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Controlling Undaria and invasive kelps through management of the gametophyte.

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Controlling *Undaria* and invasive kelps through management of the gametophyte.

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Undaria pinnatifida is an invasive species of Asian kelp that was first discovered in California harbors in 2001 (Silva et al. 2002). It has established itself as a successful invasive species in other countries and the California coast is also speculated to be a beneficial habitat for it. To better understand where this new kelp might spread, how successful it might be, and how to manage it in terms of containment more information needs to be gained on its biology and ecology. Along the coast of California there are a variety of native kelps that play key roles in their habitats. An invasive kelp like *Undaria* has the potential to compete with, or out compete, some of these native kelps. Since *Undaria* is a species of kelp it has a heteromorphic life history that includes a microscopic gametophyte stage that has the potential to act as a perennial seed stock. The presence of a seed bank for an invasive species is a very useful reproductive strategy since it could provide an invasive species with multiple opportunities to establish a population in a new habitat. The studies conducted examined this gametophyte life history stage to better understand how it might affect the success of *Undaria* as an invader in California waters.

For this research we examined the growth and reproduction of gametophytes from our ecologically and economically important *Egregia menziesii* and *Macrocystis pyrifera* kelps and compared them with *Undaria*. Newly released spores and already established gametophytes from *Egregia*, *Undaria*, and *Macrocystis* were placed in different combinations with each other. For the purpose of these experiments the older, established gametophytes from cultures are referred to as gametophytes while new gametophytes that were initiated in to the experiment as a spore suspension are referred to as spores. In the first set of experiments the pairs of potential competitors were gown together in the same media but physically separated by a membrane filter. There were two control treatments, one was with no competitor and the other was when the competitor was from the same original culture or spore suspension. The goal of this experiment was to test for the presence of any chemicals that one culture might release that would alter the normal

recruitment, reproduction, or growth of the other. Gametophyte recruitment was determined for spore competitors by counting the number of newly established gametophytes.

These experiments showed that the number of sporophytes produced and gametophyte recruits were influenced by the presence of other gametophytes or spores. *Egregia* gametophytes had similar responses in all treatments. *Undaria* gametophytes produced more sporophytes in the presence of *Egregia* gametophytes and *Egregia* spores than in control treatments. *Egregia* spores had fewer recruits in the presence of *Undaria* spores and *Macrocystis* spores than control treatments. For sporophyte production *Egregia* spores produced more sporophytes in the presence of all tested species of gametophytes (*Egregia*, *Undaria*, and *Macrocystis*). In all treatments *Undaria* spores had very high numbers of recruits and similar numbers of sporophytes produced from the new gametophytes. *Macrocystis* spores had increased recruitment with all competitors, whether spore or gametophyte. All sporophyte production was similar for *Macrocystis* spores. This experiment shows that for *Undaria* gametophytes, *Egregia* spores, and *Macrocystis* spores there were definite interactions occurring that affected gametophyte recruitment and/or the production of sporophytes. These interactions are present between species and within species when considering gametophytes of different ages.

The second set of experiments included the same sets of paired competitors but involved exchanging the media. This media exchange experiment used media from the gametophyte cultures of one species as the new media for the spores and gametophytes of another species. This tested for any allelochemical interactions but eliminated reproductive pheromones and chemicals released in response to other chemicals from the other competitor.

For the media exchange experiment gametophyte recruitment and gametophyte reproduction were again influenced by the gametophyte media in which they were grown. *Egregia* gametophytes had sporophyte production similar to controls. When compared with the response to blank media *Undaria* gametophytes showed a strong trend for less

sporophyte production when given media from *Undaria* gametophytes. *Egregia* spores had a lower number of sporophytes produced when given media from *Egregia* gametophytes and *Undaria* gametophytes than media from the control or from *Macrocystis* gametophytes. *Undaria* spores had more gametophyte recruits in the presence of media from all gametophytes. *Macrocystis* spores showed the same responses as with the membrane competition experiment. There were fewer *Macrocystis* recruits when given media from all gametophytes tested. The media from cultures of gametophytes can affect the recruitment of kelp spores and may also have an affect on sporophyte production. For a summary of all results see table 1.

It is well documented that kelps have the ability to hybridize with other kelps and an invasive kelp could provide greater risk. Gametophytes of *Egregia*, *Undaria*, and *Macrocystis* were separated by sex and then crossed with *Undaria*. Sporophytes that were produced were then assumed to be the result of hybridization between the two species. Sporophytes were produced in combinations that included *Undaria* females with *Macrocystis* males, *Macrocystis* females with *Undaria* males, *Undaria* females with *Egregia* males, and *Egregia* females with *Undaria* males. These sporophytes could be the result of hybridization but there is also the possibility of parthenogenesis or apogamy. Parthenogenetic sporophytes and apogamy produced sporophytes would be the result of a single gametophyte producing a sporophyte without the other sex. To test for this male and female gametophytes of *Egregia*, *Undaria*, and *Macrocystis* were separated and monitored (negative controls). Tests that contained *Undaria* females and tests that contained *Undaria* males produced sporophytes. If the negative cultures did indeed have only one sex these sporophytes could be haploid sporophytes and the sporophytes produced in the hybridization tests may not be hybridized sporophytes. Without DNA testing experimental error, parthenogenesis, and apogamy can not be eliminated as the reasons for the observed sporophytes.

For all experiments it is evident that *Undaria* gametophytes are capable of reproducing after years of vegetative growth. In comparison *Egregia* and *Macrocystis* gametophytes produced much fewer, if any, gametophytes after just a few months of vegetative growth.

Undaria gametophytes have a much higher reproductive capacity than *Egregia* and *Macrocystis* after months of vegetative growth.

It is evident that kelp interactions are not limited to the sporophyte life stage. Our research suggests that the gametophyte life history stage is an important factor in kelp interactions. The data indicate that the establishment of each new generation of sporophyte kelps will be influenced by the reproductive interactions of spores and gametophytes, which to our knowledge has not been observed before.

This research was included in the following publications:

Inderjit, D. J. Chapman, and M. Ranelletti. In press 2005/6. Invasive marine algae: an ecological perspective. Botanical Review.

Ranelletti, M. 2004. Competition among kelp gametophytes, round 1: invasive *Undaria pinnatifida* vs. native *Egregia menziesii*. Western Society of Naturalists Annual Meeting, program of abstracts.

Research included in this report will also be included in full detail with discussion in Marla Ranelletti's thesis for her Master of Science degree in marine science.

Cited reference:

Silva, P. et al. 2002. First report of the Asian kelp *Undaria pinnatifida* in the northeastern Pacific Ocean. Biological Invasions. 4: 333-338.

	EG		UG		MG		egsp		undsp		msp	
	g	sp	g	sp	g	sp	g	sp	g	sp	g	sp
EG	na	=	na	>	na	na	=	>, <	>	=	>	=
UG	na	=	na	=, <	na	na	=	>, <	>	=	>	=
MG	na	=	na	=	na	na	=	>, =	>	=	>	=
egsp	na	=	na	>	na	na	=	=	na	=	>	=
undsp	na	=	na	na	na	na	<	=	na	=	>	=
msp	na	na	na	na	na	na	<	=	na	=	=	=

Table 1.
This table is a summary of the trends seen from all of the competition experiments.
EG: *Egregia* gametophytes
UG: *Undaria* gametophytes
MG: *Macrocystis* gametophytes
egsp: *Egregia* spores
undsp: *Undaria* spores
msp: *Macrocystis* spores
g: gametophyte recruits
sp: produced sporophytes
All comparisons are in relation to the control treatment of blank media.
An "=" means that the final count was similar to the comtrol.
">" is when the count is greater than the control.
"<" is when the count is less than the control.
"=, < and >, < and >, =" show when the two experiments indicated different trends.
"na" is placed where there is not data present or uncountable treatments.