*The following supplements accompany the article*

# Effects of large enemies on success of exotic species in marine fouling communities of Washington, USA

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## SUPPLEMENT 1. ENEMY FUNCTIONAL GROUPS

I defined enemies as any mobile organism that is known to consume all or part of sessile fouling organisms. Enemies visible to my eye were identified and quantified during surveys from 2006 to 2007 (13–16 surveys per site over 16 months). I then classified them into 3 functional groups: large mollusks, small mollusks and flatworms.

**Large mollusks** included species of chitons and keyhole limpets whose adults where >1 cm in length. All large mollusk species recorded in this study (Table S1a) have been reported to cause fouling invertebrate mortality either through direct consumption or inadvertent ‘bull-dozing’ while grazing for algae.

**Small mollusks** included gastropods whose adults were <1 cm in length and nudibranchs of all sizes (Table S1b). These species are believed to be more specialized predators, and either bull-doze very little given their small size and radula morhpology (gastropods, Steneck & Watling 1982) or do not bull-doze but rather specialize on taxonomically narrow group of prey (nudibranchs, Behrens 1991).

**Flatworms** included any species in the phylum Platyhelminthes or Acoela (Table S1c). Flatworms are generally small, mobile predators and their prey can include ascidians, bryozoans, crustaceans, hydroids, mollusks and polycheates. *Eurylepta leoparda*, a large flatworm that consumes the solitary ascidian *Corella inflata* (Lambert 1968), was found only at Wayne.

## LITERATURE CITED

Behrens DW (1992) Pacific Coast nudibranchs, 2nd edn. Sea challengers, Monterey, CA

Lambert G (1968) The general ecology and growth of a solitary ascidian, *Corella willmeriana*. Biol Bull 135:296–307

Steneck RS, Watling L (1982) Feeding capabilities and limitation of herbivorous mollusks: a functional group approach. Mar Biol 68:299–319

**Table S1.** Species composition of each functional group across sites. Taxon presence at a study site at any time during May 2006–Sep 2007 is denoted by an ‘x’

**a. Large Mollusks**

| Species | Description | Makah | Lopez | Wayne | Pleasant |
|---|---|---|---|---|---|
| *Diodora aspera* | keyhole limpet | x | | | |
| *Mopalia muscosa* | chiton | x | | x | |
| *Mopalia* sp. | chiton | x | x | x | x |
| *Mopalia spectablis* | chiton | x | x | x | x |
| *Tonicella lineata* | chiton | | x | x | |

**b. Small Mollusks**

| Species | Description | Makah | Lopez | Wayne | Pleasant |
|---|---|---|---|---|---|
| *Aeolidia papillosa* | nudibranch | x | x | | x |
| *Dendronotus frondosus* | nudibranch | x | x | x | |
| *Dialula sandiegensis* | nudibranch | | x | | |
| *Dirona albineata* | nudibranch | x | x | | x |
| *Doris monteryensis* | nudibranch | x | x | | |
| *Doto* sp. | nudibranch | x | x | x | |
| *Janolus fuscus* | nudibranch | x | x | | x |
| *Lacuna* sp. | gastropod | | x | x | x |
| *Laila cockerelli.* | nudibranch | x | | | |
| *Lottia* sp. | limpet | x | x | x | |
| *Margarites* sp. | gastropod | | x | | |
| *Meladobenna* sp. | limpet | | x | | |
| *Onchidoris bilamellata* | nudibranch | | x | | x |
| *Phidiana crassicornis* | nudibranch | x | x | x | x |
| *Sacglossian* sp. | nudibranch | | x | | x |
| small gastropod | gastropod | x | x | | x |
| small nudibranch | nudibranch | x | x | x | x |
| *Triopha maculata* | nudibranch | x | | | |

**c. Flatworms**

| Species | Description | Makah | Lopez | Wayne | Pleasant |
|---|---|---|---|---|---|
| *Eurylepta leoparda* | leopard flatworm | | | x | |
| flatworm | small flatworm | x | x | x | x |
| *Kaburakia excelsa* | giant flatworm | | x | x | x |
| *Notoplana* sp. | common flatworm | x | x | x | x |
| *Vorticeros* sp. | acoel flatworm | x | x | x | x |

# SUPPLEMENT 2. PLOTS OF ALL EXOTIC SPECIES AND 8 MOST ABUNDANT NATIVE SPECIES

In this supplement, the plots of the mean abundance (±1 SE) of all exotic species and the 8 most common native in each experimental treatment (Control, Cage-Control, and Cage) are presented. Species were classified as either exotic or native according to Cohen et al. (2004). The relative abundance of each species (total # individuals of each species/total # individuals of all species*100%) is given in parentheses following the species names. Treatment effects on species abundance were tested with a repeated-measures ANOVA with plate as a random effect. To meet the assumption of normality for the ANOVA test, I log-transformed all data except Corella inflata at Wayne, which required square-root transformation. ANOVA tables are available by request. Significant cage effects are denoted by a large red star in the upper left hand corner of the plot. Significant Cage Treatment*Date effects are denoted by smaller red stars on the bottom of the plots adjacent to the date of the significant effects.

**Fig. S2.1.** Abundance of exotic species and the 8 most common native species at Makah

A. Exotic species at Makah

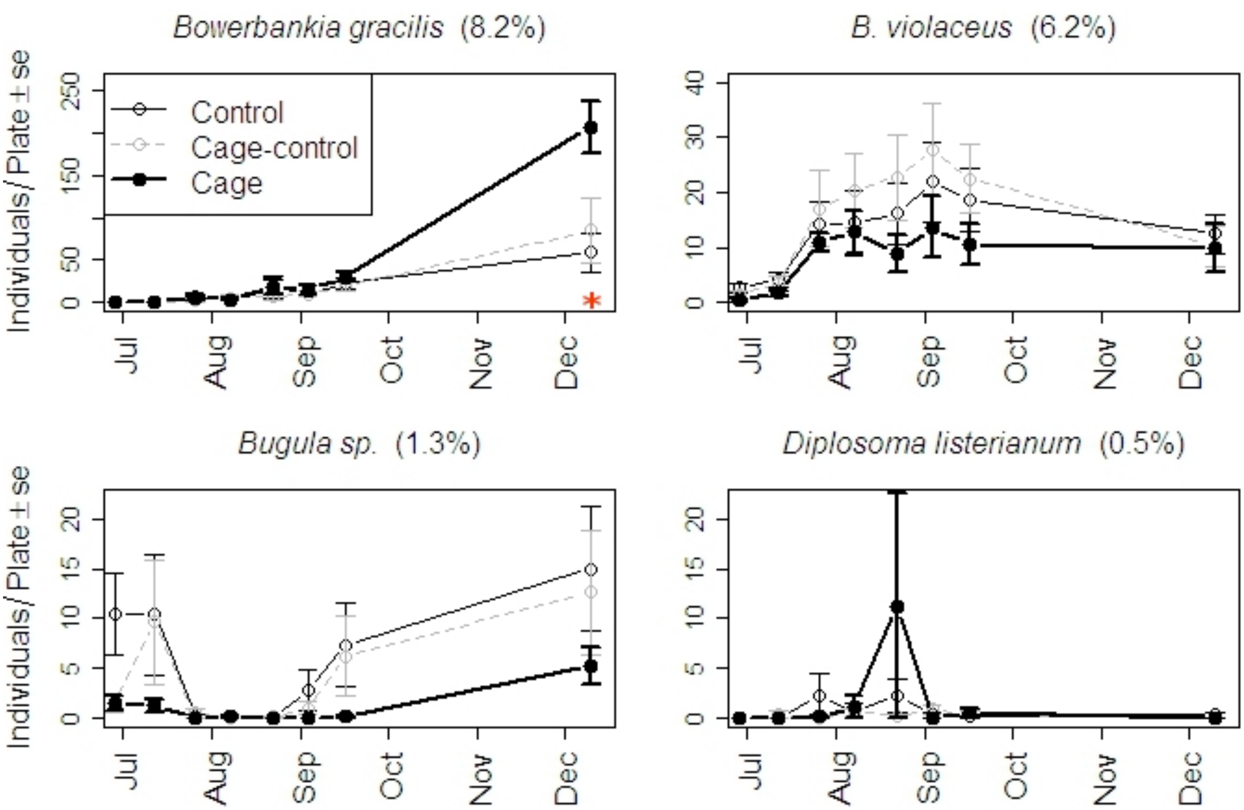


**Fig. S2.1** (continued)

B. Native species at Makah

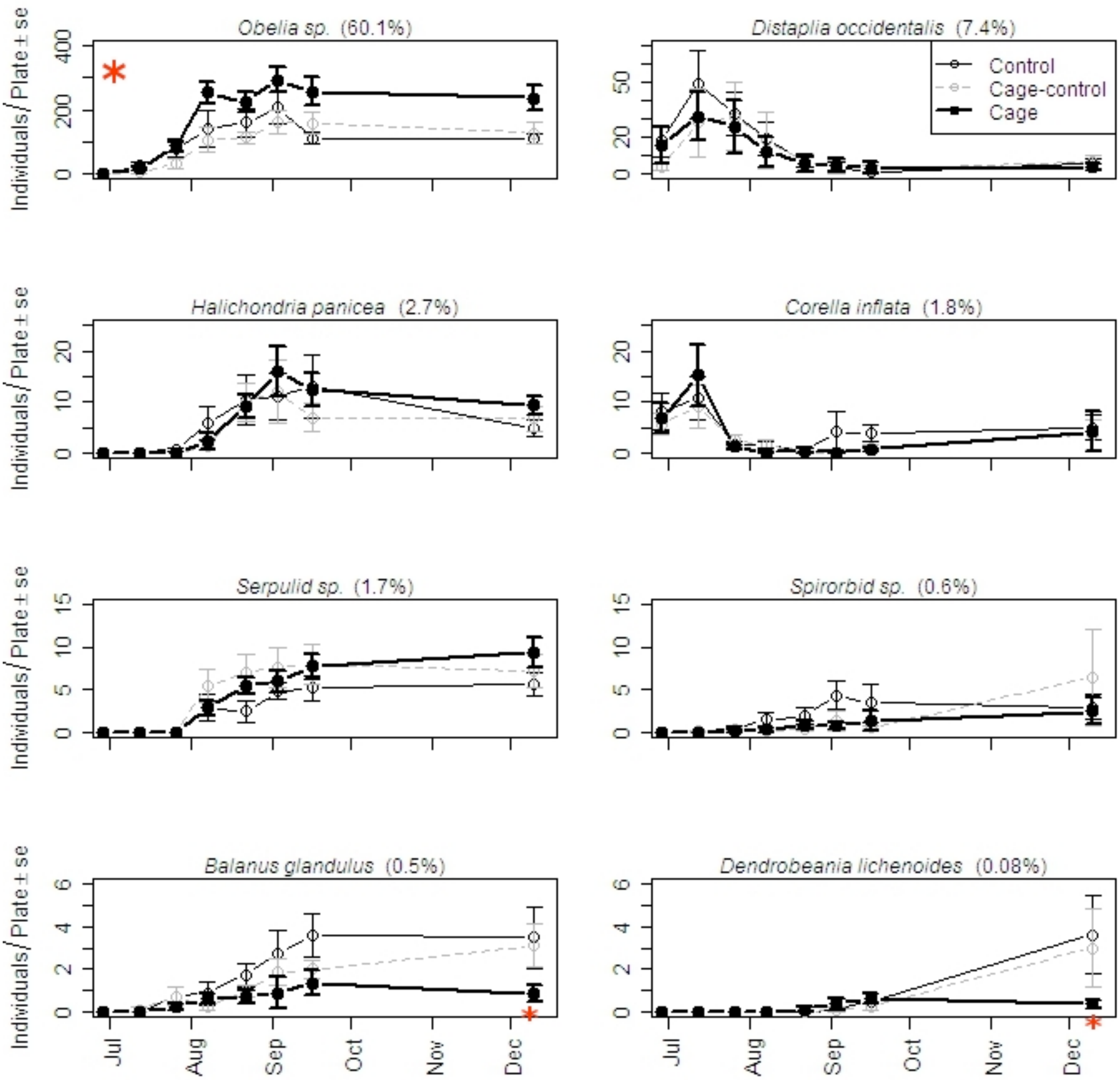


**Fig. S2.2.** Abundance of exotic species and the 8 most common native species at Wayne

A. Exotic species at Wayne

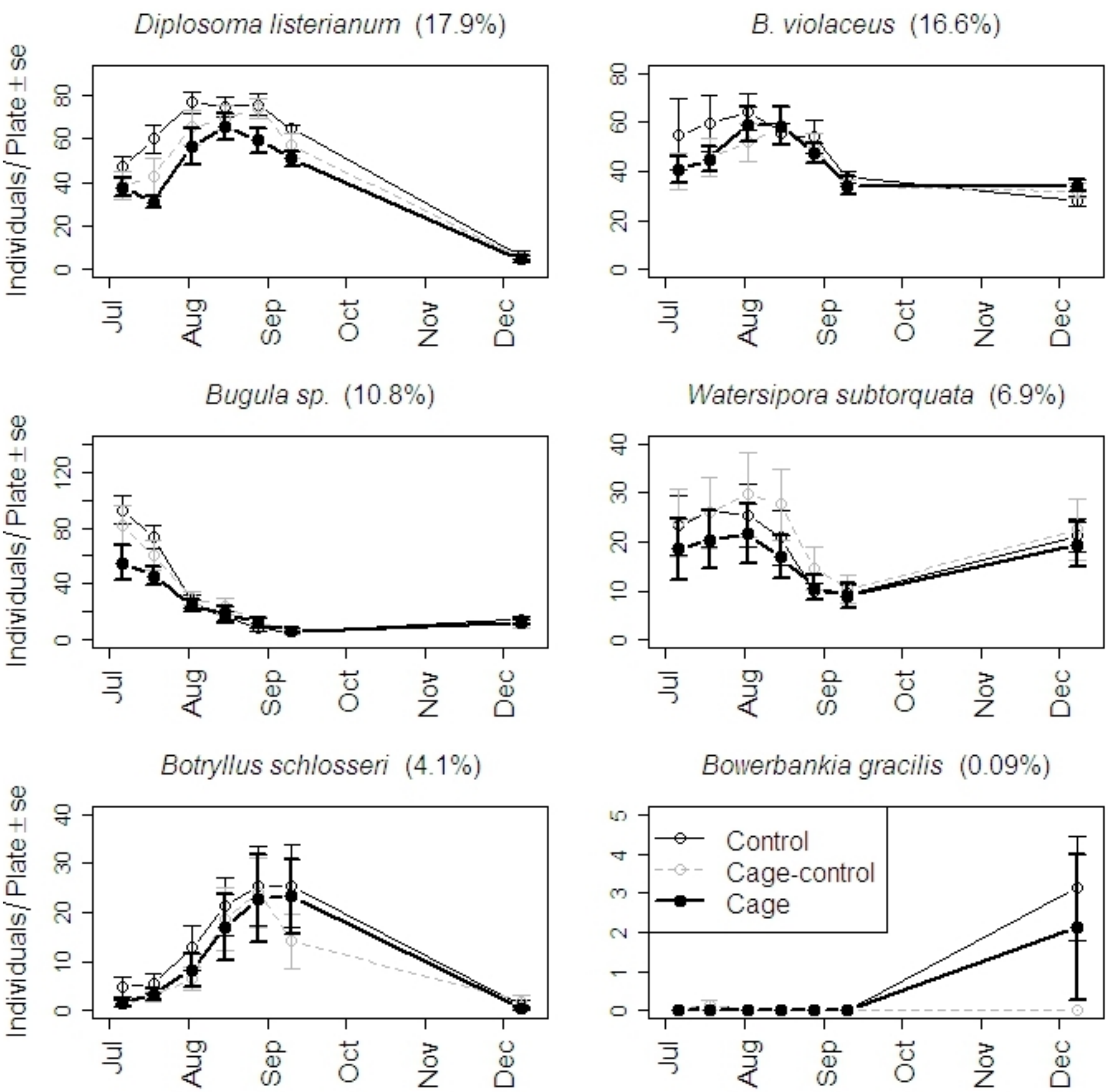


**Fig. S2.2** (continued)

B. Native species at Wayne

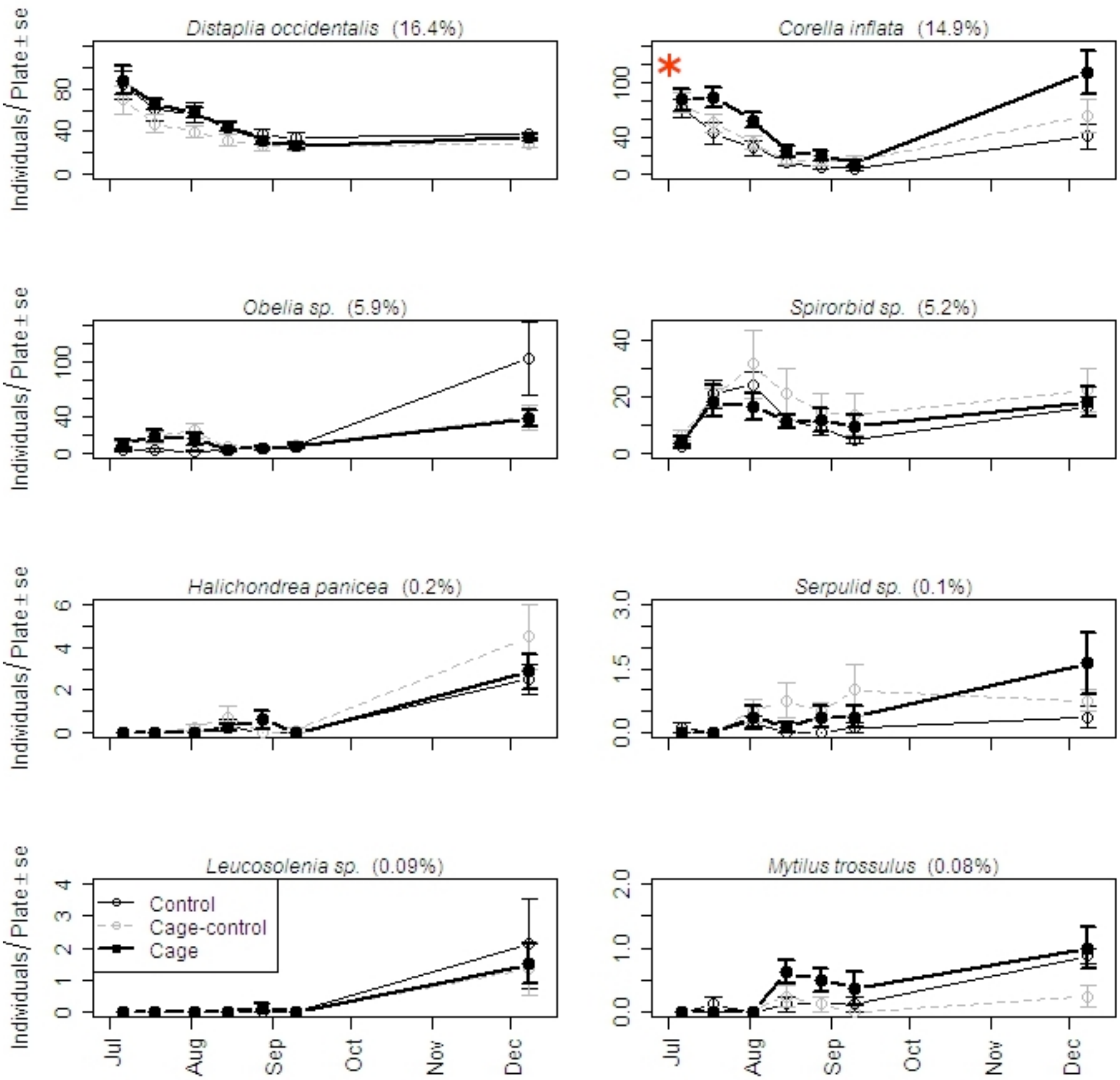


**Fig. S2.3.** Abundance of exotic species and the 8 most common native species at Pleasant

A. Exotic species at Pleasant

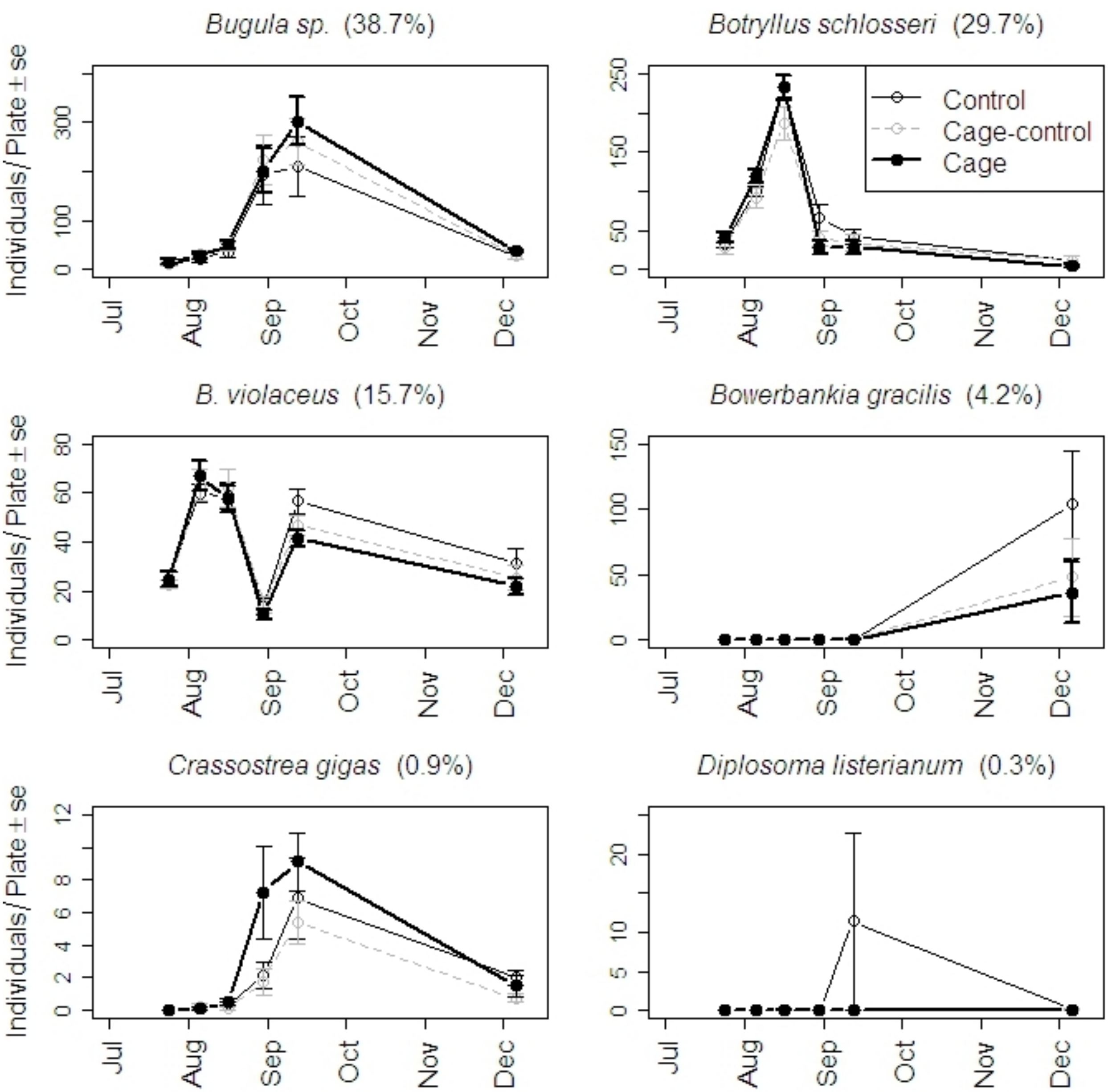


**Fig. S2.3** (continued)

B. Native species at Pleasant

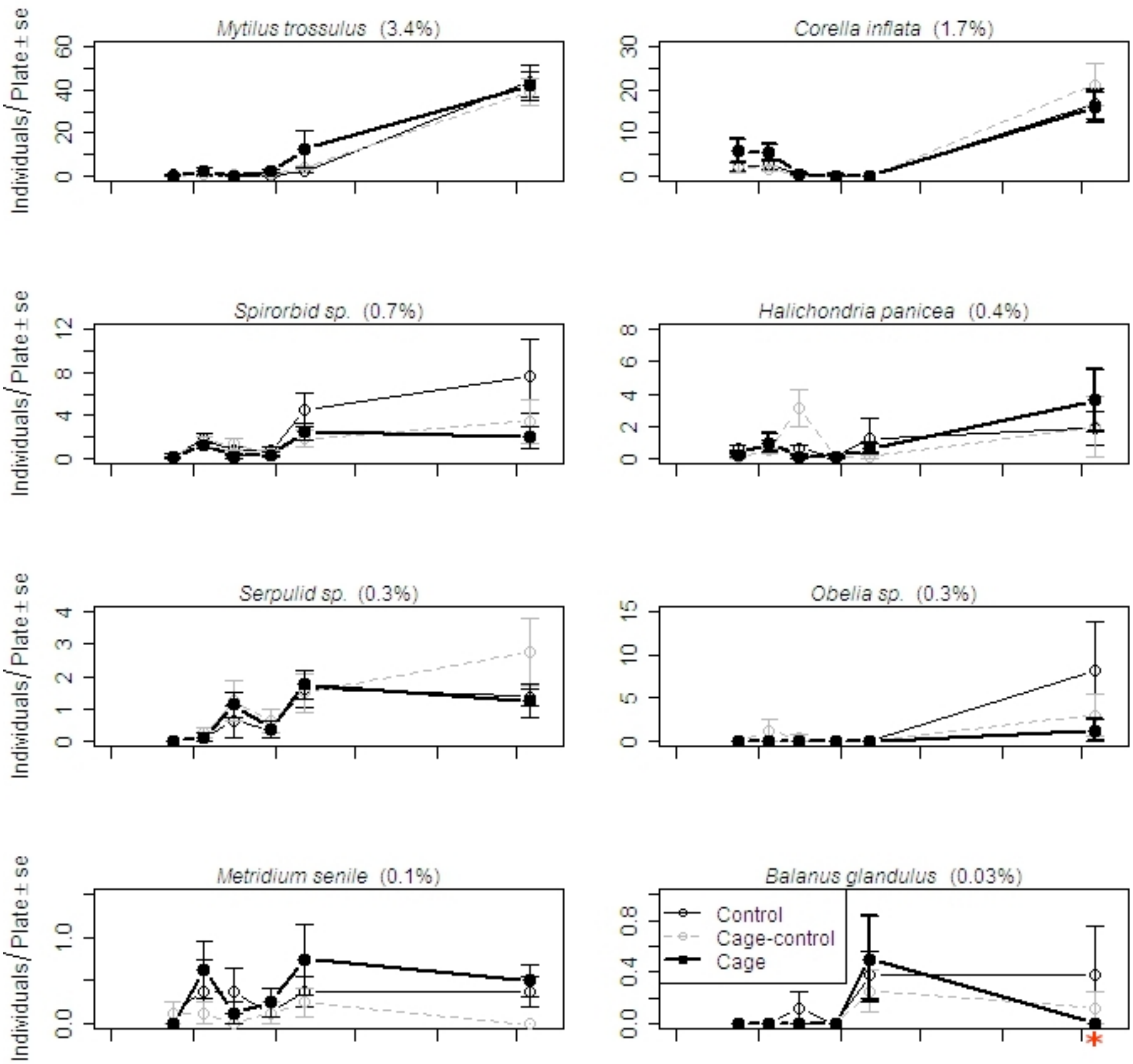


**Fig. S2.4.** Abundance of exotic species and the 8 most common native species at Lopez

A. Exotic Species at Lopez

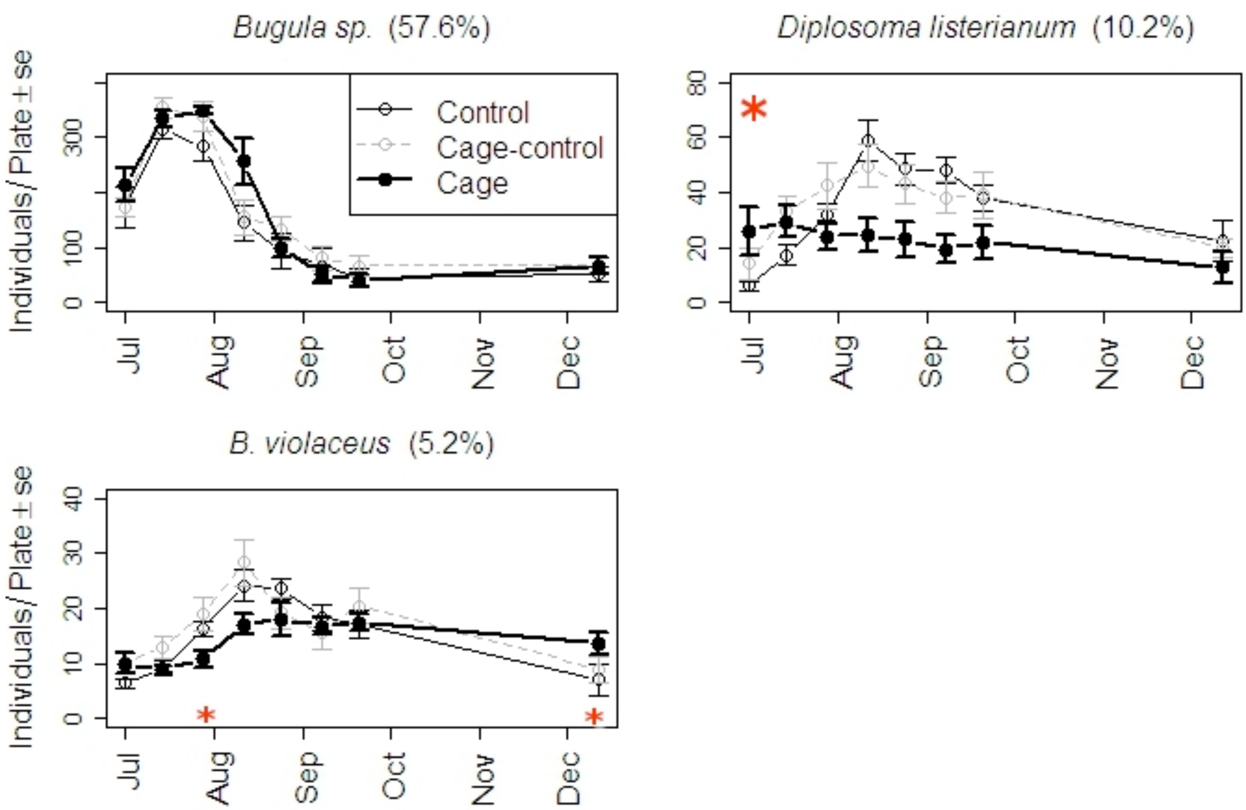
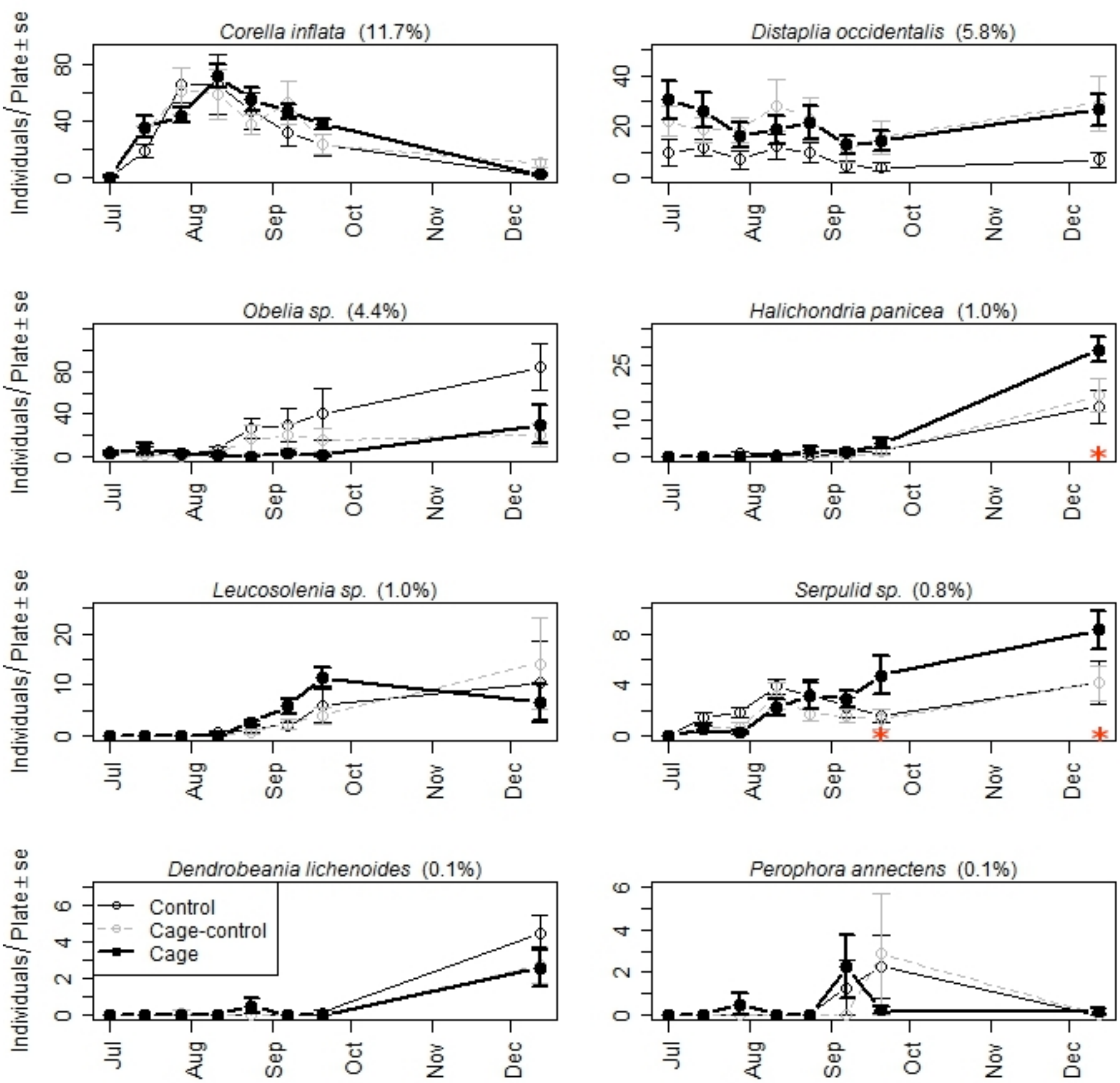


**Fig. S2.4** (continued)

B. Native species at Lopez



## SUPPLEMENT 3. POWER ANALYSIS OF CAGING EXPERIMENT

Given inherent spatial and temporal variability of fouling communities, the predator-exclusion experiments may not have been replicated well enough to detect significant effects of caging treatments on species abundances. I thus conducted a post-hoc power analysis to determine the effect size (% change in mean abundance) that could have been detected by this experiment at each census date (see Thomas 1997 for a review of post-hoc power analysis controversies). I calculated the power to detect a cage treatment response in 3 variables: *Botrylloides violaceus* abundance, the abundance of the most common native species and the abundance of the 2nd most common species at each site.

The power of a statistical test is defined as 1–β, where β is the probability of accepting the null hypothesis (in this case no caging-effect) when it is false. A commonly accepted value for β is 0.2, thus the power of a test is 0.8 under standard assumptions (Magid et al. 1985). For a simple ANOVA, given known variability ($s^2$) and known number of replicates ($n$), the effect-size ($\delta$) can thus be calculated as:

$$\delta^2 = \frac{10*(1-\beta)*s^2}{n} \qquad \text{(S3.1)}$$

I used this equation to calculate the detectable effect-size at β = 0.2 for each species at each census, using the standard deviation of abundance in control and cage-control replicates as a measure of variance ($s^2$). I then calculated and report the effect size (Table S3.1), which is the % change of the mean abundance that would result in rejection of the null hypothesis of no significant cage effect (effect size = $\frac{\sqrt{s^2}}{\bar{x}*100}$, where $\bar{x}$ = mean abundance among cage and cage-control plates).

LITERATURE CITED

Magid MA, Hemmasi M, Lewis MF (1985) In search of power: a statistical power analysis of contemporary research in strategic management. Acad Manage Proc, p 30–34

Thomas L (1997) Retrospective power analysis. Conservn Biol 11:276–280

**Table S3.1.** Statistically detectable effects sizes for each species and each census date. Detectable effects are the treatment effect sizes, measured as percent of means that would have been detected assuming a power of 0.8

| Site | Date | Detectable effects (% of mean) | | |
|---|---|---|---|---|
| | | **Exotic** | **1st Native** | **2nd Native** |
| **Makah** | | *Botrylloides* ***violaceus*** | ***Obelia* sp.** | ***Distaplia occidentalis*** |
| | 6/28/2005 | 194.6 | x | 22.1 |
| | 7/12/2005 | 118.8 | 91.8 | 12.9 |
| | 7/26/2005 | 54.5 | 47.3 | 13.3 |
| | 8/7/2005 | 44.9 | 38.4 | 17.6 |
| | 8/22/2005 | 49.1 | 20.0 | 24.6 |
| | 9/3/2005 | 52.1 | 23.9 | 31.9 |
| | 9/16/2005 | 47.5 | 20.6 | 42.5 |
| | 12/10/2005 | 67.1 | 24.0 | 20.7 |
| **Wayne** | | ***B. violaceus*** | ***Distaplia occidentalis*** | ***Corella inflata*** |
| | 7/6/2005 | 21.0 | 14.9 | 17.6 |
| | 7/18/2005 | 17.0 | 22.6 | 19.3 |
| | 8/2/2005 | 16.1 | 27.9 | 19.1 |
| | 8/15/2005 | 14.1 | 34.7 | 19.9 |
| | 8/28/2005 | 14.7 | 40.1 | 20.6 |
| | 9/10/2005 | 12.6 | 42.6 | 20.3 |
| | 12/8/2005 | 14.7 | 26.3 | 15.1 |
| **Pleasant** | | ***B. violaceus*** | ***Mytilus trossulus*** | ***Corella inflata*** |
| | 7/24/2005 | 17.6 | 76.0 | 30.8 |
| | 8/5/2005 | 11.5 | 32.4 | 26.0 |
| | 8/16/2005 | 13.5 | 40.9 | X |
| | 8/30/2005 | 30.2 | 46.5 | X |
| | 9/12/2005 | 12.8 | 12.0 | X |
| | 12/6/2005 | 26.6 | 2.6 | 8.2 |
| **Lopez** | | ***B. violaceus*** | ***Corella inflata*** | ***Distaplia occidentalis*** |
| | 7/1/2005 | 33.3 | x | 19.5 |
| | 7/14/2005 | 28.7 | 22.8 | 15.2 |
| | 7/28/2005 | 20.3 | 21.7 | 20.6 |
| | 8/11/2005 | 21.5 | 26.6 | 15.8 |
| | 8/24/2005 | 19.7 | 28.0 | 15.7 |
| | 9/7/2005 | 27.5 | 37.3 | 20.6 |
| | 9/20/2005 | 22.6 | 43.1 | 15.8 |
| | 12/12/2005 | 84.0 | x | 15.7 |