

Species on the move: Impacts of marine heatwaves on coastal ecosystems

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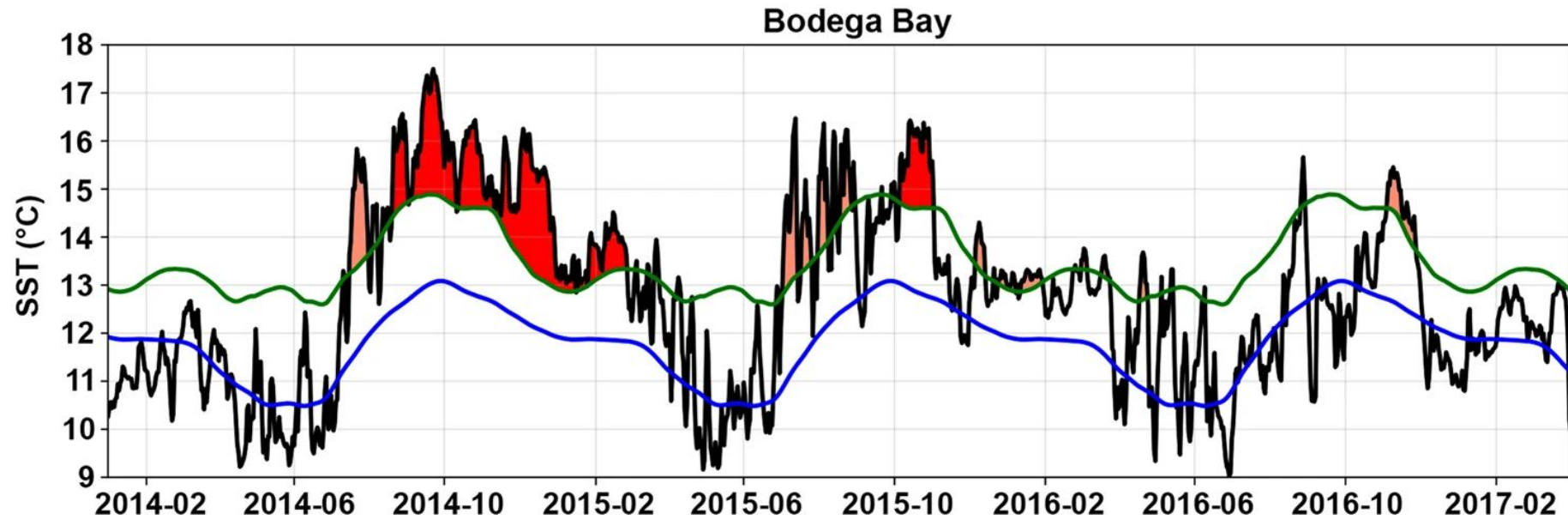
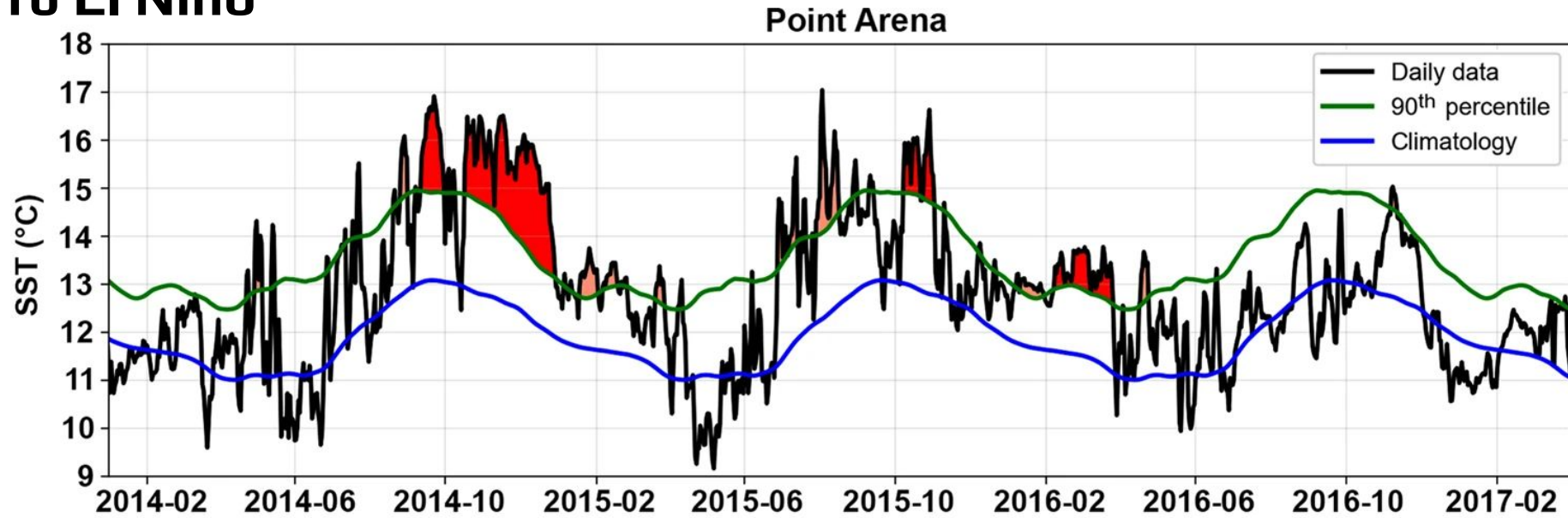
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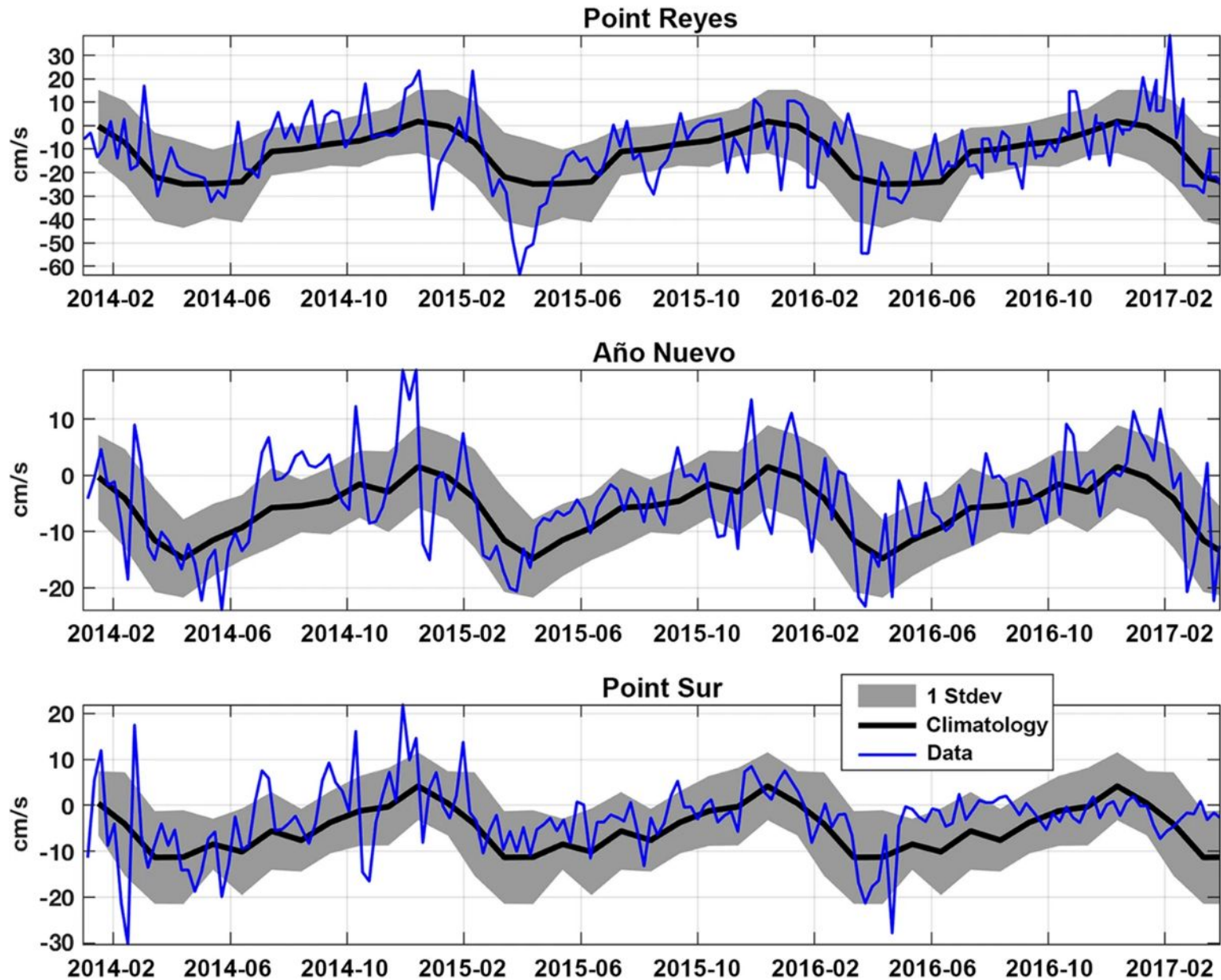
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Sea surface temperature anomalies during the warm-water Blob and 2015–2016 El Niño



Poleward alongshore current anomalies during the warm-water Blob and 2015–2016 El Niño



Geographic range expansions (n=37 species)

Taxon	Common name	Scientific name	New northern record	Former range limit	Expansion (km)
Cnidaria	Sunburst Anemone (CN)	<i>Anthopleura sola</i>	Bruhel Point, CA	Bodega Marine Reserve	165
	Siphonophore (CN)	<i>Hippopodius hippopus</i>	Salmon Creek Beach, CA	Point Conception, CA	490
	Hula Skirt Siphonophore (CN)	<i>Physophora hydrostatica</i>	Arcata, CA	Monterey Bay, CA	530
	Purple-striped Jellyfish (CN)	<i>Chrysaora colorata</i>	Arcadia Beach, OR	Bodega Bay, CA	875
	Venus' Girdle Ctenophore (CT)	<i>Cestum veneris</i>	Barkley Sound, BC	Monterey Bay, CA	1400
Mollusca	Angular Unicorn Snail (M)	<i>Acanthinucella spirata</i>	Cape Mendocino, CA	Bodega Harbor	260
	Appleseed Erato Snail (M)	<i>Hespererato vitellina</i>	Cape Mendocino, CA	Bodega Marine Reserve	255
	Purple Sea Snail (M)	<i>Janthina umbilicata</i>	Leadbetter Point, WA	Neskowin, OR	140
	Scaled Tube Snail (M)	<i>Thylacodes squamigerus</i>	Salt Point, CA	Bodega Marine Reserve	36
	Curved Needle Pteropod (M)	<i>Creseis virgula</i>	Bodega Line Station 4	off Central California	150
	Striated Sea Butterfly (M)	<i>Hyalocylis striata</i>	Bodega Line Station 4	Baja California, Mexico	1400
	Strong's Sidegill (M)	<i>Berthella strongi</i>	MacKerricker State Park, CA	Moss Beach, CA	255
	Black-tipped Spiny Dorid (M)	<i>Acanthodoris rhodoceras</i>	Barkley Sound, BC	Cape Arago, OR	620
	Olive's Nudibranch (M)	<i>Anteaeolidiella oliviae</i>	Fort Bragg, CA	Duxbury Reef, CA	210
	Rabbit Dorid Nudibranch (M)	<i>Crimora coneja</i>	Boiler Bay, OR	Cape Arago, OR	170
	Colorful Dirona Nudibranch (M)	<i>Dirona picta</i>	Barkley Sound, BC	Cape Mearns, OR	385
	White-spotted Sea Goddess (M)	<i>Doriopsilla albopunctata</i>	Whiskey Creek, OR	Mendocino, CA	335
	White-spotted Dorid (M)	<i>Doriopsilla fulva</i>	Netarts Bay, OR	Abalone Beach, CA	485
	Janolus Nudibranch (M)	<i>Janolus barbarensis</i>	Bodega Harbor, CA	San Francisco Bay, CA	87
	Los Angeles Okenia (M)	<i>Okenia angelensis</i>	Miwok Beach, CA	San Francisco Bay, CA	94
	Hilton's Nudibranch (M)	<i>Phidiana hiltoni</i>	Pinnacle Gulch, CA	Duxbury Reef, CA	63
	Orange-spike Polycera (M)	<i>Polycera atra</i>	Monas Island, BC	Westport, WA	290
	Spotted Triopha Nudibranch (M)	<i>Triopha maculata</i>	Port Hardy, BC	Bamfield, BC	425
	Crustacean	Spiny Lobster (CR)	<i>Panulirus interruptus</i>	Horseshoe Cove (BMR), CA	San Francisco Bay, CA
Chocolate Porcelain Crab (CR)		<i>Petrolisthes manimaculis</i>	Point St. George, CA	Trinidad, CA	80
Xantus' Swimming Crab (CR)		<i>Portunus xantusii</i>	Tomales Bay, CA	Morro Bay, CA	390
Pelagic Red Crab (CR)		<i>Pleuroncodes planipes</i>	Agate Beach, OR	Fort Bragg, CA	595
Pink-striped Barnacle (CR)		<i>Megabalanus californicus</i>	Humboldt State Park, OR	Humboldt Bay, CA	215
Red-striped Barnacle (CR)		<i>Paraconcaucus pacificus</i>	MacKerricher State Park, CA	San Francisco, CA	240
Echinod.	Glass-spined Brittle Star (E)	<i>Ophiothrix spiculata</i>	Patrick's Point, CA	Cordell Bank, CA	360
	Scarlet Sea Cucumber (E)	<i>Lissothuria nutriens</i>	Fort Ross, CA	Bodega Marine Reserve	25
	Red Sea Cucumber (E)	<i>Pachythyone rubra</i>	Bodega Marine Reserve	Pinnacle Gulch, CA	6
Vertebr.	Pelagic Salp (T)	<i>Thetys vagina</i>	Calvert Island, BC	Grays Canyon, WA	630
	Pacific Snake Eel (F)	<i>Ophichthus triserialis</i>	Lincoln City, OR	Klamath River, CA	395
	Wedge-rumped Storm-Petrel (B)	<i>Oceanodroma tethys</i>	Humboldt Bay, CA	Monterey Bay, CA	500
Algae	Common Bottlenose Dolphin (MM)	<i>Tursiops truncatus</i>	Little River, CA	Doran Beach, CA	130
	Red Alga (A)	<i>Dasya binghamiae</i>	Bodega Harbor, CA	Estero de San Antonio, CA	7



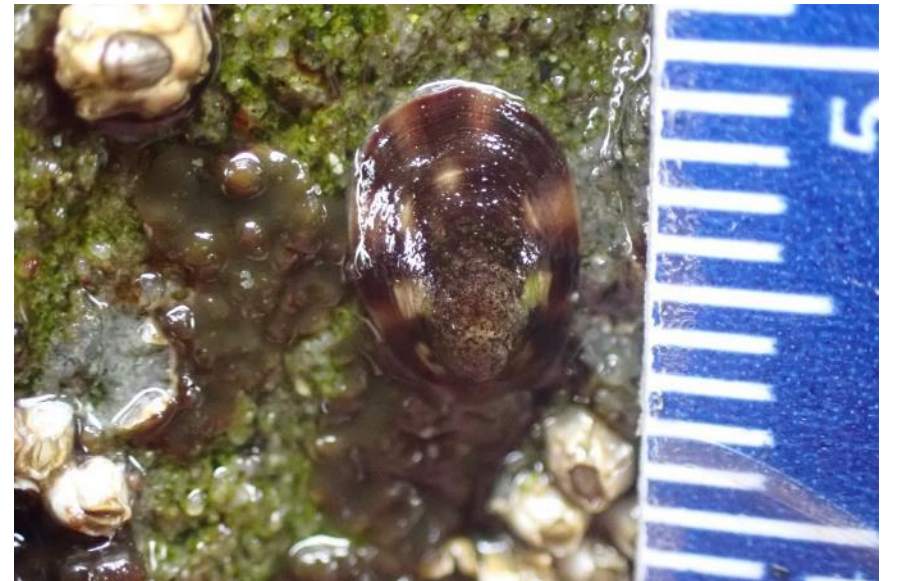
Global evidence of poleward range expansions

Ecosystem	Range expansion	<i>n</i>	Source
Marine	10.6 \pm 5.3 km/decade	87	Przeslawski et al. 2012
Marine	72.0 \pm 13.5 km/decade	111	Poloczanska et al. 2013
Marine	345.4 \pm 53.9 km/<3 yrs	35	Sanford et al. 2019
Terrestrial	6.1 \pm 2.4 km/decade	99	Parmesan & Yohe 2003
Terrestrial (mostly)	19.7 \pm 3.7 km/decade	336	Chen et al. 2011



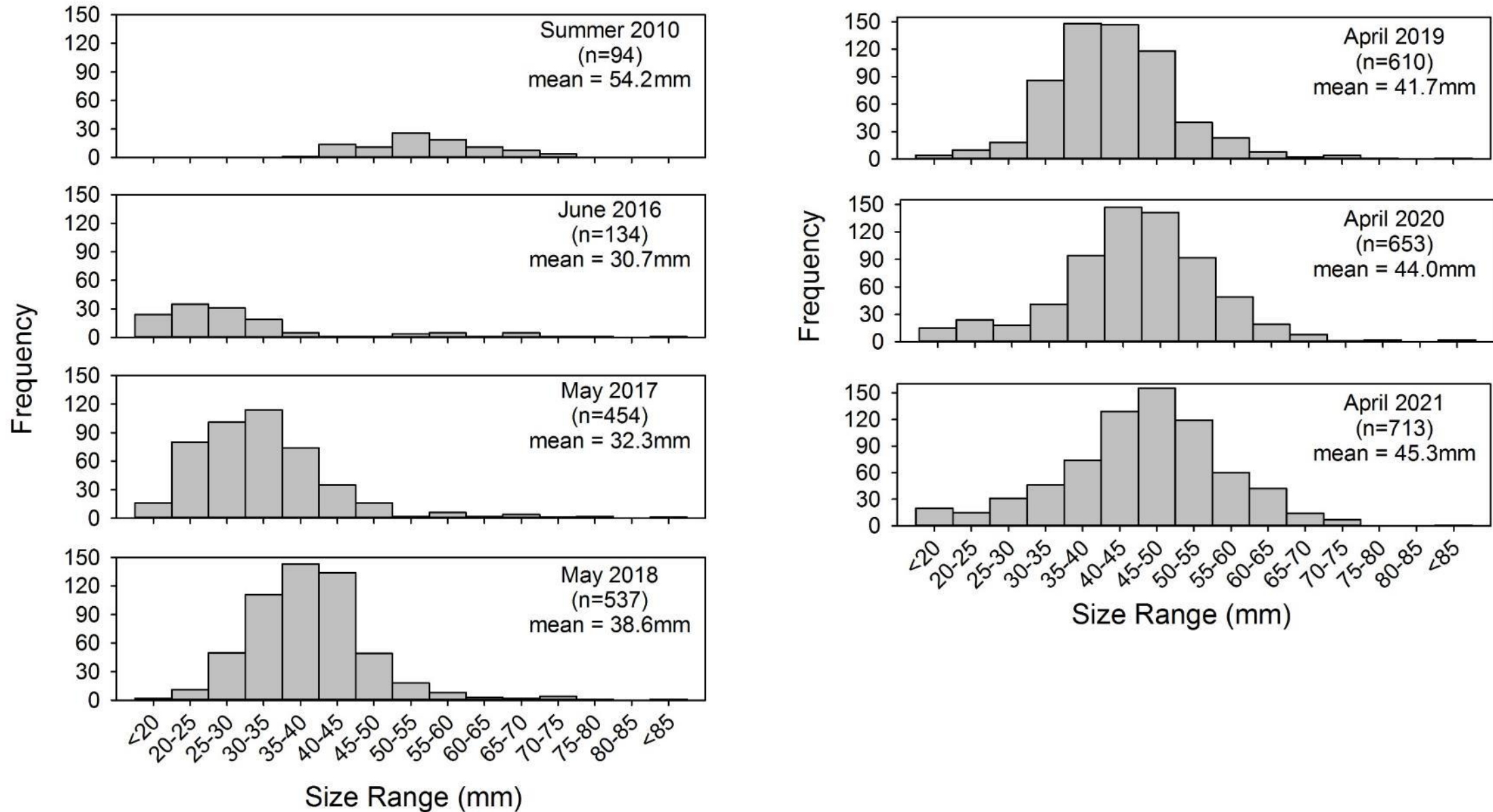
Marine heatwaves might provide a mechanism for rapid poleward expansion

Owl Limpet
(*Lottia*
***gigantea*)**



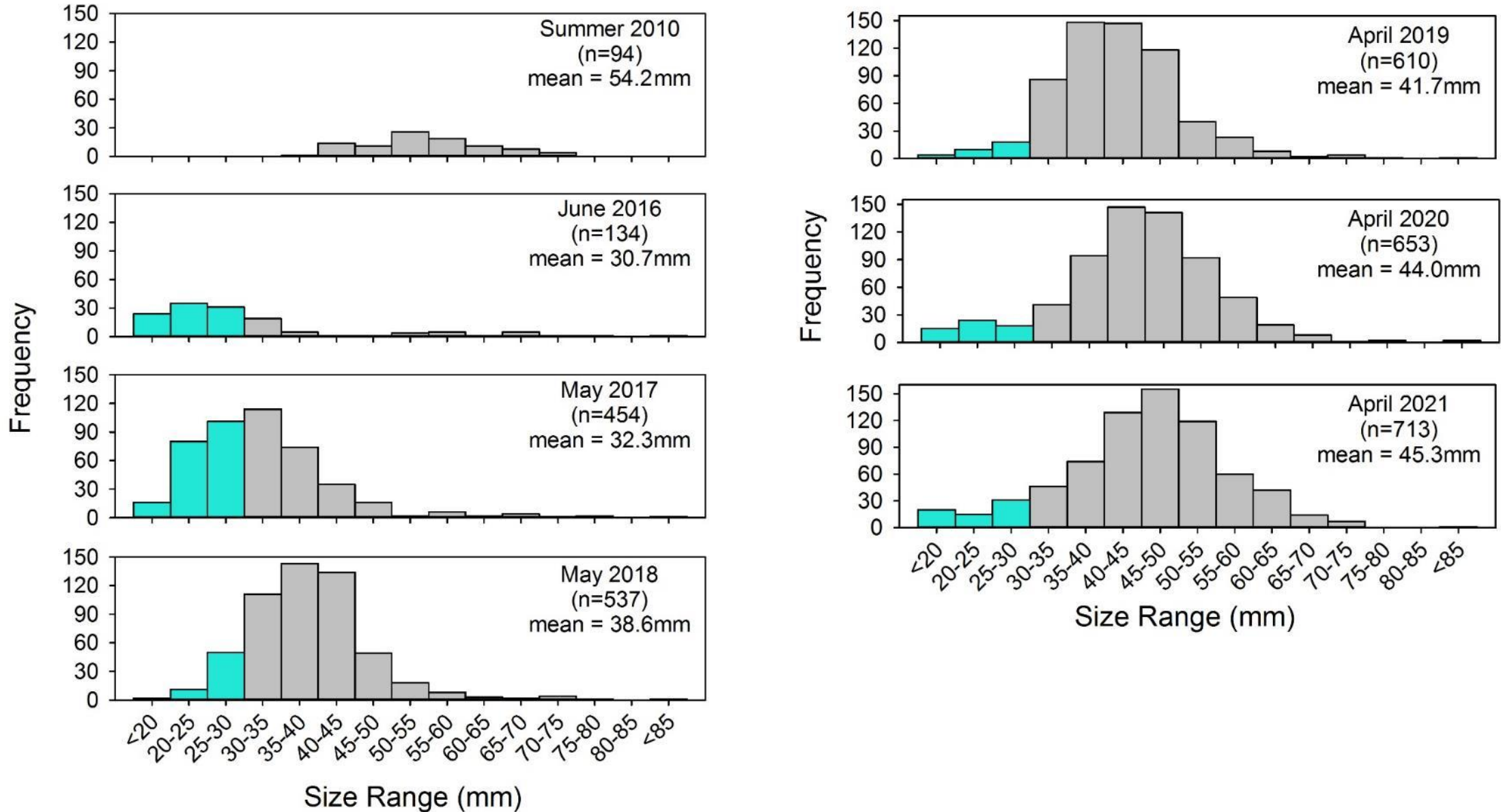


Owl Limpet size frequencies at Bodega Marine Reserve 2010-2021



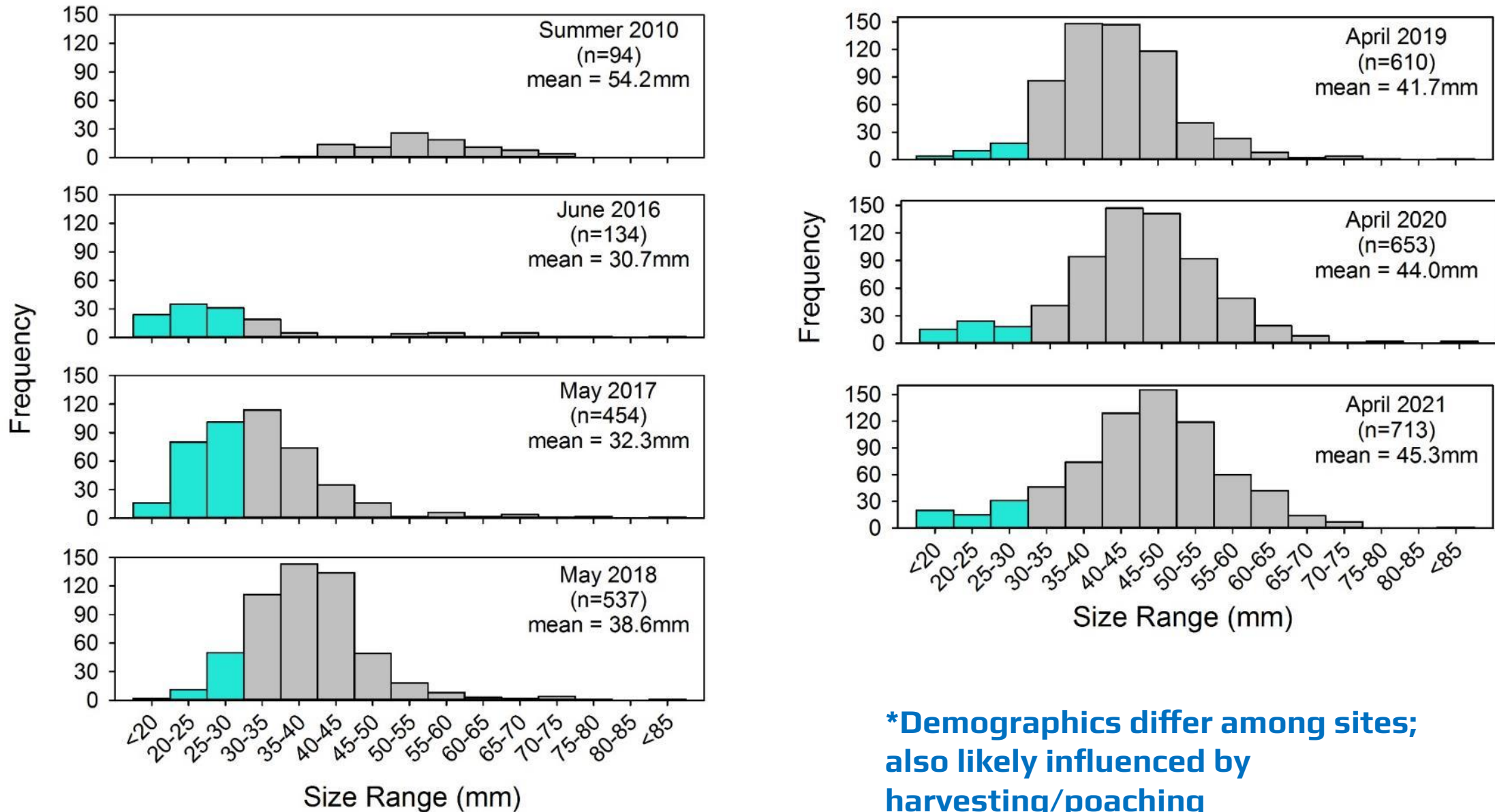


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Owl Limpet size frequencies at Bodega Marine Reserve 2010-2021



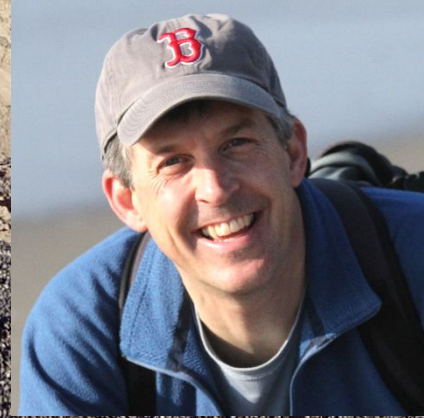
Team Owl Limpet, UC Davis



Rachael
Bay



Erica
Nielsen



Eric
Sanford



Sam
Walkes



Rick
Grosberg

New NSF-funded project (OCE-2023297):

**Combining field studies, lab experiments, and genomics to investigate
“Evolutionary and ecological dynamics of a contemporary climate-driven range expansion”**



Examples of current research questions

- **What are the ecological and evolutionary consequences of marine heatwaves?**
- **Are Owl Limpet populations north of San Francisco now dense enough to contribute to local reproduction and recruitment?**
- **Is natural selection leading to divergence in some traits between new (northern) and established (central/southern) populations?**

Take-home points and food for thought

- Range shifts might be especially common when marine heatwaves are intense and prolonged
- In some cases, the ecological consequences of marine heatwaves might persist long after the event
- There's a lot that remains to be learned (species, mechanisms, consequences)
- Standard funding cycles make studying decadal scale processes challenging
- Targeted surveys and rapid responses to extreme events are required to document species range shifts in real time

Acknowledgements

Thanks to everyone who shared observations and insights! For a full list, please see the Acknowledgements section on pp. 32-33 of the Supplementary Information file for the research article:

Sanford, E., Sones, J.L., García-Reyes, M., Goddard, J.H.R., and J.L. Largier. 2019. Widespread shifts in the coastal biota of northern California during the 2014–2016 marine heatwaves. *Scientific Reports* 9, 4216.

<https://doi.org/10.1038/s41598-019-40784-3>

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