## Supplementary information

Alabia et al. Marine biodiversity refugia in a climate-sensitive subarctic shelf

**Table S1.** Summary of the annual number of unsampled stations in the Eastern Bering Sea (EBS) trawl surveys at each sampling stratum and substratum from 1990-2018.

**Table S2.** List of species used for the regional biodiversity analyses between 1990 and 2018 in the EBS.

**Table S3**. List of environmental variables used as correlates for diversification of marine community in the Eastern Bering Sea. Highly-correlated variables ($r > 0.5$) are denoted by the asterisk and were not included in the statistical models for alpha- and beta-diversity.

**Table S4.** Model performance metrics (adjusted $R^2$ and Akaike Information Criterion, AIC) of generalized additive mixed modes for alpha (species richness) and beta diversity (Sørensen dissimilarity) built using different correlation structures. The best model is highlighted in bold.

**Table S5.** Significant species-specific contribution to Bray-Curtis dissimilarity in community composition between hwsic and lwsic regimes ($p <0.05$). Species in bold were identified as the most influential taxa to overall dissimilarity. Affinity of species to sea ice regimes was based on the point biserial correlation index computed using the multilevel pattern analysis.

**Figure S1.** Map of the Bering Sea showing the bottom trawl survey sites in the eastern shelf region. Overlain are sampling locations, color-coded based on the individual stratum between 1990 and 2018.

**Figure S2.** Annual number of distinct taxa belonging to specific taxonomic groups throughout the study area from 1990-2018.

**Figure S3.** Computed correlation (r) matrix across the initial set of environmental variables. Highly correlated environmental factors were those with r > 0.5.

**Figure S4.** Spatial distribution maps of monotonic trends and quintile-based (Q1-Q5) climatic change categories of (a,d) winter sea ice concentration and seasonal sea surface temperatures during (b,e) winter and (c,f) summer, 1990-2018 over the EBS. Overlain polygons correspond to biodiversity refugial zones in the middle shelf.

**Figure S5.** Significant partial effects of spatial (longitude, latitude) and temporal (year) factors on the (a-b) alpha diversity (species richness) and (c-d) beta diversity (Sorensen dissimilarity) predicted from a generalized additive mixed model.

**Figure S6.** Annual time series of basin-wide winter sea ice (wsic) anomaly relative to the 29-year average, where white and blue bars correspond to years when wsic are higher and lower than the long-term mean. Regime shift index (purple solid line) revealed alternating periods of (a-d) high and low wsic regimes between 1990 and 2018.

**Table S1.** Summary of the annual number of unsampled stations in the Eastern Bering Sea (EBS) trawl surveys at each sampling stratum and substratum from 1990-2018.

| Stratum | 10 | 20 | 30 | | 40 | | | 50 | 60 | | 82 | 90 | Unsampled stations | Sampled stations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Substratum/ Year | 10 | 20 | 31 | 32 | 41 | 42 | 43 | 50 | 61 | 62 | 82 | 90 | | |
| 1990 | 0 | 1 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 371 |
| 1991 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 372 |
| 1992 | 1 | 15 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 356 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 1999 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 373 |
| 2000 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 372 |
| 2001 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 375 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 375 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 3 | 373 |
| 2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2008 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 375 |
| 2009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2010 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2013 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2014 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2017 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |
| 2018 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 376 |

**Table S2.** List of species used for the regional biodiversity analyses between 1990 and 2018 in the EBS.

| Common name | Scientific name | Taxonomic group | Years present |
|---|---|---|---|
| Tanner crab | *Chionoecetes bairdi* | Crustacea | 29 |
| Hybrid tanner crab | *Chionoecetes hybrid* | Crustacea | 29 |
| Snow crab | *Chionoecetes opilio* | Crustacea | 29 |
| Circumboreal toad crab | *Hyas coarctatus* | Crustacea | 29 |
| Red king crab | *Paralithodes camtschaticus* | Crustacea | 29 |
| Pacific lyre crab | *Hyas lyratus* | Crustacea | 29 |
| Graceful decorator crab | *Oregonia gracilis* | Crustacea | 29 |
| Blue king crab | *Paralithodes platypus* | Crustacea | 29 |
| Helmet crab | *Telmessus cheiragonus* | Crustacea | 29 |
| Horsehair crab | *Erimacrus isenbeckii* | Crustacea | 29 |
| Oregon rock crab | *Cancer oregonensis* | Crustacea | 29 |
| Alaskan pink shrimp | *Pandalus eous* | Crustacea | 29 |
| Humpy shrimp | *Pandalus goniurus* | Crustacea | 29 |
| Alaskan hermit | *Pagurus ochotensis* | Crustacea | 24 |
| Giant barnacle | *Balanus evermanni* | Crustacea | 22 |
| Wide-hand hermit crab | *Elassochirus tenuimanus* | Crustacea | 22 |
| Aleutian hermit | *Pagurus aleuticus* | Crustacea | 22 |
| Hairy hermit crab | *Pagurus capillatus* | Crustacea | 22 |
| Splendid hermit | *Labidochirus splendescens* | Crustacea | 22 |
| Knobby-hand hermit | *Pagurus confragosus* | Crustacea | 22 |
| Fuzzy hermit crab | *Pagurus trigonocheirus* | Crustacea | 21 |
| Purple hermit | *Elassochirus cavimanus* | Crustacea | 21 |
| Arctic argid | *Argis dentata* | Crustacea | 21 |
| Kuro argid | *Argis lar* | Crustacea | 21 |
| Sponge hermit | *Pagurus brandti* | Crustacea | 20 |
| Longfinger hermit | *Pagurus rathbuni* | Crustacea | 20 |
| Ridged crangon | *Crangon dalli* | Crustacea | 20 |
| Basketstar | *Gorgonocephalus eucnemis* | Echinoderm | 29 |
| Sea football | *Cucumaria fallax* | Echinoderm | 29 |
| Purple-orange sea star | *Asterias amurensis* | Echinoderm | 29 |
| Polar six-rayed star | *Leptasterias polaris* | Echinoderm | 29 |
| Black-spined sea star | *Lethasterias nanimensis* | Echinoderm | 29 |
| Arctic star | *Leptasterias arctica* | Echinoderm | 29 |
| Obscure sea star | *Pteraster obscurus* | Echinoderm | 29 |
| Giant sea star | *Evasterias echinosoma* | Echinoderm | 29 |
| Common mud star | *Ctenodiscus crispatus* | Echinoderm | 29 |
| Rose sea star | *Crossaster papposus* | Echinoderm | 29 |
| Pincushion sea star | *Diplopteraster multipes* | Echinoderm | 29 |
| Green sea urchin | *Strongylocentrotus droebachiensis* | Echinoderm | 29 |
| Scarlet sea star | *Pseudarchaster parelii* | Echinoderm | 28 |
| Cushion star | *Pteraster tesselatus* | Echinoderm | 27 |
| Notched brittlestar | *Ophiura sarsi* | Echinoderm | 27 |
| Parma sand dollar | *Echinarachnius parma* | Echinoderm | 24 |
| Red bat star | *Ceramaster japonicus* | Echinoderm | 22 |
| Northern sea star | *Dipsacaster borealis* | Echinoderm | 21 |
| Ubiquitous brittle star | *Ophiopholis aculeata* | Echinoderm | 20 |
| Sawback poacher | *Leptagonus frenatus* | Fish | 29 |
| Alaska plaice | *Pleuronectes quadrituberculatus* | Fish | 29 |
| Rex sole | *Glyptocephalus zachirus* | Fish | 29 |
| Flathead sole | *Hippoglossoides elassodon* | Fish | 29 |
| Arrowtooth flounder | *Atheresthes stomias* | Fish | 29 |
| Pacific halibut | *Hippoglossus stenolepis* | Fish | 29 |
| Pacific cod | *Gadus macrocephalus* | Fish | 29 |

| Common name (cont. Table S2) | Scientific name | Taxonomic group | Years present |
|---|---|---|---|
| Walleye pollock | *Gadus chalcogrammus* | Fish | 29 |
| Bigmouth sculpin | *Hemitripterus bolini* | Fish | 29 |
| Yellowfin sole | *Limanda aspera* | Fish | 29 |
| Sturgeon poacher | *Podothecus accipenserinus* | Fish | 29 |
| Yellow Irish lord | *Hemilepidotus jordani* | Fish | 29 |
| Wattled eelpout | *Lycodes palearis* | Fish | 29 |
| Searcher | *Bathymaster signatus* | Fish | 29 |
| Spinyhead sculpin | *Dasycottus setiger* | Fish | 29 |
| Shortfin eelpout | *Lycodes brevipes* | Fish | 29 |
| Thorny sculpin | *Icelus spiniger* | Fish | 29 |
| Capelin | *Mallotus villosus* | Fish | 29 |
| Butter sole | *Isopsetta isolepis* | Fish | 29 |
| Starry flounder | *Platichthys stellatus* | Fish | 29 |
| Eulachon | *Thaleichthys pacificus* | Fish | 29 |
| Plain sculpin | *Myoxocephalus jaok* | Fish | 29 |
| Great sculpin | *Myoxocephalus polyacanthocephalus* | Fish | 29 |
| Whitespotted greenling | *Hexagrammos stelleri* | Fish | 29 |
| Kamchatka flounder | *Atheresthes evermanni* | Fish | 29 |
| Greenland turbot | *Reinhardtius hippoglossoides* | Fish | 29 |
| Bering poacher | *Occella dodecaedron* | Fish | 29 |
| Longhead dab | *Limanda proboscidea* | Fish | 29 |
| Bering wolffish | *Anarhichas orientalis* | Fish | 29 |
| Pacific ocean perch | *Sebastes alutus* | Fish | 29 |
| Marbled eelpout | *Lycodes raridens* | Fish | 29 |
| Bering flounder | *Hippoglossoides robustus* | Fish | 29 |
| Butterfly sculpin | *Hemilepidotus papilio* | Fish | 29 |
| Sakhalin sole | *Limanda sakhalinensis* | Fish | 29 |
| Ribbed sculpin | *Triglops pingeli* | Fish | 28 |
| Daubed shanny | *Lumpenus maculatus* | Fish | 28 |
| Atka mackerel | *Pleurogrammus monopterygius* | Fish | 28 |
| Armorhead sculpin | *Gymnocanthus galeatus* | Fish | 28 |
| Saffron cod | *Eleginus gracilis* | Fish | 28 |
| Arctic cod | *Boreogadus saida* | Fish | 28 |
| Pacific herring | *Clupea pallasi* | Fish | 27 |
| Pacific sandfish | *Trichodon trichodon* | Fish | 27 |
| Aleutian alligatorfish | *Aspidophoroides bartoni* | Fish | 27 |
| Rainbow smelt | *Osmerus mordax* | Fish | 26 |
| Northern rockfish | *Sebastes polyspinis* | Fish | 26 |
| Whitebarred prickleback | *Poroclinus rothrocki* | Fish | 26 |
| Hookhorn sculpin | *Artediellus pacificus* | Fish | 26 |
| Dover sole | *Microstomus pacificus* | Fish | 25 |
| Darkfin sculpin | *Malacocottus zonurus* | Fish | 25 |
| Spectacled sculpin | *Triglops scepticus* | Fish | 25 |
| Chum salmon | *Oncorhynchus keta* | Fish | 25 |
| Spatulate sculpin | *Icelus spatula* | Fish | 24 |
| Roughspine sculpin | *Triglops macellus* | Fish | 24 |
| Threaded sculpin | *Gymnocanthus pistilliger* | Fish | 24 |
| Alaska skate | *Bathyraja parmifera* | Fish | 24 |
| Bering skate | *Bathyraja interrupta* | Fish | 24 |
| Slender eelblenny | *Lumpenus fabricii* | Fish | 23 |
| Northern rock sole | *Lepidopsetta polyxystra* | Fish | 23 |
| Variegated snailfish | *Liparis gibbus* | Fish | 23 |
| Salmon snailfish | *Careproctus rastrinus* | Fish | 22 |
| Warty sculpin | *Myoxocephalus verrucosus* | Fish | 22 |
| Aleutian skate | *Bathyraja aleutica* | Fish | 22 |
| Southern rock sole | *Lepidopsetta bilineata* | Fish | 22 |
| Sablefish | *Anoplopoma fimbria* | Fish | 20 |

| Common name (cont. Table S2) | Scientific name | Taxonomic group | Years present |
|---|---|---|---|
| Prowfish | *Zaprora silenus* | Fish | 20 |
| Blotched snailfish | *Crystallichthys cyclospilus* | Fish | 20 |
| Greenland cockle | *Serripes groenlandicus* | Mollusk | 29 |
| Weathervane scallop | *Patinopecten caurinus* | Mollusk | 29 |
| Ladder whelk | *Buccinum scalariforme* | Mollusk | 29 |
| Lyre whelk | *Neptunea lyrata* | Mollusk | 29 |
| Fat whelk | *Neptunea ventricosa* | Mollusk | 29 |
| Pribilof whelk | *Neptunea pribiloffensis* | Mollusk | 29 |
| Sinuous whelk | *Buccinum plectrum* | Mollusk | 29 |
| Sea snail | *Neptunea borealis* | Mollusk | 29 |
| Sea snail | *Neptunea heros* | Mollusk | 29 |
| Oregon triton | *Fusitriton oregonensis* | Mollusk | 29 |
| Warped whelk | *Pyrulofusus deformis* | Mollusk | 29 |
| Helmet whelk | *Clinopegma magnum* | Mollusk | 29 |
| Keeled Aforia | *Aforia circinata* | Mollusk | 29 |
| Arctic surfclam | *Mactromeris polynyma* | Mollusk | 28 |
| Alaska razor | *Siliqua alta* | Mollusk | 28 |
| Angular whelk | *Buccinum angulosum* | Mollusk | 28 |
| Polar whelk | *Buccinum polare* | Mollusk | 28 |
| Fragile whelk | *Volutopsius fragilis* | Mollusk | 28 |
| Thin-ribbed whelk | *Colus herendeenii* | Mollusk | 28 |
| Whelk | *Pyrulofusus melonis* | Mollusk | 28 |
| Hairy cockle | *Clinocardium ciliatum* | Mollusk | 27 |
| Alaska volute | *Arctomelon stearnsii* | Mollusk | 26 |
| Rosy Tritonia | *Tritonia diomedea* | Mollusk | 26 |
| Eastern Pacific bobtail | *Rossia pacifica* | Mollusk | 25 |
| Discordant mussel | *Musculus discors* | Mollusk | 25 |
| Pale moon snail | *Euspira pallida* | Mollusk | 24 |
| Alaska great-tellin | *Tellina lutea* | Mollusk | 23 |
| Alaska falsejingle | *Pododesmus macrochisma* | Mollusk | 23 |
| Northern horsemussel | *Modiolus modiolus* | Mollusk | 23 |
| Broad cockle | *Serripes laperousii* | Mollusk | 22 |
| Great slippersnail | *Crepidula grandis* | Mollusk | 22 |
| Rusty moonsnail | *Cryptonatica russa* | Mollusk | 22 |
| Shrew whelk | *Colus halli* | Mollusk | 22 |
| Arctic hiatella | *Hiatella arctica* | Mollusk | 21 |
| Blue mussel | *Mytilus edulis* | Mollusk | 20 |
| Giant octopus | *Enteroctopus dofleini* | Mollusk | 20 |
| Shouldered whelk | *Volutopsius stefanssoni* | Mollusk | 20 |
| Giant scale worm | *Eunoe nodosa* | Others | 29 |
| Depressed scale worm | *Eunoe depressa* | Others | 28 |
| Leafy bryozoan | *Flustra serrulata* | Others | 28 |
| Ribbed bryozoan | *Rhamphostomella costata* | Others | 24 |
| Sea potato | *Styela rustica* | Others | 29 |
| Sea onion | *Boltenia ovifera* | Others | 29 |
| Sea peach | *Halocynthia aurantium* | Others | 28 |
| Tentacle-shedding anemone | *Liponema brevicorne* | Others | 21 |
| Sea strawberry | *Gersemia rubiformis* | Others | 20 |
| Mottled anemone | *Urticina crassicornis* | Others | 20 |

**Table S3**. List of environmental variables used as correlates for diversification of marine community in the Eastern Bering Sea. Highly-correlated variables ($r > 0.5$) are denoted by the asterisk and were not included in the statistical models for alpha- and beta-diversity.

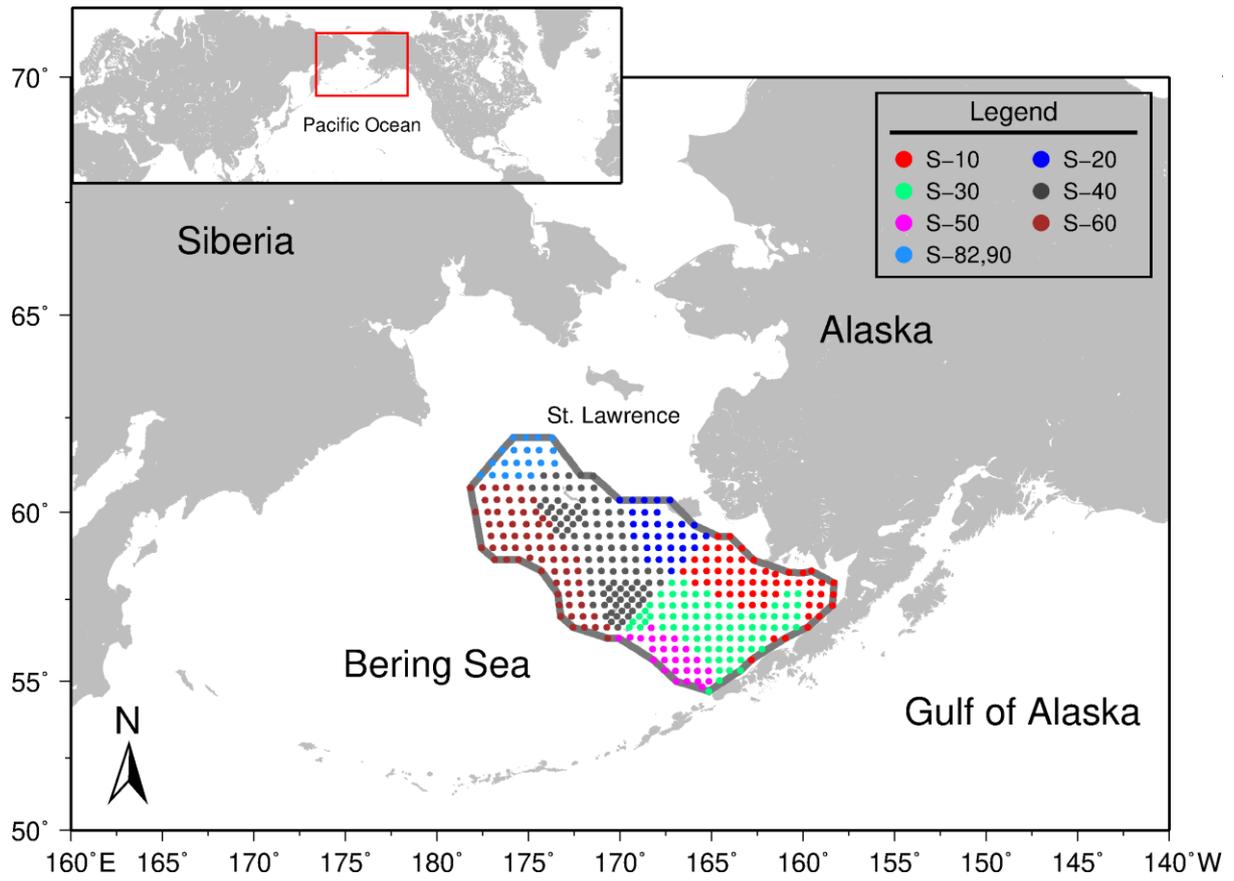| Environmental data | Abbreviation | Source |
|---|---|---|
| *In-situ measurements* | | |
| Bottom temperature | btemp* | NOAA EBS surveys |
| Bottom temperature spatial gradient | btg | NOAA EBS surveys |
| Surface temperature | stemp* | NOAA EBS surveys |
| Surface temperature spatial gradient | stg | NOAA EBS surveys |
| Bottom depth | bdep | NOAA EBS surveys |
| | | |
| *Satellite-derived data* | | |
| Winter (Jan-Apr) sea surface temperature | wsst* | AVHRR-OI |
| WSST maximum | $wsst_{max}$* | AVHRR-OI |
| WSST minimum | $wsst_{min}$* | AVHRR-OI |
| Summer (May-August) SST | ssst* | AVHRR-OI |
| SSST maximum | $ssst_{max}$ | AVHRR-OI |
| SSST minimum | $ssst_{min}$* | AVHRR-OI |
| Winter Sea ice concentration | wsic | AVHRR-OI |
| Sea ice cover duration | $sic_{day}$* | AVHRR-OI |
| Distance to the nearest coast | distc | GSFC NASA |

**Table S4.** Model performance metrics (adjusted $R^2$ and Akaike Information Criterion, AIC) of generalized additive mixed modes for alpha (species richness) and beta diversity (Sorensen dissimilarity) built using different correlation structures. The best model is highlighted in bold.

| Response variable | Model correlation structure | Adj R2 | AIC |
|---|---|---|---|
| alpha diversity | **Gaussian** | **0.458** | **49941** |
| | Exponential | 0.453 | 50804 |
| | Spherical | 0.455 | 50782 |
| beta diversity | **Gaussian** | **0.150** | **-21493** |
| | Exponential | 0.149 | -21379 |
| | Spherical | 0.150 | -21376 |

**Table S5.** Significant species-specific contribution to Bray-Curtis dissimilarity in community composition between hwsic and lwsic regimes ($p < 0.05$). Species in bold were identified as the most influential taxa to overall dissimilarity. Affinity of species to sea ice regimes was based on the point biserial correlation index computed using the multilevel pattern analysis.

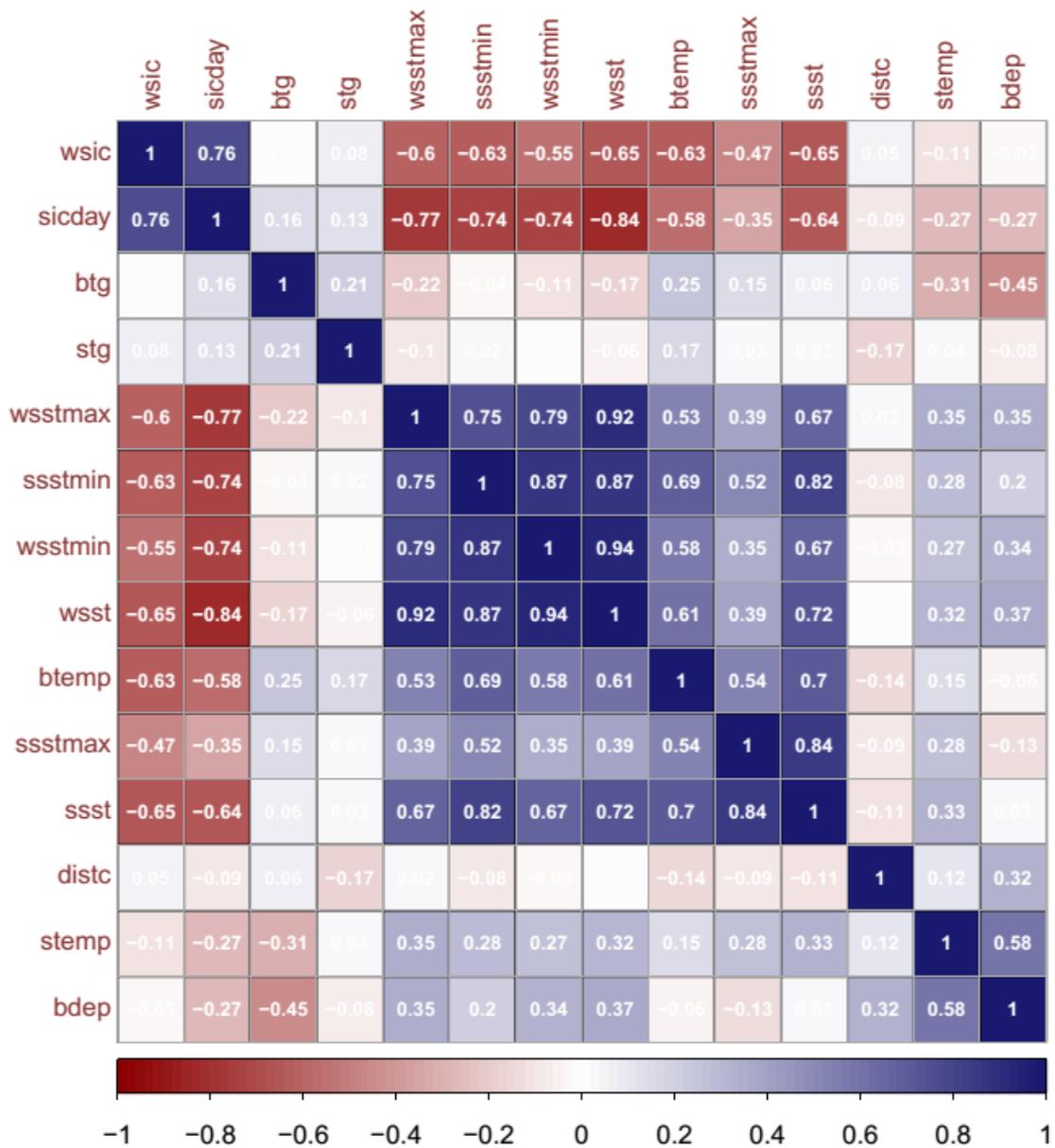| Common name | Scientific name | Taxonomic group | Mean abundance | | Contribution to overall dissimilarity | | | Regime affinity |
|---|---|---|---|---|---|---|---|---|
| | | | hwsic | lwsic | average | sd | *p* | |
| **Walleye pollock** | *Gadus chalcogrammus* | Fish | 85.1695 | 104.8599 | 0.163616 | 0.13124 | 0.001 | lwsic |
| **Northern rock sole** | *Lepidopsetta polyxystra* | Fish | 26.8236 | 39.5896 | 0.072845 | 0.08317 | 0.001 | lwsic |
| **Arrowtooth flounder** | *Atheresthes stomias* | Fish | 8.0371 | 9.1358 | 0.024695 | 0.03292 | 0.001 | lwsic |
| Snow crab | *Chionoecetes opilio* | Crustacea | 9.4232 | 6.2678 | 0.021340 | 0.02485 | 0.001 | hwsic |
| Alaska skate | *Bathyraja parmifera* | Fish | 4.6402 | 9.0311 | 0.011020 | 0.01033 | 0.001 | lwsic |
| Pribilof whelk | *Neptunea pribiloffensis* | Mollusk | 1.7331 | 2.1275 | 0.005692 | 0.00936 | 0.015 | lwsic |
| Common mud star | *Ctenodiscus crispatus* | Echinoderm | 0.7601 | 1.8022 | 0.004667 | 0.01674 | 0.001 | lwsic |
| Fuzzy hermit crab | *Pagurus trigonocheirus* | Crustacea | 0.9974 | 2.0579 | 0.004211 | 0.00633 | 0.001 | lwsic |
| Starry flounder | *Platichthys stellatus* | Fish | 0.8918 | 1.6679 | 0.003603 | 0.00917 | 0.009 | lwsic |
| Aleutian hermit | *Pagurus aleuticus* | Crustacea | 0.6057 | 1.5927 | 0.003342 | 0.00590 | 0.001 | lwsic |
| Lyre whelk | *Neptunea lyrata* | Mollusk | 0.6834 | 0.9114 | 0.002353 | 0.00482 | 0.03 | lwsic |
| Kamchatka flounder | *Atheresthes evermanni* | Fish | 0.7662 | 0.8874 | 0.002143 | 0.00234 | 0.005 | lwsic |
| Notched brittlestar | *Ophiura sarsi* | Echinoderm | 0.3497 | 0.8785 | 0.001937 | 0.00454 | 0.001 | lwsic |
| Bigmouth sculpin | *Hemitripterus bolini* | Fish | 0.5447 | 0.6664 | 0.001714 | 0.00254 | 0.017 | lwsic |
| Tentacle-shedding anemone | *Liponema brevicorne* | Others | 0.3683 | 0.4125 | 0.001573 | 0.00446 | 0.002 | lwsic |
| Hairy hermit crab | *Pagurus capillatus* | Crustacea | 0.3122 | 0.8273 | 0.001536 | 0.00373 | 0.001 | lwsic |
| Rex sole | *Glyptocephalus zachirus* | Fish | 0.2437 | 0.3370 | 0.001105 | 0.00354 | 0.001 | lwsic |
| Shortfin eelpout | *Lycodes brevipes* | Fish | 0.2693 | 0.3740 | 0.001092 | 0.00250 | 0.01 | lwsic |
| Longfinger hermit | *Pagurus rathbuni* | Crustacea | 0.1589 | 0.3997 | 0.000938 | 0.00177 | 0.001 | lwsic |
| Wattled eelpout | *Lycodes palearis* | Fish | 0.2374 | 0.3761 | 0.000889 | 0.00133 | 0.001 | lwsic |
| Alaskan hermit | *Pagurus ochotensis* | Crustacea | 0.1590 | 0.4138 | 0.000812 | 0.00172 | 0.001 | lwsic |
| Aleutian skate | *Bathyraja aleutica* | Fish | 0.1833 | 0.1862 | 0.000669 | 0.00235 | 0.003 | lwsic |
| Knobbyhand hermit | *Pagurus confragosus* | Crustacea | 0.1052 | 0.2978 | 0.000667 | 0.00156 | 0.001 | lwsic |
| Bering skate | *Bathyraja interrupta* | Fish | 0.1106 | 0.2402 | 0.000600 | 0.00119 | 0.001 | lwsic |
| Warty sculpin | *Myoxocephalus verrucosus* | Fish | 0.1015 | 0.2421 | 0.000562 | 0.00154 | 0.001 | lwsic |

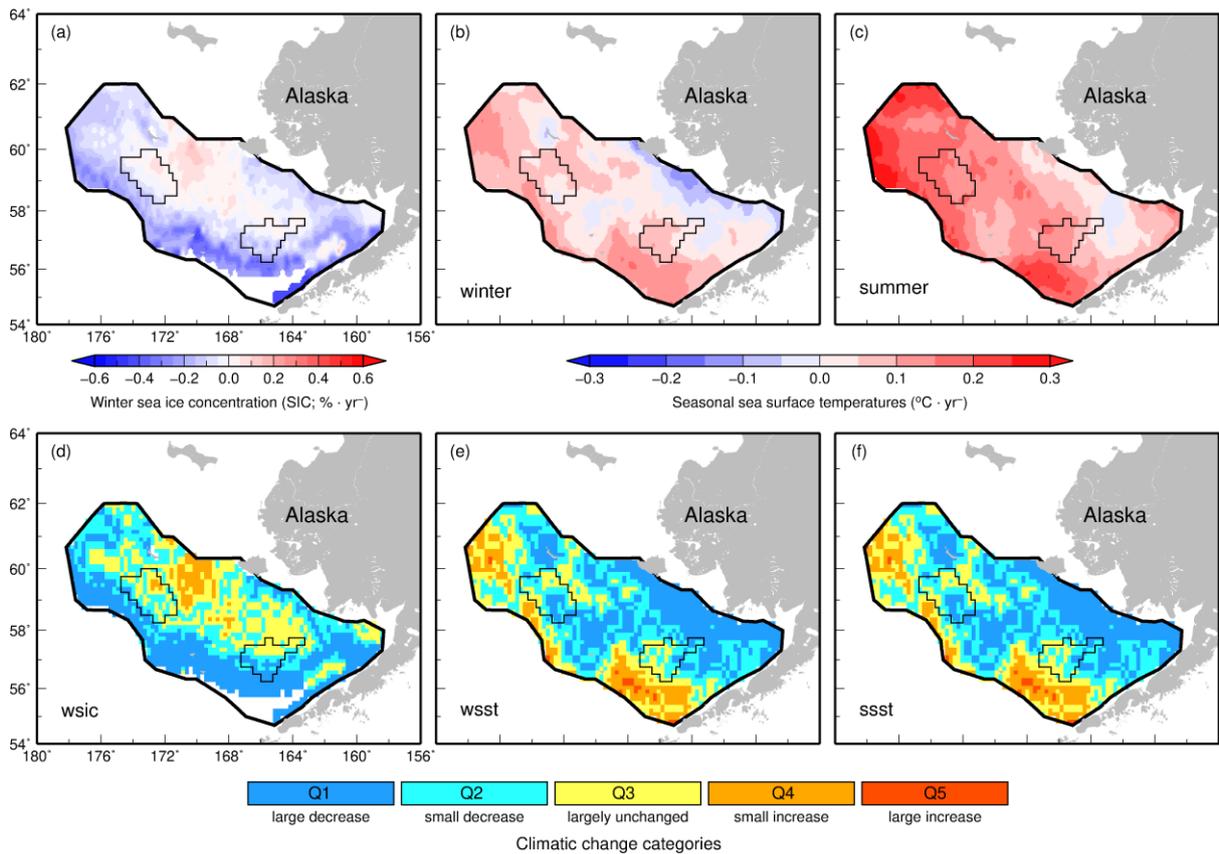| Common name (cont. Table S4) | Scientific name | Taxonomic group | Mean abundance | | Contribution to overall dissimilarity | | | Regime affinity |
|---|---|---|---|---|---|---|---|---|
| | | | hwsic | lwsic | average | sd | *p* | |
| Northern rockfish | *Sebastes polyspinis* | Fish | 0.0256 | 0.0875 | 0.000257 | 0.00387 | 0.022 | lwsic |
| Splendid hermit | *Labidochirus splendescens* | Crustacea | 0.0490 | 0.0856 | 0.000203 | 0.00045 | 0.001 | lwsic |
| Parma sand dollar | *Echinarachnius parma* | Echinoderm | 0.0405 | 0.0748 | 0.000170 | 0.00135 | 0.005 | lwsic |
| Giant octopus | *Enteroctopus dofleini* | Mollusk | 0.0122 | 0.0730 | 0.000149 | 0.00049 | 0.001 | lwsic |
| Helmet whelk | *Clinopegma magnum* | Mollusk | 0.0315 | 0.0552 | 0.000147 | 0.00030 | 0.001 | lwsic |
| Whelk | *Pyrulofusus melonis* | Mollusk | 0.0252 | 0.0554 | 0.000132 | 0.00035 | 0.001 | lwsic |
| Purple hermit | *Elassochirus cavimanus* | Crustacea | 0.0154 | 0.0400 | 0.000111 | 0.00054 | 0.001 | lwsic |
| Variegated snailfish | *Liparis gibbus* | Fish | 0.0208 | 0.0357 | 0.000110 | 0.00034 | 0.003 | lwsic |
| Sea strawberry | *Gersemia rubiformis* | Others | 0.0166 | 0.0270 | 0.000071 | 0.00020 | 0.022 | lwsic |
| Cushion star | *Pteraster tesselatus* | Echinoderm | 0.0102 | 0.0367 | 0.000070 | 0.00104 | 0.01 | lwsic |
| Southern rock sole | *Lepidopsetta bilineata* | Fish | 0.0085 | 0.0338 | 0.000065 | 0.00089 | 0.004 | lwsic |
| Discordant mussel | *Musculus discors* | Mollusk | 0.0105 | 0.0309 | 0.000064 | 0.00028 | 0.001 | lwsic |
| Sakhalin sole | *Limanda sakhalinensis* | Fish | 0.0074 | 0.0119 | 0.000058 | 0.00058 | 0.035 | lwsic |
| Chum salmon | *Oncorhynchus keta* | Fish | 0.0124 | 0.0182 | 0.000052 | 0.00012 | 0.001 | lwsic |
| Mottled anemone | *Urticina crassicornis* | Others | 0.0111 | 0.0246 | 0.000050 | 0.00021 | 0.001 | lwsic |
| Sablefish | *Anoplopoma fimbria* | Fish | 0.0021 | 0.0154 | 0.000033 | 0.00018 | 0.001 | lwsic |
| Salmon snailfish | *Careproctus rastrinus* | Fish | 0.0067 | 0.0098 | 0.000032 | 0.00007 | 0.001 | lwsic |
| Atka mackerel | *Pleurogrammus monopterygius* | Fish | 0.0019 | 0.0135 | 0.000030 | 0.00032 | 0.001 | lwsic |
| Rosy Tritonia | *Tritonia diomedea* | Mollusk | 0.0035 | 0.0072 | 0.000018 | 0.00007 | 0.001 | lwsic |
| Great slippersnail | *Crepidula grandis* | Mollusk | 0.0010 | 0.0132 | 0.000018 | 0.00031 | 0.001 | lwsic |
| Widehand hermit crab | *Elassochirus tenuimanus* | Crustacea | 0.0017 | 0.0051 | 0.000008 | 0.00006 | 0.005 | lwsic |
| Thin-ribbed whelk | *Colus herendeenii* | Mollusk | 0.0015 | 0.0031 | 0.000008 | 0.00002 | 0.001 | lwsic |
| Pale moonsnail | *Euspira pallida* | Mollusk | 0.0011 | 0.0021 | 0.000008 | 0.00003 | 0.007 | lwsic |
| Northern horsemussel | *Modiolus modiolus* | Mollusk | 0.0015 | 0.0037 | 0.000007 | 0.00004 | 0.012 | lwsic |
| Roughspine sculpin | *Triglops macellus* | Fish | 0.0005 | 0.0011 | 0.000003 | 0.00002 | 0.044 | lwsic |
| Blotched snailfish | *Crystallichthys cyclospilus* | Fish | 0.0002 | 0.0007 | 0.000002 | 0.00003 | 0.006 | lwsic |
| Kuro argid | *Argis lar* | Crustacea | 0.0009 | 0.0001 | 0.000002 | 0.00001 | 0.002 | hwsic |

**Figure S1.** Map of the Bering Sea showing the bottom trawl survey sites in the eastern shelf region. Overlain are sampling locations, color-coded based on the individual stratum between 1990 and 2018.
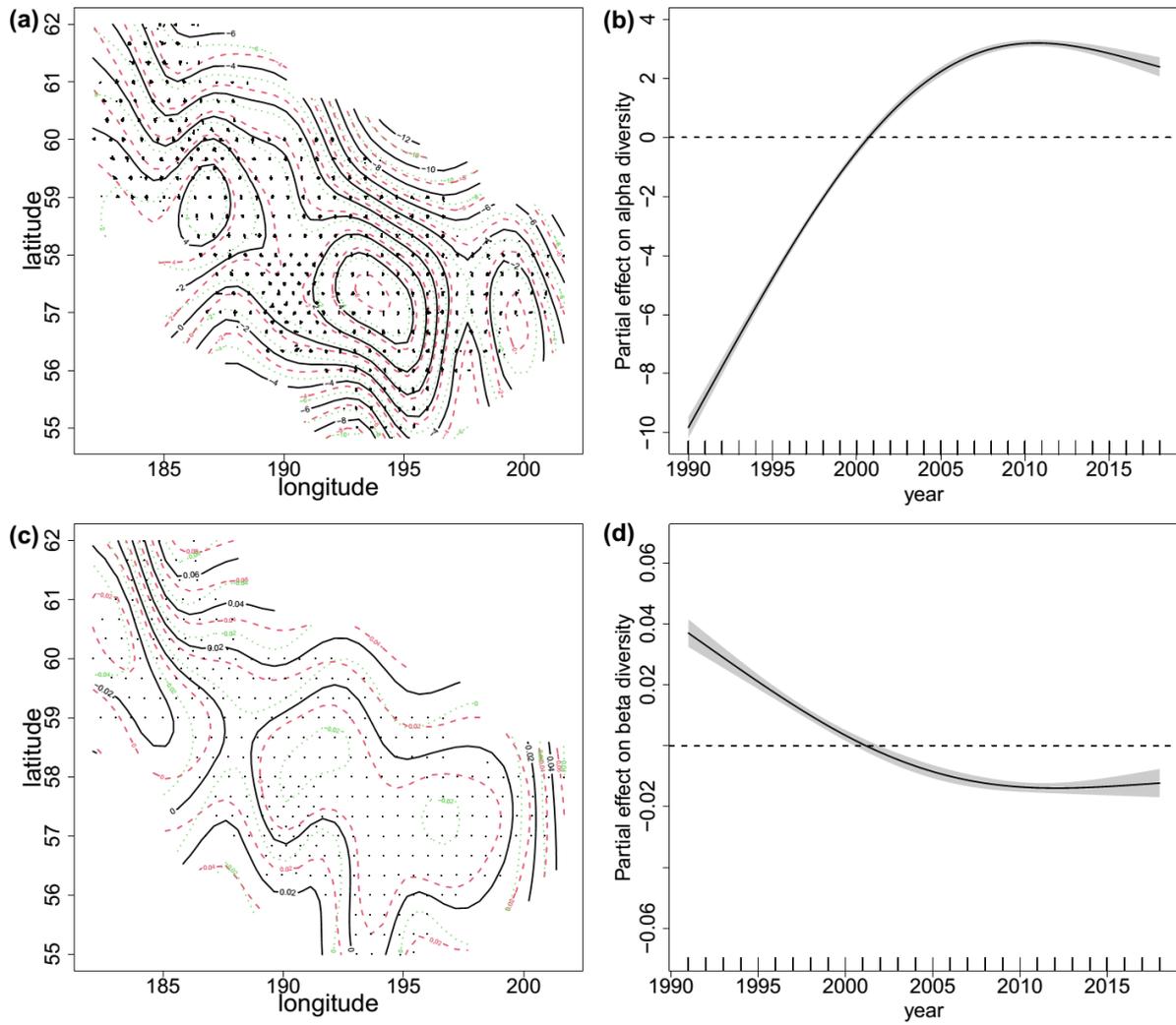
**Figure S2.** Annual number of distinct taxa belonging to specific taxonomic groups throughout the study area from 1990-2018.
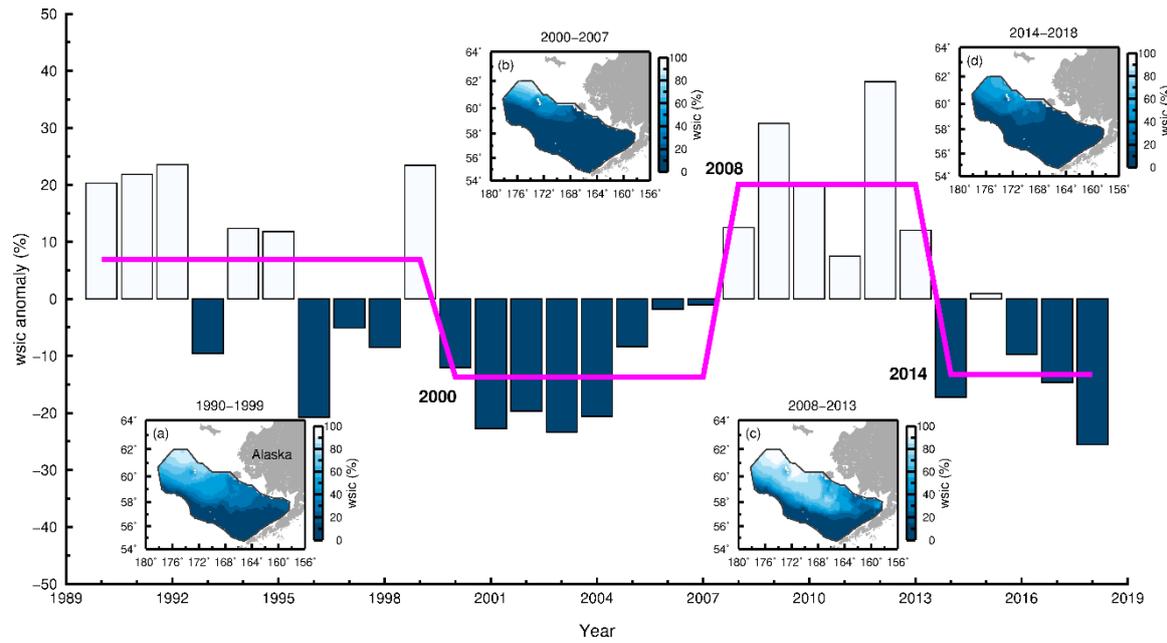
**Figure S3.** Computed correlation (r) matrix across the initial set of environmental variables. Highly correlated environmental factors were those with r > 0.5.

**Figure S4.** Spatial distribution maps of monotonic trends and quintile-based (Q1-Q5) climatic change categories of (a,d) winter sea ice concentration and seasonal sea surface temperatures during (b,e) winter and (c,f) summer, 1990-2018 over the EBS. Overlain polygons correspond to biodiversity refugial zones in the middle shelf.

**Figure S5.** Significant partial effects of spatial (longitude, latitude) and temporal (year) factors on the (a-b) alpha diversity (species richness) and (c-d) beta diversity (Sorensen dissimilarity) predicted from a generalized additive mixed model.

**Figure S6.** Annual time series of basin-wide winter sea ice (wsic) anomaly relative to the 29-year average, where white and blue bars correspond to years when wsic are higher and lower than the long-term mean. Regime shift index (purple solid line) revealed alternating periods of (a-d) high and low wsic regimes between 1990 and 2018.