Space-time modelling of survey data

PREPARED BY: IPHC SECRETARIAT (R. A. WEBSTER; 9 NOVEMBER 2024)

PURPOSE

To provide results of the space time modelling of Pacific halibut survey data for the period 1993-2024.

INTRODUCTION

Since 2016 space-time modelling has been used by the IPHC to produce estimates of mean O32 WPUE (weight per unit effort), all sizes WPUE and all sizes NPUE (numbers per unit effort) indices of Pacific halibut density and abundance. The modelling depends primarily on data from the IPHC's Fishery-Independent Setline Survey (FISS, Ualesi et al, 2024), but in the Bering Sea also integrates data from the National Oceanic and Atmospheric Administration - Fisheries annual trawl survey and the Alaska Department of Fish and Game's annual Norton Sound trawl survey. Both surveys are fishery-independent data sources.

Since 2019, weighing of Pacific halibut onboard FISS charter vessels has meant that the weight data used to compute WPUE now comes almost entirely from observed weights of fish rather than estimates from a length-net weight relationship. For fish without directly measured weights, weights are predicted from a year- and IPHC Regulatory Area-specific length-net weight relationship estimated from the FISS length and weight data. For U32 fish with round weight recorded, net weights are estimated from a round-net weight relationship estimated from coastwide sample data from the 2019 FISS.

In 2024, 50% of sets used pink salmon as bait, with the remaining sets using the standard chum salmon bait. Models therefore accounted for bait differences and output was standardized to chum baits. In IPHC Regulatory Areas 2B and 2C, "vessel captain stations" were allowed, in which vessel captains could choose to fish up to one third of their sets at a location that is optimal in terms of catch rates or revenue. Models were fitted with and without these stations to determine if their inclusion in the modelling was likely to lead to biased estimates.

RESULTS OF SPACE-TIME MODELLING IN 2024

Figure 1 shows the time series estimates of O32 WPUE (most comparable to fishery catch-rates) over the 1993-2024 period included in the 2024 space-time modelling. Coastwide, we estimate a decline in the index since 2023 of 9% (95% credible interval: −17% to −1%), largely due to a 19% estimated decline in IPHC Biological Region 3. Coastwide indices of all sizes WPUE (Figure 2) and all sizes NPUE (Figure 3) were estimated to be relatively stable, with changes of −2% (−11% to +7%) and +3% (−7% to +14%) from 2023-24.

Note Biological Region 4B has had no sampling since 2022: the degree of change in the index is highly uncertain and the estimated changes presented in Figures 1-3 are likely to be biased.

Tables of model output (time series, stock distribution estimates) are updated annually on the IPHC website at https://www.iphc.int/data/time-series-datasets.

FISS model output may also be explored interactively using the link on this page of the IPHC website: https://www.iphc.int/data/datatest/fishery-independent-setline-survey-fiss.

Ratios of the catch rate of pink salmon to chum salmon were estimated within the models for all sampled IPHC Regulatory Areas in 2024. These values are presented in Table 1. Except for O32 WPUE in IPHC Regulatory Area 2C, these ratios are all estimated to be less than 1, implying lower catch rates for pink salmon than the standard chum salmon baits. Ratios varied spatially, with western IPHC Regulatory Areas having lower values than eastern areas. Note that these ratios are based on modelling of data incorporating hook competition adjustments and do not necessarily reflect differences in raw catch rates of Pacific halibut between baits.

Table 1. Posterior estimates of the ratio of pink salmon to chum salmon catch rates for O32 and all sizes WPUE, and all sizes NPUE, by IPHC Regulatory Area (with 95% posterior credible intervals in parentheses).

IPHC Regulatory Area	O32 WPUE	All sizes WPUE	All sizes NPUE
2B	0.87 (0.68, 1.13)	0.80 (0.62, 1.02)	0.72 (0.57, 0.92)
2C	1.01 (0.81, 1.27)	0.89 (0.72, 1.11)	0.83 (0.66, 1.03)
3A	0.74 (0.59, 0.93)	0.71 (0.57, 0.87)	0.68 (0.55, 0.83)
3B	0.64 (0.49, 0.94)	0.62 (0.49, 0.78)	0.58 (0.46, 0.73)
4CDE	0.48 (0.29, 0.81)	0.32 (0.08, 1.22)	0.36 (0.10, 1.27)

Modelling showed that the inclusion of data from vessel captain stations had a large effect on estimates of indices of density for O32 WPUE and all sizes WPUE, with greater values when vessel captain station data were included (Table 2). Mean values of all sizes NPUE indices were similar with and without vessel captain station data, implying the vessels captains were able to target locations with larger Pacific halibut rather than locations with greater numbers of fish. The results imply that inclusion of data from vessel captain stations would lead to positive bias in estimated indices from the space-time model. Therefore, all model output used for stock assessment and management purposes is based on modelling that excludes data from such stations.

Table 2. Posterior means (with 95% credible intervals) for indices of density from modelling with and without vessel captain stations for O32 and all sizes WPUE, and all sizes NPUE, by IPHC Regulatory Area.

IPHC Reg. Area	O32 WPUE (lb/skate)		All sizes WPUE (lb/skate)		All sizes NPUE (halibut/skate)	
	With vessel captain stations	Without vessel captain stations	With vessel captain stations	Without vessel captain stations	With vessel captain stations	Without vessel captain stations
2B	70.5 (59.4, 82.6)	62.2 (51.5, 74.7)	97.7 (82.1, 116.0)	89.4 (74.7, 108.0)	6.8 (5.7, 8.2)	6.7 (5.4, 8.1)
2C	170.8 (147.1,195.7)	156.4 (134.0,181.5)	216.5 (188.3,248.2)	206.5 (176.7,238.4)	12.8 (11.0, 14.8)	12.9 (11.0, 15.3)

RECOMMENDATION

That the Commission **NOTE** paper IPHC-2024-IM100-10 Rev_1 which provides results of the space-time modelling of Pacific halibut survey data for 1993-2024.

REFERENCE

Ualesi, K., Rillera, R., Jack, T. and Coll, K. (2024) IPHC Fishery-independent setline survey (FISS) design and implementation in 2024. IPHC-2024-IM100-09.

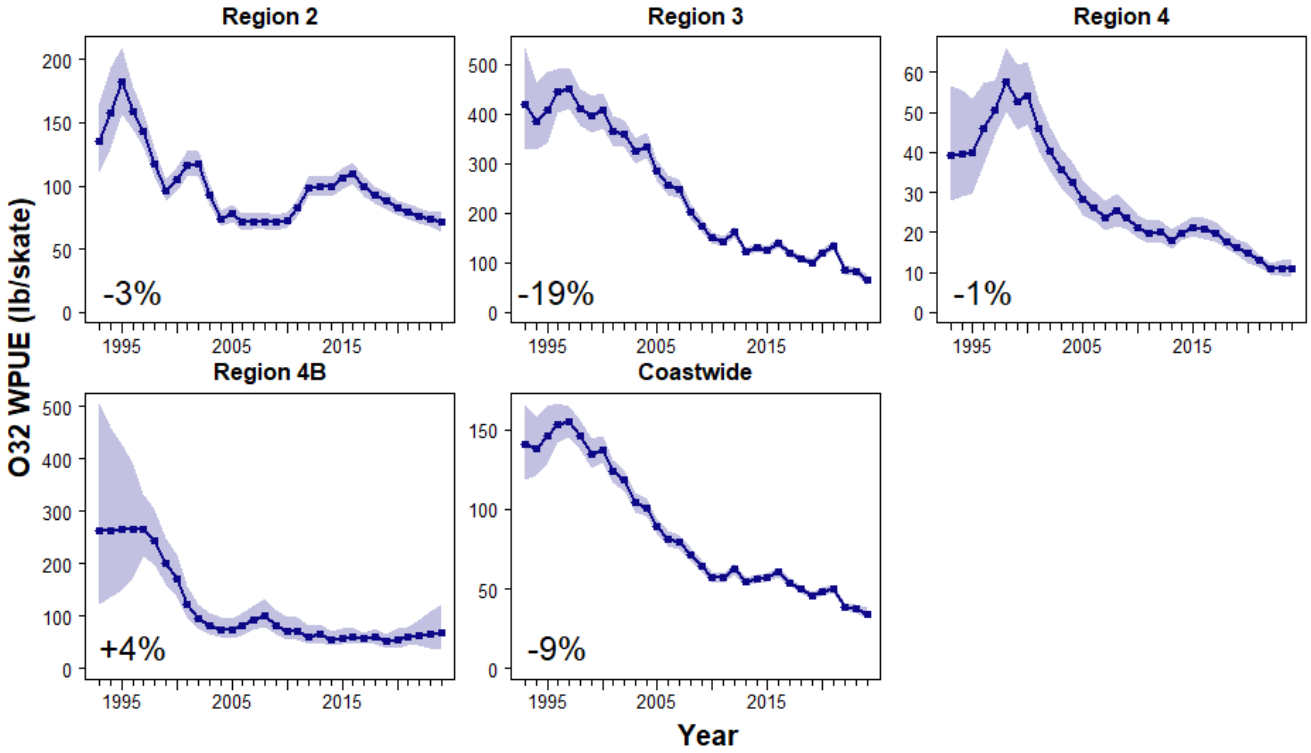

Figure 1. Space-time model output for O32 WPUE for 1993-2024 for Biological Regions. Filled circles denote the posterior means of O32 WPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean O32 WPUE from 2023 to 2024.

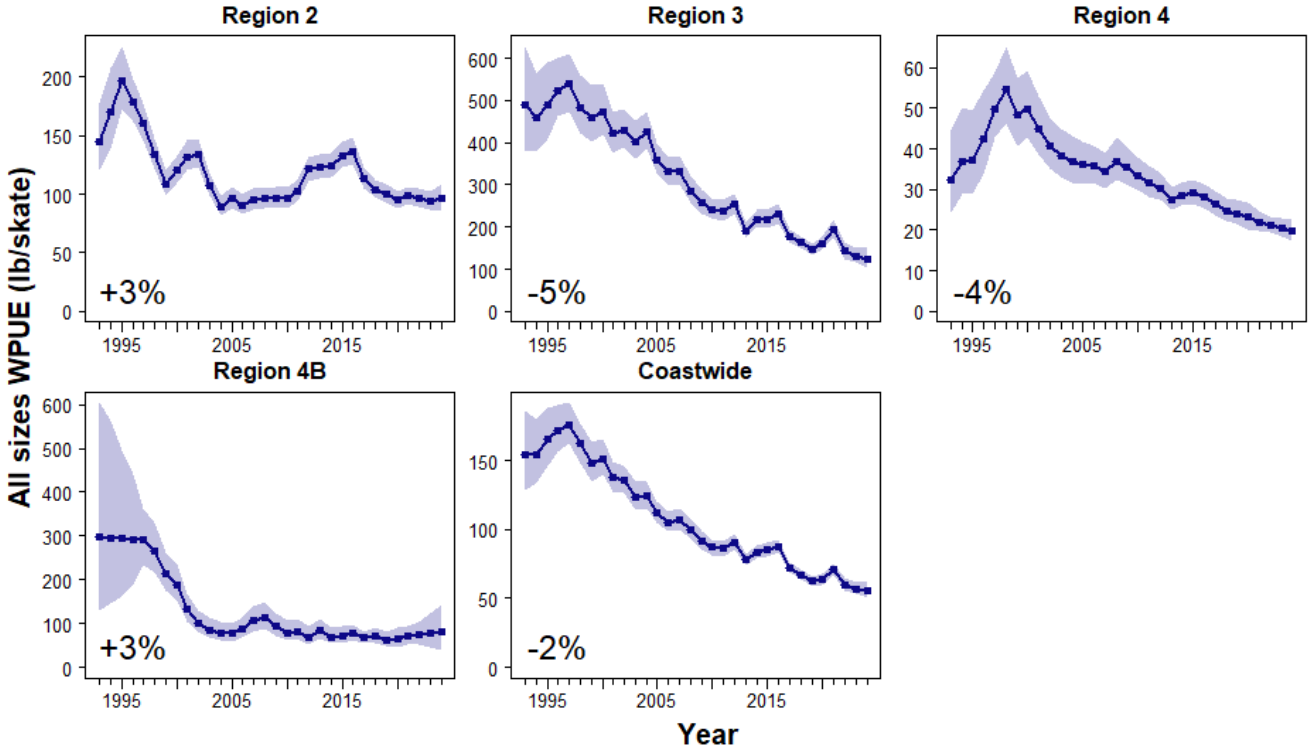

Figure 2. Space-time model output for all sizes WPUE for 1993-2024 for Biological Regions. Filled circles denote the posterior means of all sizes WPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the

uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean all sizes WPUE from 2023 to 2024.

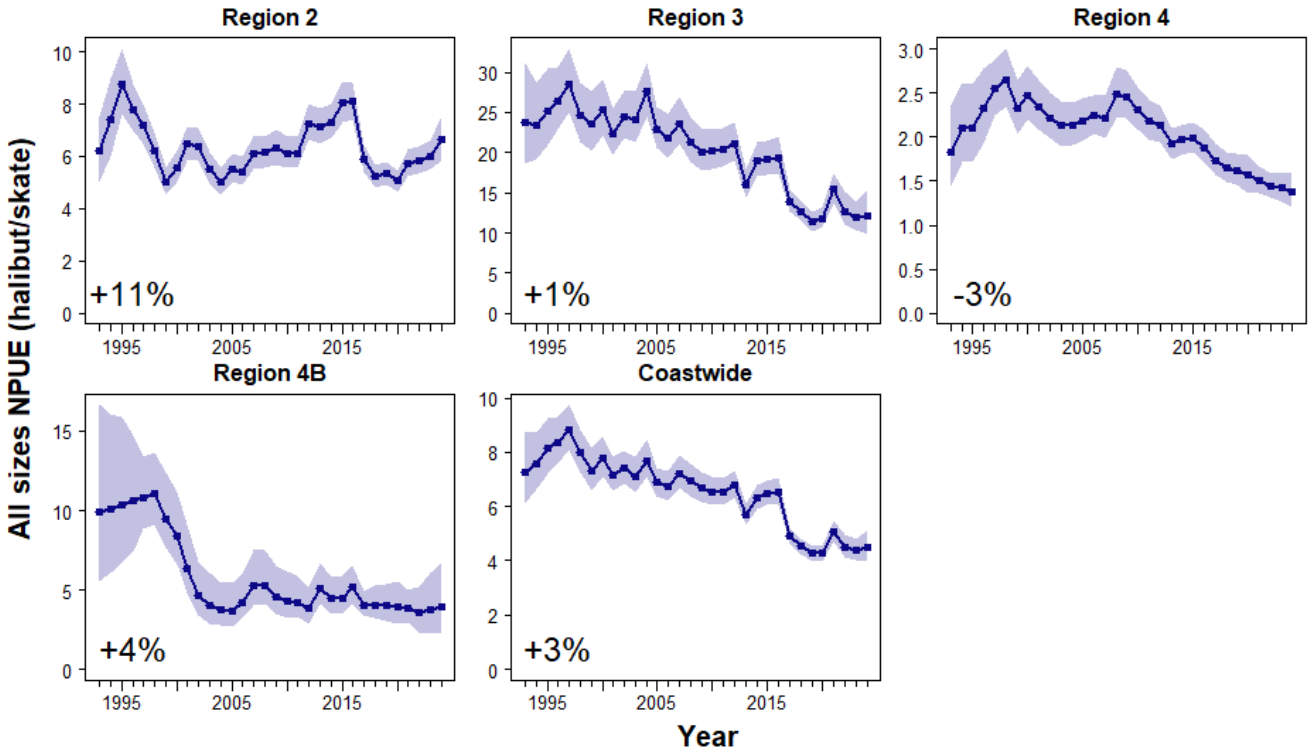

Figure 3. Space-time model output for all sizes NPUE for 1993-2024 for Biological Regions. Filled circles denote the posterior means of all sizes NPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean all sizes NPUE from 2023 to 2024.

APPENDIX A

Space-time modelling results by IPHC Regulatory Area

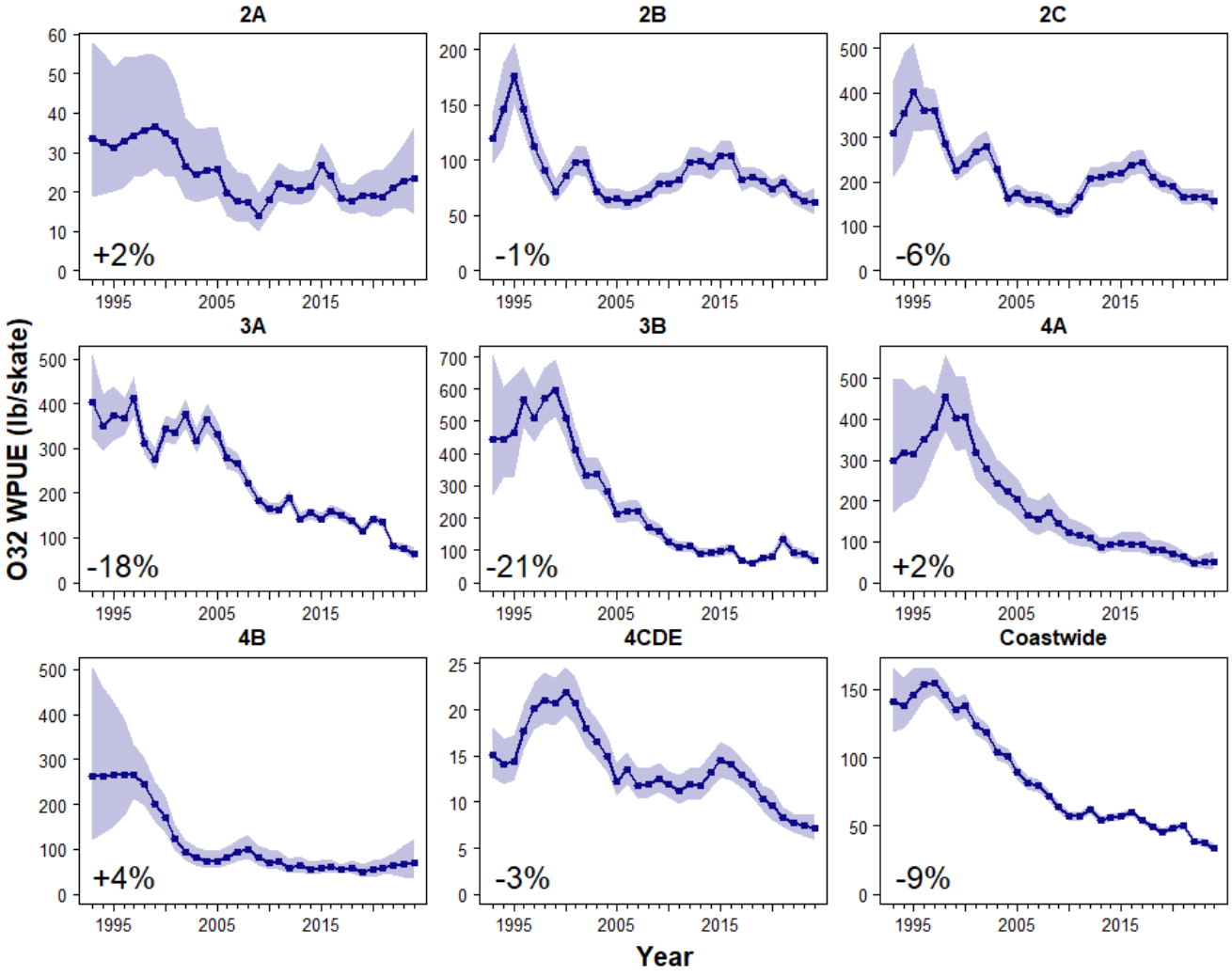

Figure A.1. Space-time model output for O32 WPUE for 1993-2024. Filled circles denote the posterior means of O32 WPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean O32 WPUE from 2023 to 2024.

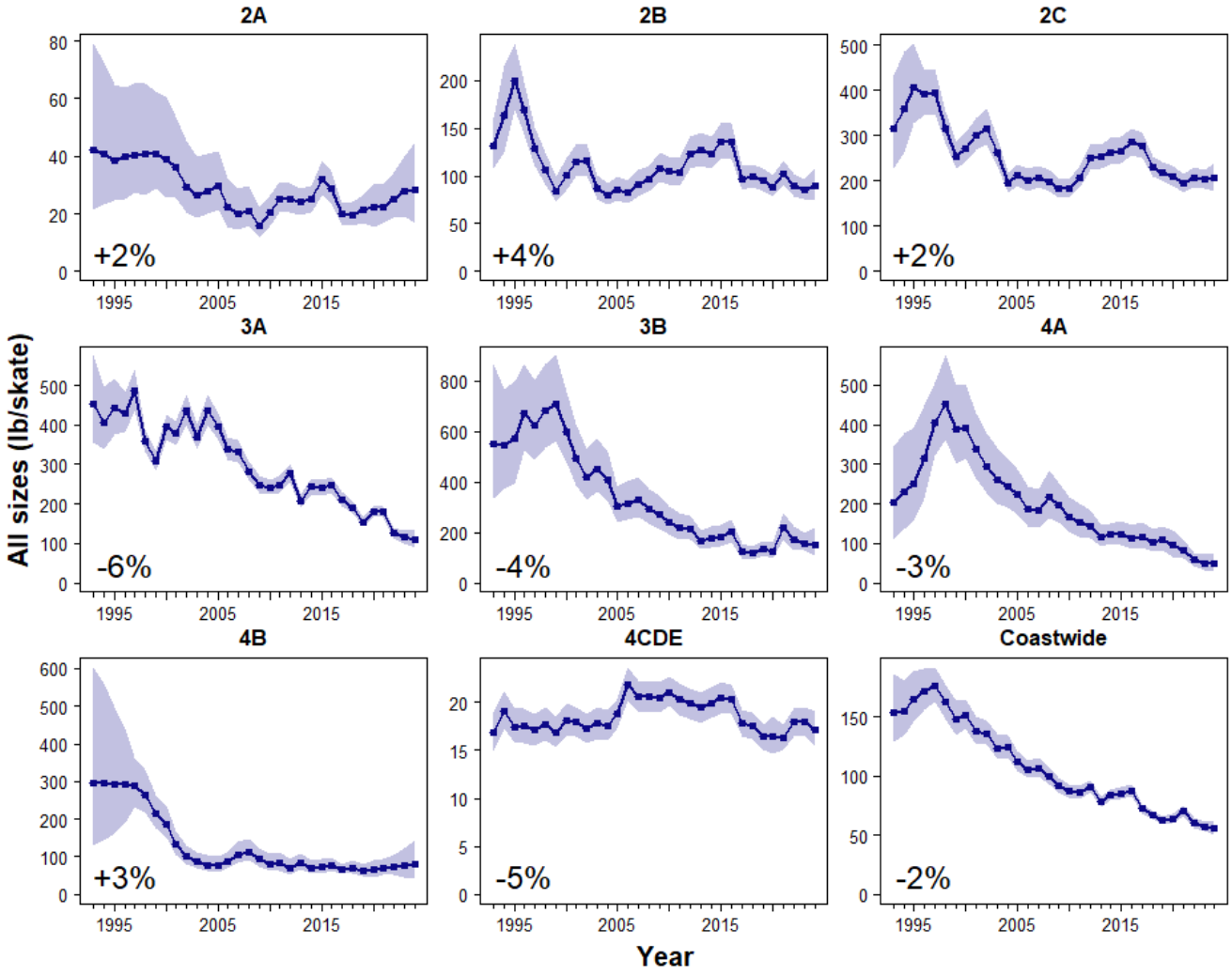

Figure A.2. Space-time model output for all sizes WPUE for 1993-2024. Filled circles denote the posterior means of all sizes WPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean all sizes WPUE from 2023 to 2024.

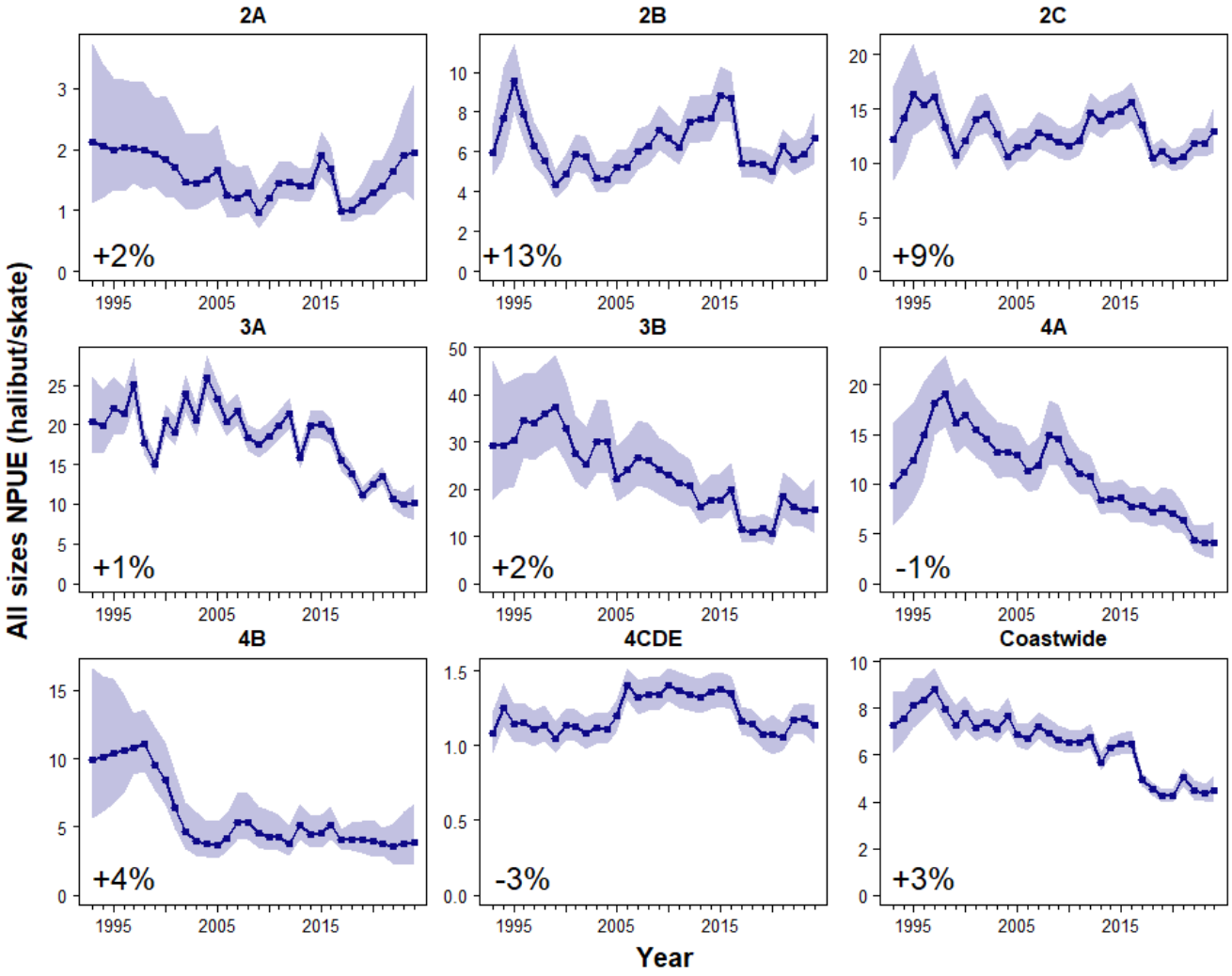

Figure A.3. Space-time model output for all sizes NPUE for 1993-2024. Filled circles denote the posterior means of all sizes NPUE for each year. Shaded regions show posterior 95% credible intervals, which provide a measure of uncertainty: the wider the shaded interval, the greater the uncertainty in the estimate. Numeric values in the lower left-hand corners are estimates of the change in mean all sizes NPUE from 2023 to 2024.