stichopus japonicus

Species composition: Single species

Stomach diet: benthic diatoms, organic matters such as animal debris, dead body etc.

Given consumption proportion: Detritus 1.0

Rapana venosa

Species composition: Single species

Stomach diet: bivalves

Given consumption proportion: Oyster 1.0

Oyster

Species composition: Single species

Phytoplankton diet: *Bacillariophyte, Pyrrrophyta, Prorocentrum micans nrenberg*

Zooplankton diet: *Tintinnidae, Microsetella*

Given consumption proportion: phytoplankton 0.5, zooplankton 0.5

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- Zhang B., Li Z.Y., Jin X.S. 2012. Functional groups of fish assemblages and their major species in the Bohai Sea. *Journal of fisheries of China*, 36 (1), 64-72. (In Chinese with English abstract)

Supplement 5. Model calibration and validation

Standard 1 EE<1.0. (Heymans et al., 2016)

Please check Table 2 ‘EE’ item, and all the values were below than 1.0 before and after artificial reefs deployments (see Table 2).

Standard 2 0.05<GE(=’P/Q’)<0.3. (Heymans et al., 2016)

Before		After	
Group name	GE(=P/Q)	Group name	GE(=P/Q)
<i>Octopodidae</i>	0.3	<i>Octopodidae</i>	0.3
Other cephalopods	0.29	Mesopelagic fishes	0.158
Mesopelagic fishes	0.16	Demersal fishes	0.073
Demersal fishes	0.04	<i>Sebastes schlegelii</i>	0.19
<i>Gobiidae</i>	0.29	<i>Hexagrammos otakii</i>	0.127
<i>Sebastes schlegelii</i>	0.23	<i>Gobiidae</i>	0.257
<i>Charybdis japonica</i>	0.13	<i>Charybdis japonica</i>	0.172
<i>Oratosquilla oratoria</i>	0.3	<i>Oratosquilla oratoria</i>	0.267
Large crustacean	0.3	Large crustacean	0.3
Zoobenthos	0.2	Other cephalopods	0.3
Zooplankton	0.22	<i>Rapana venosa</i>	0.284
		Sea cucumber	0.179
		Zoobenthos	0.2
		Oyster	0.113
		Zooplankton	0.329

The readers themselves also can divide P/B values by Q/B values to acquire P/Q values in Table 2. In addition, for the case of GE>0.3 of zooplankton, zooplankton need higher production to adapt to high predations in the scenario ‘after artificial reefs deployments’. Also it is normal in the manual that for some fast-growing fish larvae or plankton or bacteria, they have higher P/Q values. In some papers (Wu et al., 2016; Okey et al., 2004; Ortiz et al., 2002), there are many cases of P/Q(GE)>0.3 including GE>0.3 of zooplankton. Please check them as the followings.

Wu, Z., Zhang, X., Lozano-Montes, H. M., & Loneragan, N. R. (2016). Trophic flows, kelp culture and fisheries in the marine ecosystem of an artificial reef zone in the yellow sea. *Estuarine Coastal & Shelf Science*, 182, 86-97.

Okey, T. A., Banks, S., Born, A. F., Bustamante, R. H., Calvopiña, M., & Edgar, G. J., et al. (2004). A trophic model of a galápagos subtidal rocky reef for evaluating fisheries and conservation strategies. *Ecological Modelling*, 172(2), 383-401.

Ortiz, M., & Wolff, M. (2002). Trophic models of four benthic communities in tongoy bay (chile): comparative analysis and preliminary assessment of management strategies. *Journal of Experimental Marine Biology & Ecology*, 268(2), 205-235.

Standard 3 Net Efficiency>GE. (Heymans et al., 2016)

'>' in this table means 'beyond upon'.

Before		After			
Group name	Net efficiency	GE	Group name	Net efficiency	GE
Octopodidae	0.375 >	0.3 0.2	Octopodidae	0.375 >	0.3 0.15
Other cephalopods	0.357 >	9 0.1	Mesopelagic fishes	0.198 >	8 0.07
Mesopelagic fishes	0.198 >	6 0.0	Demersal fishes	0.091 >	3
Demersal fishes	0.054 >	4 0.2	Sebastes schlegelii	0.237 >	0.19
Gobiidae	0.366 >	9 0.2	Hexagrammos otakii	0.158 >	7 0.25
Sebastes schlegelii	0.283 >	3 0.1	Gobiidae	0.321 >	7 0.17
Charybdis japonica	0.162 >	3	Charybdis japonica	0.216 >	2
Oratosquilla oratoria	0.375 >	0.3	Oratosquilla oratoria	0.333 >	7
Large crustacean	0.375 >	0.3	Large crustacean	0.375 >	0.3
Zoobenthos	0.25 >	0.2 0.2	Other cephalopods	0.375 >	0.3 0.28
Zooplankton	0.365 >	2	Rapana venosa	0.355 >	4 0.17
Phytoplankton			Sea cucumber	0.298 >	9
Detritus			Zoobenthos	0.25 >	0.2 0.11
			Oyster	0.188 >	3 0.32
			Zooplankton	0.411 >	9
			Phytoplankton		
			Detritus		

Standard 4 Respiration/Assimilation Biomass (RA/AS)<1.0. (Heymans et al., 2016)

Before		After	
Group name	RA/AS	Group name	RA/AS
Octopodidae	0.625	Octopodidae	0.625
Other cephalopods	0.6428571	Mesopelagic fishes	0.8020362
Mesopelagic fishes	0.8020362	Demersal fishes	0.9090142
Demersal fishes	0.946009	Sebastes schlegelii	0.7628303
Gobiidae	0.6339678	Hexagrammos otakii	0.8416952
Sebastes schlegelii	0.7169812	Gobiidae	0.6785715
Charybdis japonica	0.8383621	Charybdis japonica	0.7844828
Oratosquilla oratoria	0.625	Oratosquilla oratoria	0.6666667
Large crustacean	0.625	Large crustacean	0.625
Zoobenthos	0.75	Other cephalopods	0.625
Zooplankton	0.6350001	Rapana venosa	0.64539
Phytoplankton		Sea cucumber	0.7023809
Detritus		Zoobenthos	0.75
		Oyster	0.8121432
		Zooplankton	0.589375
		Phytoplankton	
		Detritus	

As a guideline, K selected species, which are expected to invest a relatively small proportion of energy intake in somatic and gonadal tissue production are expected to have RA/AS ratios close to 1.0. In contrast, r-selected species are more likely to invest a greater proportion of energy intake into growth and reproduction resulting in an RA/AS ratio well below 1.0.

Standard 5 Respiration/Biomass (RA/B) indicates the “metabolic activity level” of a group. (Heymans et al., 2016)

Before		After	
Group name	RA/B (/year)	Group name	RA/B (/year)
Octopodidae	3.5	Octopodidae	3.5
Other cephalopods	3.6	Mesopelagic fishes	14.18
Mesopelagic fishes	14.18	Demersal fishes	9.99072
Demersal fishes	10.39732	Sebastes schlegelii	3.2344
Gobiidae	3.8104	Hexagrammos otakii	4.9155
Sebastes schlegelii	3.04	Gobiidae	7.6
Charybdis japonica	7.78	Charybdis japonica	7.280001
Oratosquilla oratoria	3.5	Oratosquilla oratoria	16
Large crustacean	10	Large crustacean	10
Zoobenthos	5.01	Other cephalopods	5
Zooplankton	114.3	Rapana venosa	1.456
Phytoplankton		Sea cucumber	1.416
Detritus		Zoobenthos	5.01
		Oyster	5.116502
		Zooplankton	94.3
		Phytoplankton	
		Detritus	

RA/B ratios are expected to be within $1\text{-}10 \text{ year}^{-1}$ for mammals, fishes and may be as high as $50\text{-}100 \text{ year}^{-1}$ for groups with higher turnover such as plankton. There are perfect values in this table.

Standard 6 Production/Respiration (P/RA)<1.0 (Heymans et al., 2016)

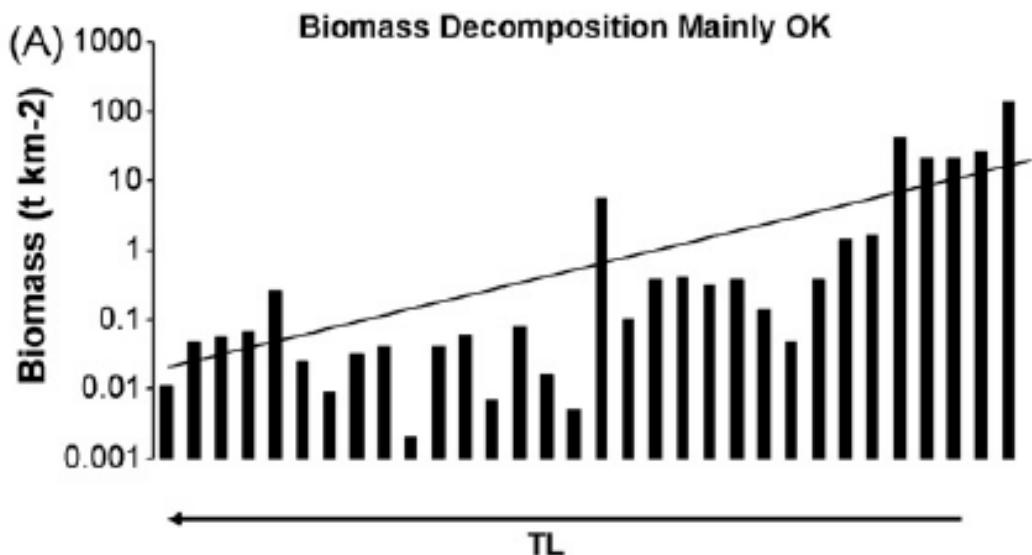
Before		After	
Group name	Production / respiration	Group name	Production / respiration
Octopodidae	0.6	Octopodidae	0.6
Other cephalopods	0.5555556	Mesopelagic fishes	0.2468265
Mesopelagic fishes	0.2468265	Demersal fishes	0.1000929
Demersal fishes	0.0570724	Sebastes schlegelii	0.3109077
Gobiidae	0.5773672	Hexagrammos otakii	0.1880785
Sebastes schlegelii	0.3947368	Gobiidae	0.4736842
Charybdis japonica	0.1928021	Charybdis japonica	0.2747253
Oratosquilla oratoria	0.6	Oratosquilla oratoria	0.5
Large crustacean	0.6	Large crustacean	0.6
Zoobenthos	0.3333333	Other cephalopods	0.6
Zooplankton	0.5748031	Rapana venosa	0.5494506
Phytoplankton		Sea cucumber	0.4237289
Detritus		Zoobenthos	0.3333333
		Oyster	0.23131
		Zooplankton	0.6967126
		Phytoplankton	
		Detritus	

According to the paper “Adding rigor to ecological network models by evaluating a set of pre- balance diagnostics: a plea for PREBAL”, we made a pre-balance analysis as the followings.

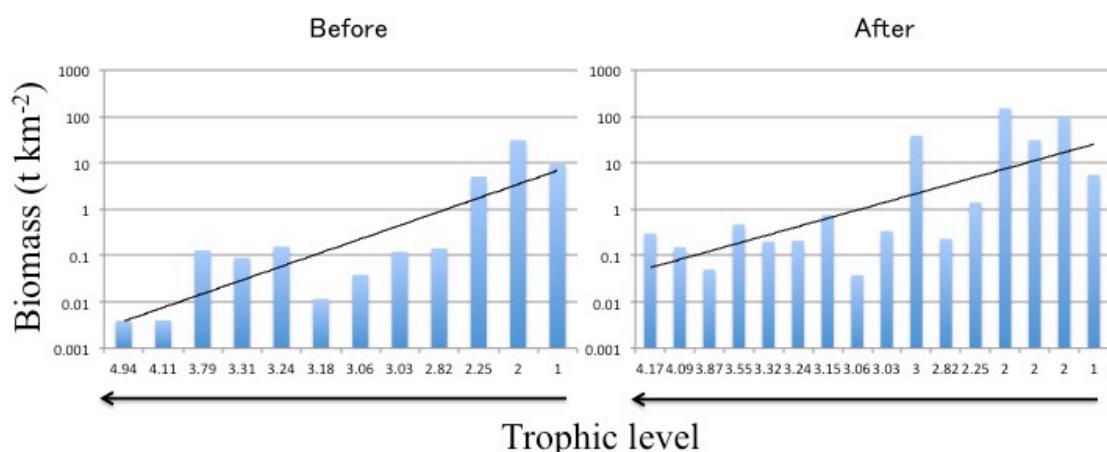
Standard 1 Biomass across taxa and trophic levels

- (1) The range of biomass should span 5-7 orders of magnitude (y-axis log scale).
- (2) Slope (on log scale) should be ~5-10% decline.

The sample figure (Link et al. 2010)



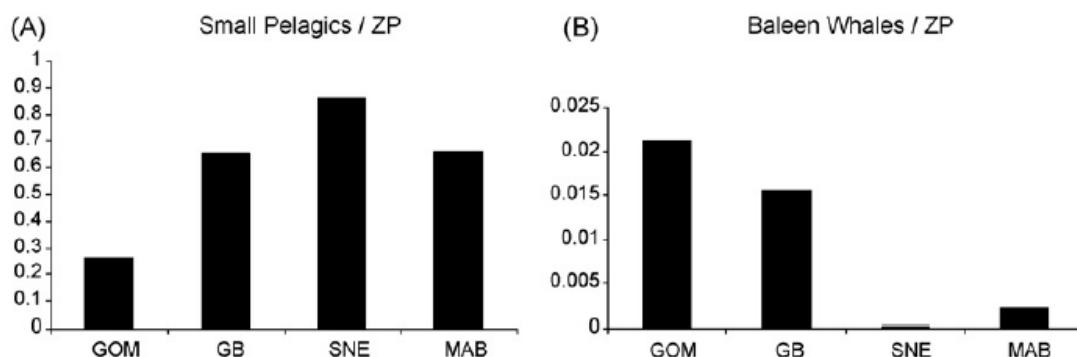
Biomass Decomposition mainly OK.



Standard 2 Biomass ratios

- (1) Compared across taxa, total predator biomass should less than that of their prey.
- (2) The number of zeros in these ratios indicates the potential trophic difference between predators and prey.

The sample figure (Link et al. 2010)



Before Artificial reefs deployments

e.g. Predator item biomass/prey item biomass

Octopodidae/Demersal fishes	0.027452903
Octopodidae/Gobiidae	0.030153846
Octopodidae/Charybdis japonica	0.340277778
Octopodidae/Oratosquilla oratoria	0.102003643

Other cephalopods/Zoobenthos	0.005025765
Other cephalopods/Zooplankton	0.030872258

Mesopelagic fishes/Other cephalopods	57.67%
Mesopelagic fishes/Demersal fishes	63.03%
Mesopelagic fishes/Gobiidae	69.23%
Mesopelagic fishes/Large crustacean	75.00%
Mesopelagic fishes/Zoobenthos	0.29%
Mesopelagic fishes/Zooplankton	1.78%
Mesopelagic fishes/Phytoplankton	0.95%

Demersal fishes/Other cephalopods	0.915027235					
Demersal fishes/Zoobenthos	0.004598712					
Demersal fishes/Zooplankton	0.028248956					
Demersal fishes/Phytoplankton	0.015138889					
Demersal fishes/Detritus	0.005739309					
Gobiidae/Other cephalopods	0.833066325					
Gobiidae/Zoobenthos	0.004186795					
Sebastes schlegelii/Other cephalopods	0.02563281					
Sebastes schlegelii/Mesopelagic fishes	0.044444444					
Sebastes schlegelii/Demersal fishes	0.028013166					
Sebastes schlegelii/Gobiidae	0.030769231					
Sebastes schlegelii/Large crustacean	0.033333333					
Charybdis japonica/Gobiidae	8.86%					
Charybdis japonica/Zoobenthos	0.04%					
Oratosquilla oratoria/Zoobenthos	0.12%					
Oratosquilla oratoria/Zooplankton	0.76%					
After Artificial reefs deployments						
e.g. Predator item biomass/prey item biomass						
	Gobiidae		Charybdis japonica			
Octopodidae	63.83%		39.79%			
	Gobiidae	Large crustacea	Other cephalopods	Zoobenthos	Zooplankton	Phytoplankton
Mesopelagic fishes	42.55%	58.82%	95.24%	0.64%	14.27%	3.60%

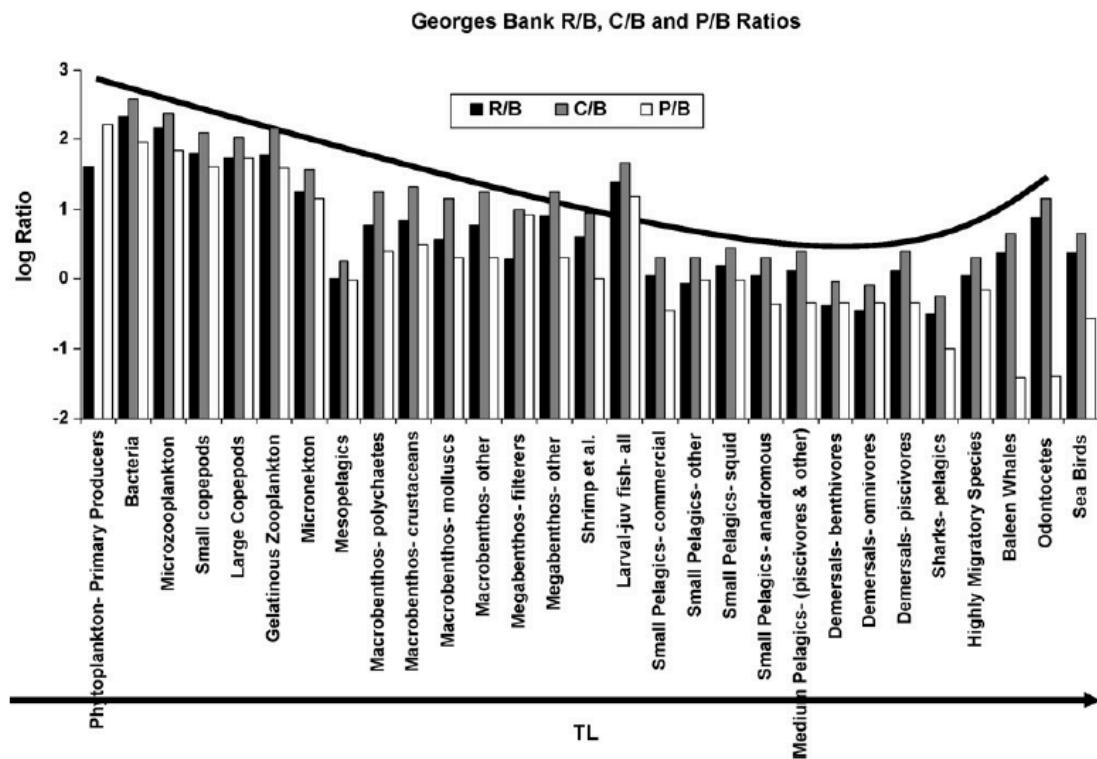
	Gobiid ae	Large crustacean	Zoobenth os	Zooplankt on	Phytoplankt on	Detrit us
Demersal fishes	48.94%	67.65%	0.74%	16.41%	4.14%	0.92%
	Mesopelagic fishes	Demersal fishes	Gobiid ae	Large crustacean	Other cephalopods	
<i>Sebastes schlegelii</i>	75.50%	65.65%	32.13 %	44.41%	71.90%	
	Large crustacean	Other cephalopods	Zoobenthos	Zooplankto n		
<i>Hexagrammos otakii</i>	14.71%	23.81%	0.16%	3.57%		
	Zoobenthos					
<i>Gobiidae</i>		1.51%				
	Zoobenthos					
<i>Charybdis japonica</i>		2.43%				
	Zoobenthos		Zooplankton			
<i>Oratosquilla oratoria</i>	0.12%		2.71%			
	Zoobenthos		Zooplankton			
Other cephalopods	0.68%		14.98%			
	Oyster					
<i>Rapana venosa</i>		39.87%				

They are both ok in the standard 2 biomass ratio.

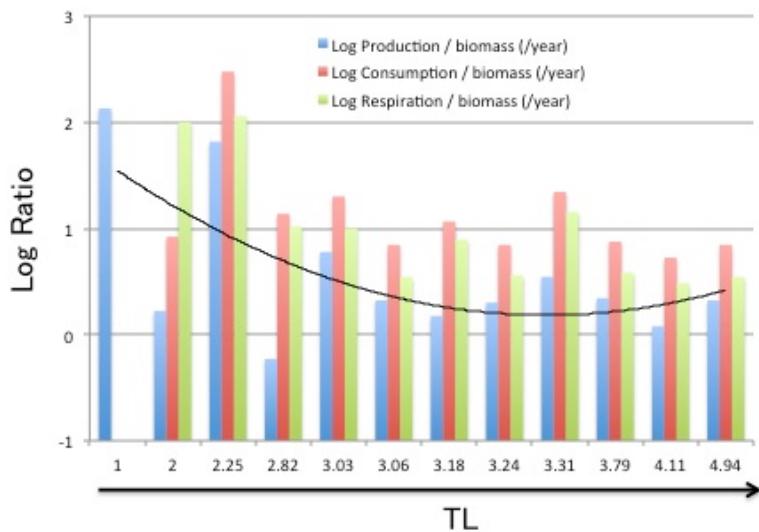
Standard 3 Vital rates across taxa and trophic levels

- (1) Q/B(Consumption/biomass), P/B(Production/biomass), R/B (Respiration/biomass), the principle being similar to *Standard 1 “Biomass across taxa and trophic levels”*.
- (2) Taxa notably above or below trend merit further attention.

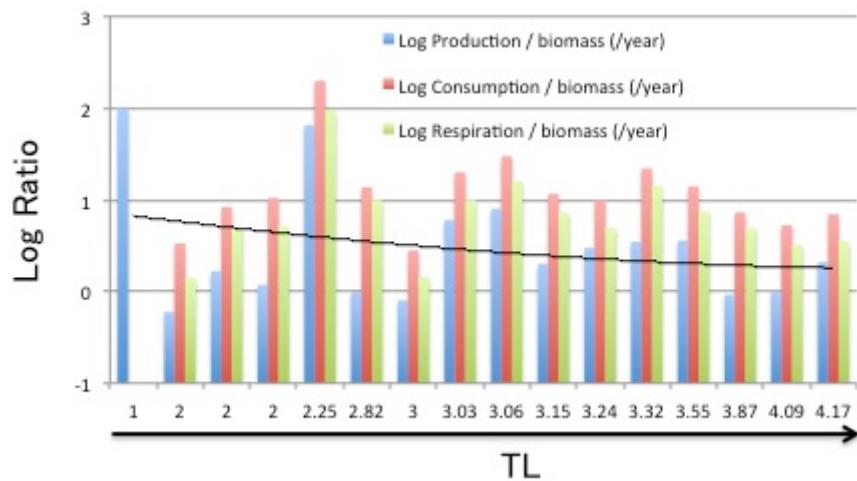
The sample figure (Link et al. 2010)



Before Artificial reefs deployments



After Artificial reefs deployments

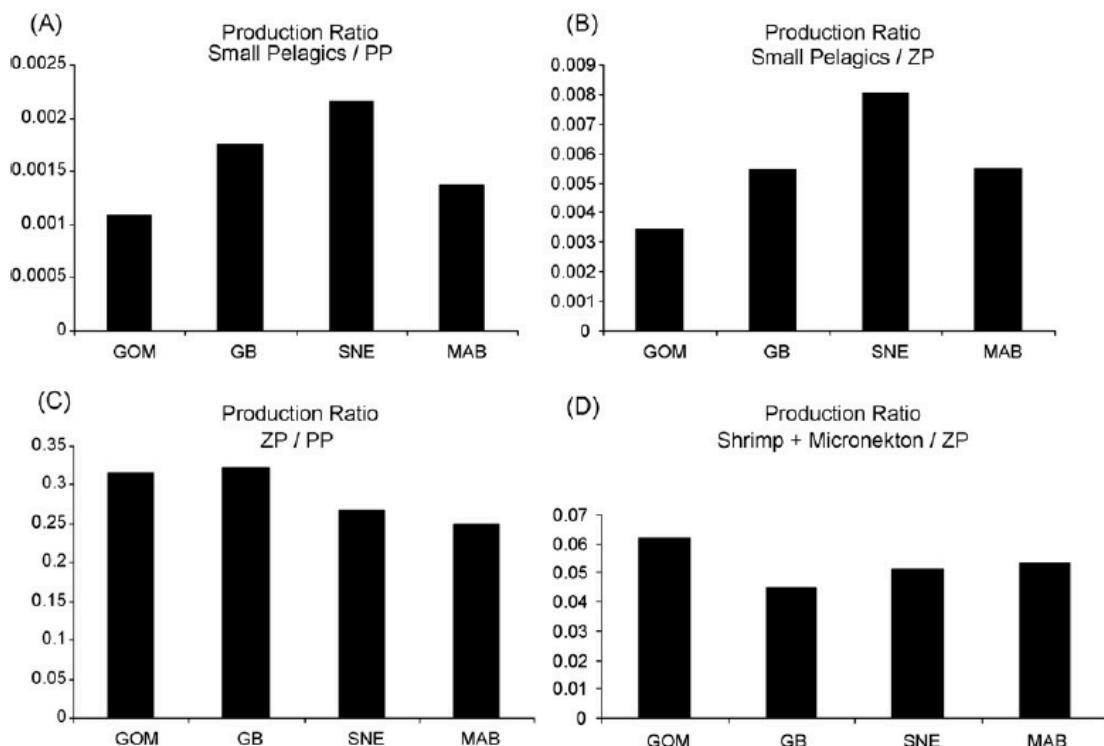


These 2 figures basically obey the principle, so there passed the test.

Standard 4 Vital rate ratios (Q/B, P/B, R/B)

- (1) Compared across taxa, predators *should* be less than 1 relative to their prey.
(Q/B, P/B, R/B)
- (2) No taxa should have a P relative to PP>, or even close, to 1 (only P/B)
- (3) Compared across vital rates; P/Cs or P/Rs near 1 merit reevaluating (P/Q,P/R)

The sample figure (Link et al. 2010)



Before Artificial reefs deployments

Most of ratios of P/Bs, Q/Bs and R/Bs were less than 1, showing the correctness of the model before artificial reefs deployments.(Compared across taxa, predators *should* be less than 1 relative to their prey. (Q/B, P/B, R/B))

	P/B	Q/B	R/B
Octopodidae/Demersal fishes	3.559322034	0.509461426	0.336625207
Octopodidae/Gobiidae	0.954545455	0.932090546	0.918538736
Octopodidae/Charybdis japonica	1.4	0.603448276	0.449871465
Octopodidae/Oratosquilla oratoria	1	1	1

	P/B	Q/B	R/B
Other cephalopods/Zoobenthos	1.19760479	0.838323353	0.718562874
Other cephalopods/Zooplankton	0.0304414	0.023333333	0.031496063

	P/B	Q/B	R/B
Mesopelagic fishes/Other cephalopods	1.75	3.157142857	3.938888889
Mesopelagic fishes/Demersal fishes	5.93220339	1.608442504	1.363812983
Mesopelagic fishes/Gobiidae	1.590909091	2.942743009	3.721394079
Mesopelagic fishes/Large crustacean	0.583333333	1.105	1.418
Mesopelagic fishes/Zoobenthos	2.095808383	2.646706587	2.830339321
Mesopelagic fishes/Zooplankton	0.053272451	0.073666667	0.124059493
Mesopelagic fishes/Phytoplankton	0.025925926		

	P/B	Q/B	R/B
Demersal fishes/Other cephalopods	0.295	1.962857143	2.888144444
Demersal fishes/Zoobenthos	0.353293413	1.645508982	2.075313373
Demersal fishes/Zooplankton	0.008980213	0.0458	0.090965179
Demersal fishes/Phytoplankton	0.00437037		

	P/B	Q/B	R/B
Gobiidae/Other cephalopods	1.1	1.072857143	1.058444444
Gobiidae/Zoobenthos	1.317365269	0.899401198	0.760558882

	P/B	Q/B	R/B
Sebastes schlegelii/Other cephalopods	0.6	0.757142857	0.844444444
Sebastes schlegelii/Mesopelagic fishes	0.342857143	0.239819005	0.21438646
Sebastes schlegelii/Demersal fishes	2.033898305	0.38573508	0.292383037
Sebastes schlegelii/Gobiidae	0.545454545	0.705725699	0.797816502
Sebastes schlegelii/Large crustacean	0.2	0.265	0.304

	P/B	Q/B	R/B
Charybdis japonica/Gobiidae	0.681818182	1.54460719	2.041780391
Charybdis japonica/Zoobenthos	0.898203593	1.389221557	1.552894212

	P/B	Q/B	R/B
Oratosquilla oratoria/Zoobenthos	1.25748503	0.838323353	0.698602794
Oratosquilla oratoria/Zooplankton	0.03196347	0.023333333	0.030621172

P/B of other taxa functional groups against P/B of primary production, and they must be less than 1. (No taxa should have a P relative to PP>, or even close, to 1. (only P/B)).

They are prefect in the following table.

Octopodidae/PP	0.015555556
Other cephalopods/PP	0.014814815
Mesopelagic fishes/PP	0.025925926
Demersal fishes/PP	0.00437037
Gobiidae/PP	0.016296296
Sebastes schlegelii/PP	0.008888889
Charybdis japonica/PP	0.011111111
Oratosquilla oratoria/PP	0.015555556
Large crustacean/PP	0.044444444
Zoobenthos/PP	0.01237037
Zooplankton/PP	0.486666667

Compared across vital rates; P/Qs or P/Rs near 1 merit reevaluating (P/Q,P/R). We had reported P/Q in the above table. Here we report the values of P/Rs. They are prefect in this table.

Group name	P/R
Octopodidae	0.6
Other cephalopods	0.555555556
Mesopelagic fishes	0.246826516
Demersal fishes	0.056745392
Gobiidae	0.577367206
<i>Sebastes schlegelii</i>	0.394736842
<i>Charybdis japonica</i>	0.192802057
<i>Oratosquilla oratoria</i>	0.6
Large crustacean	0.6
Zoobenthos	0.333333333
Zooplankton	0.57480315
Phytoplankton	
Detritus	

After Artificial reefs deployments

	P/B	Q/B	R/B
Octopodidae/Gobiidae	0.583333333	0.5	0.460526316
Octopodidae/ <i>Charybdis japonica</i>	1.05	0.603448276	0.480769165

	P/B	Q/B	R/B
Mesopelagic fishes/Gobiidae	0.972222222	1.578571429	1.865789474
Mesopelagic fishes/Large crustacean	0.583333333	1.105	1.418
Mesopelagic fishes/Other cephalopods	1.166666667	2.21	2.836
Mesopelagic fishes/Zoobenthos	2.095808383	2.646706587	2.830339321
Mesopelagic fishes/Zooplankton	0.053272451	0.1105	0.150371156
Mesopelagic fishes/Phytoplankton	0.035		

	P/B	Q/B	R/B
Demersal fishes/Gobiidae	0.277777778	0.981285714	1.314568421
Demersal fishes/Large crustacean	0.166666667	0.6869	0.999072
Demersal fishes/Zoobenthos	0.598802395	1.645269461	1.994155689
Demersal fishes/Zooplankton	0.0152207	0.06869	0.105946129
Demersal fishes/Phytoplankton	0.01		

	P/B	Q/B	R/B
Sebastes schlegelii/Mesopelagic fishes	0.287428571	0.239819005	0.22809591
Sebastes schlegelii/Demersal fishes	1.006	0.385791236	0.323740431
Sebastes schlegelii/Gobiidae	0.279444444	0.378571429	0.425578947
Sebastes schlegelii/Large crustacean	0.167666667	0.265	0.32344
Sebastes schlegelii/Other cephalopods	0.335333333	0.53	0.64688

	P/B	Q/B	R/B
Hexagrammos otakii/Large crustacean	0.154166667	0.365	0.49155
Hexagrammos otakii/Other cephalopods	0.308333333	0.73	0.9831
Hexagrammos otakii/Zoobenthos	0.553892216	0.874251497	0.981137725
Hexagrammos otakii/Zooplankton	0.014079148	0.0365	0.052126193

	P/B	Q/B	R/B
Gobiidae/Zoobenthos	2.155688623	1.676646707	1.516966068

	P/B	Q/B	R/B
Charybdis japonica/Zoobenthos	1.19760479	1.389221557	1.453094012

	P/B	Q/B	R/B
Oratosquilla oratoria/Zoobenthos	4.790419162	3.592814371	3.193612774
Oratosquilla oratoria/Zooplankton	0.121765601	0.15	0.169671262

	P/B	Q/B	R/B
Other cephalopods/Zoobenthos	1.796407186	1.19760479	0.998003992

Other cephalopods/Zooplankton	0.0456621	0.05	0.053022269
	P/B	Q/B	R/B
Rapana venosa/Oyster	0.67624683	0.268571429	0.284569419

P/B of other taxa functional groups against P/B of primary production, and they must be less than 1. (No taxa should have a P relative to PP>, or even close, to 1. (only P/B)). They are prefect in the following table.

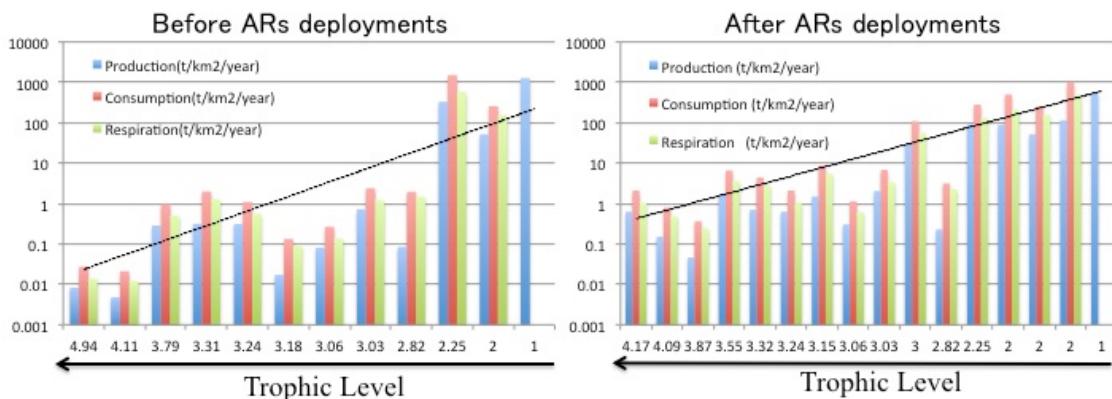
Octopodidae/PP	0.021
Mesopelagic fishes/PP	0.035
Demersal fishes/PP	0.01
Sebastes schlegelii/PP	0.01006
Hexagrammos otakii/PP	0.00925
Gobiidae/PP	0.036
Charybdis japonica/PP	0.02
Oratosquilla oratoria/PP	0.08
Large crustacean/PP	0.06
Other cephalopods/PP	0.03
Rapana venosa/PP	0.008
Sea cucumber/PP	0.006
Zoobenthos/PP	0.0167
Oyster/PP	0.01183

Compared across vital rates; P/Qs or P/Rs near 1 merit reevaluating (P/Q,P/R). We had reported P/Q in the above table. Here we report the values of P/Rs. They are prefect in this table.

Group name	P/R
Octopodidae	0.6
Mesopelagic fishes	0.246826516
Demersal fishes	0.100092886
Sebastes schlegelii	0.311031412
Hexagrammos otakii	0.188180246
Gobiidae	0.473684211
Charybdis japonica	0.274725237
Oratosquilla oratoria	0.5
Large crustacean	0.6
Other cephalopods	0.6
Rapana venosa	0.549450549
Sea cucumber	0.423728814
Zoobenthos	0.333333333
Oyster	0.231212653
Zooplankton	0.696712619

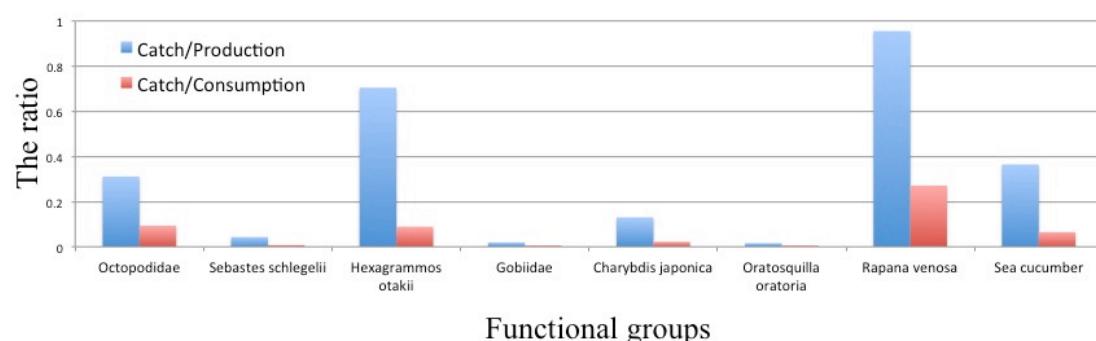
Standard 5 Total production and removals

- (1) Total, scaled values should again follow a decomposition with increasing TL
(Production, Consumption, and Respiration)
- (2) Total human removals should be less than total production of a taxa.
- (3) Total human removals should be compared to consumption of a taxa
Total, scaled values should again follow a decomposition with increasing TL
(Production, Consumption, and Respiration).



Total human removals should be less than total production of a taxa. Total human removals should be compared to consumption of a taxa. (Catches/Production<1, Catches/Consumption<1)

They are perfect in these ratios according to the following figure.



References

- Link, J.S., 2010. Adding rigor to ecological network models by evaluating a set of pre-balance diagnostics: a plea for PREBAL. *Ecol. Model.* 221, 1580–1591.
- Heymans, J.J., Coll, M., Link, J.S., Mackinson, S., Steenbeek, J., Walters, C., Christensen, V., 2016. Best practice in Ecopath with Ecosim food-web models for ecosystem-based management. *Ecol. Model.* 331, 173–184.