

Rapid Funding Report:

Assessing the prevalence and virulence of sea star wasting along the California coastline

Pete Raimondi
University of California Santa Cruz

December 16, 2014

Executive Summary

Sea stars along much of the North American Pacific coast are dying in great numbers from a mysterious wasting syndrome. As yet, the cause of the syndrome is unidentified, and it's not clear whether it's due to an environmental stressor, disease, or an interaction between the two. The combination of its geographic scope, lethality across many species, and unknown cause make this a particularly worrisome phenomenon and one that requires urgent attention. In fall 2013, North Central Coast MPA Baseline Program partners (i.e., California Ocean Science Trust's MPA Monitoring Enterprise, California Sea Grant, California Ocean Protection Council, and California Department of Fish and Wildlife), with funding from the Ocean Protection Council provided rapid funding to: (1) assess the extent, virulence, and timing of wasting events along the California coast, particularly in the north-central region, and (2) establish a baseline where one did not exist to interpret change to communities. The activities conducted (at least in part) with the funding include:

- Assessment of extent and prevalence of wasting
- Continuation of long term sampling to maintain a baseline for the abundance of *Pisaster ochraceus* adults and recruits
- Maintenance of our interactive websites with particular emphasis on Citizen Science activities
- Visualization of disease progression

We continue to assess the progression of wasting, however, we are now moving into a new phase in the assessment of sea star wasting: the ecological consequences from the loss of these species. This has two major thrusts: (1) assessing recovery of affected sea star species through recruitment of new individuals, and (2) determining the initial ecological changes to the rest of the community resulting from the loss of sea stars. These questions are incredibly important for ecological and policy considerations. The ecological importance stems from the impact of the decline of top predators on the system. The policy considerations relate to the expectation of community change that accompanies loss of sea stars and the effect of the change in the ability to assess current management actions such as the effect of MPA related protection from take. Without a data driven understanding of the community level effects of wasting, assessment of MPA protection may be, at best, unreliable, and at worst, misleading.

Introduction

Sea stars along much of the North American Pacific coast are dying in great numbers from a mysterious wasting syndrome. As yet, the cause of the syndrome is unidentified, and it's not clear whether it's due to an environmental stressor, disease, or an interaction between the two. Similar die-offs have occurred before in the 1970s, 80s, and 90s, but never before at this magnitude and over such a wide geographic area. Moreover, past events have usually been associated with warm ocean conditions during ENSO events. The combination of its geographic scope, lethality across many species, and unknown cause make this a particularly worrisome phenomenon and one that requires urgent attention.

In fall 2013, North Central Coast MPA Baseline Program partners (i.e., California Ocean Science Trust's MPA Monitoring Enterprise, California Sea Grant, California Ocean Protection Council, and California Department of Fish and Wildlife), with funding from the Ocean Protection Council provided rapid funding to: (1) assess the extent, virulence, and timing of wasting events along the California coast, particularly in the north-central region, and (2) establish a baseline where one did not exist to interpret change to communities. These funds provided match for additional funding from the UC Santa Cruz Packard Endowment. Jointly, these funds allowed us to carry out 1 and 2 above and also initiate subtidal surveys in central California, initiate sampling in southern California, update our interactive website, and assess recruitment events that have occurred in many affected species.

Background and Results

Description of effect of sea star wasting

Sea star wasting syndrome is a general description of a set of symptoms that are found in sea stars. Typically, lesions appear in the ectoderm followed by decay of tissue surrounding the lesions, which leads to eventual fragmentation of the body and death. A deflated and twisting appearance can precede other morphological signs of the disease. All of these symptoms are also associated with ordinary attributes of unhealthy stars and can arise when an individual is stranded too high in the intertidal zone (for example) and simply desiccates. "True" wasting disease will be present in individuals that are found in suitable habitat, often in the midst of other individuals that might also be affected. The progression of wasting disease can be rapid, leading to death within a few days, and its effects can be devastating on sea star populations.

History of recent sea star wasting event

The current bout of this wasting syndrome was first noted in ochre stars (*Pisaster ochraceus**) in June 2013 along the coast of Washington state during monitoring surveys conducted by MARINE researchers from Olympic National Park (ONP).

MARINE monitoring groups have since documented wasting in *Pisaster ochraceus* from Alaska through California (Figures 1 & 2; see wasting map for specific locations). Two common attributes for some, but not all, of the sites are: (1) the period prior to wasting was characterized by warm water temperatures, and (2) the effects were dramatic.

The majority of early observations were made in intertidal (tidepool) habitats, and as a result, most of the early reports were for ochre stars, the most common in the habitat, but others species affected include the mottled star (*Evasterias troschelii*), leather star (*Dermasterias imbricata*), and six-armed stars (*Leptasterias*).

In August 2013, divers investigating subtidal habitats reported massive die-offs of sunflower stars (*Pycnopodia helianthoides*) just north of Vancouver, British Columbia. Shortly afterwards, other subtidal sea star species in the region began showing signs of wasting. During October and November 2013, we saw a similar mass death of sea stars in Monterey, California, and another die-off of sunflower and ochre stars around Seattle, Washington, with the syndrome spreading throughout the Puget Sound.

In mid-December 2013, substantial numbers of wasting stars were spotted around southern California. By the summer of 2014 it has spread to Mexico and parts of Oregon, which had previously been unaffected. It is also intensifying, appearing at additional sites in those regions already affected.

In subtidal habitats, the sunflower star is typically the first species to succumb, followed by the rainbow star (*Orthasterias koehleri*), giant pink star (*Pisaster brevispinus*), giant star (*Pisaster giganteus*), mottled star, ochre star and sun star (*Solaster*), leather star, vermilion star (*Mediaster aequalis*), six-armed stars, and bat star (*Patiria miniata*). At this point, we don't know whether the syndrome spreads sequentially from one species to the next, or if some species simply take longer to express symptoms.

Much of the reporting relates to *Pisaster ochraceus* and *Pycnopodia helianthoides*. This is for a number of reasons including (1) they are typically very conspicuous in the intertidal and subtidal respectively, (2) impacts to these species are usually the first to occur at a site, and (3) ecologists consider both sunflower and ochre stars to be keystone species because they have a disproportionately large influence on other species in their ecosystems. Our long-term monitoring data, including population estimates prior to the wasting event, in combination with our biodiversity surveys and surveys done under the referenced funding, will allow us to interpret change to communities that might result from severe population declines. The collected information will also be used to document recovery of both sea star populations and the community affected by way of the loss of sea stars. We have seen a few sites where substantial recruitment has occurred, including Terrace Point, Santa Cruz, CA (Figure 3). Whether this will continue and spread to other sites is unknown.

Outlook

Over the past year, much of our effort has focused on documenting the progression of sea star wasting along the West Coast of North America and across a range of sea star species. That effort was greatly enhanced by funding provided by North Central Coast MPA Baseline Program partners (i.e., California Ocean Science Trust's MPA Monitoring Enterprise, California Sea Grant, California Ocean Protection Council, and California Department of Fish and Wildlife), with funding from the Ocean Protection Council. We continue to assess the progression of wasting, however, we are now moving into a new phase in the assessment of sea star wasting: the ecological consequences from the loss of these species. This has two major thrusts: (1) assessing recovery of affected sea star species through recruitment of new individuals, and (2) determining the initial ecological changes to the rest of the community resulting from the loss of sea stars. These questions are incredibly important for ecological and policy considerations. The ecological importance stems from the impact of the decline of top predators on the system. The policy considerations relate to the expectation of community change that accompanies loss of sea stars and the effect of the change in the ability to assess current management actions such as the effect of MPA related protection from take. It is quite likely that community change related to loss of these top predators, because of disease, will be at least as substantial as MPA protection in rocky intertidal and subtidal areas. Without a data driven understanding, the community level effects of wasting, assessment of MPA protection may be, at best, unreliable, and at worst, misleading.

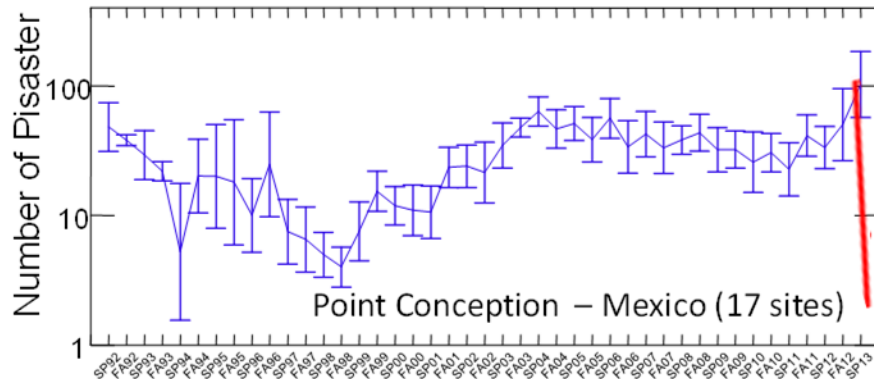
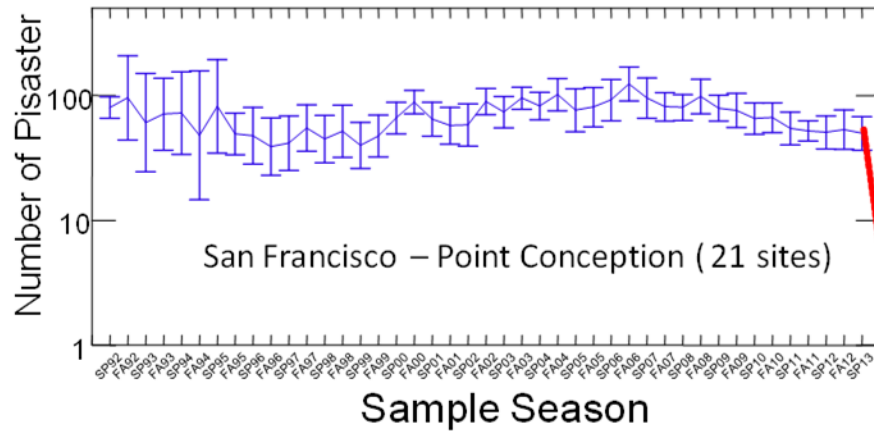
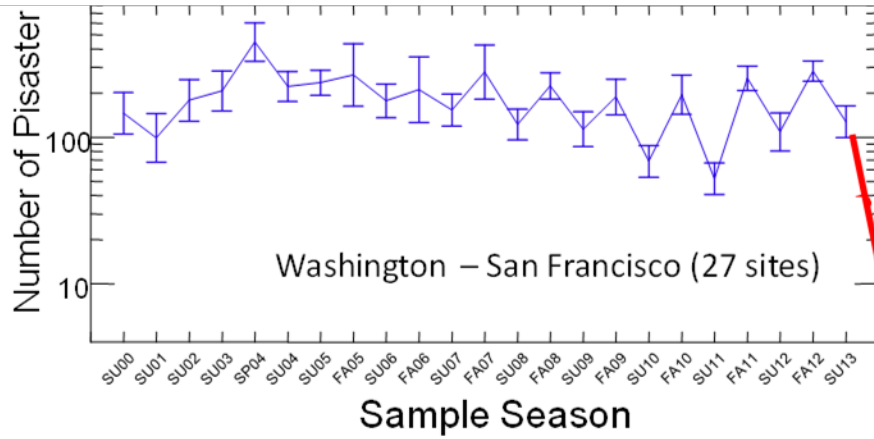


Figure 1: *Pisaster ochraceus* abundance in three west coast regions through 2014. The y-axis is log (base 10) transformed. Note the precipitous drop over the last years. This corresponds to the dramatic consequences of sea star wasting.

Progression of the disease shows no sign of slowing down

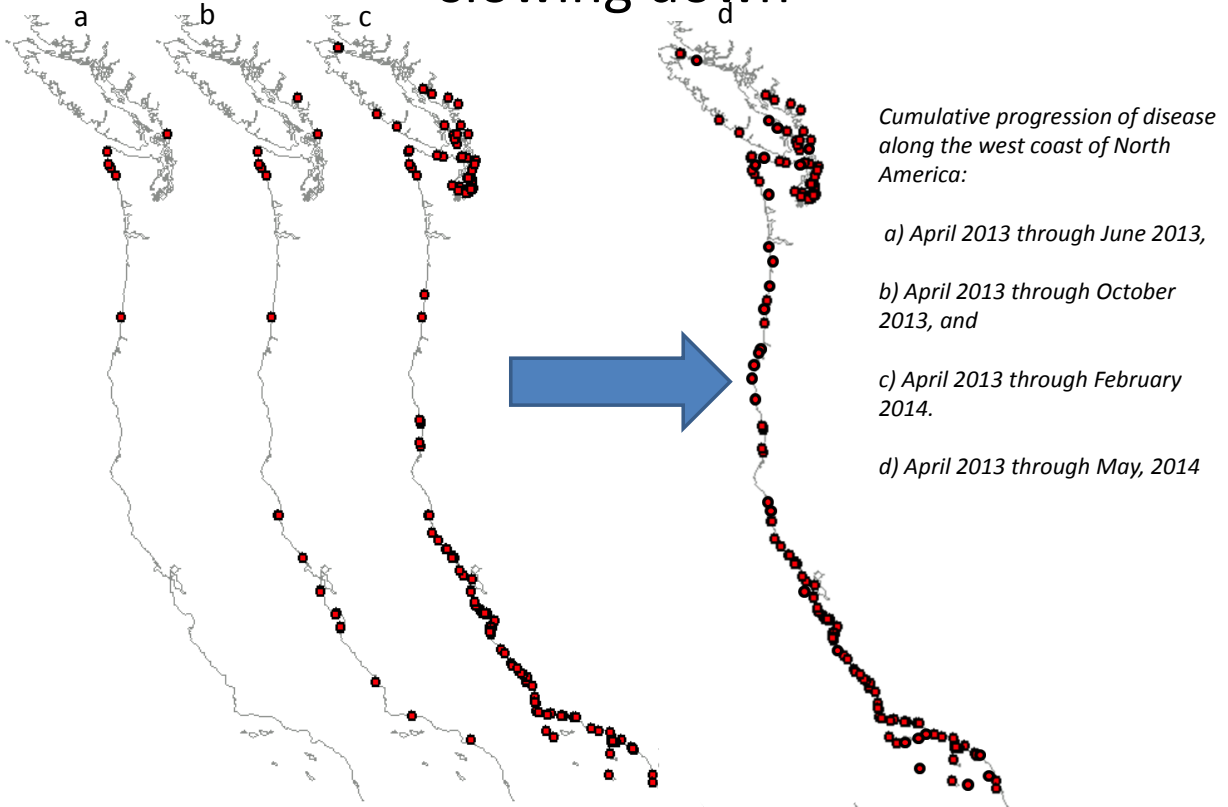


Figure 2: Progression of sea star wasting from April 2013 – May 2014. Note how the areas without disease have been lost over time. It is worth noting that the pattern of spread has continued unabated since May 2014 (up to date maps are on the referenced website).

New Recruits & Juveniles!

Recent Reports From:

- Puget Sound
- Oregon Coast
- Sonoma Coast
- Santa Cruz
- Big Sur Coast

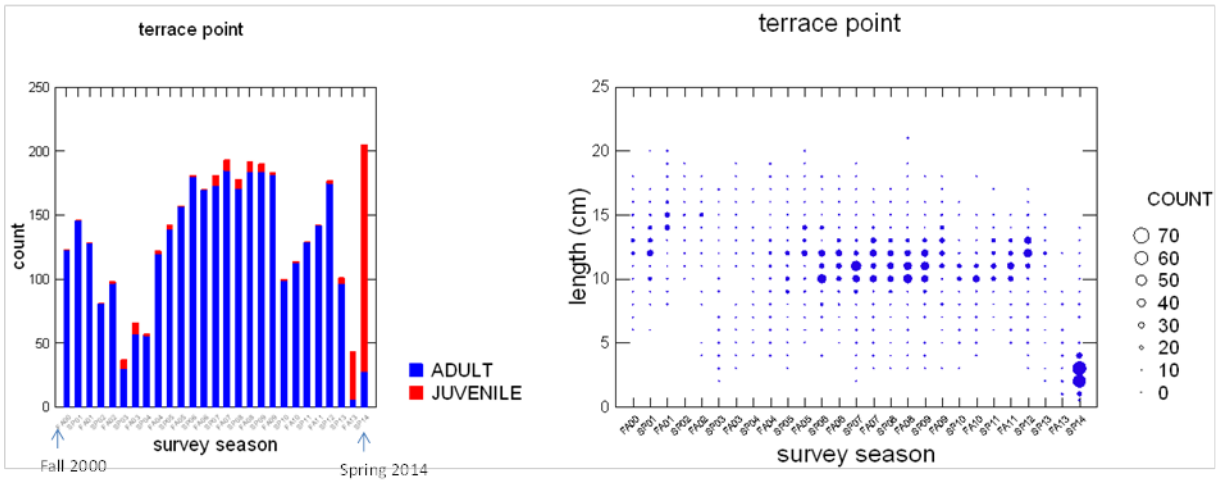


Figure 3: Adult and recruitment numbers at Terrace Point (Santa Cruz, CA). Note that recruitment in 2014 is greater than the sum of all previous recruitment events.

Appendix A

Activities conducted (at least in part) with funding provided by the North Central Coast MPA Baseline Program partners (i.e., California Ocean Science Trust's MPA Monitoring Enterprise, California Sea Grant, California Ocean Protection Council, and California Department of Fish and Wildlife), with funding from the Ocean Protection Council (with hyperlinks to products).

- 1) Assessment of extent and prevalence of wasting
 - a. In the intertidal of the North Central Coast of California
 - b. In the subtidal of the Central Coast of California
 - c. In the intertidal of the South Coast of California
- 2) Continuation of long term sampling to maintain a baseline for the abundance of *Pisaster ochraceus* adults and recruits
- 3) Maintenance of our interactive websites with particular emphasis on
 - a. Citizen Science activities
 - i. Reporting of wasting
 - ii. Reporting of recruitment
 - iii. Identification of juveniles
 - b. Visualization of disease progression (time lapse video) – also see below

All of our data and products are available on either www.seastarwasting.org (for explicitly sea star related data and products) or www.pacificrockyintertidal.org (for all intertidal data and products).

Appendix B

Media postings: list of media publications through May 2014 (*not all relate to CA or to UCSC research*)

- [Sea Star Deaths along the West Coast Elicit Close Study](#) (Aug 14, 2014)
 - [Scientists Investigate Outbreak Of Sea Star Wasting Syndrome](#) (Aug 11, 2014)
 - [Disease killing sea stars reaches local public aquariums](#) (Aug 7, 2014)
 - [Peninsula marine life centers losing sea stars to mysterious disease](#) (July 28, 2014)
 - [Warming Water Temperatures Could Be Driving Massive Sea Star Die Off](#) (July 26, 2014)
 - [Dying starfish stump experts](#) (July 26, 2014)
 - [Scientists Look for Causes of Baffling Die-Off of Sea Stars](#) (July 17, 2014)
 - [What's killing all the sea stars?](#) (July 2, 2014)
 - [Sunflower stars found in sound](#) (July 2, 2014)
 - [Starfish are 'just melting': Disease killing 80 percent of them](#) (June 28, 2014)
 - [Peninsula volunteers pitching in on sea star wasting disease research](#) (June 23, 2014)
 - [Dissolving sea stars hit San Diego](#) (June 20, 2014)
 - [Scientists Close in on the Cause of Sea Star Wasting Syndrome](#) (June 17, 2014)
 - [Sea Star Video - "Falling Stars"](#) (June 13, 2014)
 - [Mystery Sea Stars 'Goo' Disease Spreads to Oregon](#) (June 10, 2014)
 - [Sea star wasting syndrome epidemic along the coast](#) (June 7, 2014)
 - [Sea Star Disease Hits Hard On Oregon Coast](#) (June 6, 2014)
 - [A plot to spot wasted stars](#) (June 4, 2014)
 - [Sea star disease epidemic surges in Oregon, local extinctions expected](#) (June 4, 2014)
 - [Die-Off Spawns New Sea Stars](#) (May 24, 2014)
 - [Scientists scurrying to determine what's killing starfish](#) (May 23, 2014)
 - [Biologists investigate mysterious sun star beach stranding](#) (May 14, 2014)
 - [Mystery starfish plague extends to Canada and Mexico, but the answer is within our grasp](#)(May 8, 2014)
 - [Scientists look for pathogen that's killing sea stars](#) (May 7, 2014)
 - [Sea Star Wasting Syndrome Arrives In Oregon](#) (May 5, 2014)
 - [Scientists narrow in on Sea Star Wasting Syndrome devastating the West Coast](#) (May 4, 2014)
-

[Death of the Stars \(May 2, 2014\)](#)

[Slideshow: Sea Stars Dying in Mysterious Plague \(May 1, 2014\)](#)

[Starfish mysteriously disappearing along the Pacific Coast \(May 1, 2014\)](#)

[Sea star population plummets at Shell Beach from mysterious wasting disease \(Apr 5, 2014\)](#)

[Mysterious sea star disease hitting San Diego \(Apr 3, 2014\)](#)

[Sea stars in Southern California are dying in droves from mysterious disease \(Apr 3, 2014\)](#)

[Professor Studies Disappearing Sea Stars \(Mar 26, 2014\)](#)

[Mass Sea Star Death Leaves Researchers Perplexed \(Mar 11, 2014\)](#)

[What's Killing the Starfish - KQED broadcast \(Mar 5, 2014\)](#)

[Ocean Currents Broadcast on KWMR \(Mar 3, 2014\)](#)

[Sea Star Wasting Syndrome \(Thank You Ocean Report\) \(Mar 3, 2014\)](#)

[Sea star wasting devastates Pacific Coast species \(Feb 17, 2014\)](#)

[Starfish Disease, 'Sea Star Wasting Syndrome,' Finds Way Into Anchorage Museum \(Feb 10, 2014\)](#)

[Cornell scientists race to understand devastating starfish epidemic \(Feb 4, 2014\)](#)

[Mysterious epidemic devastates starfish population off the Pacific Coast \(Jan 30, 2014\)](#)

[Devastating disease now found in Nanaimo starfish \(Jan 3, 2014\)](#)

[The starfish are dying, and no one knows why \(Dec 31, 2013\)](#)

[Massive starfish deaths baffling biologists \(Dec 24, 2013\)](#)

[Where are all the sea stars? Massive mortality raises questions and concerns \(Dec 7, 2013\)](#)

[Watch Underwater Video of Sea Stars Dying off West Seattle \(Dec 3, 2013\)](#)

[Divers search for clues to an epidemic killing millions of starfish \(Nov 30, 2013\)](#)

[Sea stars stricken by mysterious wasting disease \(Nov 26, 2013\)](#)

[Sea stars are wasting away in larger numbers on a wider scale in two oceans \(Nov 22, 2013\)](#)

[Sea Star Wasting Disease Hits the West Coast \(Nov 21, 2013\)](#)

[Pisaster disaster: When starfish wasting disease strikes, there's only one man to call \(Nov 14, 2013\)](#)

[What's wiping out the starfish in California \(Nov 12, 2013\)](#)

[Sea Star Wasting Syndrome Reaches Santa Barbara County \(Nov 7, 2013\)](#)

[Starfish wasting disease baffles US scientists \(Nov 5, 2013\)](#)

[Falling Stars: Starfish Dying From "Disintegrating" Disease \(Nov 5, 2013\)](#)

'Wasting' disease turning West Coast starfish to mush; experts stumped (Nov 4, 2013)

Wasting disease devastating starfish along Sonoma Coast (Nov 2, 2013)

Marine Scientists Investigate Massive Sea Star Die-Off (October 10, 2013)

Starfish Deaths Alarm Vancouver Aquarium (October 7, 2013)

Dead starfish in Vancouver waters puzzle scientists (September 12, 2013)

Why Are Sea Stars Dying from New Jersey to Maine? Divers Asked to Report Large Groupings of Starfish (July 23, 2013)

Effects of temperature, season and locality on wasting disease in the keystone predatory sea star *Pisaster ochraceus* (Nov 9, 2009)