Invert Analysis OCNMS

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Exploratory analysis

These are some analyses based on the 2015-19 survey data for invertebrates. I've done a bunch of processing in the Git repo (file "/GitHub/OCNMS/R scripts/Fish, Invert, Kelp Analysis/Swath Inverts.R"").

During the sampling, a total of 71 invertebrate species and species groups were observed. Here is how the sampling was distributed across sites and 5m and 10m depths among years (2015-present). Surveys from pre-2015 were not collected by NWFSC and have a different design and methods. They also are only available for some species

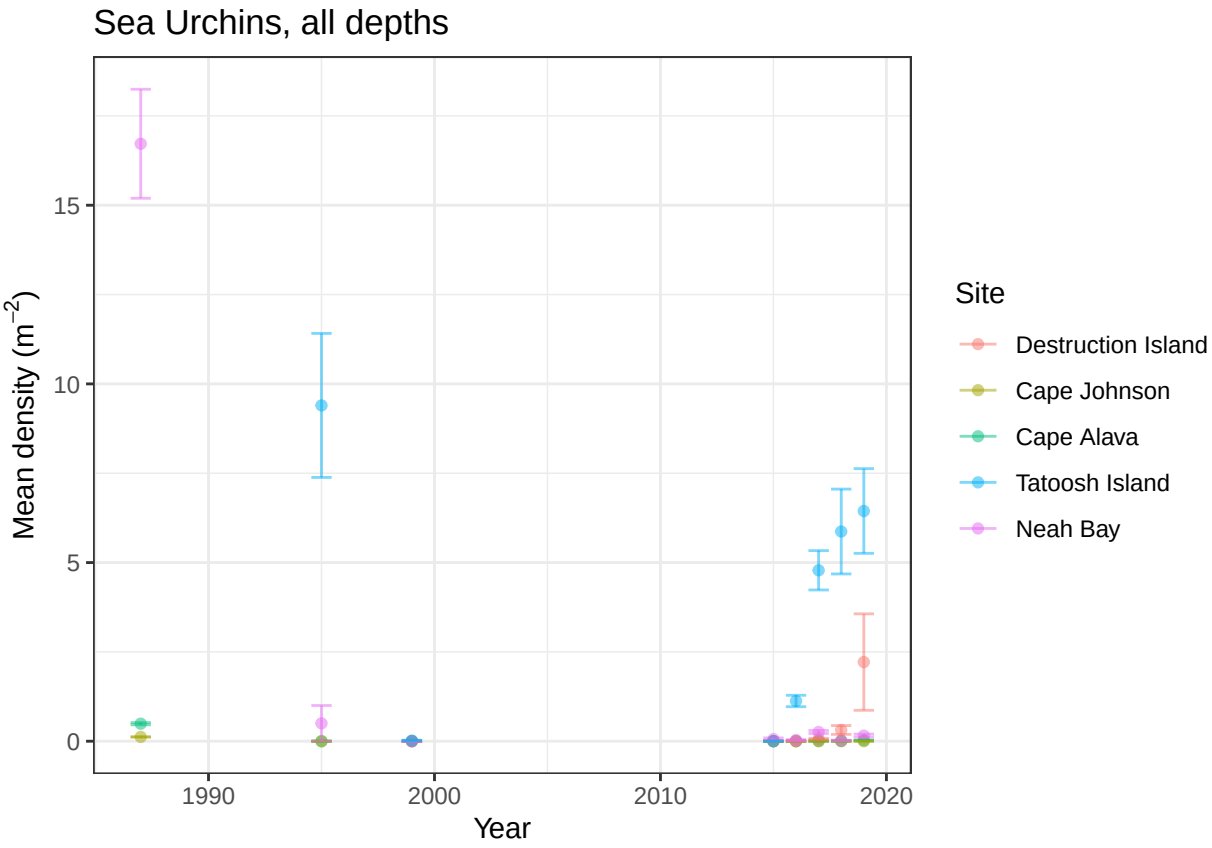
year	site	5	10
2015	Teahwhit Head	4	0
2015	Rock 305	4	0
2015	Cape Johnson	4	0
2015	Anderson Point	4	0
2015	Cape Alava	4	0
2015	Point of the Arches	4	0
2015	Tatoosh Island	4	0
2015	Chibadehl Rocks	4	0
2015	Neah Bay	4	0
2015	NA	2	0
2016	Destruction Island	3	2
2016	Cape Johnson	6	7
2016	Cape Alava	5	5
2016	Tatoosh Island	5	4
2016	Neah Bay	5	5
2017	Destruction Island	6	6
2017	Cape Johnson	7	6
2017	Cape Alava	8	3
2017	Tatoosh Island	5	6
2017	Neah Bay	6	5
2018	Destruction Island	6	8
2018	Cape Johnson	6	6
2018	Cape Alava	6	6
2018	Tatoosh Island	6	6
2018	Neah Bay	7	9
2019	Destruction Island	6	5
2019	Cape Johnson	7	7
2019	Cape Alava	7	7
2019	Tatoosh Island	4	5
2019	Neah Bay	7	7

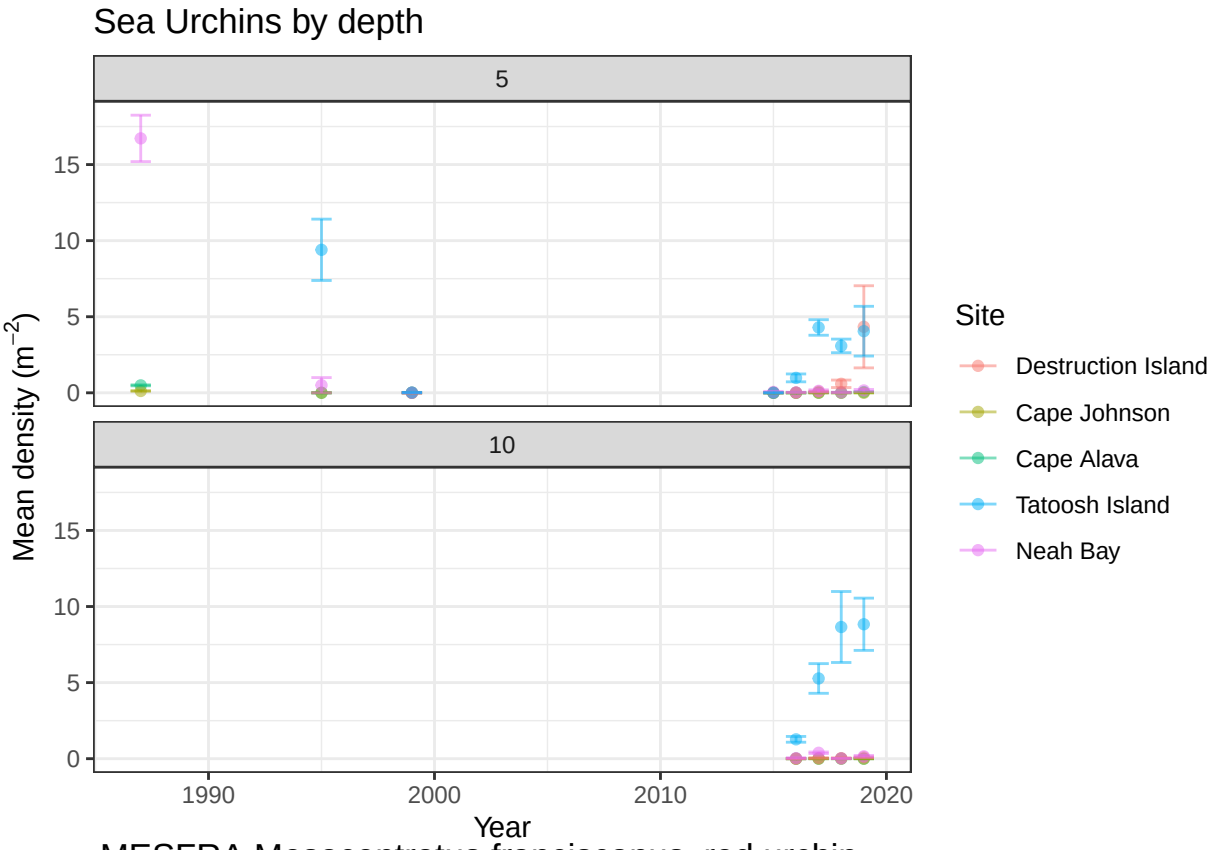
Let's go through the main species groups individually to look at changes through time.

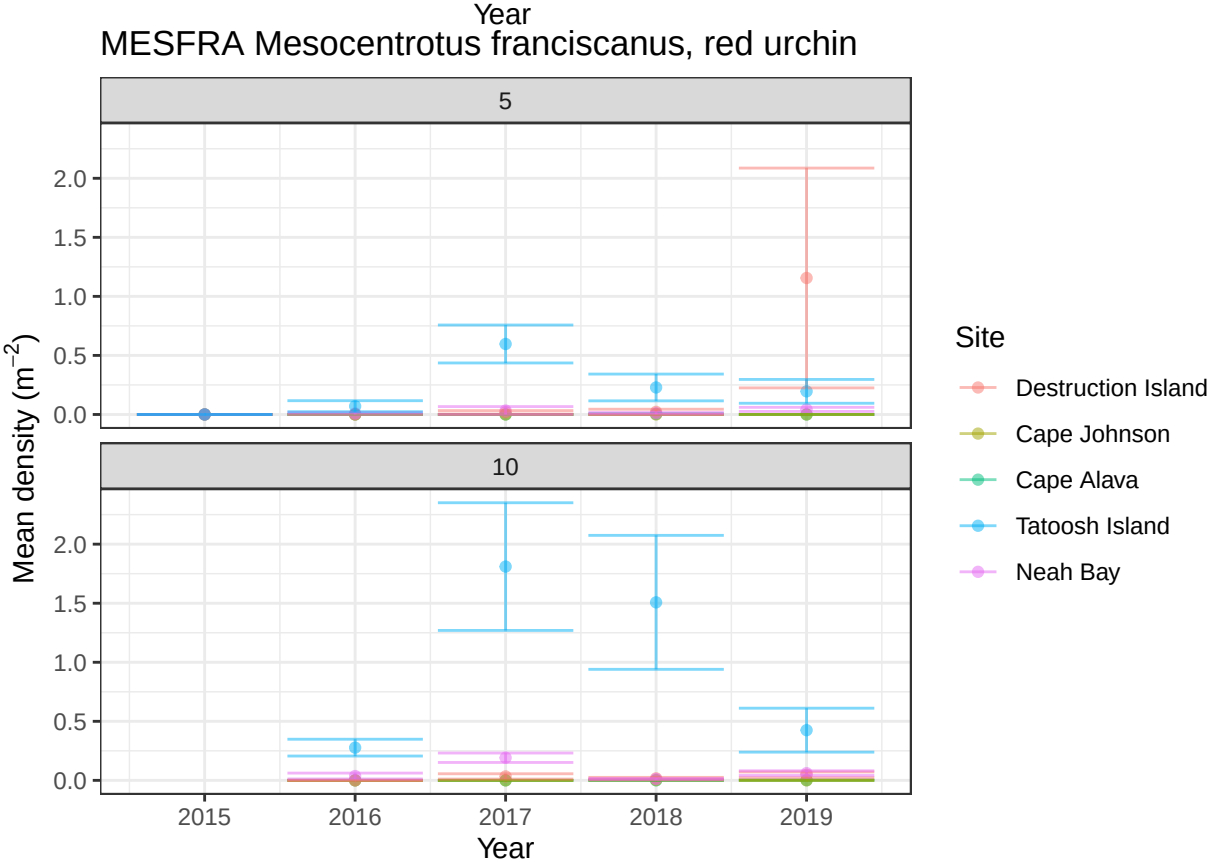
Sea urchins

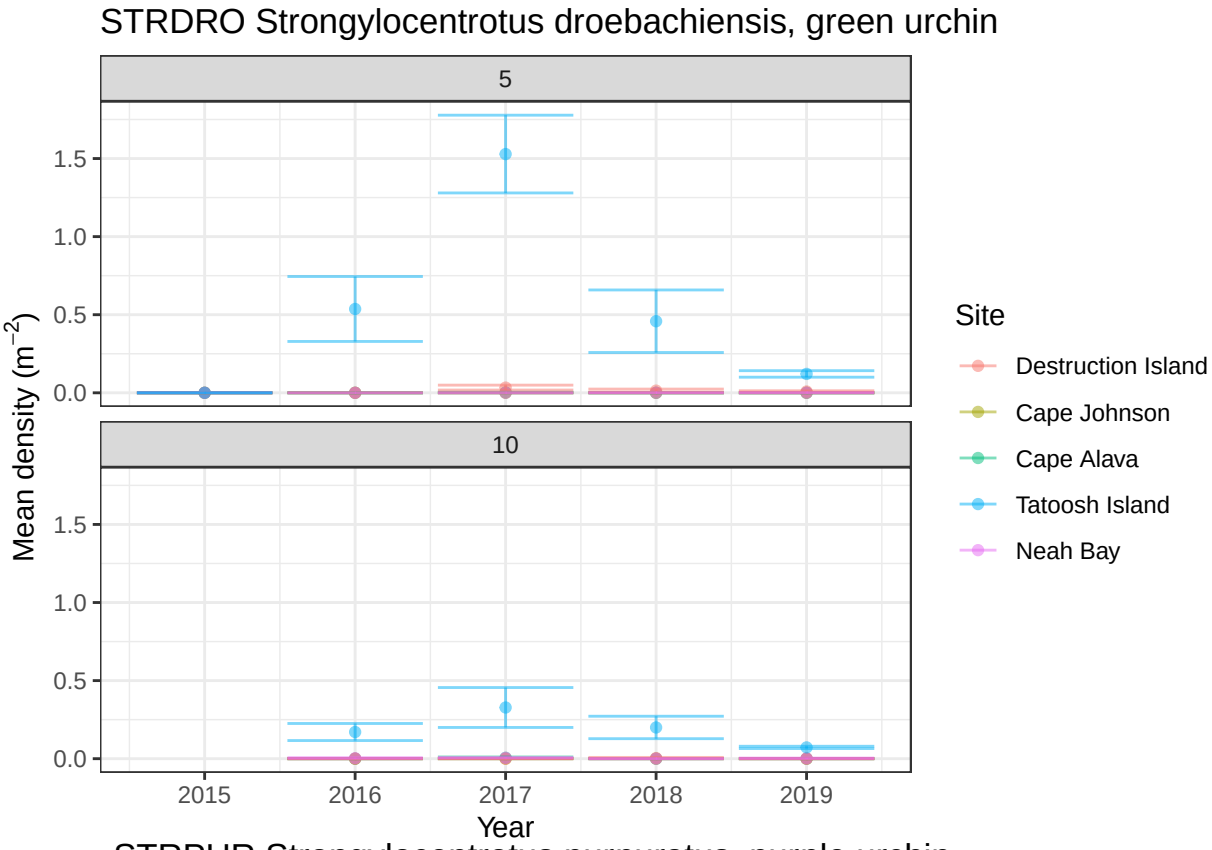
Urchins include these species

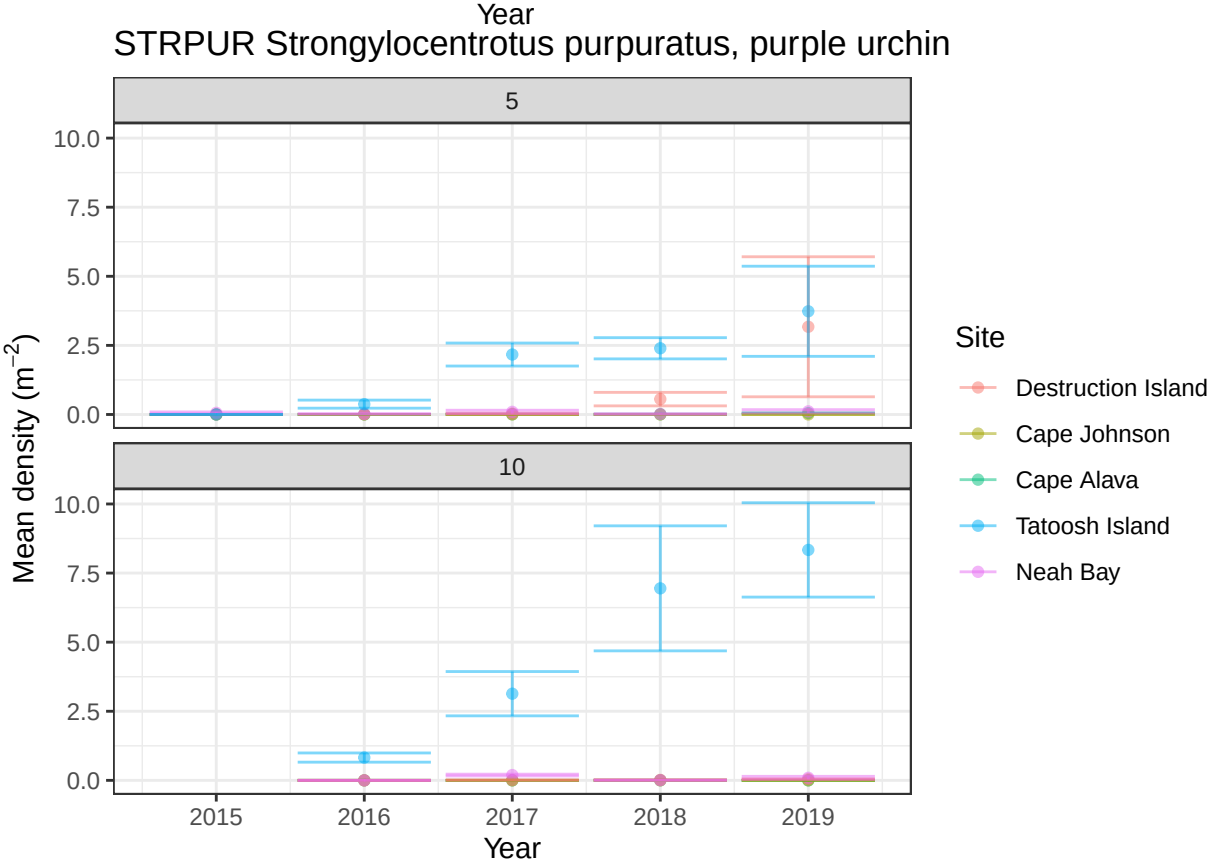
code	common.name
MESFRA	Mesocentrotus franciscanus, red urchin
STRDRO	Strongylocentrotus droebachiensis, green urchin
STRPUR	Strongylocentrotus purpuratus, purple urchin




Sea Urchins by depth
5
10
15
10
5
0
Mean density (m^{-2})
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay


MESFRA Mesocentrotus franciscanus, red urchin
5
10
2.0
1.5
1.0
0.5
0.0
Mean density (m^{-2})
2015
2016
2017
2018
2019
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay


STRDRO Strongylocentrotus droebachiensis, green urchin
5
10
1.5
1.0
0.5
0.0
Mean density (m^{-2})
2015
2016
2017
2018
2019
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay


STRPUR Strongylocentrotus purpuratus, purple urchin
5
10
10.0
7.5
5.0
2.5
0.0
Mean density (m^{-2})
2015
2016
2017
2018
2019
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

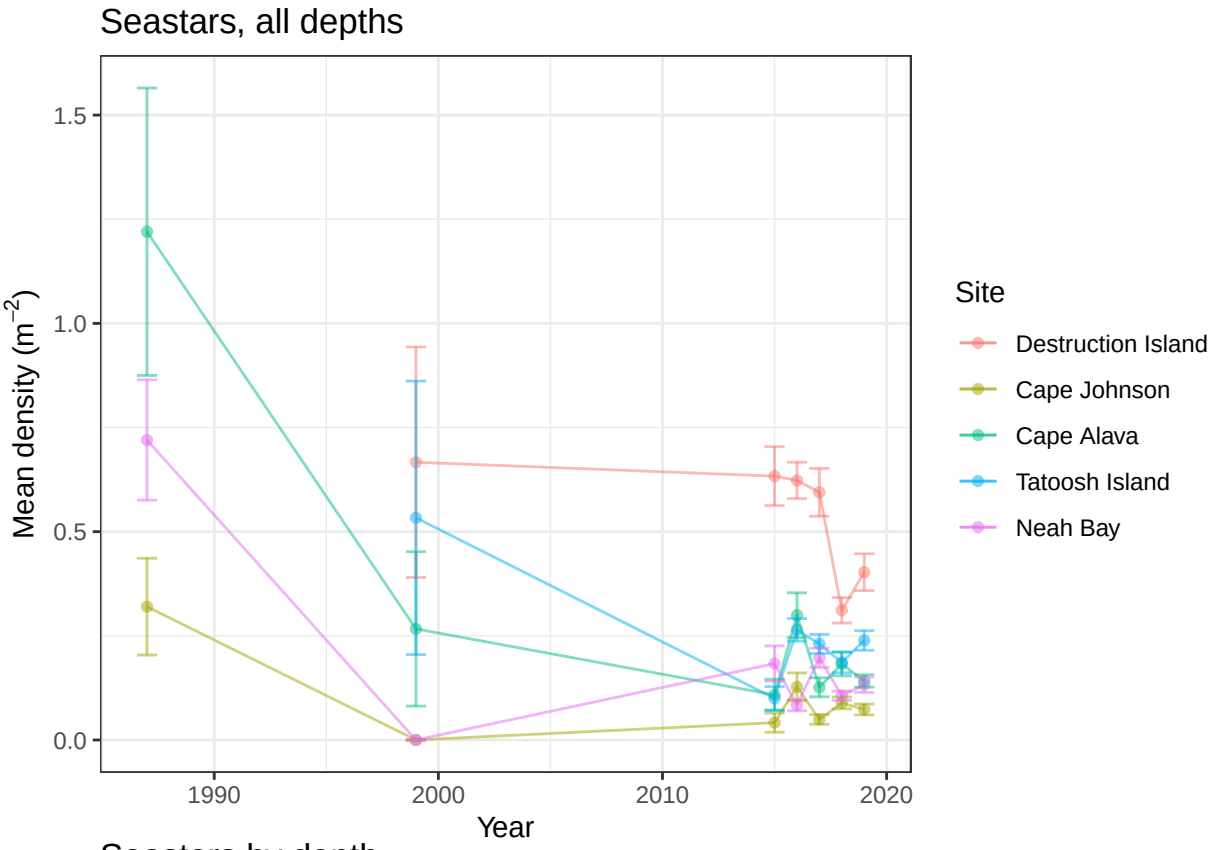
Seastars

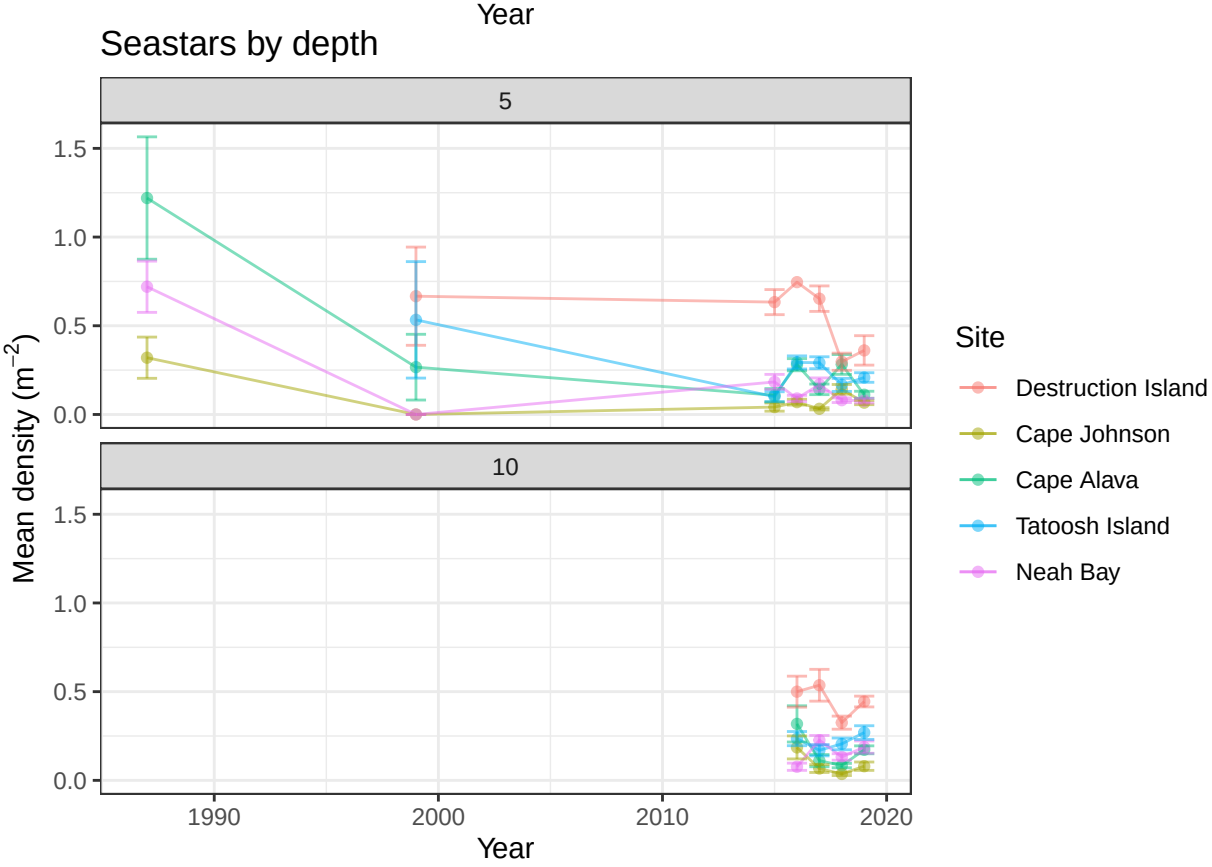
Seastar plots include these species

code	common.name
ASTSPP	unknown seastar
CROPAP	Crossaster papposus, sea star
DERIMB	Dermasterias imbricata, leather star
EVATRO	Evasterias troschelii, mottled star
HENLEV	Henricia leviuscula, blood star
MEDAEQ	Mediaster aequalis, red star
ORTKOE	Orthasterias koehleri, rainbow star
PATMIN	Patiria miniata, bat star
PISBRE	Pisaster brevispinus, short spined star
PISGIG	Pisaster giganteus, giant spined star
PISOCH	Pisaster ochraceous, ochre star
PISSPP	Pisaster spp. (unidentified species)
PYCHEL	Pycnopodia helianthoides, sunflower star
SOLSTI	Solaster stimpsoni, orange sun star

We also see these species, but they are often below the size threshold (2.5cm radius) so we do not include them in the summaries below

code	common.name
LEPSPP	Lepasterias spp.
STARREC	sea star recruits (unidentifiable to species)

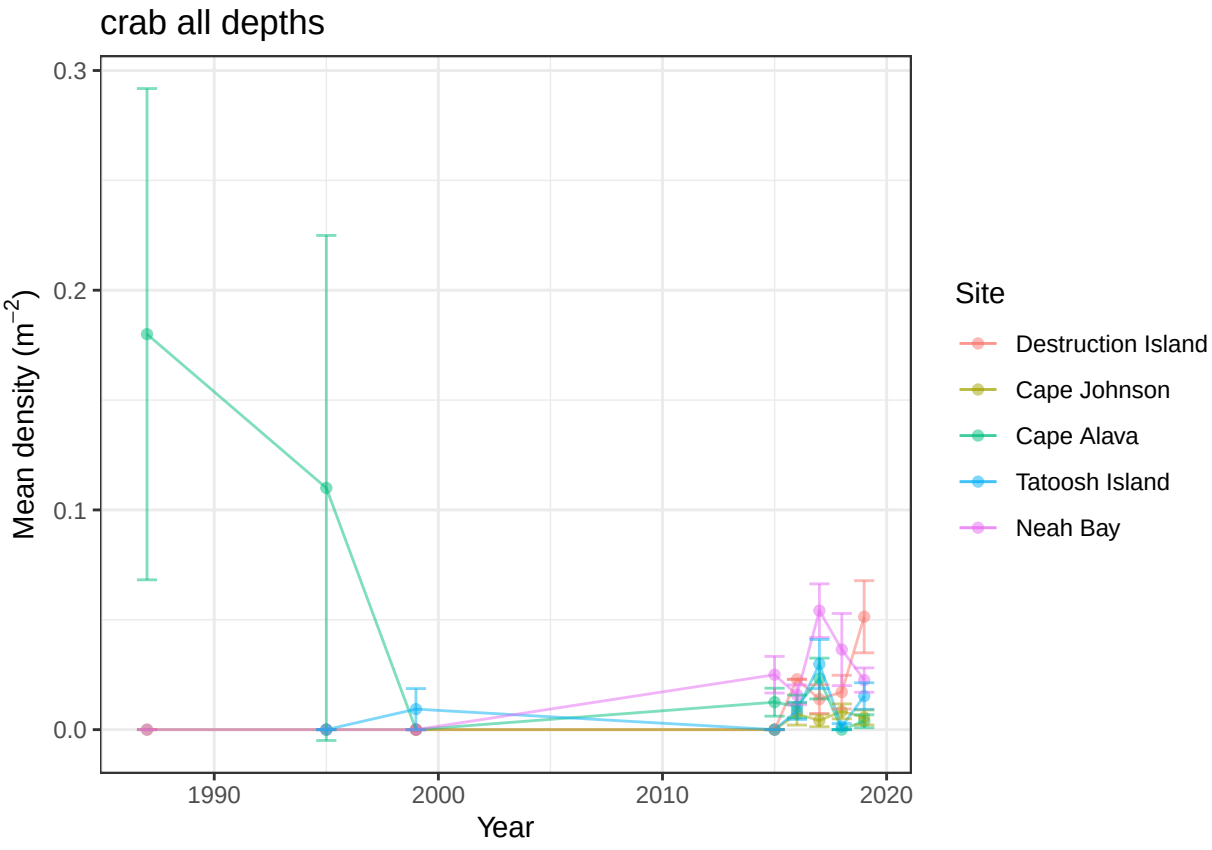

Seastars, all depths
Mean density (m^{-2})
1.5
1.0
0.5
0.0
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

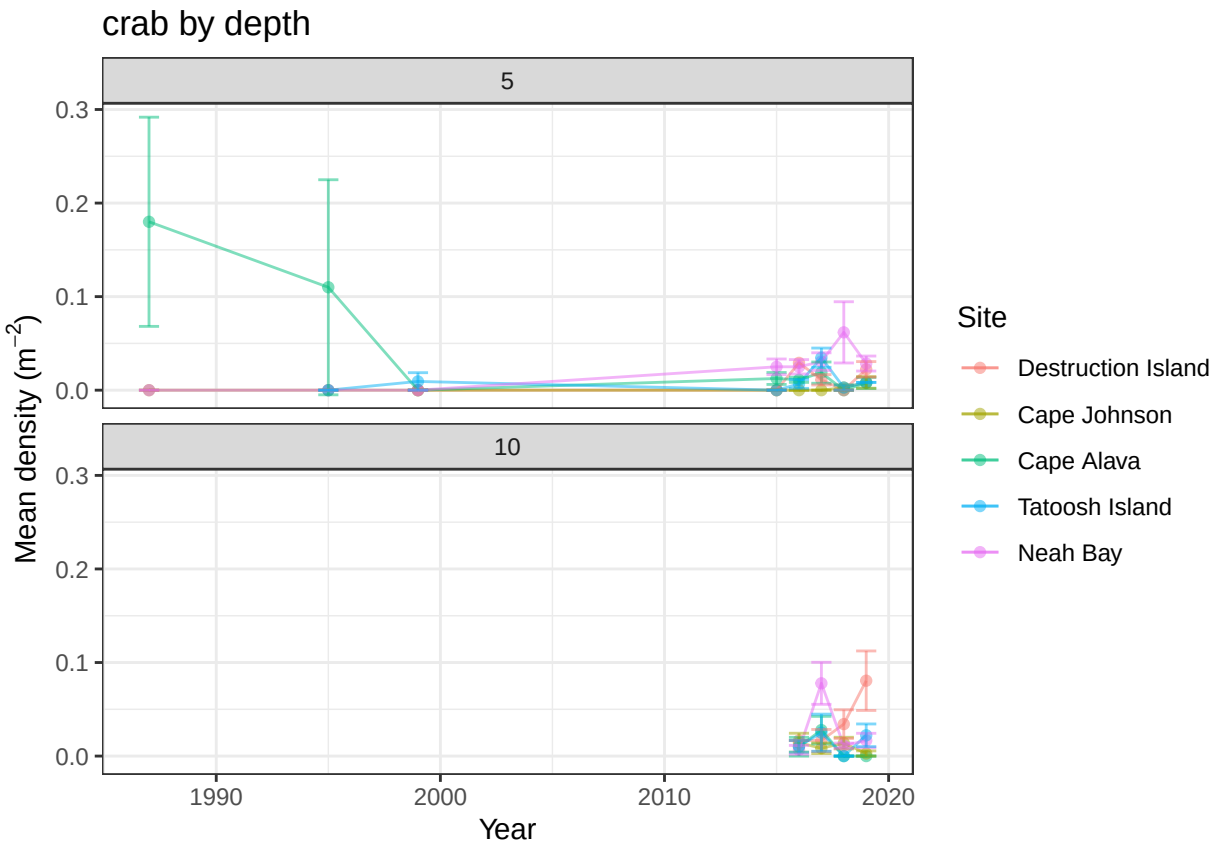

Seastars by depth
5
10
Mean density (m^{-2})
1.5
1.0
0.5
0.0
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

Crabs

Crabs plots include these species

code	common.name
CANORE	Cancer oregonensis, pygmy rock crab
CANSPP	Cancer spp., cancer crab
CRYDEC	cryptic decorator crab unid. Spp.
CRYSIT	Cryptolithoides sitchensis, umbrella crab
LOPMAN	Lopholithodes mandtii, Puget Sound king crab
MIMFOL	Mimulus foliatus, mimicking crab
PUGGRA	Pugettia gracilis, graceful kelp crab
PUGPRO	Pugettia producta, kelp crab
SCYDEC	Scyra spp., decorator crab, moss crab

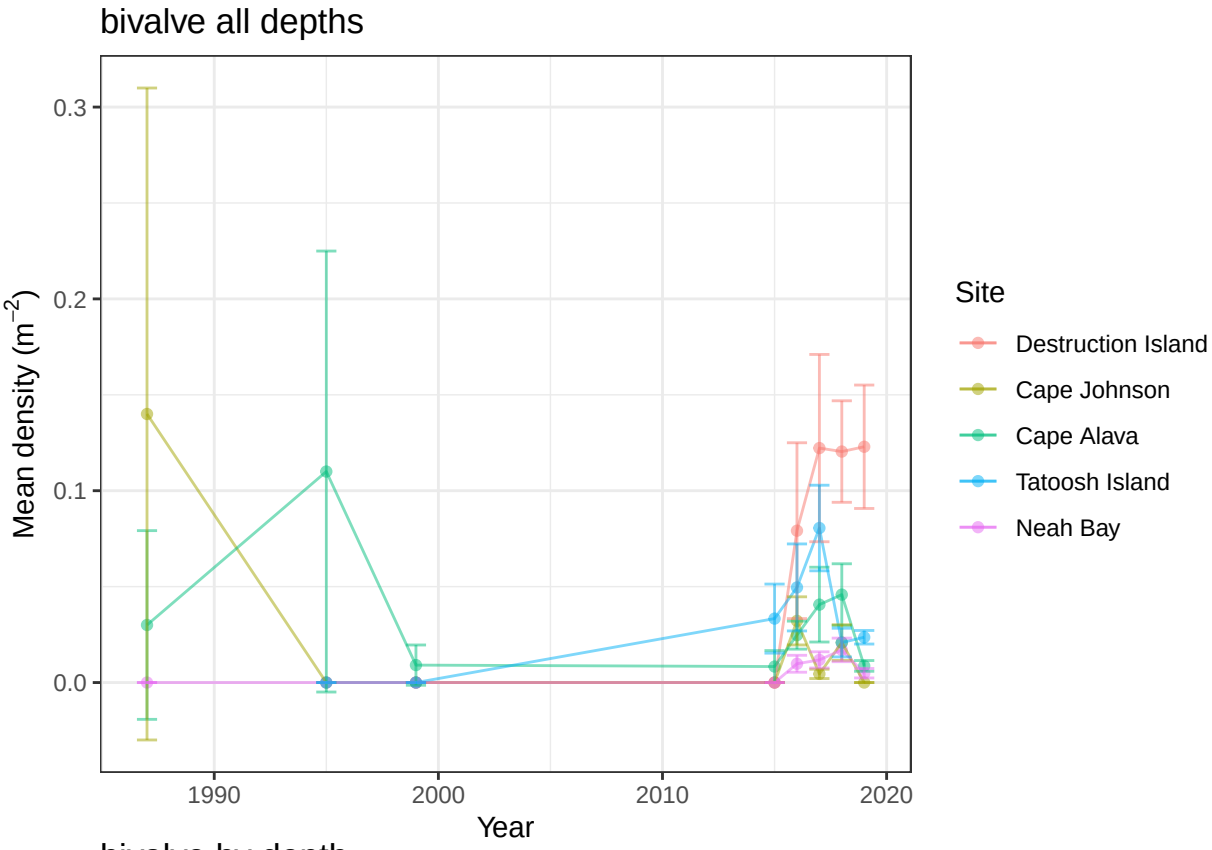


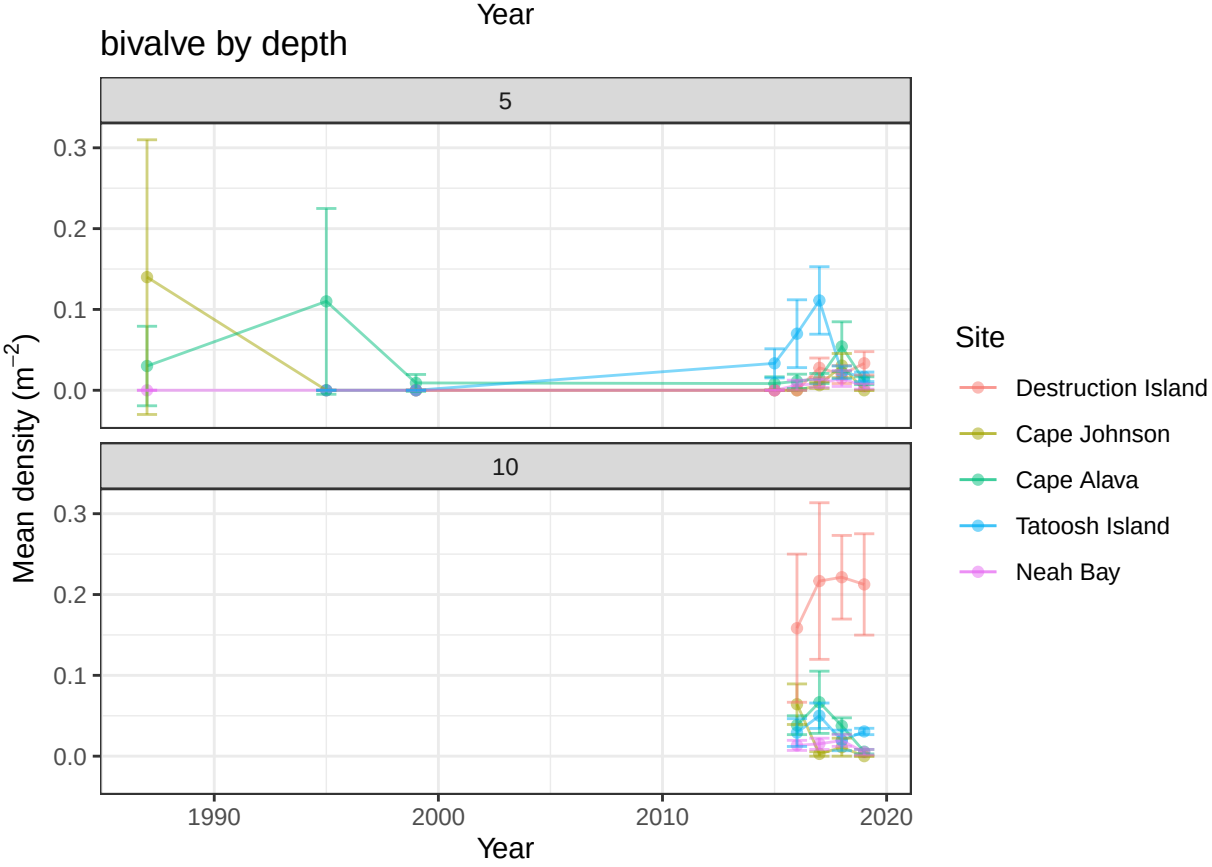


Bivalves

Bivalve plots include these species

code	common.name
CLAMSP	misc clams
CRAGIG	Crassadoma gigantea, rock scallop
MYTCAL	Mytilus californianus, California mussel
PODSPP	Pododesmus spp. Jingle shells
SCALLOP	misc. scallops (not rock)

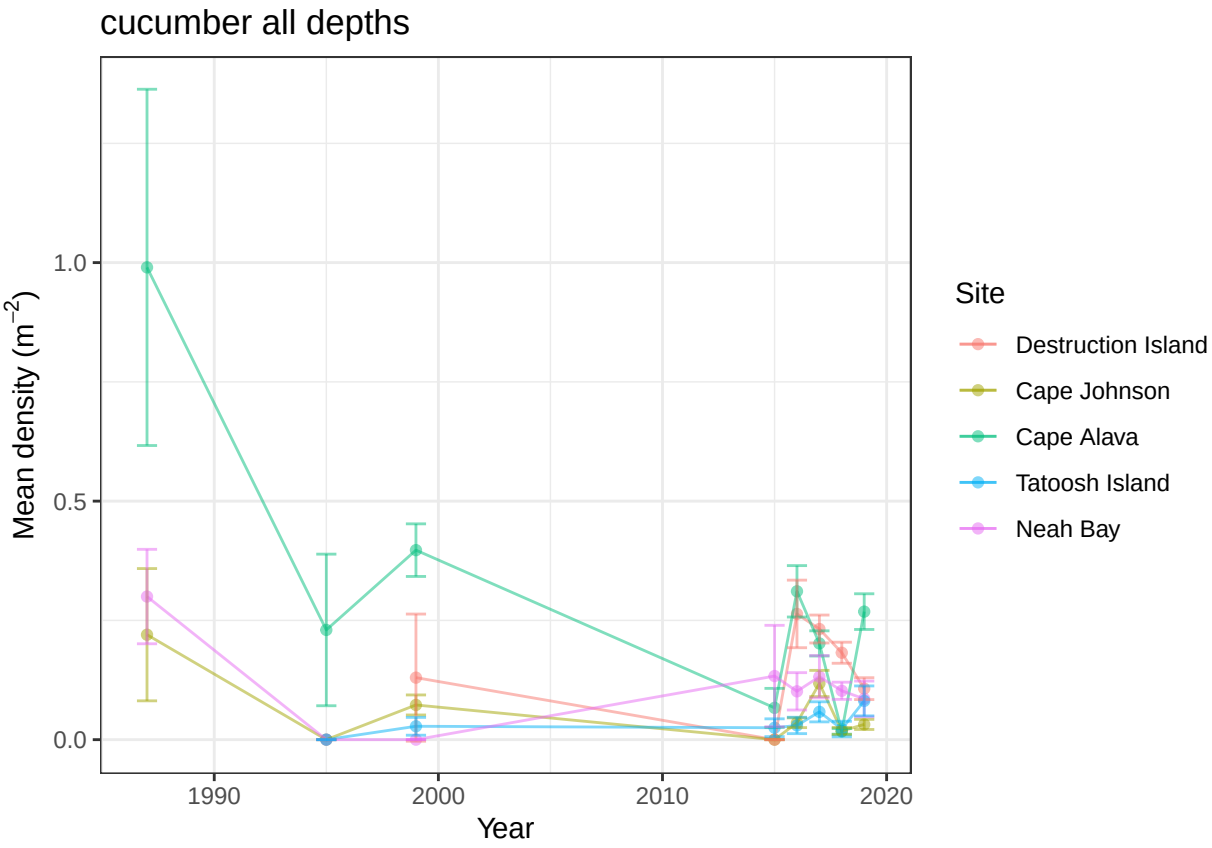

bivalve all depths
Mean density (m^{-2})
0.3
0.2
0.1
0.0
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

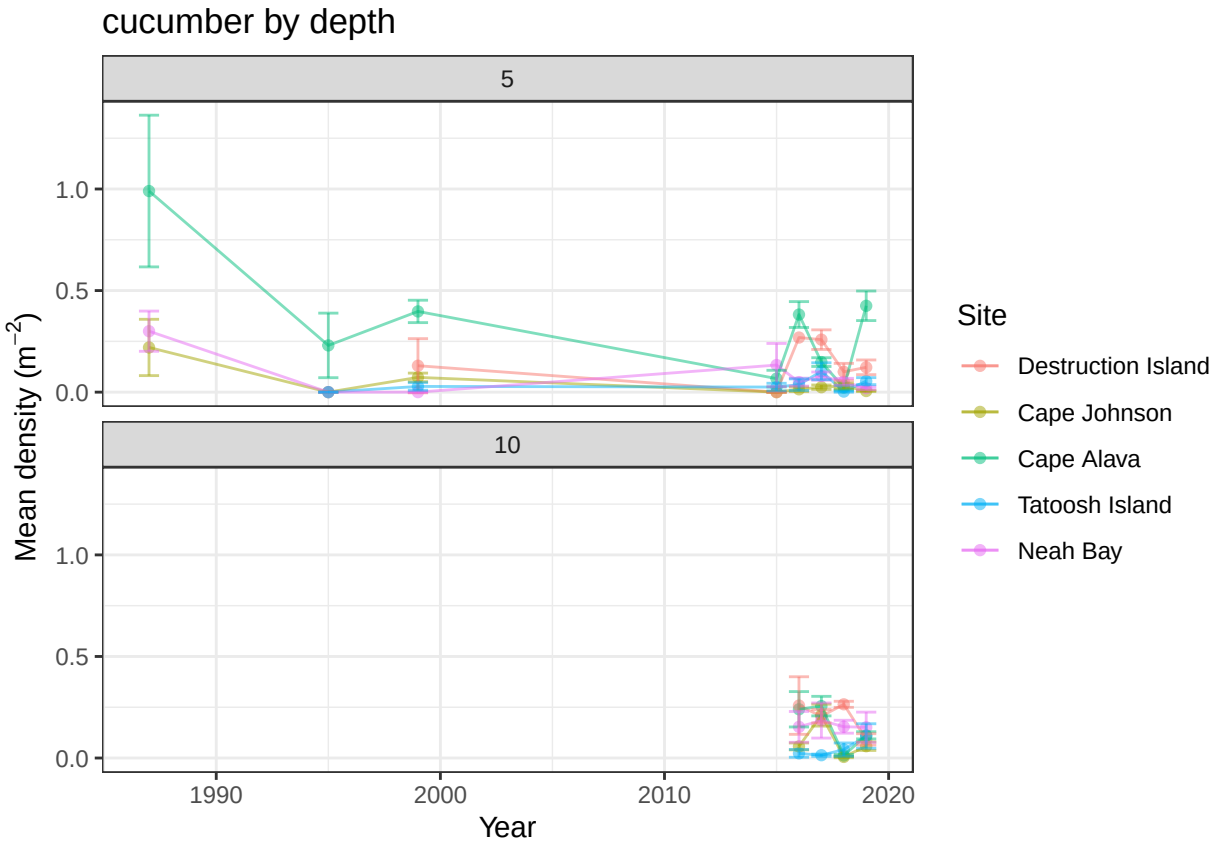

bivalve by depth
5
10
Mean density (m^{-2})
0.3
0.2
0.1
0.0
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

Sea Cucumber

Sea cucumber plots include these species

code	common.name
CUCMIN	Cucumaria miniata, orange sea cucumber
EUPQUI	Eupentacta quinquesemita, white sea cucumber
PARCAL	Parastichopus californicus, california sea cucumber

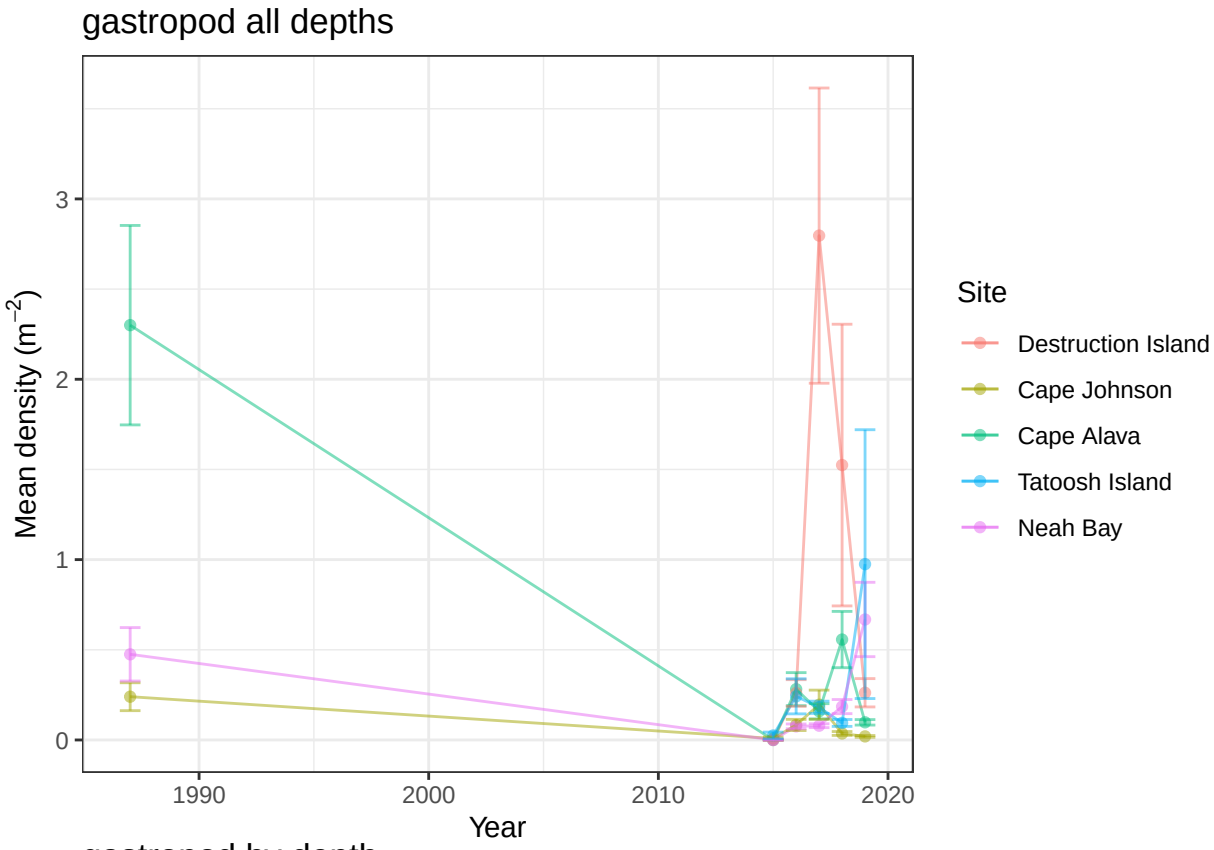


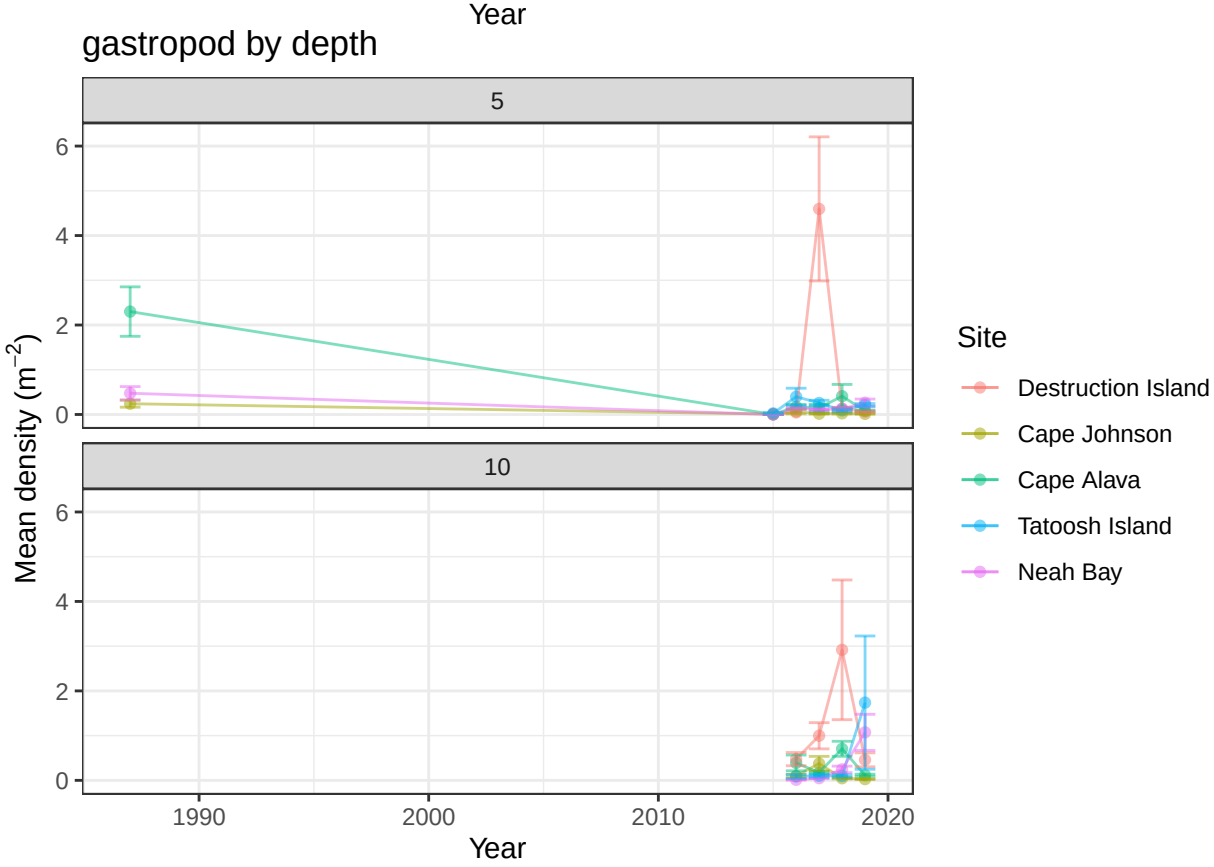


Gastropodss

Gastropod plots include these species

code	common.name
ACMMIT	Acmaea mitra, white cap limpet
CERFOL	Ceratostoma foliatum, Leafy hornmouth
DIOASP	Diodora aspera, rough keyhole limpet
FUSORE	Fusitriton oregonensis, Oregon hairy triton
HALKAM	Haliotis kamtschatkana, pinto abalone
LIRDIR	Lirabuccinum dirum, dire whelk
NUCLAM	Nucella lamellosa, whelk (used generally for rough predatory whelks)
TEGSPP	Tegula spp., turban snails

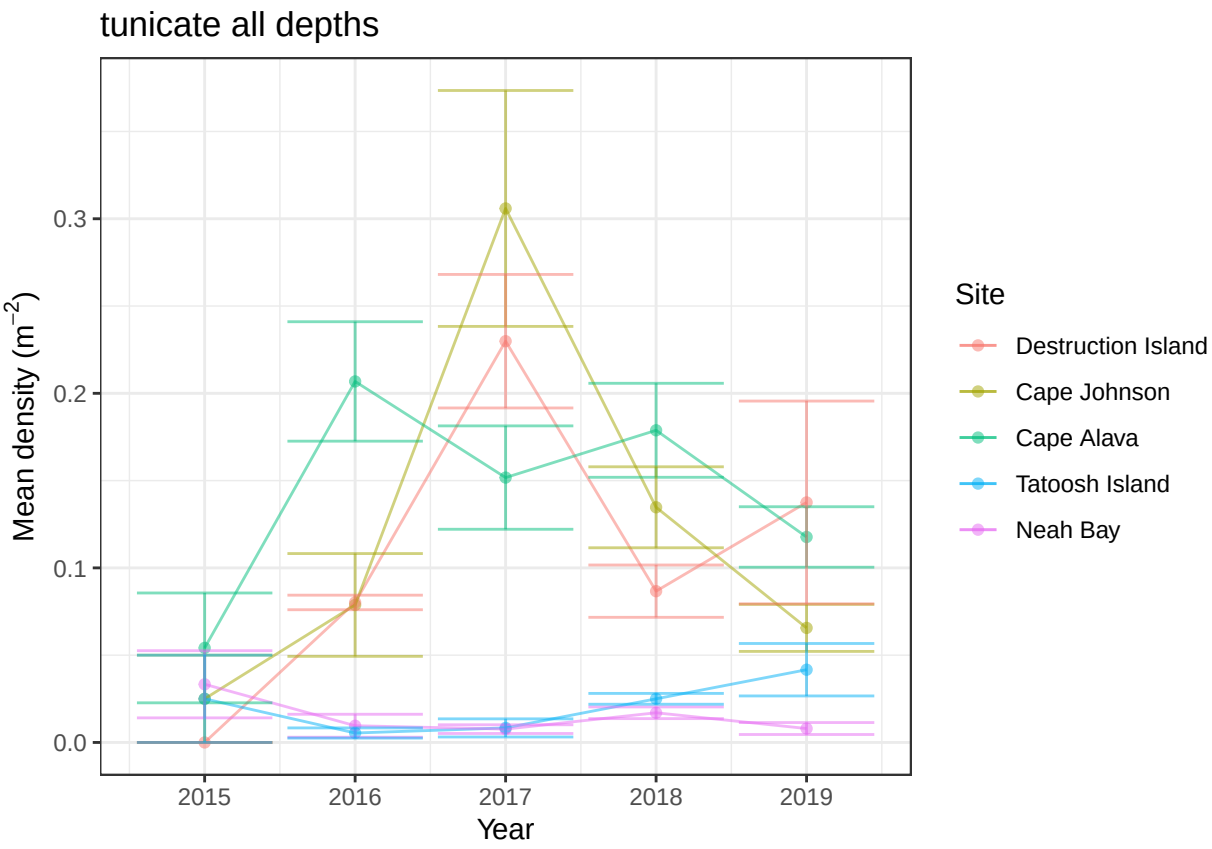

gastropod all depths
Mean density (m^{-2})
0
1
2
3
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

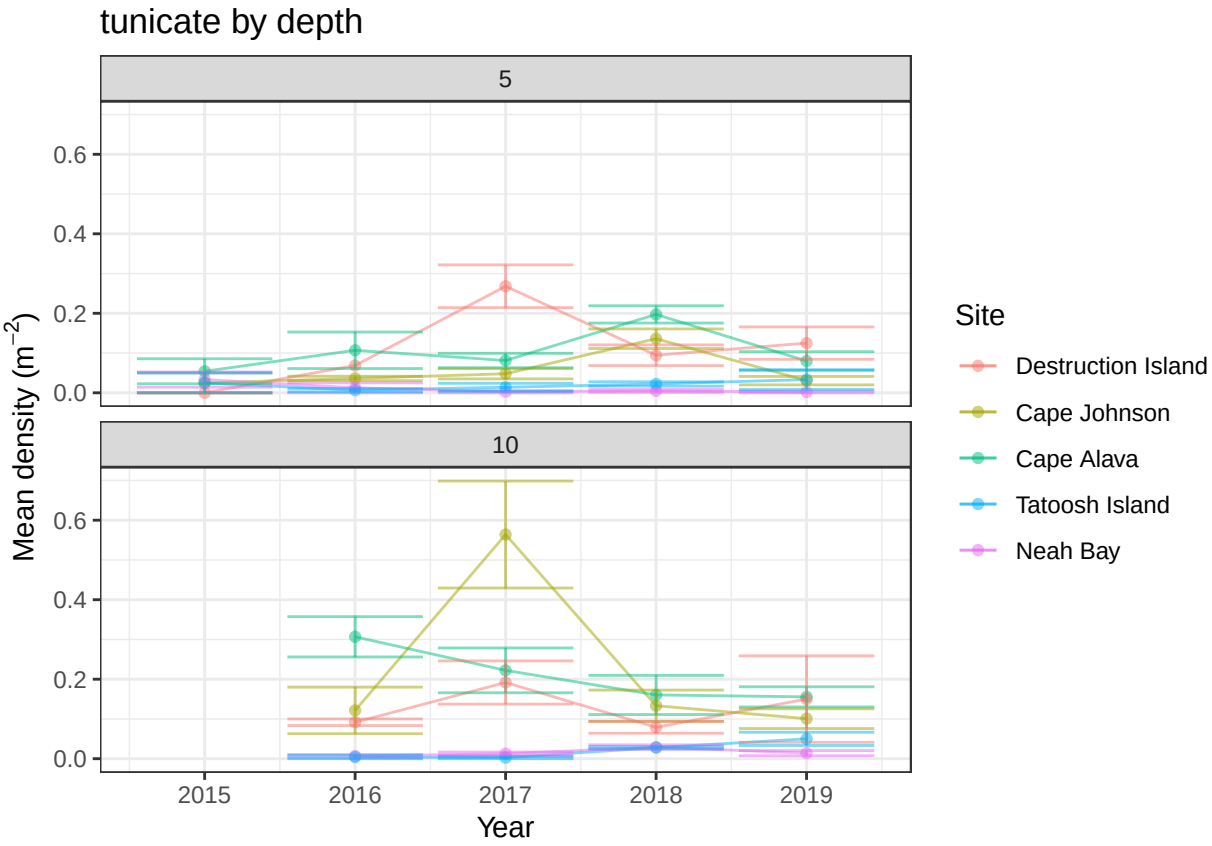

gastropod by depth
5
10
Mean density (m^{-2})
0
2
4
6
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

Tunicates

Tunicates plots include these species

code	common.name
STYMON	Styela montereyensis, stalked tunicate

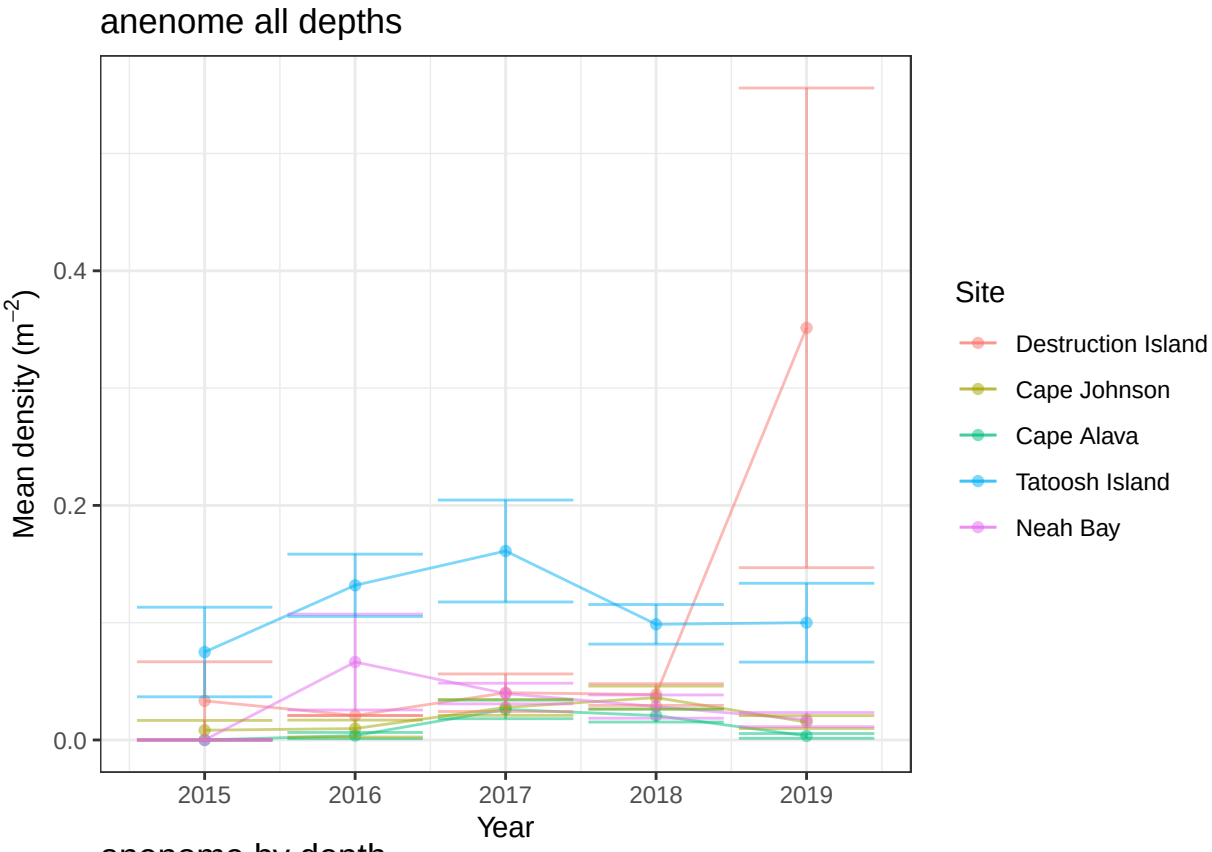


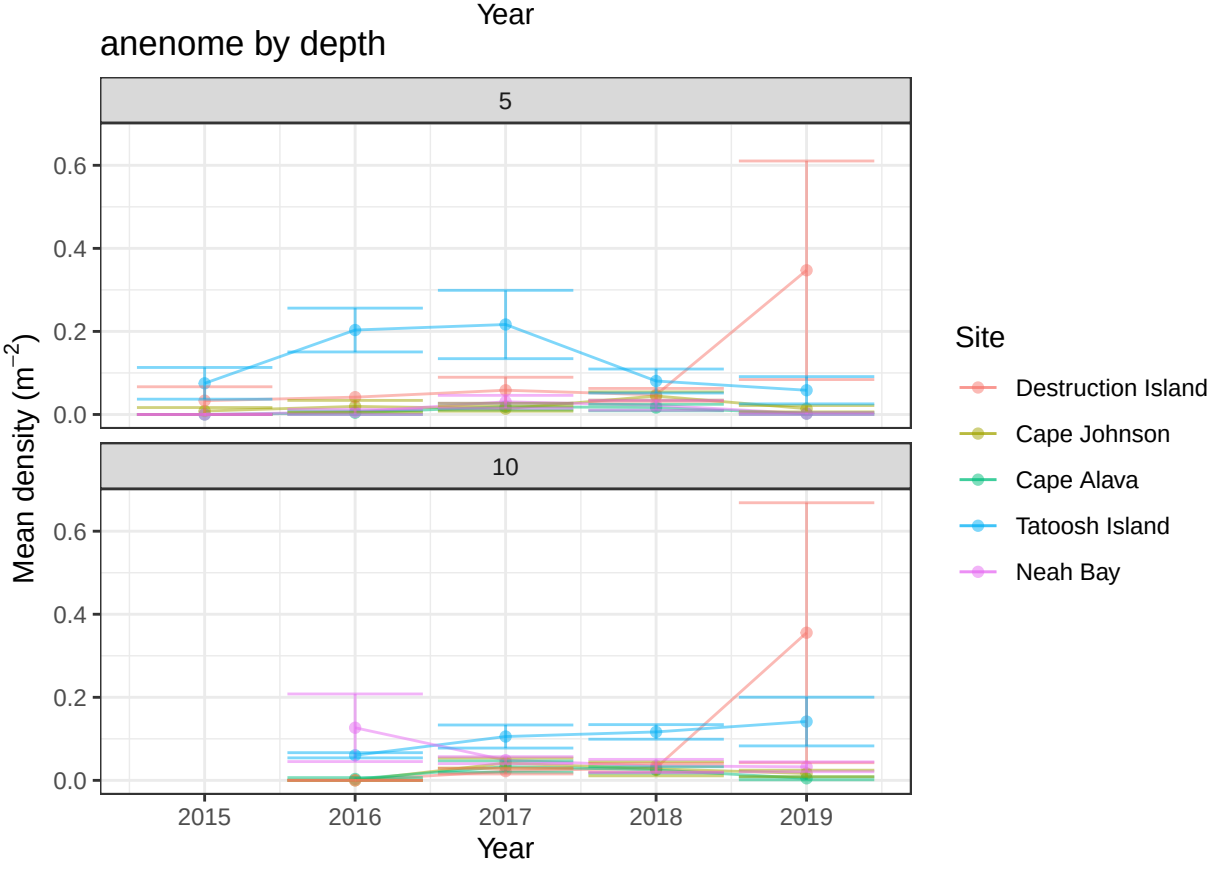


Anenomes

Anenomes plots include these species

code	common.name
ANTELE	Anthopleura elegantissima, aggregating anemone
ANTSPP	Anthopleura spp., unidentified anemone
ANTXAN	Anthopleura xanthogrammica, giant green anemone
EPIPRO	Epiactis prolifera, brooding anemona
METGIG	Metridium giganteum, giant plumose anemone
METSPP	Metridium spp., white plumed anemones
URTCRA	Urticina crassicornis, Christmas anemone
URTLOF	Urticina lofotensis, white-spotted rose anemone
URTPIS	Urticina piscivora, fish-eating anemone
URTSPP	Urticina spp., Urticina spp.

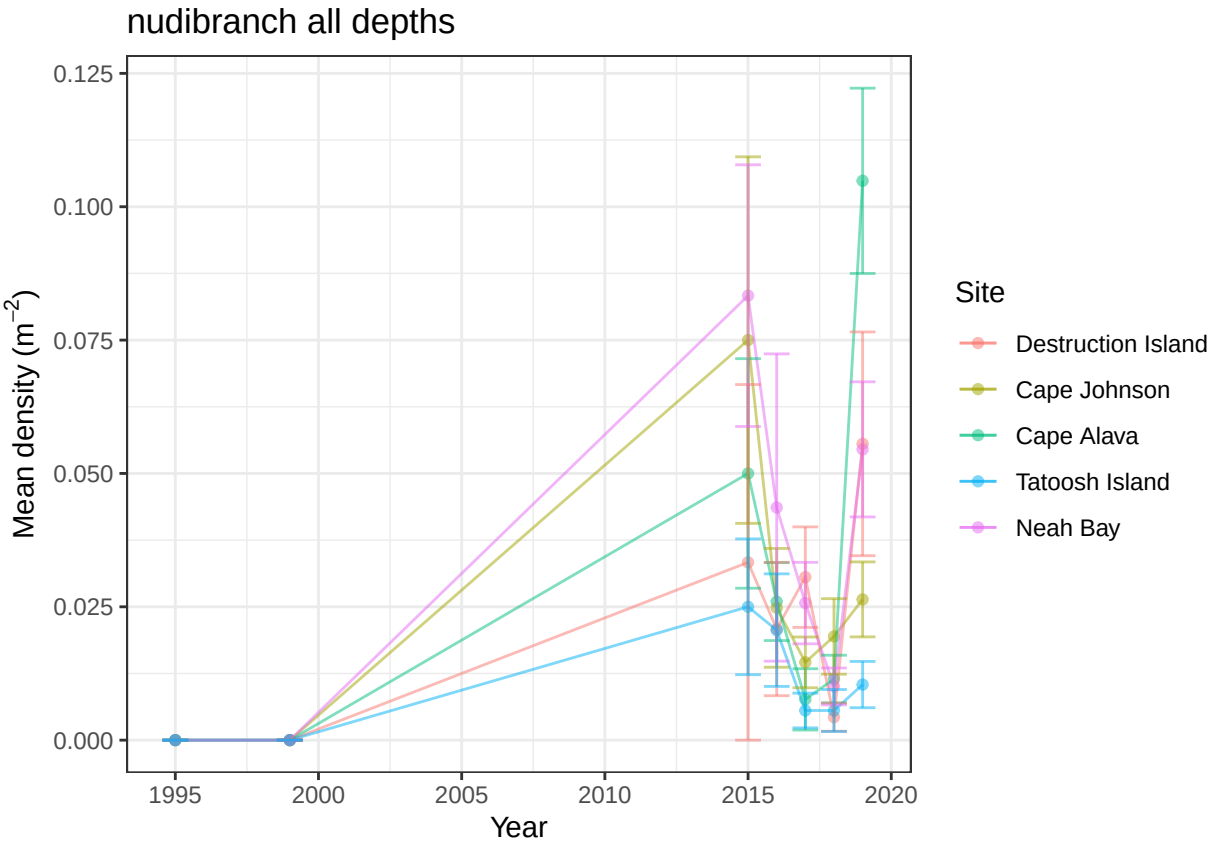

anenome all depths
Mean density (m^{-2})
0.0
0.2
0.4
2015
2016
2017
2018
2019
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

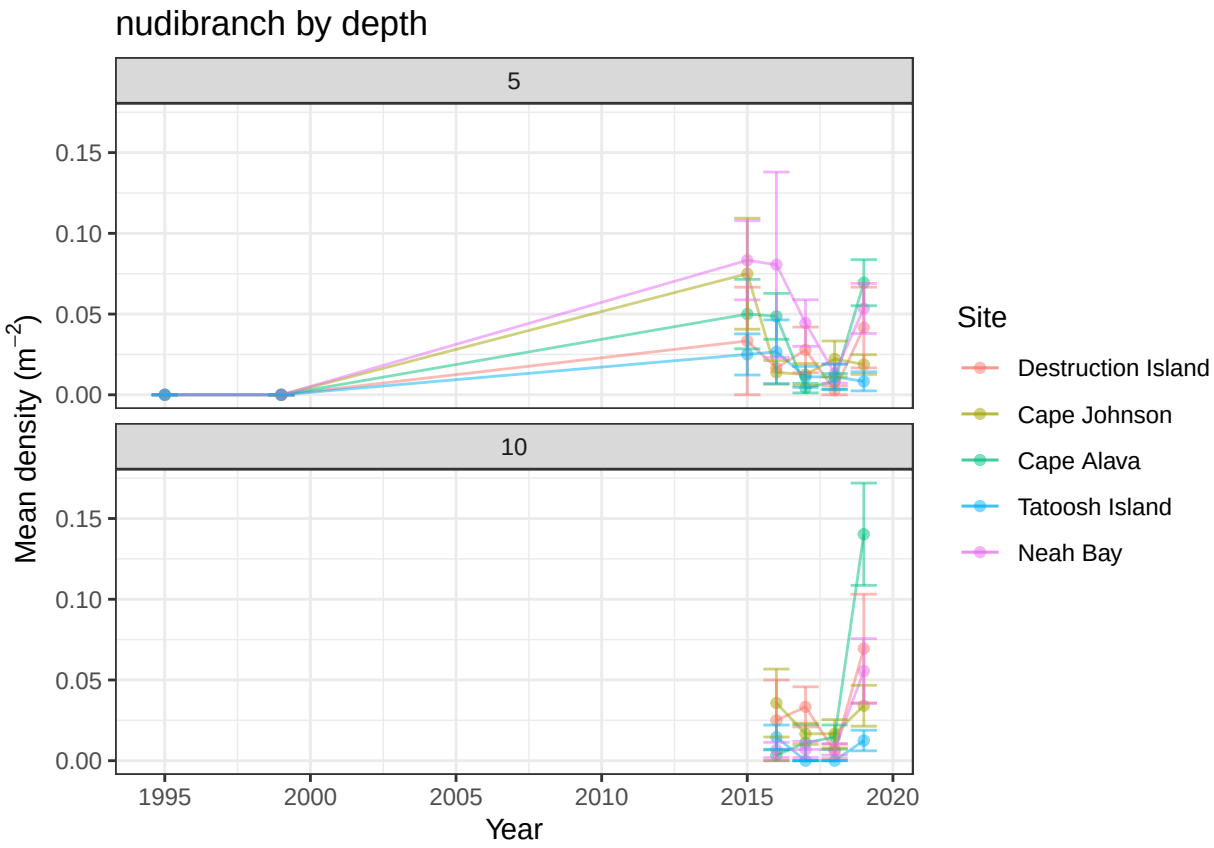

anenome by depth
5
10
Mean density (m^{-2})
0.0
0.2
0.4
0.6
2015
2016
2017
2018
2019
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay

Nudibranch

Nudibranch plots include these species

code	common.name
ACAHUD	Acanthodoris hudsoni, white nudibranch with yellow margin (we lump with Cadlina luteomarginata)
ACANAN	Acanthodoris nanaimo
DIASAN	Dialula sandiegensis
DIRALB	Dirona albolineata, white lined nudibranch
DORODH	Doris odhneri, white knight dorid nudibranch
DOROHD	
HERCRA	Hermissenda crassicornis, opalescent nudibranch
JANFUS	Janolus fuscus, nudibranch
LIMCOC	Limacia cockerelli
NUDIBR	unknown nudibranch
PELNOB	Peltodoris nobilis, pacific sea lemon
TRICAT	Triopha catalinae, sea clown nudibranch

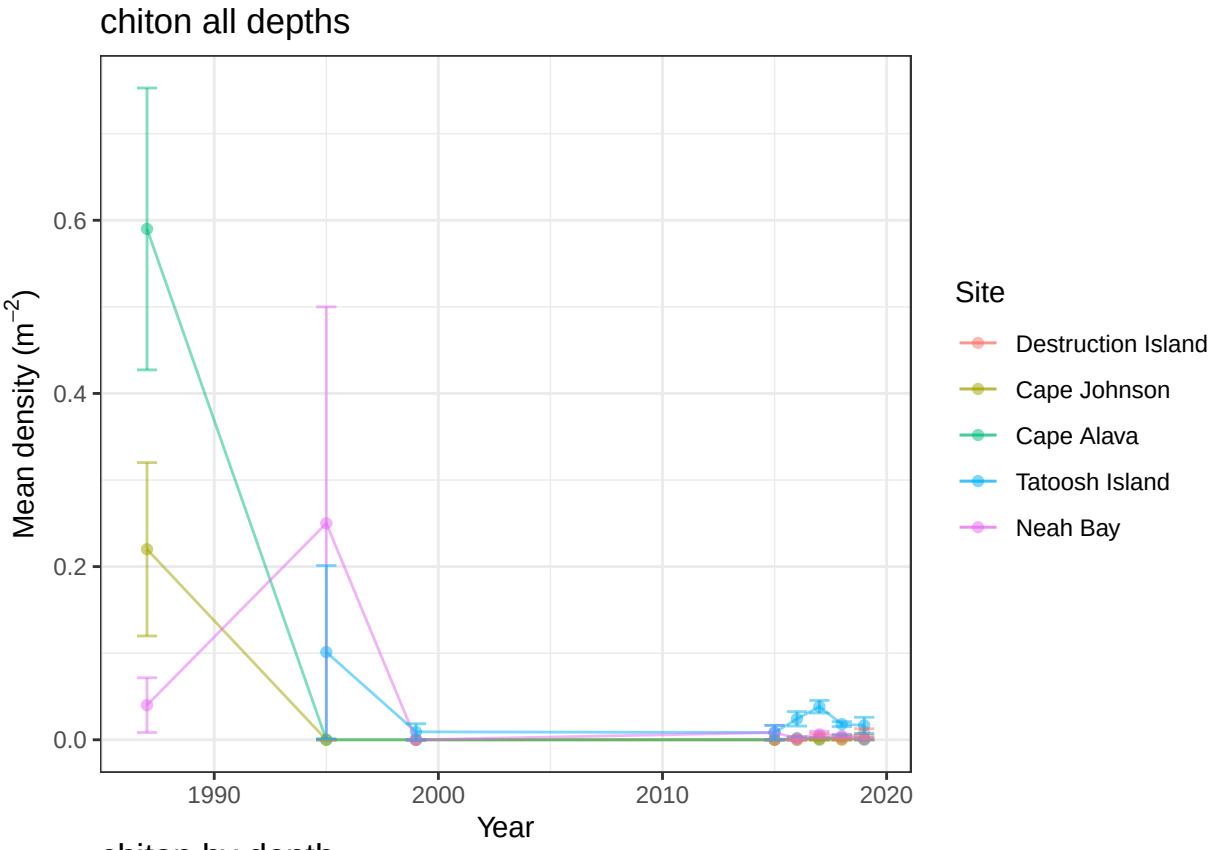


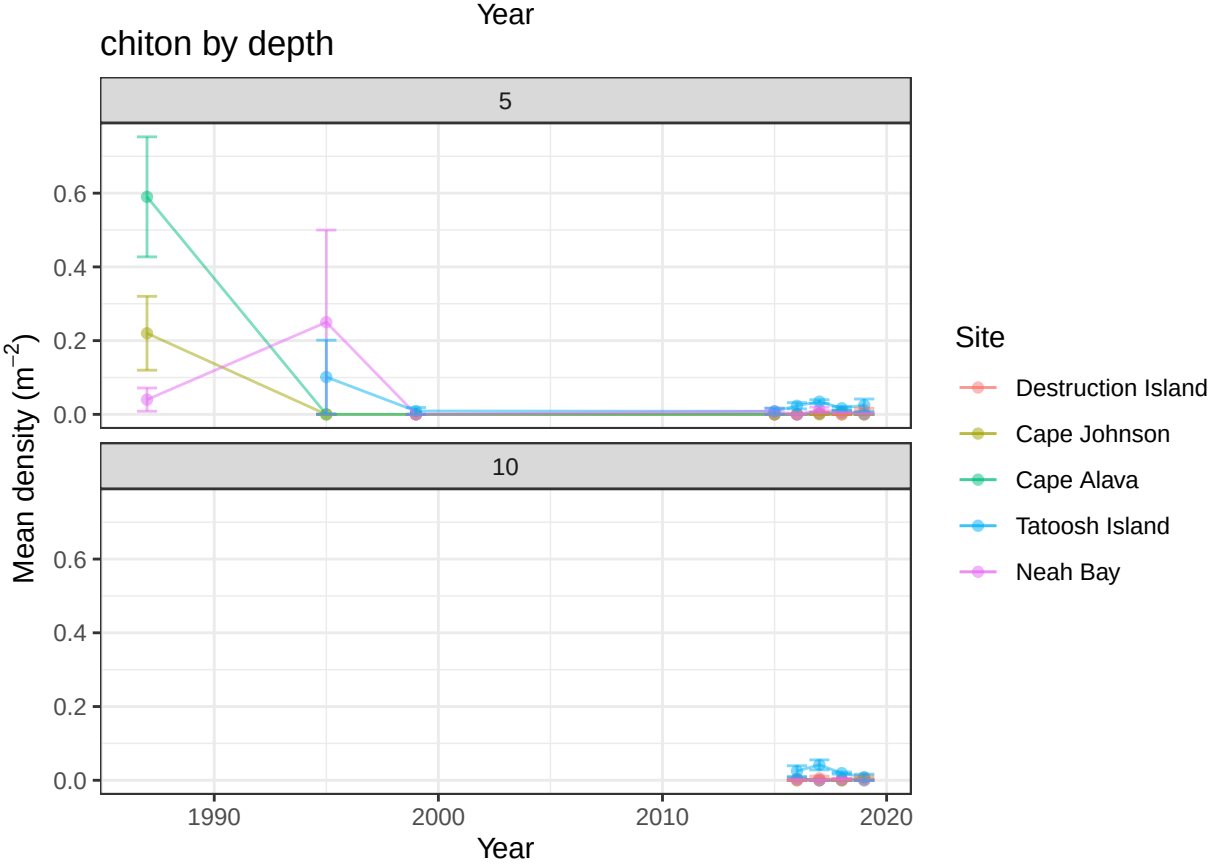


Chiton

Chiton plots include these species

code	common.name
CRYSTE	Cryptochiton stelleri, gumboot chiton


chiton all depths
Mean density (m^{-2})
0.0
0.2
0.4
0.6
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay


chiton by depth
5
10
Mean density (m^{-2})
0.0
0.2
0.4
0.6
1990
2000
2010
2020
Year
Site
Destruction Island
Cape Johnson
Cape Alava
Tatoosh Island
Neah Bay