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Identifying management actions that promote sustainable fisheries

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Which management actions work best to prevent or halt overfishing and to rebuild depleted populations? A comprehensive evaluation of multiple, co-occurring management actions on the sustainability status of marine populations has been lacking. Here we compiled detailed management histories for 288 assessed fisheries from around the world (accounting for 45% of those with formal stock assessments) and used hierarchical time-series analyses to estimate effects of different management interventions on trends in stock status. Rebuilding plans, applied less commonly than other management measures (implemented at some point historically for 43% of stocks), rapidly lowered fishing pressure towards target levels and emerged as the most important factor enabling overfished populations to recover. Additionally, the ratification of international fishing agreements, and harvest control rules specifying how catch limits should vary with population biomass, helped to reduce overfishing and rebuild biomass. Notably, we found that benefits of management actions are cumulative—as more are implemented, stock status improves and predicted long-term catches increase. Thus, a broad suite of management measures at local, national and international levels appears to be key to sustaining fish populations and food production.

Well-designed management systems can improve environmental outcomes of renewable resources. In many regions, fisheries management now effectively regulates fishing pressure, either to maintain population biomass within sustainable, productive ranges or to rebuild populations back to more productive levels[1–4]. In other regions, fisheries regulation and enforcement are lacking or insufficient, and as a result many stocks have become overfished[5–7]. Management systems are complex, and it is unclear which specific management measures are most influential because many may be applied simultaneously, in different combinations and with varying impacts on individual fished stocks[7–11]. The numerous measures used to manage fisheries also vary considerably among stocks and regions[1,7,9], and may have stronger effects on some life-history types or fishing fleets than on others[12]. Our limited understanding of the relative effectiveness of different management measures hinders fishery-rebuilding initiatives around the world, impedes progress towards the zero-overfishing target of the United Nations Sustainable Development Goals[13] and diminishes potential global food production from capture fisheries[14].

Here we distinguish between management measures applied to individual stocks from those applied at the country level as mandated by broader legislative policies or commitments in international agreements[15–17]. Previous studies have identified measures such as catch limits[6,18], harvest control rules that specify how catch limits should vary with stock abundance[19] and individual quotas[18], which have helped to meet management targets. Although overall management intensity and comprehensive reforms generally aid in meeting objectives for target species[3,4,7,14], there are also cases where fishing pressure was not reduced, and cases where fishing pressure was reduced but stocks nevertheless did not recover[1,12,20]. To identify the combinations of management actions most consistently effective at reducing overfishing and rebuilding depleted stocks, in this article we collate the multi-level management history of hundreds of individual stocks, and then assess which actions are most influential.

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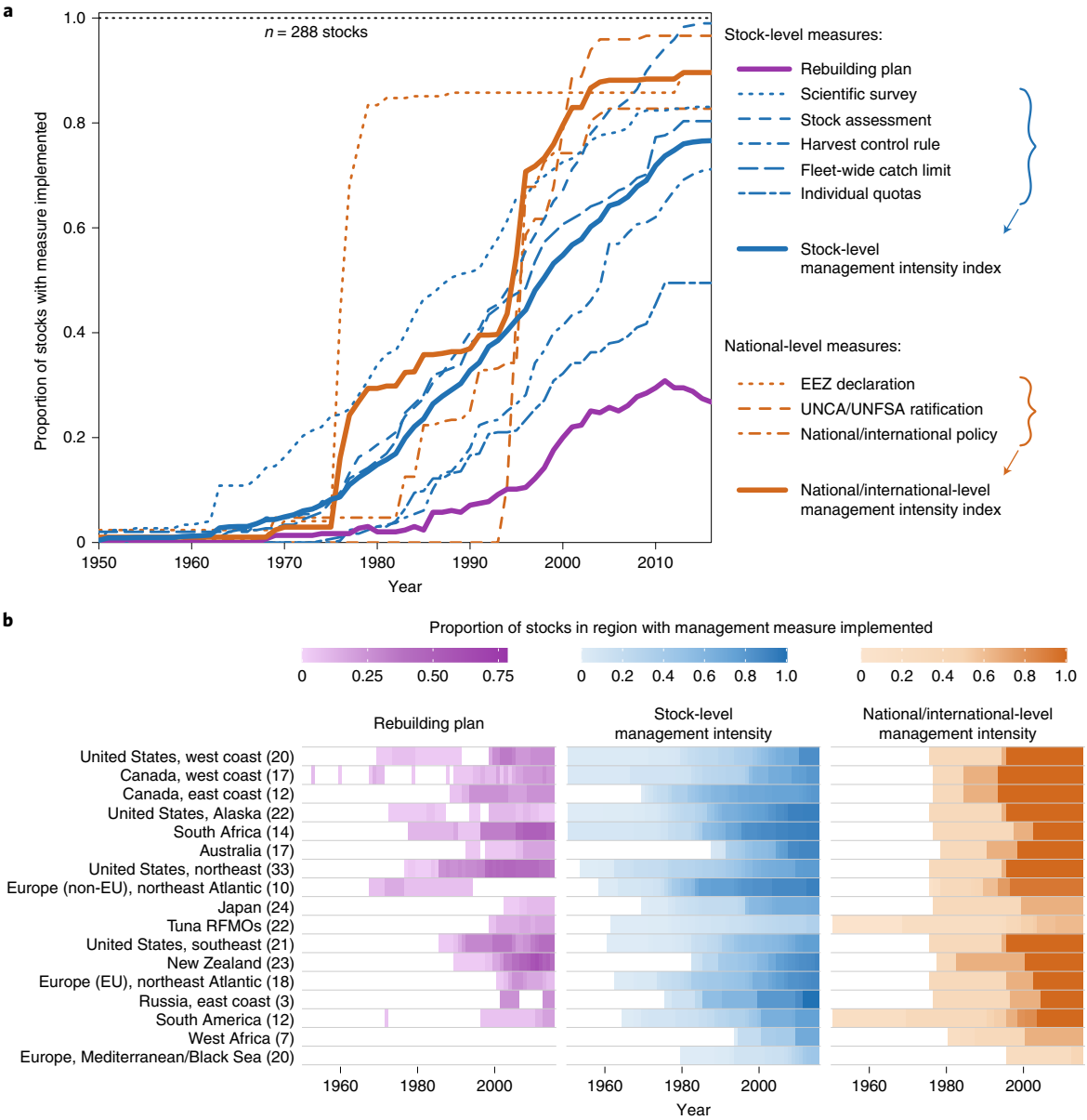


Fig. 1 | Implementation history of fisheries management measures for assessed stocks, showing steady increases globally over the past half century. **a**, Thick solid lines represent the proportion of stocks under a rebuilding plan (purple), and aggregate indices of management intensity at the stock level (blue) or national/international level (orange). Thin dotted/dashed lines show individual measures that comprise these aggregate indices. **b**, Region-specific proportions of stocks for the three thick solid lines in **a**. Numbers in parentheses show the number of stocks in analyses, and regions are ordered top to bottom by median U/U_{REF} of stocks over their last five years of available data (lowest to highest). EEZ, exclusive economic zone; RFMO, Regional Fisheries Management Organization.

Management histories of fished populations

Management histories for 288 well-studied stocks from 17 regions around the world covered a range of measures implemented at the stock level and at national/international levels (Supplementary Table 1). Use of stock-level measures increased steadily from low levels in 1950 (Fig. 1 and Supplementary Figs. 1–3). One of the key measures, rebuilding plans, involves fishery moratoria or substantial reductions in allowable catches for stocks with depleted biomass, typically used as an emergency measure. Rebuilding plans are incredibly diverse across stocks and regions in terms of the criteria that trigger implementation, the specific measures enacted under the plan and the degree to which those measures are enforced[20]. Rebuilding plans became more commonly used after the mid-1980s in most regions (particularly in the northeast and southeast United States, South Africa and New Zealand; Fig. 1b), and for the past two decades have been in place for roughly one-quarter of sampled stocks in any given year (Fig. 1a). Five additional measures have also been increasingly implemented: at least three-quarters of sampled stocks are currently managed using scientific surveys of fish abundance, stock assessments, fleet-wide catch limits and harvest control rules; and half of sampled stocks are managed using individual quotas, where fishing access is divided among vessels or other entities (Fig. 1a).

In contrast to the incremental addition of stock-level measures, nationally and internationally mandated measures are usually applied simultaneously for many stocks in a country or region (Fig. 1 and Supplementary Figs. 2 and 3). These measures include declaration of exclusive economic zones, primarily in the late

1970s[15]; ratification of the Compliance Agreement of the Food and Agriculture Organization of the United Nations (UNCA)[16] or the UN Fish Stocks Agreement (UNFSA)[17], mainly during the 1990s; and major fishery legislation at the country or regional level, implemented mostly during the 1980s–1990s but varying by region (Supplementary Table 2 and Supplementary Discussion).

Treating management changes as policy interventions

We hypothesize that each of the management measures shown in Fig. 1 and described in Supplementary Table 1 should strongly influence the fishing pressure and biomass of stocks. Because the timing of implementation varies by stock and region (Supplementary Figs. 2 and 3 and Supplementary Discussion), each application of a management measure can be modelled as a policy intervention that affects fishing pressure (U, the annual fraction harvested) and, through U, indirectly affects stock biomass (B). Time series of U and B relative to fisheries management target reference points (U_{REF} and B_{REF}, which are usually related to maximum sustainable yield, MSY, or approximations of MSY) were assembled for 288 stocks from the RAM Legacy Stock Assessment Database (RAMLDB)[21,22], with regional representation reflective of all assessed stocks from these regions (Supplementary Table 3). Fisheries on these 288 stocks accounted for 30% (mean, 23.8 million t) of all global marine catch from 1970 to 2017 (Supplementary Table 3). These stocks represent a variety of fish and invertebrate taxa, comprise both large and small populations, and are harvested by diverse gear types and industry structures.

For each stock, we examine the impact of rebuilding plans, an aggregate management intensity index of the other five stock-level measures and an index of the three national-level measures (Fig. 1). The two indices range from 0 to 1 (Supplementary Methods). To quantify influences of management interventions during the most relevant portion(s) of a stock's fishing history, we partition time series of U/U_{REF} and B/B_{REF} into a 'developing' phase (with low fishing pressure and catch) and a 'mature' phase (after development) (Fig. 2). Across stocks, levels of U/U_{REF} and B/B_{REF} varied widely at the start of available time-series data, at the start of the 'mature' phase and when individual management measures were first applied (Supplementary Table 4); analyses integrate over this variability in initial conditions of fishing pressure and biomass status.

Hierarchical autoregressive integrated moving average (ARIMA) time-series models (Methods) allow us to relate changes in U/U_{REF} and B/B_{REF} to the implementation of management measures. For any given stock and intervention, years before the intervention contribute information to the baseline trend, and years after the intervention contribute to the impacted trend. We use these models with verified temporal causality in U/U_{REF} and B/B_{REF} (Supplementary Note 1) to address three questions: (1) How do different types of management measures, fishery attributes and life-history traits affect trends in fishing pressure and biomass? (2) What are the short-term predicted responses in fishing pressure and biomass trends after implementing a combination of management measures? (3) What are the predicted equilibrium levels of fishing pressure, biomass and fishery yield relative to targets under a given set of management conditions?

Results

The three subsections below directly correspond to research questions (1)–(3).

Management measures collectively meet objectives. Strong fisheries management reduced fishing pressure and increased biomass towards their targets. In the absence of any management measures, on average U/U_{REF} increased by 2.9–4.8% annually and B/B_{REF} decreased by 3.1–4.4% annually during the 'mature' fishery phase across three taxonomic groups (Fig. 3). Incrementing either of the two management intensity indices slowed these trends, and if implemented along with a rebuilding plan, reversed these trends to reduce U/U_{REF} (by 56.3–57.0% in the first year of a rebuilding plan and 4.9–6.6% annually thereafter) and increase B/B_{REF} (by 5.2–6.6% annually after the first year of a rebuilding plan). Across stocks, the mean magnitude of U/U_{REF} was >1 and the mean magnitude of B/B_{REF} was <1 during the 'mature' fishery phase; therefore, on average, these directional changes under management imply moving towards target ratios of 1. Rebuilding plans tended to be implemented when several other measures were already in place (Supplementary Fig. 4). With the influence of rebuilding plans separated into immediate (first year) and persistent (all remaining years) components, for U/U_{REF} the immediate effect was strongest, and for B/B_{REF} the persistent effect was strongest (Fig. 1).

Influences of management on stock status were robust to alternative model structures and weighting assumptions. Aside from rebuilding plans, if components of management intensity indices are disaggregated for reanalysis, the individual measures with greatest influence on stock status were enacting the UNCA or UNFSA (negative effect on fishing pressure and positive effect on biomass); and harvest control rules (slight positive effect on biomass; Supplementary Fig. 5). Other management measures considered individually did not significantly affect fishing pressure or biomass trends (Supplementary Fig. 5), but still contributed to influence stock status via their inclusion in aggregate indices of management intensity (Fig. 3). If stocks are instead weighted by their maximum sustainable landed value (the product of MSY and average price, which both drive incentives for fishing[23]), the immediate decrease in fishing pressure from implementing a rebuilding plan was still the greatest effect overall (Supplementary Fig. 6), but was less pronounced than the effect under equal weighting (Fig. 3). The relative influence of the two management intensity indices on stock status differed slightly depending on whether stocks were equally weighted or weighted by landed value, but effects were similar in magnitude (Fig. 3 and Supplementary Fig. 6).

Compared with time-varying management attributes, the static fishery-related attributes and life-history traits generally had weaker associations with fishing pressure and biomass trends. The patterns that did emerge were that stocks in mixed-species fisheries had a slower increase in fishing pressure than stocks in single-species fisheries (Fig. 3), and later-maturing species had faster rates of biomass decline during baseline periods and slower rates of biomass recovery after management measures were implemented. No significant effects of landed value, body size or taxonomic group on trends in fishing pressure or biomass were observed, and other life-history variables were not included as predictors due to collinearity (Supplementary Fig. 7).

Rebuilding plans provide rapid turn-around. To address question (2), estimated parameters from fitted models were used to predict fishing pressure and biomass trends for nine years before and ten years after management interventions (Methods). Shortly before interventions, the modelled stock was overfished ($U/U_{REF} \approx 2$) and biomass was depleted ($B/B_{REF} \approx 0.5$; Fig. 4).

Rebuilding plans rapidly decreased fishing pressure and accelerated the recovery of depleted stocks. By implementing a full suite of five stock-level management measures and a full suite of three national-level measures, the baseline increase in average fishing pressure was reversed, and the baseline decrease in average biomass was slowed (Fig. 4). By also implementing a rebuilding plan simultaneously, the model predicted that fishing pressure would be reduced sharply in the first year after implementation to below target levels ($U/U_{REF} < 1$), and that biomass would increase to near targets within a ten-year projection period (Fig. 4). Scenarios with lower levels of stock-level and national-level management intensity had weaker

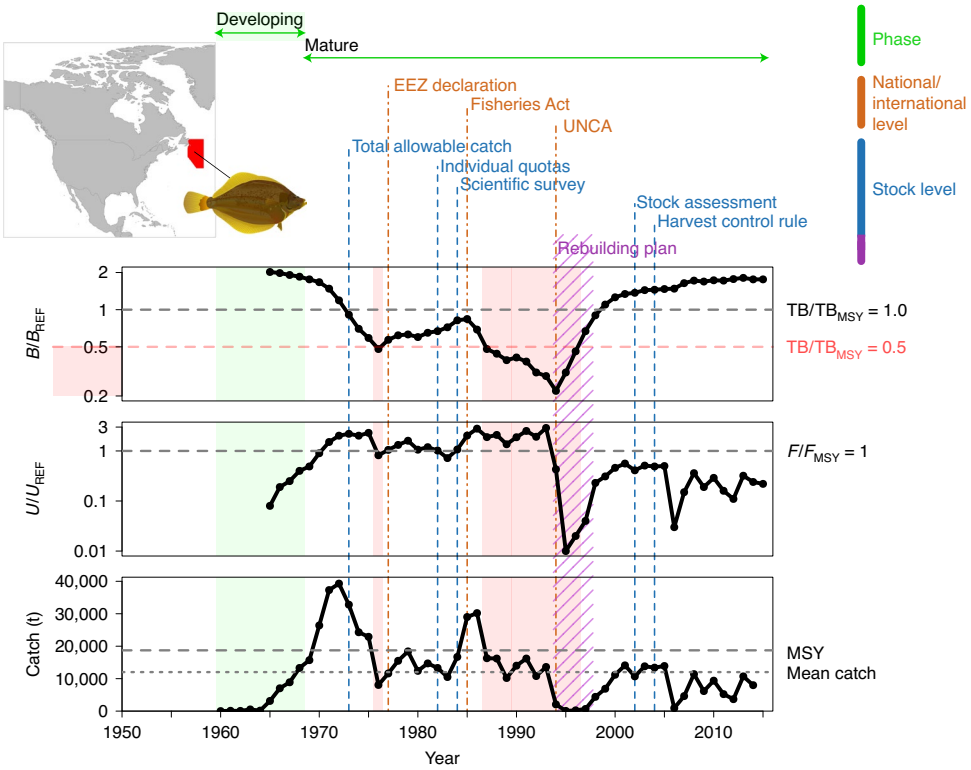


Fig. 2 | Stock status history relative to the timing of fisheries management interventions. Data for yellowtail flounder on the Grand Banks of Newfoundland (statistical area 3LNO) are shown as an example. Similar figures are provided for all 288 stocks in Supplementary Fig. 1. Panels show time series of relative biomass (B/B_{REF}), relative fishing pressure (U/U_{REF}) and catch. For this stock, B/B_{REF} is best represented by total biomass relative to a benchmark based on maximum sustainable yield (TB/TB_{MSY}), and U/U_{REF} is best represented by the fishing mortality rate relative to an MSY-based benchmark (F/F_{MSY}). Stock histories are partitioned into 'developing' (shaded green) and 'mature' fishery phases (Supplementary Methods). Years during which $B/B_{REF} < 0.5$ are shaded light red. Years under a rebuilding plan are shown with purple hatching. Years when other management measures were first implemented are indicated by vertical dashed lines. Flounder image reproduced with permission from Fisheries and Oceans Canada.

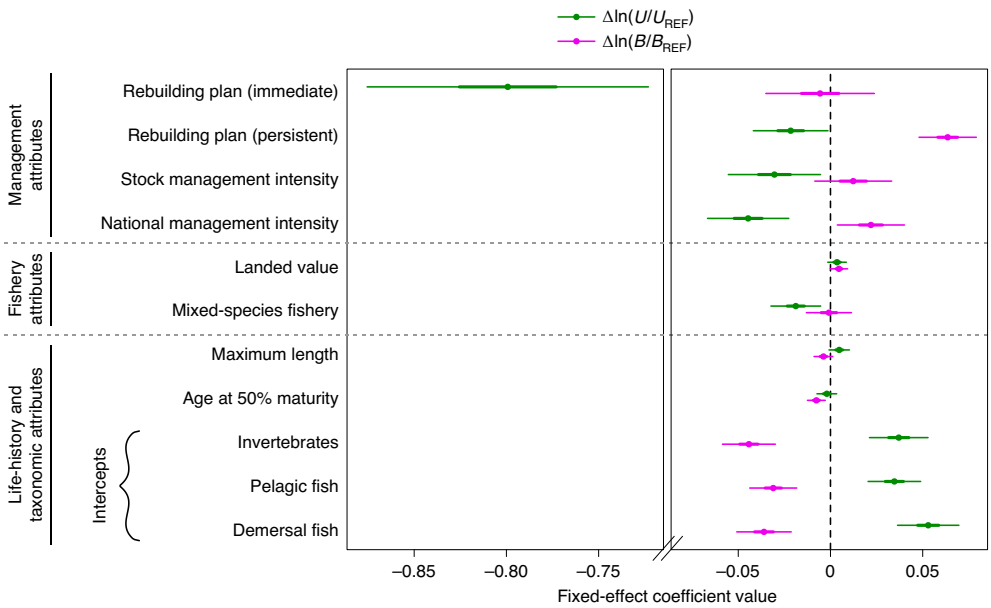


Fig. 3 | Effects of management, fishery and life-history attributes on annual changes in relative fishing pressure and relative biomass. Positive (or negative) coefficients reflect increasing (or decreasing) trends in fishing pressure (U/U_{REF}, in green) and biomass (B/B_{REF}, in purple) during the 'mature' fishery phase. The horizontal axis is broken for visual clarity because one coefficient differs substantially in magnitude from the others. The reference group for overall intercepts is 'single-species fishery', with the categorical 'mixed-species fishery' representing a difference from these intercepts. Thick and thin error bars represent standard errors and 95% confidence intervals, respectively.

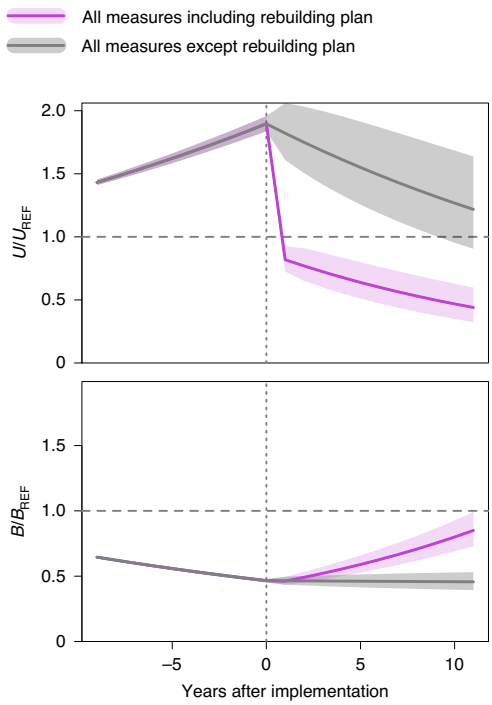


Fig. 4 | Predicted effects of fisheries management interventions on stock status. Predictions are shown for relative fishing pressure (U/U_{REF}) and relative biomass (B/B_{REF}) of an average stock during its 'mature' fishery phase. Year 0 represents when a full suite of five stock-level measures and three national/international-level measures were implemented, either with or without a rebuilding plan. Predicted trends are shown over nine preceding (baseline) years in the absence of management, and over ten subsequent (impacted) years. Shaded regions denote 95% confidence bands. Horizontal dashed lines show management targets.

responses, but the effect of rebuilding plans on stock status trends remained strong across scenarios (Supplementary Fig. 8).

If the fitted model is based on stocks weighted by landed value instead of weighted equally, the immediate decrease in fishing pressure following a rebuilding plan intervention was less pronounced, but the persistent increase in biomass under a rebuilding plan was stronger (Supplementary Fig. 8). There is considerable variability in the raw data around these mean predictions (Supplementary Fig. 9); nevertheless, among the nine individual management measures, the implementation of rebuilding plans had the strongest association with reduced fishing pressure and increased biomass (Supplementary Fig. 9).

Necessity of multi-level management approaches. To address question (3), long-term predictions of biomass and fishing pressure under a given management regime were obtained by additionally using B/B_{REF} as a predictor for change in U/U_{REF}, and U/U_{REF} as a predictor for change in B/B_{REF}, and then projecting U/U_{REF} and B/B_{REF} forward together to equilibrium (Methods). At this equilibrium, expected catch relative to MSY is given by $B/B_{REF} \times U/U_{REF}$. During projections, rebuilding plans were assumed to activate when B/B_{REF} fell to <0.5, and to deactivate when B/B_{REF} increased to >1.

We found that strong fisheries management at both stock and national levels was required to prevent overfishing and maintain stocks at their most productive levels. Equilibrium predictions of biomass, fishing pressure and catch were sensitive to both stock-level and national-level management intensity (Fig. 5). At the highest levels of management intensity (index values ≥0.75), equilibrium biomass was greater than targets, fishing pressure was lower than targets and catches were near targets; rebuilding plans were unnecessary because mean biomass did not decline below activation levels. As one or both management indices decreased towards intermediate levels, equilibrium biomass and catch dropped to less than targets and fishing pressure increased to greater than targets. As the combined management intensity dropped further and crossed a threshold (into the shaded region of the right-most panel in Fig. 5), the equilibrium switched from a stable point to a cycle of periodic rebuilding plans (Supplementary Fig. 10), with biomass occasionally dropping below the activation threshold of $0.5B_{REF}$ and then, under active rebuilding, increasing to $>B_{REF}$ at which point the rebuilding plan was deactivated.

The predicted proportion of time spent under rebuilding plans varied inversely with management intensity (Fig. 5; in practice, use of rebuilding plans usually coincides with moderate to high values of management intensity, Supplementary Fig. 4). During these cycles, average catch remained relatively high, ~0.75MSY, but this was obtained only by applying high average fishing pressures ($U/U_{REF} \approx 1.5$) to low average biomass ($B/B_{REF} \approx 0.5$), through cycles of alternating overfishing and rebuilding periods. In the absence of rebuilding plans at low to moderate levels of management intensity, stocks would be depleted and average catches would be lower.

Discussion

Among commonly used management measures, rebuilding plans had the strongest effect overall on changes in stock status. Implementing a rebuilding plan resulted in rapid drops in fishing pressure, from overfishing in one year to below targets in the next, and accelerated the rebuilding process of depleted stocks in our short-term projections. While previous studies have described the effectiveness of rebuilding plans in specific regions[20,24], our global analysis revealed the great extent to which they outperformed other individual management actions. This stronger response compared to other measures might be expected given that rebuilding plans are typically implemented when fishing pressure is high and biomass is depleted (Supplementary Table 4), leaving much room for improving stock status. Specific criteria for implementing a rebuilding plan, and targets for recovery, vary among fisheries and regions. Rebuilding plans have usually been implemented when levels of management intensity were already moderate or high (Supplementary Fig. 4), and multiple measures may be incorporated into a rebuilding plan that includes sharp reductions in catch or effort limits; setting and enforcement of bycatch limits for the species; expansion of temporal or spatial closures; and gear restrictions to reduce discards. As part of a rebuilding plan 'package', these and other measures have usually resulted in depleted stocks recovering. Biomass increased for over three-quarters of the stocks in our dataset for which rebuilding plans were in place for at least five of the last ten years of available data ($n=69$ of 88; Supplementary Fig. 1). When stocks did not show signs of biomass increase despite being under rebuilding plans ($n=19$), this was typically because the rebuilding plan had failed to halt overfishing ($n=14$; that is, fishing pressures were $>U_{REF}$ targets in most or all years during this period), supporting previous findings[12,20]. Although rebuilding plans have not always led to populations recovering to target levels[20], in most cases they have succeeded through reductions in fishing pressure that stemmed from substantial reductions in catch or effort limits[2,6,25]. Indeed, the two regions in our dataset with greatest median U/U_{REF} recently (Mediterranean/Black Seas and West Africa) are also the only two regions without any history of rebuilding plans implemented (Fig. 1b and Supplementary Discussion). Some of the failures of depleted stocks to recover can also result from changes in environmental conditions[26,27].

Apart from rebuilding plans, other stock-level and national-level measures contributed to regulating fishing pressure and rebuilding biomass. Notably, when multiple measures were implemented

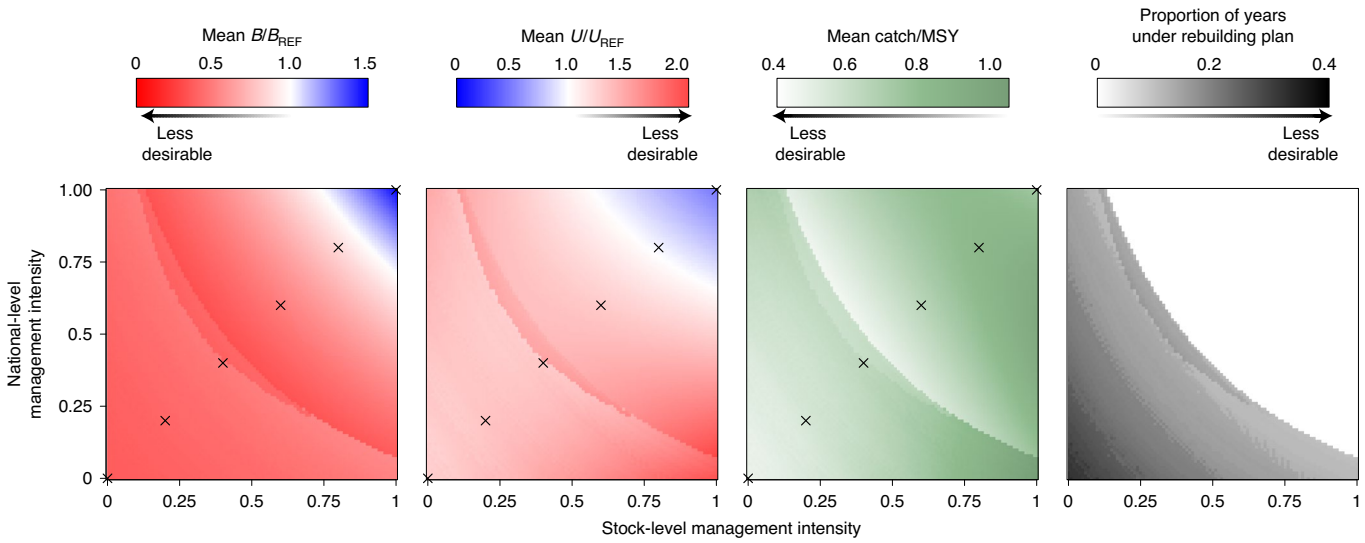


Fig. 5 | Equilibrium predictions at different combinations of stock-level and national-level management intensity. Predictions are shown for mean scaled relative biomass (B/B_{REF}), mean relative fishing pressure (U/U_{REF}), mean relative catch (catch/MSY) and the proportion of years spent under rebuilding plans for an average stock. White isoclines in the first two panels represent management target ratios of 1. For each panel, conditions generally considered as less desirable with respect to management targets are indicated. Crosses show combinations of stock-level and national-level management intensity at which representative equilibrium time series were extracted for Supplementary Fig. 10.

together to strengthen overall management intensity, the need for rebuilding plans was avoided (because the modelled stock at equilibrium was never overfished), consistent with previous suggestions for avoiding strict fishing moratoria[24,28]. The effect on stock status was particularly strong from enacting either the UNCA or the UNFSA (Supplementary Fig. 5). This was surprising because these agreements do not apply directly to the many stocks in our dataset that are caught entirely within the waters of a single country, whereas the agreements address illegal and unreported fishing on the high seas and management of transboundary stocks. The observed influence of the UN agreements might reflect countries generally intensifying their fisheries management approaches as they simultaneously instituted changes for transboundary or high-seas stocks in the mid-1990s. The non-binding Food and Agriculture Organization Code of Conduct for Responsible Fisheries was also introduced around the same time, embodying many of the same principles as the UNFSA and the UN Convention on the Law of the Sea[15], and further encouraged the strengthening of fisheries management in domestic waters. In turn, the engagement of countries in these international agreements was enabled by their management capacity, which had already been gradually developing over preceding decades.

Effects of management measures on stock status trends were stronger when considered in aggregate (Fig. 3) than individually (Supplementary Fig. 5), as found previously[29]. This suggests that comprehensive management systems with multiple measures in place provide greater opportunities and mechanisms for meeting objectives. This result further implies that of the many individual measures available to fisheries managers, there is no one-size-fits-all solution, underscoring the need for local management approaches to be tailored to each fishery's biological and socioeconomic context.

In the long term, a wide range of combinations of stock biomass and fishing pressures will often produce annual yield near MSY[30]. Likewise, equilibrium projections showed that during cycles of overfishing and rebuilding, a wide range of management intensity levels produced similar levels of equilibrium catch on average, ~0.75MSY (Fig. 5), at the cost of low biomass and high interannual variability in catch (Supplementary Fig. 10). Although fluctuations in stock biomass and catch due to environmental changes are unavoidable for some species[26,27], large fluctuations that result from controllable management policies increase the risk of stock collapse and result in poorer socioeconomic outcomes due to their boom-and-bust nature. Our equilibrium projections suggest that strong management at both stock and national levels (for example, four of five stock-level measures and all three national-level measures implemented) can avoid these unnecessary cycles, generate higher average annual yield and also reduce interannual variability in yield, consistent with previous findings[8–10,18].

The regions included in our analysis tend to contain well-studied stocks and have high management capacity compared with others around the world, yet even in these regions there are many stocks that could not be included because they lack scientific estimates of biomass or fishing pressure. Larger and more valuable stocks are disproportionately fished[23], scientifically studied[31] and managed, and therefore smaller or less valuable stocks were less likely to be included here. Furthermore, over half the world's landings from capture fisheries come from regions with more limited capacity for research and management, in which formal stock assessments are rarely conducted[7,13,14]. These regions, which lacked the status estimates to be included in our analysis, are typically of greater concern for poor and worsening stock status[7,13].

The management approaches that can attain the best possible outcomes in a given fishery depend on goals and on resources, which differ especially among regions varying in management capacity[29]. The intensive measures that have proven successful in attaining stock status objectives within our sample may not be feasible in regions without the infrastructure to conduct surveys or monitor stock-level catch by fleet or by individual vessel[13]. In those regions, typical measures include fleet size controls, area-based regulations of access for different fleets and seasonal closures. These are usually not tailored to individual stocks, and may better align with objectives of maintaining multi-species aggregate catches rather than the status of any constituent stock. Nevertheless, the insights of this study extend to aggregate catch measures: limiting fishing effort is expected to maintain fishery resources at productive levels, or to rebuild them back to these levels. Effective fisheries management

requires engaging at national, stock and fleet levels, and responding to changes in stock status or relative abundance with appropriate interventions.

Methods

This section describes model specifications and procedures for fitting ARIMA models to stock status and fisheries management data. ARIMA models, a form of time-series analysis, have been commonly used in fisheries applications to forecast landings or abundance[32,33]. Implementing a management measure can be considered a policy intervention that potentially affects stock status, that is, fishing pressure and biomass relative to target reference points (U/U_{REF} and B/B_{REF}). These possible effects were evaluated using ARIMA models, in this case not for forecasting but for attributing changes over time in stock status to management actions. The models are hierarchical, integrating effects across stocks while assuming stock-level random effects, and account for autoregressive and moving-average components in their correlation structures.

Management measures are not implemented randomly, but typically when undesirable trends are detected[6,25,34] or as social context changes[35]. Although temporal causality in the response variables was verified (Supplementary Note 1), our analysis does not account for the non-random implementation of management measures, that is, for self-selection bias. Propensities for implementing single measures have been quantified in other studies to account for non-random implementation[18,31]. For multiple measures analysed simultaneously, however, identifying suitable control stocks without management is prohibitive; stocks with less-intensive management also tend to have unknown trends in biomass and fishing pressure. Instead, information about the absence or presence of a management measure is provided by the pre- or post-intervention periods, respectively.

The following three subsections below directly correspond to research questions (1)–(3), and directly correspond to the three Results subsections. The Supplementary Methods describes the input data, data preparation procedures, pre-modelling diagnostics and sensitivity analyses conducted. Supplementary Tables 5 and 6 provide additional details for pre-modelling diagnostics, Supplementary Table 7 summarizes model fit diagnostics, while Supplementary Table 8 and Supplementary Note 2 provide additional details for sensitivity analyses.

Base model for stock status trends. To address question (1), a base model was constructed to evaluate the relative influence of management, fishery and life-history attributes on stock status trends. Response variables $y_{t,j}$ are first-order differenced time series of $\ln(U/U_{REF})_{t\to t+1,j}$ or $\ln(B/B_{REF})_{t\to t+1,j}$ representing the change from year t to year $t+1$ for stock j. Positive values reflect increases over time in U/U_{REF} or B/B_{REF}, and negative values reflect decreases. Response variables were modelled as:

$$\begin{aligned} y_{t,j} &= \beta_0 + b_{1,\mathrm{Taxon}_j} + b_{2,\mathrm{SingMix}_j} + b_3 A_{\mathrm{M50}_j} + b_4 L_{\mathrm{MAX}_j} \\ &\quad + b_5 \mathrm{MSLV}_j + b_6 \mathrm{Reb}_{\mathrm{immediate}_{t,j}} + b_7 \mathrm{Reb}_{\mathrm{persistent}_{t-1,j}} \\ &\quad + b_8 \mathrm{Mgmt}_{\mathrm{stock}_{t,j}} + b_9 \mathrm{Mgmt}_{\mathrm{national}_{t,j}} + \beta_j + \epsilon_{t,j} \\ \beta_j &\sim N(0, \sigma^2_{\mathrm{stock}}) \\ \epsilon_{t,j} &= \sum_{m=1}^{p} \phi_m y_{t-m,j} + \sum_{n=1}^{q} \theta_n \epsilon_{t-n,j} + \epsilon_{t,j} \\ \epsilon_{t,j} &\sim N(0, \sigma^2) \end{aligned} \quad (1)$$

Among fixed-effect coefficients (first line of equation (1)), life-history or fishery-related variables (b_1–b_5) are static quantities, and management variables (b_6–b_9) are time varying. Taxon_j is the three-level categorical variable of broad taxonomic groups, with two estimated parameters representing differences from the overall intercept. (For plotting in Fig. 3, these were instead shown as three overall intercepts.) $\mathrm{SingMix}_j$ is the single or mixed-species fishery categorical variable, with 'mixed-species' representing a difference from the overall intercept which represents the reference category 'single-species'. The life-history variables included are age at 50% maturity (A_{M50_j}) and maximum body length (L_{MAX_j}). MSLV_j is the maximum sustainable landed value, the product of MSY and average ex-vessel price.

In actuality, any management action lies on a continuum ranging from weak to strong, but for tractability in our analysis, we treat one management measure (rebuilding plans) as a binary category in any given year and other management measures as binary categories that increment a persistent management intensity index. Predictor variables for rebuilding plans assume a value of 1 only during the years in which rebuilding plans were active, and 0 in other years. Rebuilding plan effects (b_6 and b_7) are separated into a component that operates only in the year of implementation, $\mathrm{Reb}_{\mathrm{immediate}_{t,j}}$, and a component that operates in all years after the first year while the rebuilding plan is still active, $\mathrm{Reb}_{\mathrm{persistent}_{t-1,j}}$. With annual timesteps, $y_{t,j}$ is affected by $\mathrm{Reb}_{\mathrm{immediate}_{t,j}}$ in year t and by $\mathrm{Reb}_{\mathrm{persistent}_{t-1,j}}$ from previous years (in other words, there is a ≥1 year lag in the effect of $\mathrm{Reb}_{\mathrm{perisistent}}$ on y). This approach for rebuilding plans differs from the approach used for management intensity index variables $\mathrm{Mgmt}_{\mathrm{stock}_{t,j}}$ and $\mathrm{Mgmt}_{\mathrm{national}_{t,j}}$, for which only persistent effects were assumed to occur, beginning in the year of implementing a management measure and persisting thereafter.

The random effect term β_j (second line of equation (1)) represents stock-specific differences from the overall intercept β_0. The correlation structure function is specified by $\epsilon_{t,j}$ (third line of equation (1)): the first term represents the autoregressive component, with number of lag terms equal to p; the second term represents the moving average component, with number of propagating noise terms equal to q; and the third term $\epsilon_{t,j}$ is a homoscedastic noise term centred at zero[36,37]. In an ARIMA(1,1,1) structure (Supplementary Methods), there is one ϕ autocorrelation parameter and one θ moving-average correlation parameter to estimate, applying the same grouping structure as assumed for the random effect terms[37]. Within-group error $\epsilon_{t,j}$ in the natural-log-transformed ratios (fourth line of equation (1)) is assumed to be normally distributed and independent of the random effects. After applying filters for surplus production fits and time-series duration, sample sizes were 284 stocks for U/U_{REF} and 280 stocks for B/B_{REF}.

The above model structure (equation (1)) was used for the results shown in Fig. 3. An alternative model formulation was also considered, in which the five components of the stock-level management intensity index and the three components of the national-level management intensity index were considered as predictor variables individually instead of including the two aggregated indices of management intensity. This required estimating 17 instead of 11 fixed-effect parameters, as eight management measures replaced the two indices b_8 and b_9. The results for this alternative structure are shown in Supplementary Fig. 5.

Two weighting schemes were considered. In the main text results and Fig. 3, stocks were equally weighted. In Supplementary Fig. 6, stocks were weighted by MSLV in millions of US dollars, giving greater weight to more valuable fisheries. Additionally, two regional-level weighting schemes were considered, with sample weights proportional to the number of stocks with available stock assessments in each region (Supplementary Note 2).

Model diagnostics were checked to ensure proper model fitting. These included plotting histograms of response variables ($\ln(U/U_{REF})_{t\to t+1}$ and $\ln(B/B_{REF})_{t\to t+1}$) after calculating first-order differences, to assess assumptions of normality; plotting residuals of model fits for response variables to identify possible non-linear patterns or heteroscedastic variances; and calculating variance inflation factors to assess potential collinearity of predictors[38]. Diagnostics were generated for both the 'mature' fishery phase and the full time series. Based on the variance inflation factor results, only two life-history variables were included in analyses (Supplementary Methods and Supplementary Fig. 7). Other diagnostics showed little reason for concern about possible violations of model assumptions.

All ARIMA(1,1,1) models (equation (1) above, as well as equations (2) and (3) outlined below) were fit to data by maximizing the restricted maximum likelihood[37]. The lme() function from the R package 'nlme'[39] was used for all model fits, using first-order differenced time series as the response variables and specifying an ARMA(1,1) correlation structure (which is equivalent to an ARIMA(1,1,1) structure with undifferenced time series). 'Stock' was treated as a grouping variable for both the correlation structure and random intercepts β_j. In all analyses, a minimum of ten years of data for a given stock and response variable were required for inclusion in analyses.

Predicting short-term responses to management. To predict short-term changes in U/U_{REF} and B/B_{REF} following the implementation of management measures, a model similar to the base model in research question (1) was fit to data, and estimated coefficients were subsequently used to project baseline trends (before intervention) and impacted trends (after intervention). The model, requiring eight fixed-effect parameters to be estimated, was identical to equation (1) without terms b_{1,Taxon_j} and $b_{2,\mathrm{SingMix}_j}$:

$$\begin{aligned} y_{t,j} &= \beta_0 + b_1 A_{\mathrm{M50}_j} + b_2 L_{\mathrm{MAX}_j} + b_3 \mathrm{MSLV}_j + b_4 \mathrm{Reb}_{\mathrm{immediate}_{t,j}} \\ &\quad + b_5 \mathrm{Reb}_{\mathrm{persistent}_{t-1,j}} + b_6 \mathrm{Mgmt}_{\mathrm{stock}_{t,j}} + b_7 \mathrm{Mgmt}_{\mathrm{national}_{t,j}} + \beta_j + \epsilon_{t,j} \\ \beta_j &\sim N(0, \sigma^2_{\mathrm{stock}}) \\ \epsilon_{t,j} &= \sum_{m=1}^{p} \phi_m y_{t-m,j} + \sum_{n=1}^{q} \theta_n \epsilon_{t-n,j} + \epsilon_{t,j} \\ \epsilon_{t,j} &\sim N(0, \sigma^2) \end{aligned} \quad (2)$$

This modification allowed us to predict changes in stock status trends for an average stock across all three taxonomic groups and both fishery types. Like the base model, this model assumes that aggregate management intensity indices have a persistent effect on stock status for all years during and following the intervention, whereas the effect of rebuilding plans is separated into immediate and persistent components. Similar to analysis of the base model, two weighting schemes were evaluated: stocks weighted equally and stocks weighted by MSLV.

After fitting the model to time-series data during the 'mature' fishery phase, estimated coefficients from equation (2) were used to project U/U_{REF} and B/B_{REF} forward 20 years. For the first nine years of projections, no management measures were active, representing a baseline scenario. In the tenth year (labelled as year 0 in Fig. 4 and Supplementary Fig. 8), a set of management measures was implemented and remained in place for the following ten years. Three scenarios were considered

to represent low, medium or high levels of management intensity. These scenarios involved implementing one, three or five (of five possible) stock-level management measures along with one, two or three (of three possible) national/international-level measures, all implemented in year 0. For each of these three levels of management intensity, a rebuilding plan is either also implemented, or not implemented, in year 0 (Supplementary Fig. 8). The high-intensity scenario, either with or without rebuilding plans, is shown in Fig. 4.

Initial values of U/U_{REF} and B/B_{REF} used in projections were specified to represent typical states of overfishing and biomass depletion. These were calculated as the mean values across all stocks of U/U_{REF} and B/B_{REF} observed during years when stocks were under rebuilding plans. Means were first calculated for each stock, and the mean of means was then calculated across stocks. These overall means were calculated as $U/U_{REF}=1.45$ and $B/B_{REF}=0.65$, which were used as initial values, shown in year −9 in Fig. 4 and Supplementary Fig. 8.

After the initial year, values for following years were obtained by adding the predicted annual change in the variable, y_t, to the value from the preceding year. In the first nine years of projections, values of all management variables were set to 0 to calculate y_t, producing the baseline trends seen in Fig. 4 and Supplementary Fig. 8. By the end of this pre-management period, U/U_{REF} had increased to nearly 2, and B/B_{REF} had decreased to below 0.5. Management intensity variables were activated in year 0 and remained in place thereafter. By activating, the values of the stock-level management index switched from 0 to 0.2, 0.6 or 1 in the low-, medium- and high-intensity scenarios, respectively. Likewise, in year 0 the values of the national-level index switched from 0 to 1/3, 2/3 or 1 in the three scenarios. For rebuilding plans specifically, $\mathrm{Reb}_{\mathrm{immediate}_t}$ affects stock status in year 0 → 1, so the variable's value switched from 0 to 1 in year 0, and then switched back to 0 after the first year. Similarly, $\mathrm{Reb}_{\mathrm{persistent}_{t-1}}$ affects stock status in years after the first year, so the variable's value remained at 0 in year 0, and then switched to 1 in year 1 and remained at a value of 1 thereafter.

Total uncertainty around projected trends was estimated from the variances of four individual components. The first two were constant over the 20 year projection, the third was constant at one value for the first ten years and constant at a different value for the last ten years and the fourth component increased gradually over time because annual predicted changes y_t are cumulative over the projection period, updating values of U/U_{REF} and B/B_{REF} each year:

(1) One thousand random draws of fixed-effect parameters were resampled from a multivariate normal distribution of the covariance matrix for fixed-effect coefficients, accounting for covariances among fixed effects. Predicted values of y_t were generated for each sampled set of parameter values, and the variance across y_t predictions was calculated. Only applicable fixed effects were considered; for scenarios without rebuilding plans, parameter values for $b_4\mathrm{Reb}_{\mathrm{immediate}_t}$ and $b_5\mathrm{Reb}_{\mathrm{persistent}_{t-1}}$ were omitted.
(2) The variance of the random effect, $\sigma^2_{\mathrm{stock}}$ (stock-level differences from the overall intercept for y, β_0), was extracted from model fit outputs.
(3) Variances and covariances of fixed effects were extracted from the covariance matrix of the fitted model and summed. For the first ten years, only variances corresponding to non-management parameters (β_0, b_1, b_2, b_3) were included in the sum. For the last ten years, terms corresponding to applicable management parameters were also included in the sum.
(4) Annual variances over the 20 year period were assumed to increase because values of U/U_{REF} and B/B_{REF} in each year incremented with the added y_t. This incremental variance began at 0 in the year (−9) of initial conditions. For the next nine years of the pre-management period, the estimated variance of the overall intercept β_0 was added to the previous year's incremental variance component. For the last ten years, in the post-intervention period, the estimated variance associated with applicable management parameters was also added incrementally each year along with the variance of the overall intercept.

The largest variance component was the post-implementation period of (3). Variances of the four individual components were summed, and 95% confidence limits were calculated from the resulting total variance. These confidence limits were back-transformed from log space and are shown in Fig. 4 and Supplementary Fig. 8.

While Fig. 4 and Supplementary Fig. 8 show predictions resulting from the above fitted model (equation (2)), Supplementary Fig. 9 shows raw data for individual stocks in a similar format. Time series of U/U_{REF} and B/B_{REF} for each stock are shifted so that the year in which a given management measure was implemented aligns with year 0.

Predicting equilibrium responses to management. To predict long-term equilibrium states in U/U_{REF} and B/B_{REF} under a specified set of management conditions, a model similar to the base model in research question (1) was fit to data, estimated coefficients were used to predict annual changes in these variables and coupled projections of these predicted changes were together run out to equilibrium.

Changes in fishing pressure and biomass are influenced not only by management measures, but also by one another[40], as fishing pressure (that is, exploitation rate) is a proportion of the biomass, and biomass responds to fishing. The magnitude of B/B_{REF} was considered as another predictor of $\ln(U/U_{REF})_{t\to t+1}$, and the magnitude of U/U_{REF} was considered as another predictor of $\ln(B/B_{REF})_{t\to t+1}$. Predictions for annual change in U/U_{REF} feed into the function for predicting annual change in B/B_{REF}, which in turn feed back again into the following year's predictions for annual change in U/U_{REF}. This proceeds until equilibrium is reached. Coupling these functions for change allows for generating equilibrium (*) predictions of $(U/U_{REF})^*$, $(B/B_{REF})^*$, and their product, $(\mathrm{catch/MSY})^*$. Predicted equilibrium values depend on the selected values for stock-level and national-level management intensity, which were held fixed. We assume stationarity in stock-recruitment and production relationships throughout these projections.

Coefficients were estimated from the following model, which builds on equation (2):

$$\begin{aligned} y_{t,j} &= \beta_0 + b_1 A_{\mathrm{M50}_j} + b_2 L_{\mathrm{MAX}_j} + b_3 \mathrm{MSLV}_j + b_4 \mathrm{Reb}_{\mathrm{immediate}_{t,j}} \\ &\quad + b_5 \mathrm{Reb}_{persistent_{t-1,j}} + b_6 \mathrm{Mgmt}_{\mathrm{stock}_{t,j}} + b_7 \mathrm{Mgmt}_{national_{t,j}} + b_8 \frac{B}{B_{\mathrm{REF}_{t,j}}} \\ &\quad + b_9 \left(\frac{B}{B_{\mathrm{REF}_{t,j}}}\right)^2 + b_{10} \mathrm{Mgmt}_{\mathrm{stock}_{t,j}} : \mathrm{Mgmt}_{\mathrm{national}_{t,j}} + \beta_j + \epsilon_{t,j} \\ \beta_j &\sim N(0, \sigma^2_{\mathrm{stock}}) \\ \epsilon_{t,j} &= \sum_{m=1}^{p} \phi_m y_{t-m,j} + \sum_{n=1}^{q} \theta_n \epsilon_{t-n,j} + \epsilon_{t,j} \\ \epsilon_{t,j} &\sim N(0, \sigma^2) \end{aligned} \quad (3)$$

The above model for $\ln(U/U_{REF})_{t\to t+1,j}$ (with predictor terms B/B_{REF}) was coupled with the similar model for $\ln(B/B_{REF})_{t\to t+1,j}$ (with predictor terms for U/U_{REF} instead of B/B_{REF}). Quadratic predictor terms (b_9) were included to allow for non-linearities in the values below and above target levels of 1. Again, the categorical fixed effects Taxon (taxonomic group) and SingMix (single or mixed-species fishery) used in the base model were omitted here, which allowed for making equilibrium predictions for an average stock across these groups. Combinations of stock-level and national-level management intensity values between 0 and 1 were selected and held fixed throughout projections, and the interaction between these two indices was included in the model (b_{10}) to allow for possibilities of redundancy between them. This model is most suitable for the full time series of each stock, including the 'developing' phase, because this allows for a greater range of U/U_{REF} and B/B_{REF} magnitudes and thus more reliable model fits with the greater contrast provided. The dataset for fitting equation (3) included 277 stocks that had B/B_{REF} and U/U_{REF} data both available (the remaining 11 of 288 stocks had one or the other time series missing).

Presence/absence of a rebuilding plan was not held fixed during projections, but was instead modelled as responding to predicted biomass, activating when B/B_{REF} decreased below 0.5, and deactivating when B/B_{REF} increased to above 1. Equilibrium may thus consist of a stable cycle during which rebuilding plans alternate between periods of activity and inactivity. In practice, it would be unlikely that rebuilding plans would be implemented at stock-level management intensity ~0 or national-level management intensity ~0 (Supplementary Fig. 4), but for consistency, we did not impose additional restrictions on the conditions under which rebuilding plans would activate. Once activated, the term $\mathrm{Reb}_{\mathrm{immediate}}$ affected predictions in the first year of the rebuilding plan and $\mathrm{Reb}_{\mathrm{persistent}}$ affected predictions in years thereafter (with one exception, see next paragraph).

Because $(U/U_{REF})^*$ and $(B/B_{REF})^*$ were generated from coupled statistical models and not from a population dynamics model, there are no inherent negative feedback mechanisms operating, so three adjustments were made to ensure more realistic projections of these variables. First, if the decrease in U/U_{REF} in the first year of a rebuilding plan was insufficient to reduce $U/U_{REF}<1$, then $\mathrm{Reb}_{\mathrm{immediate}}$ was applied for a second year to ensure U/U_{REF} fell to <1. This avoided unrealistic scenarios in which U/U_{REF} increased without limit while under a rebuilding plan, never falling to <1, because the estimated coefficient for $\mathrm{Reb}_{\mathrm{persistent}}$ was slightly positive.

Second, a logistic growth adjustment was applied to predicted biomass to prevent unrealistically high biomass increases in cases where biomass might approach carrying capacity:

$$\frac{B}{B_{\mathrm{REF}_{t+1}}} = e^{\left(\ln\left(\frac{B}{B_{\mathrm{REF}_t}}\right)+y_t\right)} + r_{\mathrm{MAX}}\left(\frac{B}{B_{\mathrm{REF}_t}}\right)\left(1-\frac{\frac{B}{B_{\mathrm{REF}_t}}}{2}\right) \quad (4)$$

The first term represents the updated relative biomass from the statistical model, in which y_t is the predicted annual change in ln-biomass under the given management regime and magnitude of $(U/U_{REF})_t$. The second term is the logistic growth model applied, assuming the carrying capacity is $2B_{REF}$ (hence 2 in the denominator) and average intrinsic growth rate $r_{MAX}=0.0437$. This value for r_{MAX} was estimated across stocks over their full time series by calculating the change in B from a fitted model while fixing U/U_{REF} to 0 and omitting management variables. After reaching equilibrium, $\ln((U/U_{REF})^*)$ and $\ln((B/B_{REF})^*)$ were exponentiated.

Third, the equilibrium value of $(B/B_{REF})^*$ was scaled to ensure closer correspondence with $(U/U_{REF})^*$, as small $(U/U_{REF})^*$ are typically associated with large $(B/B_{REF})^*$ and vice versa. The scaling factor simultaneously incorporated the maximum value of $(B/B_{REF})^*$ paired with the minimum value of $(U/U_{REF})^*$, and the

minimum value of $(B/B_{REF})^*$ paired with the maximum value of $(U/U_{REF})^*$, across all possible combinations k of stock-level and national-level management intensity:

$$\frac{B^*}{B_{REF_{scaled}}} = \frac{B^*}{B_{REF}} \left(\max_k \left(\frac{B^*}{B_{REF}} \right) \times \min_k \left(\frac{U^*}{U_{REF}} \right) \right) \left(\max_k \left(\frac{U^*}{U_{REF}} \right) \times \min_k \left(\frac{B^*}{B_{REF}} \right) \right) \quad (5)$$

Equilibrium values of (catch/MSY)* were calculated as the product of $(U/U_{REF})^*$ and $(B/B_{REF})^*_{scaled}$. The above model structure (equations (3)–(5)) was used for the results shown in Fig. 5; asterisks are omitted in the main text and figures.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

Stock assessment data are compiled in RAMLDB (version 4.491-mdl-fits)[22], which is publicly available at https://zenodo.org/record/3877545.

Code availability

All data input files and code to reproduce analyses are publicly available at https://github.com/mcmelnychuk/MCM-NatSust_2020-12-05.

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Author contributions

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Competing interests

Most authors are involved in fisheries management or provide fisheries advice in ways that can be viewed by some as competing interests. Many are employed by national fisheries agencies or non-governmental organizations that advocate for specific fisheries

policies. The academic scientists have received funding from sources that include government fisheries agencies, fishing companies and environmental non-governmental organizations.

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nature research

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Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	Stock assessment data are compiled in the publicly-available RAM Legacy Stock Assessment Database, which is hosted on a cited Zenodo repository. Data from this version 4.491 are available for download either as .RData files for use in R, or as .xlsx files for use in Excel.
Data analysis	All data analyses for this study were conducted using R version 3.6.3. Key R packages used are cited in the reference list with version numbers. All data input files and code to reproduce analyses are publicly available (https://github.com/mcmelnychuk/MCM-NatSust_2020-07-08).

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Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

Stock assessment data are compiled in RAMLDB (version 4.491-mdl-fits), which is publicly available (DOI 10.5281/zenodo.3877545).

Field-specific reporting

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Ecological, evolutionary & environmental sciences study design

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Study description	This study uses time series of stock biomass (B) and fishing pressure (U) relative to their biological reference points (Bref and Uref), collated for 288 fish and invertebrate stocks worldwide. Interannual changes in the trends of these variables are used as response variables in ARIMA models. These ARIMA models incorporate management, life-history, and fishery-related variables as predictor variables potentially influencing changes in B/Bref and U/Uref. Interactions among these predictor variables are included in some models. The models are hierarchical, incorporating random intercepts for each population. Treatments are neither controlled nor randomised; information about the influence of predictors on responses in these observational data is based on differences between the pre- and post-intervention periods in the time series for each individual stock, with overall effects across stocks estimated.
Research sample	Biomass and fishing pressure time series for individual stocks are estimated from stock assessments, typically carried out by governmental fisheries agencies. Biological reference points are also estimated within the assessment framework of most stock assessments, or otherwise are estimated post-hoc with previously-developed methods. These estimates are compiled in the publicly-available RAM Legacy Stock Assessment Database, from which data for the response variables was drawn. A variety of marine fish and invertebrate stocks are included in the analysis.
Sampling strategy	We primarily focussed on stocks that at some point in their fishing history had high levels of relative fishing pressure and/or low levels of relative biomass, i.e. stocks that at some point had undergone overfishing or been overfished to some degree. We prioritized stocks on this basis and targeted our collection of management attribute data accordingly. In the end, we included 288 stocks in the analysis that had both sufficient data for one or the other response variable, as well as sufficient management attribute data used as predictor variables. As the focus is on overall effects across stocks (in a hierarchical model), this number of sampled stocks is sufficient for estimating effects of management interventions and other influences on changes in response variables.
Data collection	Data for response variables were drawn from the RAM Legacy Stock Assessment Database, a publicly-available compilation of stock assessment outputs for assessed marine fish and invertebrate stocks around the world. Assessment data are entered into the database from a variety of sources: some contributed by government agencies, some by a network of scientists around the world (including several co-authors), and others by staff at the University of Washington. Data for management attributes were collected by co-authors in their contries or regions of familiarity; some regional experts collected the necessary information themselves, others co-ordinated data collection in their region, drawing on the expertise of people familiar with individual stocks.
Timing and spatial scale	The duration of time series of estimated biomass and fishing pressure vary by stock, as stock assessments are conducted for stocks individually and are limited by available information. The full time series for each stock is contained in the RAM Legacy Stock Assessment Database, with varying dates of earliest data availability among stocks. There were few stocks with data available for years after 2016, so time series were capped at 2016 for analyses. Stock assessments are carried out for individual defined stocks, which are typically considered to be biological populations but are also based on considerations of statistical fishing areas. We used the same spatial definitions of stocks as used in stock assessments.
Data exclusions	No samples (i.e. individual stocks) were excluded from analyses. For some analyses, earlier years of the time series ('Developing fishery' phase, as described in the paper) were excluded for some stocks to focus on the years in which the fishery had already matured. Pre-established rules for distinguishing 'developing' from 'mature' phases, based on values of estimated biomass, fishing pressure, and catch, were described in the paper. In other analyses, the 'developing' and 'mature' phases of stock time series were both included, to provide greater contrast.
Reproducibility	All input data and code for analyses are cited and publicly available. These provide the ability to reproduce all figures presented in the main text and Supplementary Information.
Randomization	Individual stocks were allocated into one of 17 regions around the world for presentation of management histories by region (Fig. 1 and Supplementary Figures 2 and 3). This allocation was based on geographical location and/or management authority for each stock. This allocation has no impact on analyses because random intercepts were specified for individual stocks, not regions.
Blinding	Blinding is not relevant here, as there were no controlled or randomised treatments. Stock status data were drawn from published sources, and management attribute data were collected for specified stocks.

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

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Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Supplementary Information for

Identifying Management Actions that Promote Sustainable Fisheries

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suppl-table-2.pdf (Supplementary Table 2. National/international-level fisheries management measures treated as interventions potentially affecting stock status)

suppl-table-8.pdf (Supplementary Table 8. Summary of comparisons between sensitivity analyses and main run of results)

suppl-fig-1.pdf (Supplementary Figure 1, with caption. Stock status history relative to the timing of fisheries management interventions for 288 individual stocks included in analyses—this is the full 289-page extension to the example shown in Fig. 2 of the main text.)

Supplementary Methods

Input data: stock status response variables

Stock assessment outputs are compiled for marine fish and invertebrate populations from around the world in the RAM Legacy Stock Assessment Database[21] (RAMLDB, version 4.491[22]). Assessments are usually conducted by government agencies, and key outputs are estimated time series of biomass (B, either total biomass or spawning stock biomass; commonly termed abundance) and fishing pressure (U, either an annual fraction harvested or an instantaneous fishing mortality rate; commonly termed exploitation rate). The start year considered in assessments is highly variable among stocks (Supplementary Table 4; Supplementary Figure 1). Some assessments further provide estimates of target reference points for biomass (B_{REF}) and fishing pressure (U_{REF}) that pair with biomass or fishing pressure time series. These target reference points are often based on maximum sustainable yield (MSY) or proxies for MSY[34] but may be based on other factors. For stocks with MSY-based reference points as well as actual target reference points provided in assessments, the actual targets were preferred. Pairing the time series with their respective target reference points, we obtain target ratios of $B/B_{REF} = 1$ and $U/U_{REF} = 1$. We note that the assumption of stationarity in reference points B_{REF} and U_{REF} is unlikely to be met for most stocks[27], however, the time series analysis involves annual changes in B/B_{REF} and U/U_{REF} rather than their magnitudes, and slow temporal variability in the reference points does not alter the direction of annual change in B or U.

For stocks that did not have target reference points provided in assessments, we fit surplus production models to catch and total biomass time series taken from assessments, similar to approach used previously[4,9,10,18,21]. Annual net surplus production values were calculated as the sum of annual catch and the change in total biomass from the current year to the following year, all in tonnes. We used a Pella-Tomlinson model[41] parameterised with B_{MSY} (with B as total biomass, TB), U_{MSY} (with U as harvest fraction, ER), and shape parameter γ to predict annual net surplus production ($\hat{S}$):

$$\hat{S} = \left(\left(\frac{\gamma}{\gamma - 1}\right) U_{MSY}\ B\right) - \left(\frac{U_{MSY}\ B^{\gamma}}{(\gamma - 1)\ B_{MSY}{}^{(\gamma-1)}}\right)$$

(Supplementary Equation 1)

For stocks that had a single missing reference point, the value for the other reference point was held fixed during the fitting procedure to estimate the single missing reference point. For stocks that had both reference points missing, both parameters were estimated simultaneously. Cross-validations with assessment-estimated reference points showed greater prediction accuracy for estimating both reference points when γ was fixed at the value 1.736, as previously estimated in a meta-analysis[42]. When only B_{MSY} was estimated (with U_{MSY} held fixed at the assessment-derived value), cross-validations showed greater prediction accuracy when γ was fixed at ≈1, which defines the Fox model[43]. When only U_{MSY} was estimated (with B_{MSY} held fixed at the assessment-derived value), cross-validations showed greater prediction accuracy when γ was specific to one of 13 taxonomic groups with values ranging from 0.65-2.43. These values were determined empirically by estimating a freely-varying γ while U_{MSY} and B_{MSY} were held fixed at assessment-derived values, and then calculating the arithmetic mean across the stocks in each taxonomic group.

A series of filters applied to surplus production model outputs guarded against poorly-estimated reference points. Similar filters were applied previously[4]. Estimated reference points were rejected if any of the following failures were observed:

(1) fewer than five years of annual net production and biomass were available
(2) estimated $U_{MSY} < 0.005$
(3) estimated $U_{MSY} > 0.85$
(4) estimated $B_{MSY} < 0.07B_{MAX}$, where B_{MAX} is the maximum recorded value in the total biomass time series
(5) estimated $B_{MSY} > 2.085B_{MAX}$
(6) the biomass range between 0 and the lesser of estimated carrying capacity, K, and B_{MAX} was divided into four equal intervals, and in the middle two intervals, three criteria were all required to fail in order for this filter (6) to be considered an overall failure: at least six net production values were negative; more than 50% of net production values were negative; and the sum of net production values was negative
(7) the calculated AICc value (Akaike's Information Criterion, adjusted for sample size) of the surplus production model fit was greater than any of three AICc values calculated for linear fits to annual surplus production values and biomass (fixed slope = 0 with freely-varying intercept; fixed intercept at origin with freely-varying slope; and both intercept and slope freely-varying)
(8) if B_{MSY} was available from the assessment and held fixed for estimating U_{MSY}, predicted surplus production at this fixed B_{MSY} was negative.

Numerical thresholds assumed for criteria 2-5 were based on ranges of values available from stock assessments. Typically, these filters 1-8 collectively exclude 13-19% of surplus production model fits (including fits for stocks that already had B_{REF} and U_{REF} available in assessments; these fits are still evaluated for use in cross-validations). Specifically for 83 stocks in our dataset without B_{REF} and/or U_{REF} from assessments, these filters collectively resulted in excluding B_{MSY} estimates for 13 of 55 stocks (24%) and excluding U_{MSY} estimates for nine of 63 stocks (14%); seven of these excluded stocks overlapped.

A sensitivity analysis ('Sensitivity 1—reference points') was conducted to examine the influence of including these *post-hoc* surplus production reference point estimates on observed results from later data analyses. Time series analyses (main Methods) were repeated after omitting these estimates, limiting the dataset to only stocks with reference points extracted from assessments. Comparisons of results with the main run are described in Supplementary Note 2.

Input data: predictor variables

There are 644 unique stocks contained in RAMLDB[22] with at least some available time series of B/B_{REF} or U/U_{REF}, including those with *post-hoc* estimated reference points. It was not feasible to collect management-related information for all of these, but we collected sufficient information for inclusion in analyses for 288 of these. In collecting management information, we ensured a high level of representation in terms of geography (Supplementary Table 3), taxonomic groups, population size, and fishing gears used. We focused mostly on stocks that are targeted in capture fisheries and that have been fished to such an extent that at some point in their history, fishing pressure had increased above U_{REF} or biomass had decreased below B_{REF}. These are typically the stocks of greatest management interest.

Fisheries management measures were considered at the stock level and at the national (or international) level as potentially influencing stock status. Stock-level measures consisted of two types of time series variables that were assembled by experts or during interviews with experts for each stock, and were occasionally supplemented with literature searches. First, the years in which a stock was under a formal rebuilding plan were assigned a '1', while all years not under a rebuilding plan were assigned '0'. Rebuilding plans vary in their duration after activation, are usually de-activated following stock recovery, and may later be re-activated as deemed necessary for rebuilding (Supplementary Figure 1). Rebuilding plans are commonly implemented when a stock's relative biomass B/B_{REF} is estimated to be 'too low' or below some threshold such as 0.5 (Supplementary Table 4). Rebuilding plans were the only management measure considered to have potential influence only in the years in which they were active (Supplementary Table 1). Second, similar to a previous approach[29], an aggregate variable of stock-level management intensity ranged from 0-1 and comprised five components other than rebuilding plans: scientific surveys of fish abundance; stock assessments; harvest control rules; fleet-wide catch limits; and individual quotas. The year in which each of these measures was first implemented for a stock incremented the aggregate index by 1/5. Any order of the five components was allowed, and if two components were implemented in the same year, the index incremented by 2/5 in that year. Unlike rebuilding plans, these other measures were treated as having a potential influence that persists indefinitely after they were first implemented (Supplementary Table 1). All years during and after the first use of these components were considered to be potentially influential, so (in contrast to how rebuilding plans were treated) the aggregate index increases monotonically. For example, if scientific surveys were implemented in some year and then ceased in some later year, or if they are only conducted every few years, the aggregate index does not decrease after first usage. Rebuilding plans were not considered as part of the aggregate index because their effect on stock status is expected to occur only in years in which they are active.

Similar to the stock-level aggregate index of management intensity, an aggregate variable of national-level management intensity ranged from 0-1, increased monotonically, and comprised three components, each of which incremented the aggregate index by 1/3: country-specific declaration of an Exclusive Economic Zone (EEZ)[15]; country-specific ratification of either the United Nations Food and Agriculture Organisation Compliance Agreement (UNCA)[16] or the United Nations Fish Stocks Agreement (UNFSA)[17], whichever was ratified first; and implementation of a major fisheries policy considered to have potential influence on most or all stocks in the country or region. Examples of this major fisheries policy included the U.S. Sustainable Fisheries Act and the European Union's 2002 reform of the Common Fisheries Policy. For stocks managed under tuna Regional Fisheries Management Organisations (tRFMO), this major fisheries policy consisted of the convention that governs the tRFMO. For stocks that are fished by multiple countries (e.g., West African stocks), management measures were specific to the country with the greatest proportion of catch of the stock. For tuna stocks, the year of first ratification of a UN agreement was likewise based on the country with the greatest proportion of catch of the stock. The national/international-level fisheries policies considered in analyses are listed in Supplementary Table 2 along with their year of implementation.

Rebuilding plans, stock-level management measures, and national/international-level management measures tended to co-vary in their usage. There were few stock:years that had low stock-level management intensity and high national-level management intensity together, and few stock:years that had the opposite (Supplementary Figure 4a). Rebuilding plans did not occur when stock-level management intensity was 0, and rarely occurred when national-level management intensity was 0. Rebuilding plans were most commonly activated when both

management indices were high, although there were also cases in which one or the other management index was low or intermediate while rebuilding plans were in place (Supplementary Figure 4a). Across all stocks, EEZs were in place for 72% of stock:years, individual quotas were in place for 23% of stock:years, and other management measures were intermediate between these proportions (Supplementary Figure 4b). Considering only the years while under active rebuilding plans, the proportions ranged from 94% of stock:years (for EEZs) to 43% of stock:years (for individual quotas; Supplementary Figure 4b), suggesting that rebuilding plans tended to be used after various other measures had already been implemented. Years of implementation of stock-level measures and national-level measures are shown in Supplementary Figure 1 for each stock, and summarised in Supplementary Table 4. Regional changes over time in the implementation of individual management measures and aggregate indices of management intensity are shown in Supplementary Figure 2 for each region and in Supplementary Figure 3 for each measure.

Management measures were treated either as a Boolean variable (rebuilding plan) or as incremental indices in analyses, but in reality, they represent a continuum. For example, some harvest control rules would be expected to have greater effect on stock status than other harvest control rules[19], particularly when output harvest recommendations are backed by law instead of being discretionary[9]. Some rebuilding plans are stronger than others, ranging from complete fishery closures to temporary, modest reductions in fishing pressure[20,24]. Some stock assessments provide more accurate estimates of stock status than others[24], which affect the basis on which management decisions are made. While such nuances are frequent and may realistically influence stock status differently, it was necessary to make simplifying assumptions when categorising management measures consistently across diverse regions and stocks.

Life-history traits and taxonomic groups were also considered as potentially influencing stock status. Life-history traits initially considered included: (1) natural mortality rate, M; (2) age at 50% maturity, A_{M50}; (3) length at 50% maturity, L_{M50}; (4) maximum age, A_{MAX}; (5) maximum length, L_{MAX}; (6) von Bertalanffy growth, κ; and (7) trophic level, TL. Variables 1-3 were available for some individual stocks; otherwise, values from a nearby stock were assumed, and if still not available, average values at the global species level were extracted from FishBase[44] or SeaLifeBase[45]. Paired scatterplots showed strong correlation between several pairs of variables in either linear (Supplementary Figure 7) or log space. To avoid problems with collinearity, variance inflation factors were calculated[38] and only two life-history variables were carried forward into regression analyses, A_{M50} and L_{MAX}. A categorical variable representing broad taxonomic groups (demersal fish; pelagic fish; invertebrates) was also considered as a predictor variable.

Two fishery-related attributes were considered as predictor variables potentially influencing stock status. First, a categorical variable distinguishing single-species fisheries from mixed-species fisheries was considered for each stock. In cases where some fleets catch the stock alone while other fleets catch the stock in a mix of species, the variable was assigned according to the principal fleet. Second, the product of MSY and average ex-vessel price for a given stock represented its Maximum Sustainable Landed Value ($MSLV$), as quantity and price together drive incentives for targeting by fishing fleets[23]. If an estimate of MSY was not available for a stock (which was the case for only 6.6% of stocks), the mean catch across the full time series with leading zeros removed was instead used (Supplementary Figure 1). These values of MSY and mean catch were highly correlated for the stocks that had both values available ($r = 0.964$). Predicted prices were generated from an external mixed-effects regression model fit to observed ex-vessel prices from national price datasets. This provided predicted prices even for stocks

without observed prices, based on their nested taxonomic levels and regional covariates. The mean price during 2001-2010 was calculated and was multiplied by MSY (or mean catch) to obtain *MSLV*. Time series of catches, observed and predicted prices, as well as estimates of MSY, mean catch, and mean predicted price for years 2001-2010 are shown in Supplementary Figure 1.

For plotting, stocks were assigned to regions based on their geographic distributions and management authorities. The 288 sampled stocks for data analyses were distributed among 17 regions, with 3-31 stocks per region (Supplementary Table 3; Supplementary Figures 1-2).

Data preparation

Management measures and other predictor variable data were collected for 296 stocks, but U/U_{REF} or B/B_{REF} response variable data were available for only 288 of these. Reference point estimates were drawn from stock assessments for 232 stocks (U_{REF}) and 240 stocks (B_{REF}), and were drawn from surplus production model fits for 54 stocks (U_{REF}) and 42 stocks (B_{REF}). The other eight of the originally-available 296 stocks were excluded because they did not have available reference points after applying the set of filters described above to surplus production model estimates. The 288 stocks included in analyses had between 1-67 years of U/U_{REF} and/or B/B_{REF} estimates available (mean 41.8 years for U/U_{REF} and 43.1 years for B/B_{REF}). Stocks with <10 years of available data were excluded from analyses. This yielded a total of 11,944 stock:years of U/U_{REF} estimates and 12,162 stock:years of B/B_{REF} estimates across all stocks. Missing values within otherwise contiguous time series existed for nine stock:years of B/B_{REF} (across four stocks) and one stock:year of U/U_{REF}; these few missing values were linearly interpolated.

In the regression models described in the main Methods, the potential effect on stock status of most management measures was assumed to be persistent following the implementation of a measure. Two management-related variables (stock-level aggregate index of management intensity; and national/international-level aggregate index of management intensity) were considered to potentially influence stock status during their year of implementation and all years following in the stock's time series. In contrast, the third management-related variable, 'under rebuilding plan', was considered to potentially affect stock status only during the specific year(s) in which it was active (Supplementary Figure 1). The rebuilding plan effect was separated into two components, an immediate component (in the first year of implementing a rebuilding plan) and a persistent component (for all years after the first year, until the rebuilding plan was de-activated or until the end of the time series). This separation of components, described further in the main Methods, allowed for distinguishing immediate effects from longer-term effects. In particular, fishing pressure is likely to decrease immediately after activating a rebuilding plan (because fishing fleets can respond to management changes within the same year or fishing season), whereas biomass may require several years under a rebuilding plan before starting to recover (because of biological constraints on rates of population increase).

Stock time series were partitioned into (up to) two distinct phases based on values of U/U_{REF}, B/B_{REF}, and catch/MSY or catch/(mean catch). This allowed us to focus our research questions (about management influences on fishing pressure and biomass) on the most applicable portion(s) of a stock's available time series. The first phase, 'developing fishery', was considered from the start of a stock's available time series until any of the following criteria were met: (a) $B/B_{REF} < 0.8$; (b) $U/U_{REF} > 1$; (c) catch/MSY > 1; (d) catch/(mean catch) > 1.25; or (e) a rebuilding plan was implemented. To guard against misclassifications arising from truncated time series (if data were available only after actual fishery development), if either of the two following

conditions were observed, the stock was assumed to already be past the 'developing' phase: (f) $B/B_{REF} < 1$ in the first year of the available time series; or (g) catch in the first year when both B/B_{REF} and U/U_{REF} data were available was less than 1.25 times the mean catch in the previous ten years (which may occur if catch time series extend further into the past than B or U estimates provided in assessments). The second phase, 'mature fishery', was assumed to include all years after the 'developing' phase. For stocks lacking a 'developing' phase in their available time series, the full time series was considered to be 'mature'.

Stocks in some regions tended to pass from 'developing' to 'mature' fishery phase sooner than stocks from other regions. For example, among the regions considered, fisheries in Australia, New Zealand, West Africa, South America, and tRFMOs tended to develop later than fisheries in other regions (Supplementary Figure 1). In contrast, declaration of EEZs and ratification of UN agreements tended to cohere more closely in time across regions (Supplementary Figures 2 and 3). This implies that EEZ declaration and ratification of UN agreements would generally be well into the 'mature' fishery phase for stocks in earlier-developing regions, but may be either in the 'developing' phase or early in the 'mature' phase for stocks in later-developing regions. If the implementation of a management measure occurred prior to the beginning of a stock's 'mature' fishery phase, it would have no influence on analyses that were restricted to the 'mature' fishery phase.

We recognise that other factors besides management actions, such as environmental conditions, may influence stock abundance and therefore affect the timing of transitions from the 'developing' phase into the 'mature' phase. Despite these possible external influences, the blocking of time series data into 'developing' and 'mature' phases allows for some analyses to be focused solely on the 'mature' phase, when implementation of management measures is most relevant (main Methods sections '*Base model for stock status trends*' and '*Predicting short-term responses to management*'). In other analyses, when a greater range of magnitudes of U/U_{REF} and B/B_{REF} was necessary (main Methods section '*Predicting equilibrium responses to management*'), the full time series including the 'developing' phase was considered. Classified phases are shown for all stocks in Supplementary Figure 1. The start years of phases, and status of U/U_{REF} and B/B_{REF} at the time of these phase starts, are summarised in Supplementary Table 4. Some 'mature' phases were only a few years in duration, so to guard against small sample sizes, all analyses described below required a minimum of 10 years of data in the 'mature' phase for a given stock and response variable. This filtered out 1 stock for U/U_{REF} only, 1 stock for B/B_{REF} only, and 1 stock for both U/U_{REF} and B/B_{REF}.

A sensitivity analysis ('Sensitivity 2—time series length') was conducted to examine the influence on observed results of this 10-year threshold for inclusion. Data analyses were repeated, instead requiring a minimum of 20 years of data for a given stock and response variable. Comparisons of results with the main run are described in Supplementary Note 2.

Response variables U/U_{REF} and B/B_{REF} were ln-transformed to ensure symmetrical proportional changes above and below target ratios of 1 (e.g., a doubling from $U/U_{REF} = 1$ to 2 is symmetrical with a halving from $U/U_{REF} = 1$ to 0.5). Response variables were subsequently differenced for time series regression analysis to achieve stationarity[36]. First-order differences were determined to be sufficient for most stocks (see next section). Numerical predictor variables for regression analyses (A_{M50}, L_{MAX}, and $MSLV$) were centred by subtracting the arithmetic mean and standardised by dividing the result by the standard deviation. Model fit diagnostics were evaluated, and are reported in Supplementary Table 7 for both response variables, $\Delta\ln(U/U_{REF})$ and $\Delta\ln(B/B_{REF})$.

Correlation structures

ARIMA (autoregressive integrated moving average) model correlation structures contain components for autoregression (p), differencing (d), and moving average prediction errors (q) for a univariate time series. The appropriate orders of p, d, and q can be determined for a given time series through statistical tests for stationarity, inspection of autocorrelation function plots and partial autocorrelation function plots, or evaluating criteria for statistical fitting[36]. The auto.arima() function of the R package 'forecast'[46] combines several of these checks to provide an optimal set of parameters for a given time series. In a hierarchical model with multiple time series, however, the same orders of p, d, and q must be assumed across all groups (using the same grouping structure as for random effects[37]) even though the optimal set of parameters may vary among individual groups. To identify the best overall set of p, d, and q parameters across stocks, we used the auto.arima() function[46] to identify the best set of parameters for each stock in the 'mature' fishery phase (as well as for the full time series, including the 'developing' phase), and then we summarised these best-identified sets across stocks to reveal an overall best set.

First, we evaluated the order of required differencing to ensure stationarity. For $\ln(U/U_{\mathrm{REF}})$, the most frequent order of required differencing was 1 for both the 'mature' phase and for the full time series (Supplementary Table 5). The next-most-frequent required order was 0; few stocks required second-order differencing. For $\ln(B/B_{\mathrm{REF}})$, the most frequent required order of differencing was also 1, followed by order 2 for both the 'mature' phase and full time series (Supplementary Table 5). This most frequent order of 1 was assumed for all analyses ($d = 1$).

Second, using first-order differenced time series, the order of autoregressive and moving average components required to minimise AICc were identified[46]. For $\ln(U/U_{\mathrm{REF}})$, the most frequent combination of parameters was an ARIMA(0,1,0) structure in the 'mature' phase as well as for the full time series (Supplementary Table 6). However, there were also several stocks for which the best-fit structure required 1 or 2 orders of p (with $q = 0$), or 1 or 2 orders of q (with $p = 0$). Few stocks required >0 orders of p and >0 orders of q simultaneously. For $\ln(B/B_{\mathrm{REF}})$, the most frequent combination of parameters was an ARIMA(1,1,0) structure, i.e., lag-1 autoregression, in the 'mature' phase as well as for the full time series. However, orders of $p = 0$ or 2 were also relatively frequent, as were orders of $q = 1$ (Supplementary Table 6). Because most stocks had best-fit orders of $p = 0$ or 1 and $q = 0$ or 1, an ARIMA(1,1,1) structure was selected for the main analysis, erring on the side of including additional parameters that may be unnecessary for some stocks (rather than failing to include additional parameters that may be necessary for other stocks). The selected ARIMA(1,1,1) structure was applied, with calendar year treated as the time covariate and stock as the grouping variable[37]. To correspond with this grouping structure, stock was also treated as a random intercept in regression models[37]. In this ARIMA structure with $p = 1$ and $q = 1$, there is one autoregressive parameter ϕ and one moving average parameter θ to estimate, respectively. The magnitudes of the estimated values of these parameters are indicative of whether the fitted model is considered to be temporally causal (see Supplementary Note 1).

Four sensitivity analyses ('Sensitivity 3a,b,c,d—ARIMA structure) were conducted to examine the influence of ARIMA model structure assumptions (i.e., the selected values of p and q) on observed results. Analyses were repeated assuming alternative structures of ARIMA(0,1,0), ARIMA(1,1,0), ARIMA (2,1,0), and ARIMA(0,1,1). Comparisons of these sensitivity results with those of the main run are described in Supplementary Note 2.

Supplementary Discussion

Regional differences in management history

Management measures at the stock level and at the national (or international) level considered in analyses are defined in Supplementary Table 1. Summarising all stocks in our analysis (which comprise assessed stocks primarily from regions with high research and management capacity), Fig. 1 shows the history of implementing these management measures since 1950. While these management measures have all been increasingly used over this period, considerable variability exists among regions and individual stocks in whether and when these measures have been applied. Variability among regions also exists in the timing of implementing management measures with respect to the timing of when stocks transitioned from their 'developing' fishery phase to 'mature' fishery phase (Supplementary Figure 1). For example, the declaration of EEZs and ratification of UN agreements tended to occur prior to the transition into the 'mature' fishery phase for stocks in some regions, but well after the transition for stocks in other regions. Because the timing of changes in mean stock status differed among regions[4], while the timing of implementing EEZs and UN agreements tended to be synchronous across regions (Supplementary Figures 2-3), this implies that regions differ in their patterns of management history with respect to stock status history. The history of implementing management measures for individual stocks is shown in the multi-page Supplementary Figure 1. Grouping stocks by region, Supplementary Figures 2 and 3 show how temporal patterns of implementing management measures have varied among regions.

At the stock level, rebuilding plans or catch moratoria have been in place in any given year for nearly half the studied stocks in the United States[20,34], Canada, New Zealand[47], and South Africa (Supplementary Figures 2 and 3). In contrast, they have not been applied for any stocks in our dataset from the Mediterranean or Black Seas ('Europe–Med/Black Sea') or West Africa despite a long history of overfishing in these regions[4,5] (Supplementary Figure 3). Regions with at least some history of implementing rebuilding plans include European Union waters of the northeast Atlantic[25] ('Europe(EU) NE Atl', including Atlantic Ocean, North Sea, and Baltic Sea, but not the Mediterranean), Australia[48], Japan[49], South America, tuna RFMOs[28], Russia East Coast, and European (but non-European Union) waters of the northeast Atlantic ('Europe(non-EU) NE Atl'), consisting of Norway[50], Iceland, the Faroe Islands, and some transboundary stocks shared with Russia (Supplementary Figures 2 and 3).

Among the other five stock-level management measures, scientific surveys tended to be implemented earliest in most regions, with the exception of Europe(non-EU) NE Atl, Australia, and tuna RFMOs (where formal stock assessments and fleet-wide catch limits were generally implemented earlier), Russia East Coast (where fleet-wide catch limits were implemented earlier), and New Zealand and South Africa (where fleet-wide catch limits and individually-allocated catch quotas were implemented earlier; Supplementary Figures 2 and 3). In US regions, individual quotas tended to be implemented most recently. In other regions (Canada East Coast, Europe(non-EU) NE Atl, Europe(EU) NE Atl, Russia East Coast, Australia, and New Zealand), harvest control rules tended to be implemented most recently. Regions with limited use of harvest control rules tended to have the highest relative fishing pressures in recent years (Supplementary Figure 3). While most regions have by now implemented these five stock-level management measures for at least half the assessed stocks, some management measures have been implemented for no or few stocks in other regions. These include Europe–Med/Black Sea (no individual quotas; few fleet-wide catch limits or harvest control rules, although as of 2019

maximum allowable fishing efforts have been established for the trawl fleets targeting 29 demersal stocks in the West Mediterranean and Adriatic Seas), West Africa (no harvest control rules), South America (no harvest control rules), Japan (no individual quotas), US Northeast and Southeast (few individual quotas), Canada East Coast (few harvest control rules), and tuna RFMOs (few harvest control rules, individual quotas, or scientific surveys; Supplementary Figures 2 and 3).

At the national (or international) level, management measures are typically applied simultaneously across most stocks in a country or region, so the changes over time are more discrete compared to the more gradual implementation of stock-level management measures (Supplementary Figures 2 and 3). There also tends to be less variability among regions in the implementation of national management measures, as many involve international agreements that in most cases were ratified by countries around the same time[16,17]. Most countries declared EEZs[15] in the late 1970s, with the exception of South America (Chile and Peru declared earlier, in 1947; Supplementary Table 2), Europe–Med/Black Sea (France and Spain have declared EEZs in the Mediterranean, but only recently), and tuna RFMOs (these stocks are highly migratory and are typically distributed across an ocean basin, so EEZs are less relevant). The ratification of the UN Compliance Agreement[16] or the UN Fish Stocks Agreement[17], whichever was first ratified by a country, occurred around the same time across regions, between the mid-1990s to early 2000s (Supplementary Figures 2 and 3; Supplementary Table 4). These international agreements are specifically related to the high seas or illegal fishing for cross-boundary stocks, but they may also exert an indirect influence on stocks in national or sub-national waters as stronger fisheries management commitments at the international level may permeate down into national and sub-national management systems. The implementation of other major pieces of fisheries legislation at the national or international level was more variable across regions (Supplementary Table 2). Conventions for some tuna RFMOs were established in the 1950s or 1960s (IATTC, ICCAT) while others were not established until the 1990s or 2000s (CCSBT, IOTC, WCPFC). At the national level, most of the key pieces of fisheries legislation thought to potentially affect stocks were implemented in the 1980s (New Zealand[47], Canada, Norway[50]) or 1990s (Iceland[51], Australia[48], Chile, Peru, Faroe Islands[52], US[34], South Africa, Argentina), while others were implemented more recently in the 2000s (EU[2,25,53] and Russia). Comparable pieces of major fisheries legislation (Supplementary Table 2) have not been implemented in Japan, Europe–Med/Black Sea (before 2016, but after which new demersal management plans have been adopted), or West Africa.

The five stock-level management measures and three national/international-level measures described above were modelled as remaining in place after their initial implementation. This is a reasonable assumption for the vast majority of measures that have been applied to stocks. One rare exception occurred for Faroe Plateau Atlantic cod, for which a quota system was implemented in 1994, but remained in place only until 1996, when a system of individual effort allocations was implemented in its place[52]. Other temporary interruptions in the use of a management measure are more common, for example if a stock assessment or a scientific survey is not carried out every year, but only periodically.

Aggregate indices of stock-level management intensity (comprising use of scientific surveys, stock assessments, harvest control rules, fleet-wide catch limits, and individual quotas) and of national-level management intensity (comprising EEZ declaration, first ratification of UN Compliance Agreement or UN Fish Stocks Agreement, and a major piece of national fisheries legislation) are also variable among regions in their timing and prevalence (Supplementary Figures 2 and 3). Stock-level management intensity increased gradually over several decades

while increases in national-level intensity were generally more punctuated as EEZs were declared and international agreements were ratified. Sums in Supplementary Figure 2 and proportions in Supplementary Figure 3 reflect the number or proportions of stocks as well as the values ranging from 0-1 for each individual stock. For example, in these aggregate sums or joint proportions, a value of half the number of stocks could result from half of the stocks at value 1, from all of the stocks at value 0.5, or any such combination. These aggregate sums or joint proportions are currently at least three quarters of the number of stocks in most regions, with the exception of Europe–Med/Black Sea (both indices at about half the number of stocks), Japan and West Africa (both indices at about two thirds the number of stocks), and tuna RFMOs (stock-level index at about one third the number of stocks and national-level index at about two thirds the number of stocks). Two of these four regions have the highest median U/U_{REF} among all regions, Europe–Med/Black Sea (2.3) and West Africa (1.6) (Supplementary Figure 3).

Most regions shown in Supplementary Figures 2 and 3 contain a high proportion of stocks that would typically be considered as data-rich. At least some of the stocks from Europe–Med/Black Sea[5], West Africa, and tuna RFMOs[6,11] may arguably be considered to have intermediate levels of data availability, with limited use of scientific surveys or application of relatively simple stock assessment methods. Due to the lack of available scientific estimates of fishing pressure or abundance relative to reference points, this study does not include stocks that would typically be considered as data-poor, which tend to occur disproportionately in developing countries. Owing to limited financial resources, these same regions tend to have more limited capacity in their fisheries management systems[7,13]. These differences in overall capacity among regions are likely to affect how effective any given management measure may be. Our analysis evaluated overall effects of management measures on trends in stock status across all regions simultaneously, even though those regions differ in management capacity. Future work could involve more detailed analyses of how the effectiveness of any given management measure (i.e., its influence on stock status trends) may vary among regions that differ in financial and management capacity.

Supplementary Notes

Supplementary Note 1: Verification of temporal causality

The assumption of temporal causality in ARIMA models can be verified from estimated parameters for autoregressive ($\hat{\phi}_1, \ldots, \hat{\phi}_p$) and moving average ($\hat{\theta}_1, \ldots, \hat{\theta}_q$) processes. We applied an ARMA(1,1) model to first-order differenced time series, which is equivalent to applying an ARIMA(1,1,1) model to un-differenced time series. In both cases, there is only one ϕ parameter and one θ parameter to estimate.

Temporal causality applies to the autoregressive component of ARMA or ARIMA models. The model can be said to be temporally causal if the time series can be written as a one-sided linear process, i.e., if the present state of the response variable depends on past-year states but not on future-year states[54]. For an ARMA(1,1) model, if the following conditions are met, then temporal causality can be verified:

- $\hat{\phi} < 1$
- there are no common roots between autoregressive and moving average polynomials
- response variable time series are stationary

These criteria were all met. For the base model (Equation 1) and coupled-variable model (Equation 3), the following parameter estimates were observed:

Equation 1, response variable $\ln(U/U_{REF})_{t\rightarrow t+1}$: $\hat{\phi} = 0.55$; $\hat{\theta} = -0.80$

Equation 1, response variable $\ln(B/B_{REF})_{t\rightarrow t+1}$: $\hat{\phi} = -0.46$; $\hat{\theta} = 0.60$

Equation 3, response variable $\ln(U/U_{REF})_{t\rightarrow t+1}$: $\hat{\phi} = 0.50$; $\hat{\theta} = -0.71$

Equation 3, response variable $\ln(B/B_{REF})_{t\rightarrow t+1}$: $\hat{\phi} = 0.16$; $\hat{\theta} = -0.03$

The parameter estimates were different within each model, so there were no common factors, and therefore no common roots. Overall across stocks, first-order differencing was sufficient to ensure stationarity (Supplementary Table 5). Therefore, the assumption of temporal causality was verified. Analyses weighted by *MSLV*, and analyses involving disaggregated management measures instead of aggregate indices of management intensity, also met the above criteria.

These parameter estimates of the ARIMA correlation structure reveal information about the time series of stocks included in our analysis. After differencing time series to ensure stationarity, autoregressive parameter estimates were between 0-1 for $\Delta\ln(U/U_{REF})$ for both the base model and coupled-variable model, indicating that unexplained changes tend to persist, but dampen, over time. For $\Delta\ln(B/B_{REF})$ in the base model, the autoregressive parameter estimate was $-1 < \hat{\phi} < 0$, indicating that unexplained changes also tended to dampen but flip from positive to negative and back. This may result from irregular recruitment anomalies affecting biomass changes over time. For $\Delta\ln(B/B_{REF})$ in the coupled-variable model, $\hat{\phi}$ was weakly positive, thus incorporating the strong influence of U/U_{REF} magnitude on $\Delta\ln(B/B_{REF})$ reduced the relative importance of autoregression on changes in biomass. Moving average parameter estimates generally followed opposite patterns as those for autoregressive terms. The negative moving average estimates for $\Delta\ln(U/U_{REF})$ may indicate that, whether (Equation 3) or not (Equation 1) B/B_{REF} magnitude is explicitly accounted for in the regression model, changes in U/U_{REF} tend to over-compensate for 'prediction errors' in previous years. For example, higher-than-expected levels of U/U_{REF} in some year may require adjustment downwards in the following year. For $\Delta\ln(B/B_{REF})$ in the base model, prediction errors tended to propagate but dampen over time, whereas in the coupled-variable model with U/U_{REF} magnitude explicitly included, the moving average parameter estimate greatly weakened.

We note that this verification of temporal causality refers to the correlation structure of the response variables. This verification does not imply causal effects of predictor variables on the response variables. As with regression models in general, in ARIMA models, predictors are assumed to be independent of the responses. In reality, however, experimental or random implementation of management measures is rare. Management measures are often implemented in response to changing stock status. Although we were not able to control for the non-random implementation of management measures, ARIMA models do at least distinguish changes in stock status that occur in the years prior to implementing a management measure from changes that occur in the years during and after implementation. In other words, these models allow for separating the baseline trends in U/U_{REF} and B/B_{REF} (pre-implementation) from the impacted trends (post-implementation) as a stock switches between treatment groups.

Supplementary Note 2: Sensitivity analyses

Four types of sensitivity analyses (eight runs in total) were conducted to evaluate how assumptions or model structures used in the main run potentially affected observed results. For evaluating results, we use two approaches for comparing outputs of sensitivity runs to those of the main run. First, we focus on coefficient estimates of the four management-related parameters (including both components of rebuilding plans) estimated under the base model, which are shown in Fig. 3 for the main run. Second, we visually compare Figs. 3-5 and Supplementary Figure 8 (Fig. 4 is a subset of Supplementary Figure 8) to their counterparts produced under sensitivity runs to evaluate whether any of the changes to assumptions or model structures result in different conclusions drawn from observed results. The four types of sensitivity analyses considered were:

1. in the main run, if reference points B_{REF} or U_{REF} were not provided in assessments, we estimated these *post-hoc* with a surplus production model (Supplementary Equation 1). In this 'Sensitivity 1—reference points', we do not estimate missing reference points, we use only the reference points provided in assessments, which reduces the sample size for analyses.
2. in the main run, we required a minimum of 10 years of B/B_{REF} or U/U_{REF} data for inclusion in time series analyses. In this 'Sensitivity 2—time series length', we instead require a minimum of 20 years of data, which also reduces the sample size.
3. in the main run, we used an ARIMA(1,1,1) correlation structure for ARIMA(p, d, q), which contains one autoregressive parameter, p, and one moving average prediction error parameter, q. In this 'Sensitivity 3—ARIMA structure', we consider four alternative correlation structures that were commonly observed to be the best parameter set for some stocks (Supplementary Table 6). These four alternative correlation structures differ in the number of parameters included for p and q:
   (3a) ARIMA(0,1,0)
   (3b) ARIMA(1,1,0)
   (3c) ARIMA(2,1,0)
   (3d) ARIMA(0,1,1).
4. in the main run, we weighted individual stocks equally. We also considered an alternative weighting scheme, in which stocks were weighted by their mean MSLV; results under this alternative stock-level weighting scheme are shown in Supplementary Figures 6 and 8. In this 'Sensitivity 4—regional weighting', we consider two regional-level weighting schemes. Regression weights are still applied to individual stocks, but in the following regional-level weighting schemes, all the stocks from a given region share the same weight:
   (4a) regional weights proportional to the number of stocks in RAMLDB with available time series of U/U_{REF} or B/B_{REF}. Regions were assigned weights of $n_{\mathrm{r,RAMLDBfull}}/n_{r,\mathrm{paper}}$, where $n_{r,\mathrm{paper}}$ is the number of stocks in region r included in this analysis, and $n_{\mathrm{r,RAMLDBfull}}$ is the number of stocks contained in RAMLDB with any available estimates of U/U_{REF} or B/B_{REF}. Stock counts for $n_{r,\mathrm{paper}}$ and $n_{\mathrm{r,RAMLDBfull}}$ are listed in Supplementary Table 3.
   (4b) regional weights proportional to the number of stocks in RAMLDB that at some point in their time series had $U/U_{\mathrm{REF}} > 1$ or $B/B_{\mathrm{REF}} < 1$. Regions were assigned weights of $n_{\mathrm{r,RAMLDBsub}}/n_{r,\mathrm{paper}}$, where $n_{\mathrm{r,RAMLDBsub}}$ is the subset of stocks in region r contained in RAMLDB that at some point in their history met at least one of these conditions for U/U_{REF} or B/B_{REF}.

These two sets of regional-level weights were each scaled by their median, such that the median weight among the 17 regions was 1. Values of sample weights are listed in the file "regional-weights.csv", one of the input files provided with code for reproducing analyses.

In general, none of the sensitivity analyses led to different take-away conclusions than those from the main results. Certain differences were observed, which are summarised in Supplementary Table 8 and described further below:

1. For 'Sensitivity 1—reference points', three of four estimated coefficients of management-related parameters for $\Delta\ln(U/U_{\mathrm{REF}})$ and all four estimated coefficients for $\Delta\ln(B/B_{\mathrm{REF}})$ were similar to those from the main run (Supplementary Table 8). The one notable difference was that the coefficient for $b_6 Reb_{immediate_{t,j}}$ in 'Sensitivity 1—reference points' was only about one quarter the magnitude of its counterpart in the main run (Supplementary Table 8). Despite this weaker effect compared to the main run, it was still the strongest effect overall in 'Sensitivity 1—reference points' (as seen in the Fig. 3 counterpart), so still resulted in decreased fishing pressure in the first year of implementing a rebuilding plan (as seen in the Fig. 4 and Supplementary Figure 8 counterparts). This immediate decrease only reduced U/U_{REF} partway to target levels of 1 (not all the way, as seen in the main run); after the first year, the decrease in U/U_{REF} continued at a slower rate, reaching target levels before the end of the 10 year in the medium and high management intensity scenarios of the counterpart to Supplementary Figure 8. Some differences were observed in equilibrium predictions (Fig. 5) between 'Sensitivity 1—reference points' and the main run. At high levels of management intensity, observed results were similar to those from the main run, although mean B/B_{REF} never exceeded 1 and mean U/U_{REF} never decreased below 1 even at management intensity values of 1. The threshold at which rebuilding plans activated occurred at slightly lower levels of management intensity in 'Sensitivity 1—reference points', and the proportion of years spent under rebuilding plans was generally greater than in the main run.
   Because reference point estimates for U_{REF} and B_{REF} from surplus production models generally show limited bias (based on cross-validations with estimates drawn from stock assessments), the differences outlined above between 'Sensitivity 1—reference points' and the main run are likely due to the subset of stocks excluded (sample size in the sensitivity analysis was reduced by 20-27% compared to the main run). Median U/U_{REF} across all stocks and years was nearly identical for the main run (0.975) and 'Sensitivity 1—reference points' (0.977), and median B/B_{REF} was similar (main run, 1.024; 'Sensitivity 1—reference points', 1.095).
2. For 'Sensitivity 2—time series length', estimated coefficients of management-related parameters were all similar to those from the main run (Supplementary Table 8). Visual comparisons with Figs. 3-5 and Supplementary Figure 8 revealed no notable differences between the main run and 'Sensitivity 2—time series length'.
3. For 'Sensitivity 3—ARIMA structure', estimated coefficients of management-related parameters were all similar to those from the main run (Supplementary Table 8). Visual comparisons with Figs. 3-5 and Supplementary Figure 8 revealed no notable differences between the main run and 'Sensitivity 3a,b,c,d—ARIMA structure'.
4. For 'Sensitivity 4—regional weighting', both weighting schemes (a, b) which involved weighting regions in proportion to numbers of assessed stocks by region had estimated coefficients of management-related parameters similar to those from the main run (Supplementary Table 8), and visual comparisons with Figs. 3-5 and Supplementary Figure 8

revealed no notable differences between the main run and 'Sensitivity 4a,b—regional weighting'.

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Supplementary Table 3 | Regional representation of stocks included in analysis compared to other datasets. Summed catches are means of individual stocks over the period 1970-2017, summed across stocks in the region.

	This analysis		RAMLDB[a]				FAO landings[b]	
Country/region	Number of stocks	Summed catch across stocks (t)	Number of stocks	% incl[c]	Summed catch across stocks (t)	% incl[c]	Summed catch in region (t)	% incl[c]
Australia	16	20,866	25	64%	52,811	40%	169,694	12%
Canada-East Coast	11	282,055	45	24%	824,856	34%	927,900	30%
Canada-West Coast	17	39,579	31	55%	47,174	84%	200,862	20%
Europe(EU) NE Atl	18	2,533,075	88	20%	5,666,003	45%	4,914,943	52%
Europe(non-EU) NE Atl	10	2,780,553	20	50%	3,831,029	73%	5,078,099	55%
Europe-Med/Black Sea	20	393,230	80	25%	577,449	68%	1,488,293	26%
Japan	24	3,636,297	37	65%	3,894,633	93%	5,842,412	62%
New Zealand	23	128,859	49	47%	232,937	55%	354,370	36%
Russia-East Coast	3	1,702,043	3	100%	1,702,043	100%	2,839,219	60%
South Africa	13	443,259	15	87%	553,267	80%	800,467	55%
South America	12	6,690,661	34	35%	9,141,082	73%	10,549,002	63%
US-Alaska	22	1,810,647	43	51%	2,015,489	90%	1,804,418	100%
US-Northeast	31	642,714	39	79%	710,751	90%	1,134,541	57%
US-Southeast	21	79,496	40	53%	705,204	11%	971,843	8%
US-West Coast	20	343,354	51	39%	397,692	86%	430,498	80%
West Africa	5	1,035,381	5	100%	1,035,381	100%	1,545,305	67%
Tuna RFMOs	22	1,269,592	38	58%	3,192,889	40%	5,224,159	24%
Other			1	0%	1,251	0%	35,276,664	0%
Total	**288**	**23,831,661**	**644**	**45%**	**34,581,943**	**69%**	**79,552,688**	**30%**

[a]Includes all available stocks in the RAM Legacy Stock Assessment Database[22] for which a time series of U/U_{REF} and/or B/B_{REF} is available. U_{REF} and B_{REF} may be extracted directly from a stock assessment, or may be estimated *post-hoc* using a surplus production model, as described above.

[b]Extracted from the Global Capture Production database of the Food and Agriculture Organization of the United Nations[55]. FAO Major Fishing Areas do not align exactly with the regions considered in this analysis, so regional catch totals are approximate. Regional sums are calculated based on the relevant country(ies) and on inclusions of the following FAO Major Fishing Areas:

Australia (Ind-E-57, Pac-WC-71, Pac-SW-81)
Canada-East Coast (Atl-NW-21)
Canada-West Coast (Pac-NE-67)
Europe(EU) NE Atl (Atl-NE-27 for EU countries)
Europe(non-EU) NE Atl (Atl-NE-27 for Norway, Iceland, Faroe Islands, Russia)
Europe-Med/Black Sea (Med-37)
Japan (Pac-NW-61)
New Zealand (Pac-SW-81)
Russia-East Coast (Pac-NW-61)
South Africa (Atl-SE-47, Ind-W-51)
South America (Atl-SW-41, Pac-SE-87 for Peru, Chile, Argentina)
US-Alaska (87.2% of U.S. landings in Pac-NE-67; proportion based on NOAA catch-by-state landings data)
US-Northeast (Atl-NW-21)
US-Southeast (Atl-WC-31)
US-West Coast (Pac-EC-77, and 12.8% of U.S. landings in Pac-NE-67; proportion based on NOAA catch-by-state landings data)
West Africa (Atl-EC-34 for Morocco, Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Cabo Verde)

All of the above summed FAO landings omitted freshwater ISSCAAP taxonomic groups, and also omitted the ISSCAAP group 'tunas, bonitos, billfishes' to avoid double-counting. For the region 'Tuna RFMOs', landings from this ISSCAAP group 'tunas, bonitos, billfishes' were summed over all countries and FAO Major Fishing Areas. For the remaining region 'Other', the sum of regional sums was subtracted from the summed mean global marine landings to represent the portion from regions in which formal stock assessments are less commonly conducted.

[c]Percentages included (% incl) are the number of stocks (or summed catch) in this analysis as a proportion of the number of stocks (or summed catch) from all available stocks (or summed catch) in RAMLDB or the FAO landings database.

Supplementary Table 4 | Levels of relative fishing pressure (U/U_{REF}) and relative biomass (B/B_{REF}) at distinct points in the time series of stocks included in analyses. Years at which the condition applied are also summarised. Summarised values for years, U/U_{REF}, and B/B_{REF} include the number of stocks (n) and percentiles of the distribution of values across stocks, as well as the proportion of stocks depleted below the level of $B/B_{REF} = 0.5$.

	Year[a]				U/U_{REF}				B/B_{REF}				
Point in time series	n[b]	25th %ile	50th %ile	75th %ile	n	25th %ile	50th %ile	75th %ile	n	25th %ile	50th %ile	75th %ile	% stocks < 0.5[c]
Year 1950	67				65	0.09	0.28	0.60	66	1.58	2.16	2.83	5%
Start of full time series	288	1952	1973	1983	286	0.21	0.66	1.48	282	0.84	1.60	2.36	12%
Start of mature fishery phase	288	1963	1977	1986	286	0.49	0.87	1.53	282	0.82	1.57	2.30	12%
First year under rebuilding plan	118	1992	1999	2005	115	0.51	1.40	2.50	118	0.22	0.40	0.64	64%
First year of scientific surveys	237	1979	1985	1996	223	0.66	1.18	2.06	226	0.50	0.99	1.57	26%
First year of stock assessment	277	1985	1995	2002	264	0.63	1.30	2.36	269	0.44	0.89	1.57	30%
First year of harvest control rule	194	1990	1998	2005	184	0.65	1.10	1.80	192	0.41	0.76	1.36	34%
First year of fleet-wide catch limits	221	1983	1992	1998	210	0.62	1.15	2.01	217	0.52	0.99	1.63	24%
First year of individual quotas	139	1988	1997	2003	133	0.53	1.10	1.93	136	0.50	0.90	1.67	25%
Year of EEZ declaration	253	1976	1978	1982	237	0.48	1.02	2.06	245	0.58	1.25	2.08	22%
Year of UN CA/FSA ratification	278	1995	1996	2000	268	0.71	1.27	2.03	271	0.42	0.81	1.35	30%
Year of national/ regional policy	239	1988	1996	1996	229	0.51	1.07	1.99	238	0.48	0.92	1.64	27%

[a]Years of first use of management measures are constrained to the range of years for which time series of U/U_{REF} and/or B/B_{REF} were available, so that these years correspond with the values of U/U_{REF} and/or B/B_{REF} in columns further to the right. If a management measure was implemented for a stock before its first available values of U/U_{REF} or B/B_{REF}, for summary purposes in this table its year of first use is considered to be the first year of available U/U_{REF} or B/B_{REF}.

[b]All 288 stocks included in analyses had a mature fishery phase, and therefore also had a full time series (including the developing phase). Relatively few stocks (67) had a time series of U/U_{REF} and/or B/B_{REF} extending back to 1950. Some stocks have never had a given management measure applied, therefore sample sizes associated with first use of the measure are less than 288.

[c]Fraction of stocks with $B/B_{REF} < 0.5$ at the distinct point in the time series listed. We note that a variety of thresholds around the world are used to define 'overfished' or 'depleted'; the value of 0.5 considered here and shown for consistency is a common threshold, but by no means the only one. Following footnote (a), if a management measure was implemented for a stock before its first available value of B/B_{REF}, its first value of B/B_{REF} in the time series was compared relative to 0.5 in the calculated fraction across stocks.

Supplementary Table 5 | Required order of differencing of response variable time series to ensure stationarity[a].

		Differences required		
Fishery phase	Response variable	0	1	2
Mature	$\ln(U/U_{REF})$	96	166	22
Full time series	$\ln(U/U_{REF})$	81	172	31
Mature	$\ln(B/B_{REF})$	52	156	72
Full time series	$\ln(B/B_{REF})$	47	163	70

[a]Values reflect frequencies of stocks for which the order of differencing was sufficient based on a one-sided KPSS test for stationarity, implemented with the auto.arima() function of the R package 'forecast'[46]. Time series for each stock were separated into 'developing' (not of interest for analyses) and 'mature' (of interest) phases, and the full time series was also evaluated. A minimum of 10 years of data per stock per phase were required for evaluation of a given response variable.

Supplementary Table 6 | Best-fit orders of autoregressive (*p*) and moving average (*q*) components of response variable time series to maximise goodness-of-fit[a].

		$\ln(U/U_{REF})$						$\ln(B/B_{REF})$					
		$q \rightarrow$						$q \rightarrow$					
Fishery phase	*p*	0	1	2	3	4	5	0	1	2	3	4	5
Mature	0	123	47	19	9	5	0	41	44	12	8	4	3
	1	28	4	0	2	1	0	65	18	9	1	0	0
	2	22	2	1	1	0	0	33	6	1	0	0	0
	3	7	2	1	0	0	0	13	2	0	0	0	0
	4	3	1	0	0	0	0	10	1	0	0	0	0
	5	3	0	0	0	0	0	7	0	0	0	0	0
Full time series	0	115	42	18	14	4	0	41	39	13	10	6	2
	1	31	5	1	3	2	0	65	16	10	1	2	0
	2	22	3	0	1	0	0	33	8	0	1	0	0
	3	10	3	2	0	0	0	11	3	0	0	0	0
	4	3	1	0	0	0	0	9	1	0	0	0	0
	5	4	0	0	0	0	0	9	0	0	0	0	0

[a]Values reflect frequencies of stocks for which the combined order of *p* and *q* minimised the AICc for first-order differenced time series, implemented with the auto.arima() function of the R package 'forecast'[46]. Time series for each stock were separated into 'developing' and 'mature' phases, and the full time series was also evaluated. A minimum of 10 years of data per stock per phase were required for evaluation of a given response variable.

Supplementary Table 7 | Model fit diagnostics for ARIMA models fit to response variables $\Delta\ln(U/U_{REF})$ and $\Delta\ln(B/B_{REF})$. Three metrics are summarised for each of two ARIMA model structures from different sections of the analysis. Summaries include the number of stocks (n), percentiles of the distribution of values across individual stocks, as well as an overall value of the metric across all stocks. .

		$\Delta\ln(U/U_{REF})$					$\Delta\ln(B/B_{REF})$				
Metric	Results section[a]	n	25th %ile	50th %ile	75th %ile	Overall across stocks[b]	n	25th %ile	50th %ile	75th %ile	Overall across stocks[b]
Mean error[c]	*i*	284	-0.02	0.00	0.02	0.000868	280	-0.02	0.00	0.02	0.000037
	iii	277	-0.04	0.00	0.03	0.001186	277	-0.02	0.00	0.02	0.000001
Root mean square error (RMSE)[d]	*i*	284	0.23	0.32	0.49	0.58	280	0.09	0.14	0.25	0.22
	iii	277	0.24	0.34	0.53	0.59	277	0.08	0.13	0.25	0.21
Persistence index[e]	*i*	284	0.41	0.54	0.62	0.60	280	-1.11	-0.09	0.37	0.42
	iii	277	0.42	0.54	0.62	0.59	277	-0.92	0.02	0.38	0.45

[a]Results section *i* , '*Base model for stock status trends*', corresponds to the base model described in Equation 1, with results presented in Figure 3. Results section *iii*, '*Predicting equilibrium responses to management*' corresponds to the coupled-variable model described in Equation 3, with results presented in Figure 5. Model fit diagnostics are not shown for Results section *ii*, '*Predicting short-term responses to management*', corresponding to Equation 2 (and Figure 4), but are similar to those listed for section *i*.

[b]Statistical fits for the hierarchical model were for all stocks simultaneously rather than for each stock individually, thus these overall values of metrics across all stocks better reflect model performance than the percentiles of the distributions of individual stocks.

[c]Mean error is the mean of predicted values minus observed values, either for an individual stock's time series or for the combined dataset across all stocks. It is calculated over years *t* as:

$$\frac{1}{T}\sum_{t=1}^{T}\left(y_{pred,t} - y_{obs,t}\right)$$

For comparison with these mean errors, overall means of response variable values across all stocks were: for $\Delta\ln(U/U_{REF})$ section *i*, observed -0.0098, predicted -0.0107; for $\Delta\ln(U/U_{REF})$ section *iii*, observed 0.0122, predicted 0.0110; for $\Delta\ln(B/B_{REF})$ section *i*, observed -0.0127, predicted -0.0127; and for $\Delta\ln(B/B_{REF})$ section *iii*, observed -0.0120, predicted -0.0120.

[d]RMSE represents the standard deviation of the model prediction error, calculated as the square root of the mean of squared deviations between observed and predicted values. This is calculated either for an individual stock's time series or for the combined dataset across all stocks. Values of RMSE are not meant to be compared between $\Delta\ln(U/U_{REF})$ and $\Delta\ln(B/B_{REF})$, nor between sections *i* and *iii*, as these represent different response variables or sample sizes. It is calculated over years *t* as:

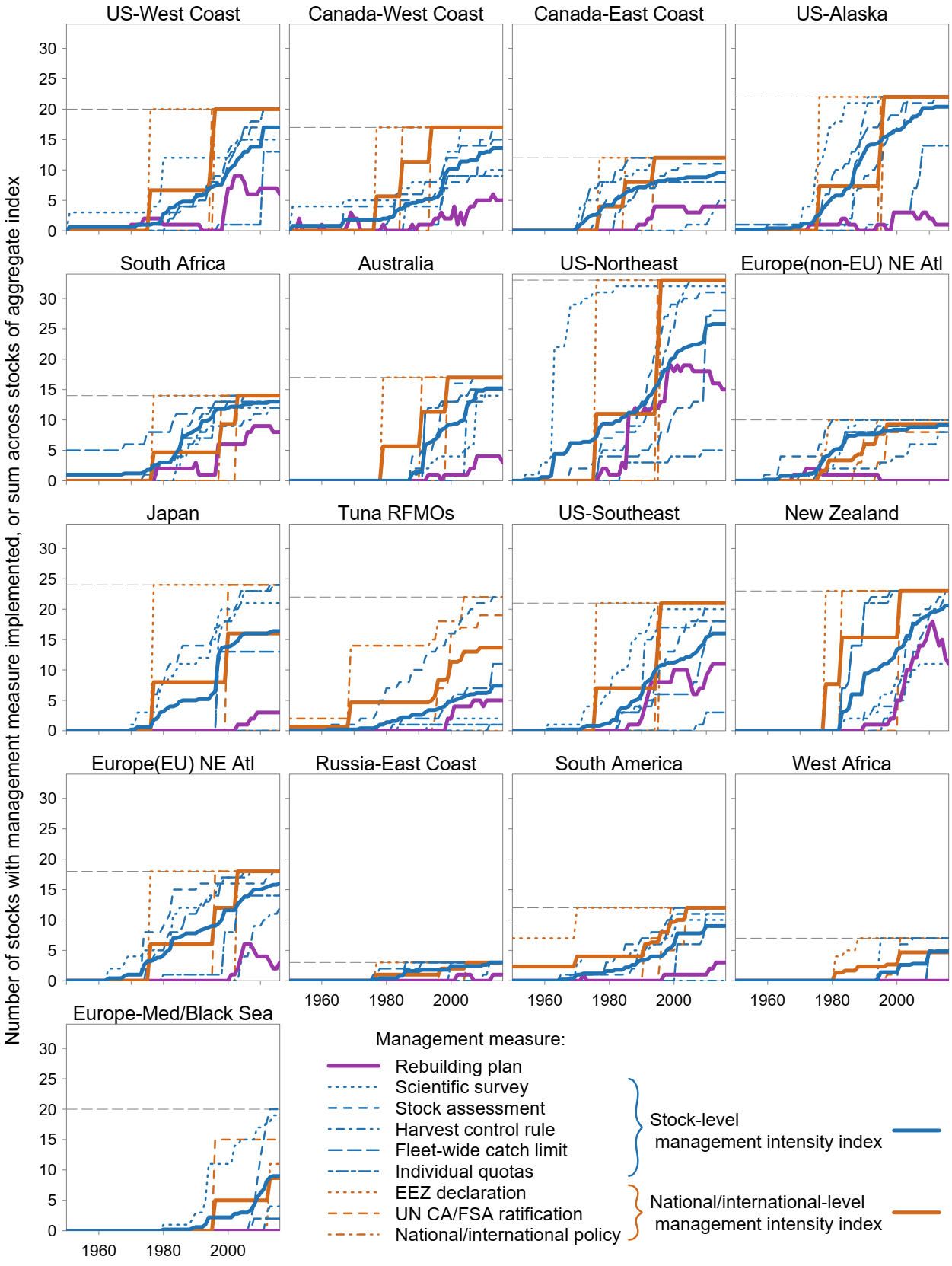
$$\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(y_{pred,t} - y_{obs,t}\right)^2}$$

[e]Persistence index, or coefficient of persistence[56], compares model performance (predicted versus observed values) against interannual changes in the observed values (from one year to the next). The latter changes represent a simpler model in which the observed value from the previous year represents the prediction for the current year. It is calculated either for an individual stock's time series or for the combined dataset across all stocks (in which the first year for each stock is omitted), as:

$$1 - \frac{\sum_{t=2}^{T}\left(y_{pred,t} - y_{obs,t}\right)^2}{\sum_{t=2}^{T}\left(y_{obs,t} - y_{obs,t-1}\right)^2}$$

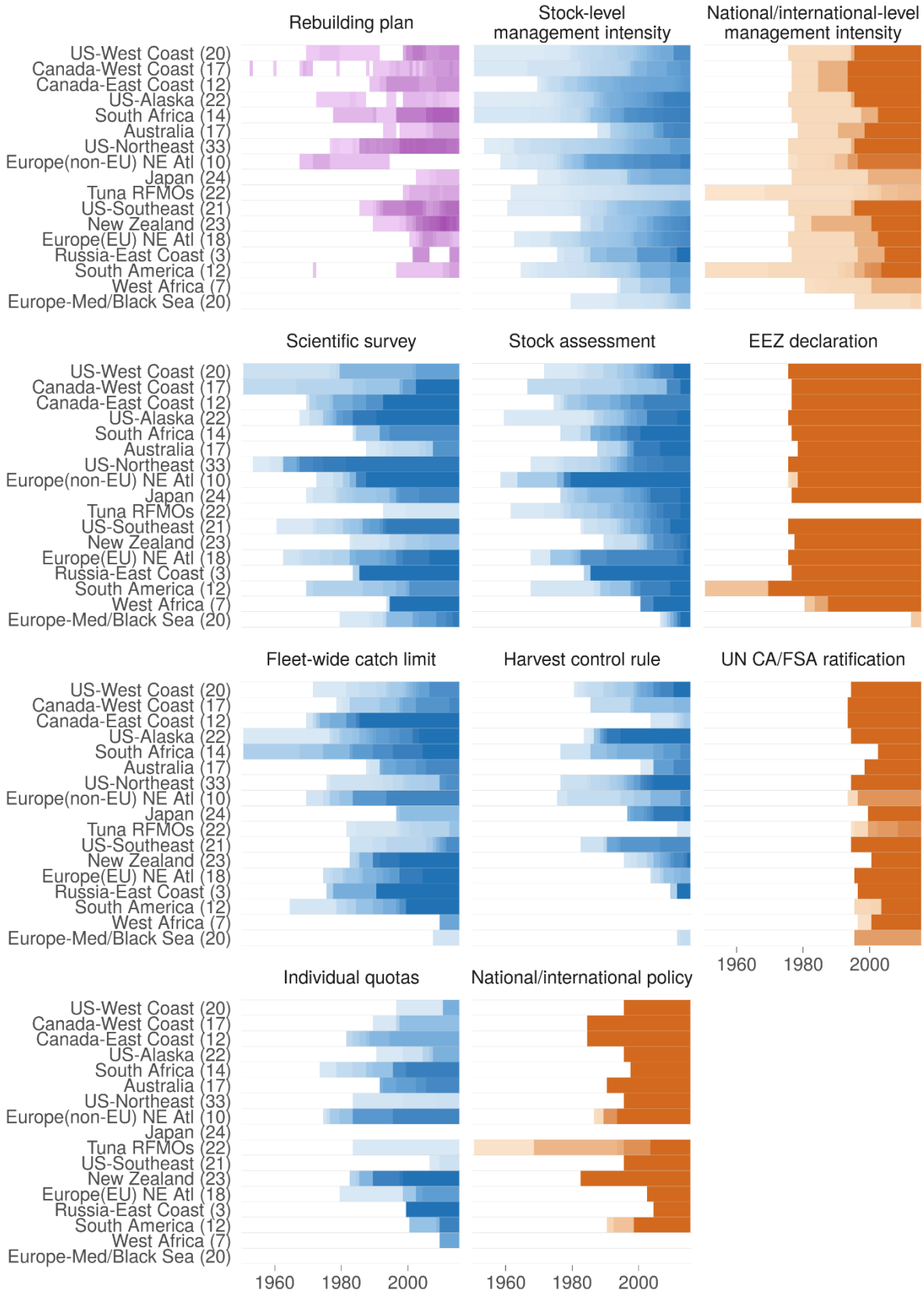
Values typically range from 0-1, with values of 1 reflect perfect model performance, and values ≤0 reflecting poor predictive performance.

Supplementary Figure 2 (next page) | Implementation history of fisheries management measures in 17 regions. Values for individual measures reflect the number of stocks in the region with the measure implemented over time. For rebuilding plans, the thick purple line shows the number of stocks currently under a rebuilding plan in any given year, so counts in the region may decrease as rebuilding plans are de-activated following recovery of a stock. For all other individual measures, counts increment with their first use on a stock but do not revert downwards if the measure is later ceased (e.g., if a survey or an assessment is not conducted in any given year), so counts represent current or previous usage of the measure. Other thick solid lines represent aggregate indices of management intensity at the stock level (blue; comprising the five management measures indicated) or at the national/international level (orange; comprising the three measures indicated). These aggregate indices range from 0-1 for each stock depending on how many of the component measures have been implemented, so lines show sums across stocks in the region and do not revert downwards. Dashed grey horizontal lines show the total number of stocks from the region included in analyses. Regions are ordered left-to-right, top-to-bottom by median U/U_{REF} across stocks over their last five years of available data (lowest-to-highest). Data shown are for the same 288 stocks as shown in Fig. 1a, here separated by region. Management measures are described in Supplementary Table 1 and implementation histories of individual stocks are shown in Supplementary Figure 1. See Supplementary Discussion for further description of this figure.

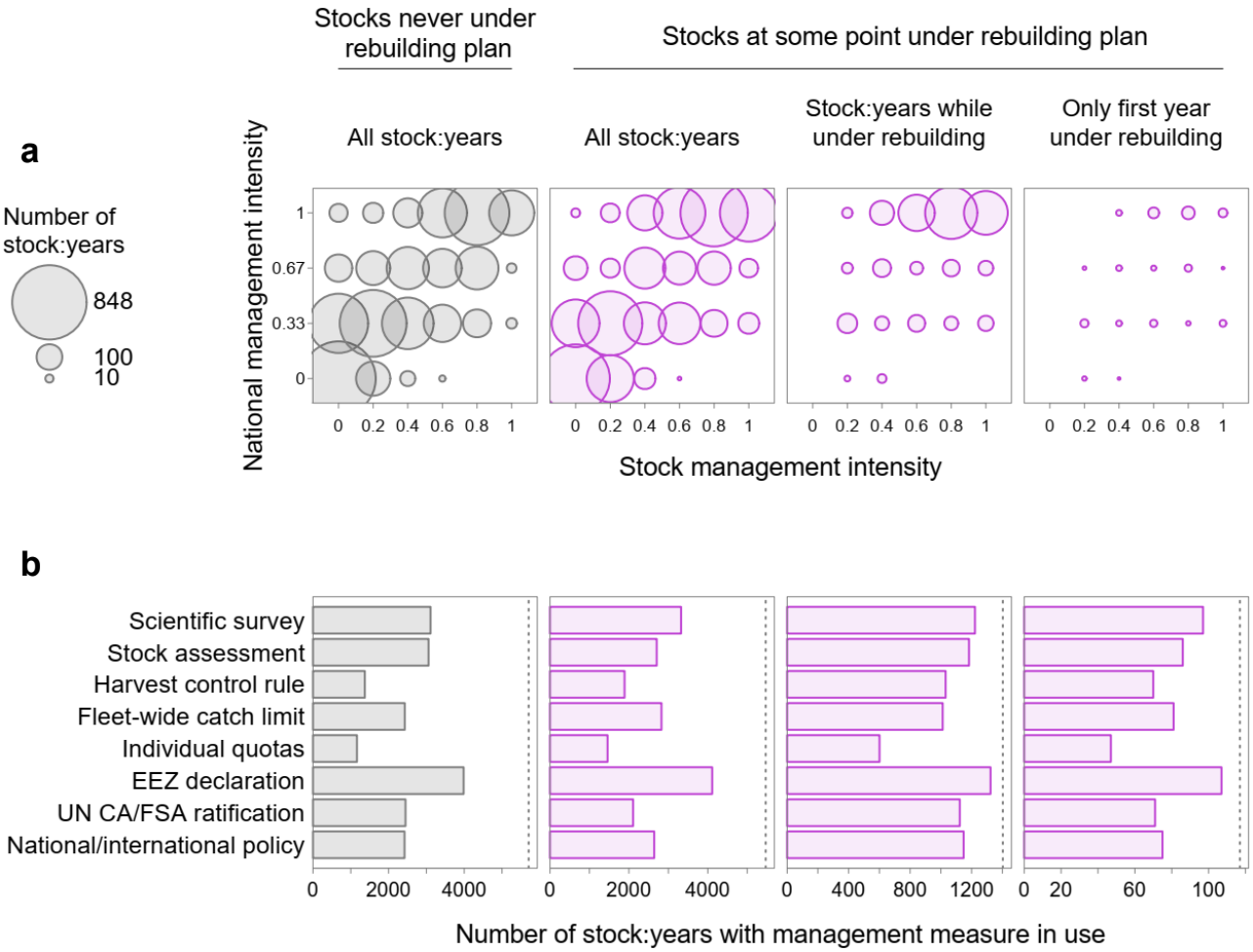


Supplementary Figure 2 continued

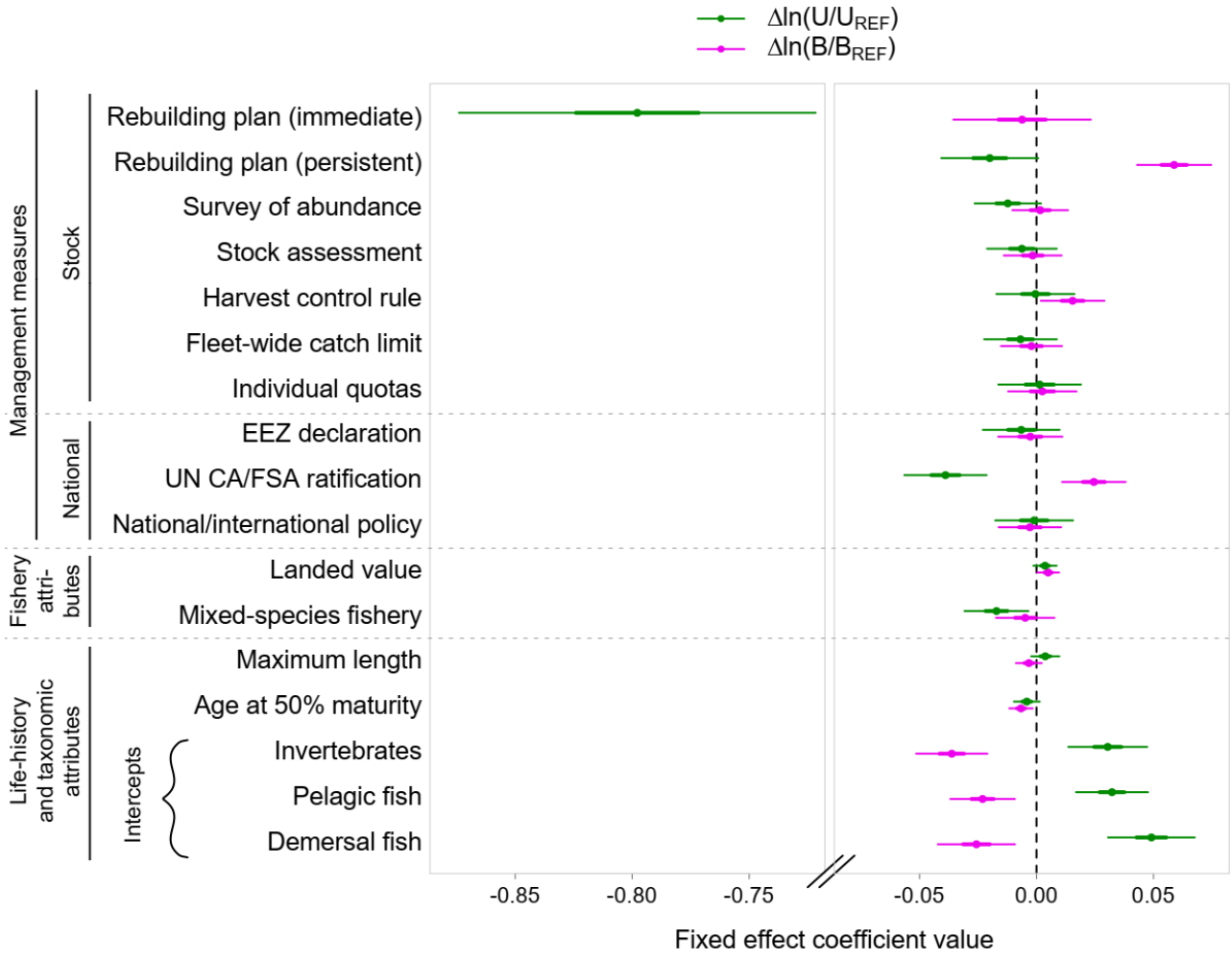
Supplementary Figure 3 (next page) | Implementation history by region of nine fisheries management measures and two aggregate indices. In each panel, shading for each region reflects the proportion of stocks with the measure implemented. For rebuilding plans, proportions show stocks currently under a rebuilding plan in any given year, so proportions may decrease as rebuilding plans are de-activated. For all other individual management measures in the lower eight panels, proportions increment with first use of the measure for a stock, but do not revert downwards if the measure is later ceased. Top row panels for aggregate indices of management intensity at the stock level (comprising five measures) or at the national/international level (comprising three measures) show joint proportions of stocks and index values. The number of stocks in each region is shown in parentheses. Regions are ordered top-to-bottom by median U/U_{REF} across stocks over their last five years of available data (lowest-to-highest). The top three panels were shown in Fig. 1b. Management measures are described in Supplementary Table 1 and implementation histories of individual stocks are shown in Supplementary Figure 1. See Supplementary Discussion for further description of this figure.



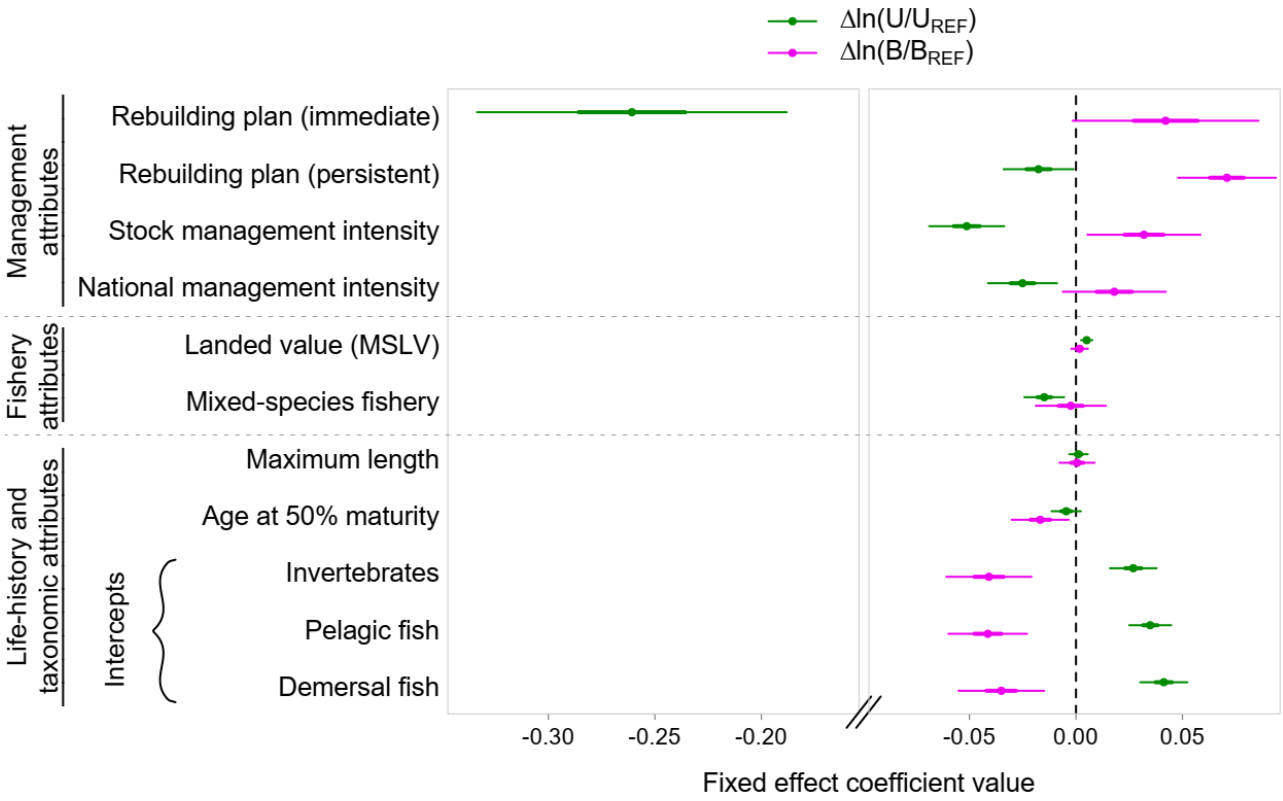
Supplementary Figure 3 continued



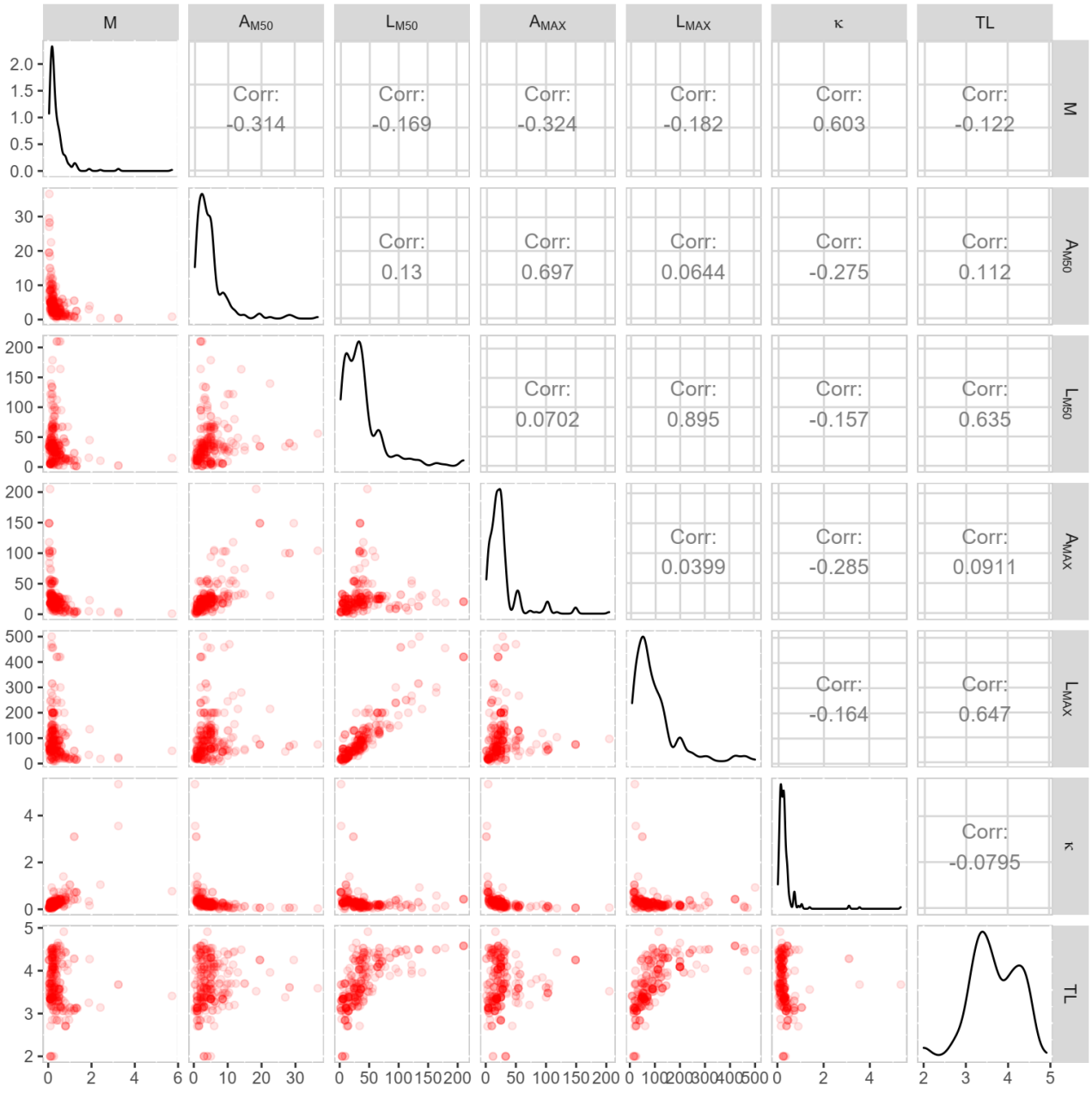
Supplementary Figure 4 | Associations between implementing rebuilding plans and concurrent use of other management measures. Frequencies of management measures in use are shown for four data subsets: all years of stocks that have never been under a rebuilding plan (grey); all years of stocks that have at some point been under a rebuilding plan (purple, left); years while under an active rebuilding plan (purple, middle); and a stock's first year under a rebuilding plan (purple, right). In (**a**), panels show all possible combinations of stock-level management intensity and national/international-level management intensity. Symbol size is proportional to the number of stock:years of data at each combination. In (**b**), panels show frequencies of individual management measures in use. Vertical dotted lines show the total number of stock:years in the data subset.



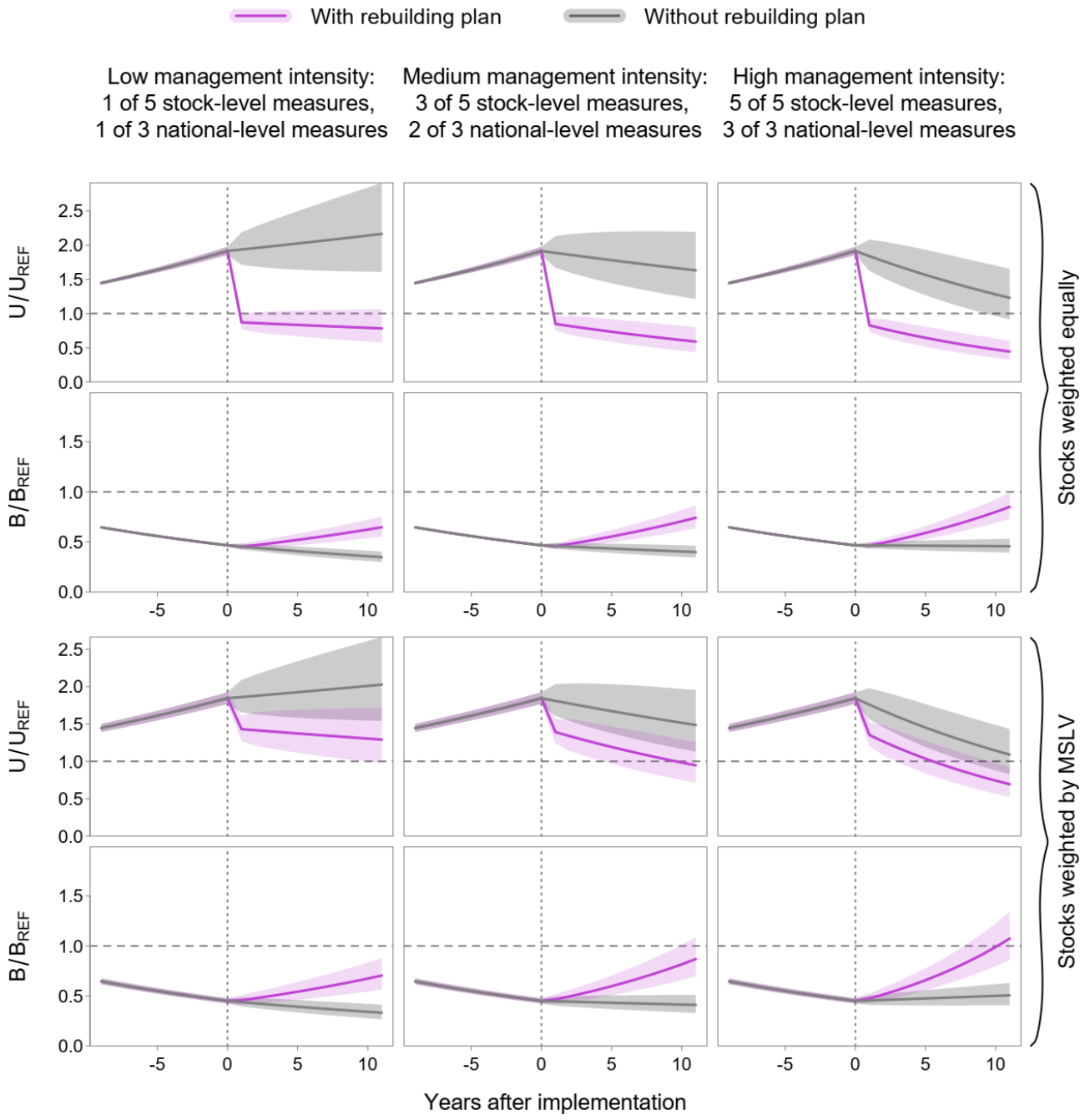
Supplementary Figure 5 | Effects of individual management measures, fishery attributes, and life-history traits on annual changes in relative fishing pressure and relative biomass. Positive (or negative) coefficients reflect increasing (or decreasing) trends in fishing pressure (U/U_{REF}) and biomass (B/B_{REF}) during the 'mature' fishery phase. The horizontal axis is broken for visual clarity, as one coefficient differs substantially in magnitude from the others. Model structure is identical to the base model (main Methods *i* and Fig. 3), except the individual components of management intensity indices (five stock-level components and three national-level components) are included as predictors instead of the two aggregate indices. Stocks are weighted equally. The reference group for overall intercepts is 'Single-species fishery', with the categorical 'Mixed-species fishery' representing a difference from these intercepts. Thick and thin error bars represent standard errors and 95% confidence intervals, respectively.



Supplementary Figure 6 | Effects of management, fishery, and life-history attributes on annual changes in relative fishing pressure and relative biomass under an alternative weighting assumption. Positive (or negative) coefficients reflect increasing (or decreasing) trends in fishing pressure (U/U_{REF}) and biomass (B/B_{REF}) during the 'mature' fishery phase. The horizontal axis is broken for visual clarity, as one coefficient differs substantially in magnitude from the others. Model structure is identical to the base model (main Methods *i* and Fig. 3), except instead of equal weighting, stocks are weighted by maximum sustainable landed value (*MSLV*), the product of maximum sustainable yield and average ex-vessel price. The reference group for overall intercepts is 'Single-species fishery', with the categorical 'Mixed-species fishery' representing a difference from these intercepts. Thick and thin error bars represent standard errors and 95% confidence intervals, respectively.

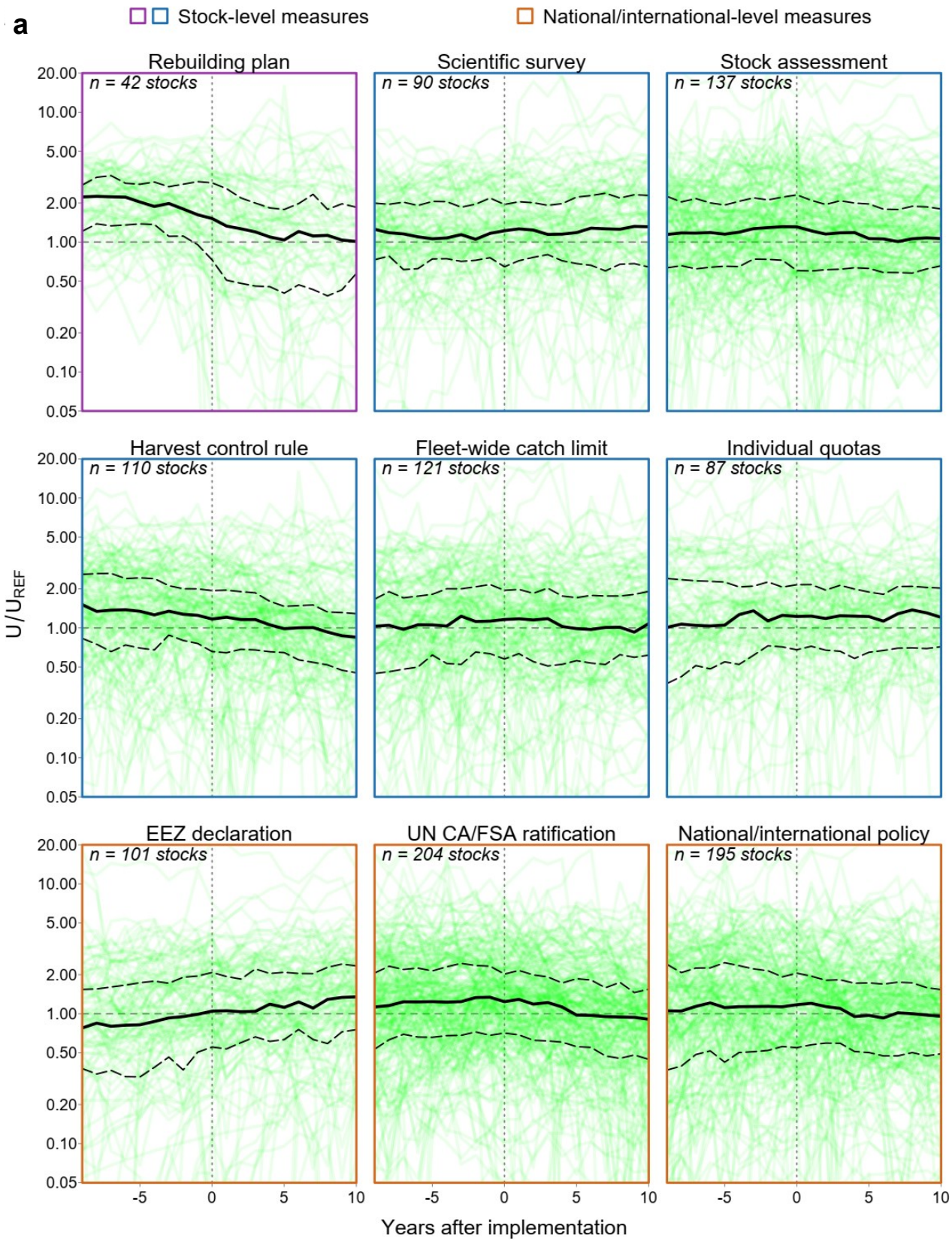


Supplementary Figure 7 | Associations between life-history traits initially considered as potential predictor variables for analyses. Scatterplots (lower panels) and correlation coefficients (upper panels) are shown for of all pairs of variables: natural mortality rate, M; age at 50% maturity, A_{M50}; length at 50% maturity, L_{M50}; maximum age, A_{MAX}; maximum length, L_{MAX}; von Bertalanffy growth, κ; and trophic level, TL. Density plots are shown on the diagonal. As a result of strong correlation with other traits, most traits were omitted as predictor variables. Only A_{M50} and L_{MAX} were carried forward as predictors in regression analyses.

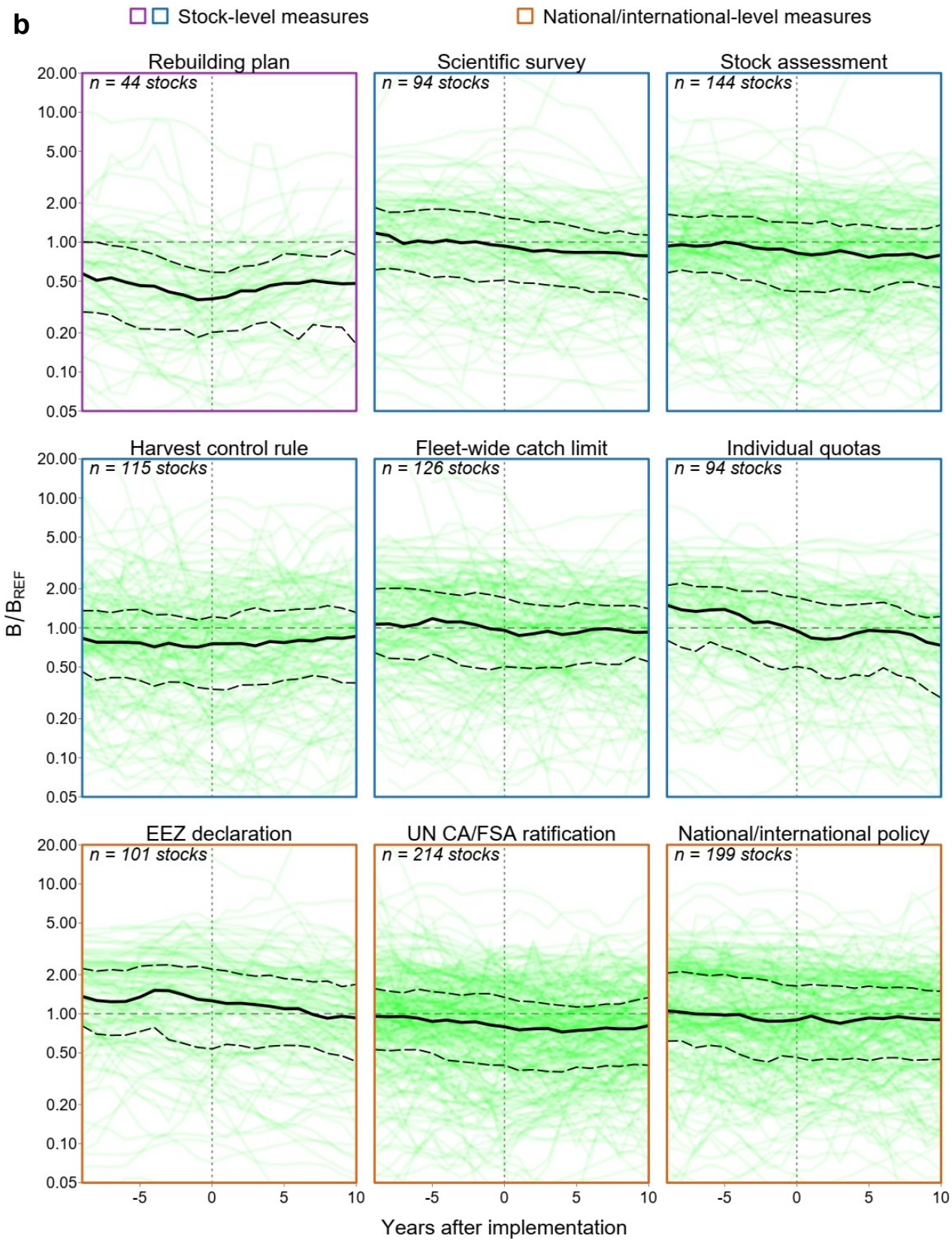


Supplementary Figure 8 | Predicted effects of fisheries management interventions on stock status under varying levels of management intensity and alternative weighting assumptions. Predictions are shown for low (left panels), medium (middle panels), and high (right panels) levels of management intensity. For a given management intensity, the number of measures indicated are implemented in year 0, either with or without a rebuilding plan. Stocks are either equally-weighted (top two rows) or weighted by maximum sustainable landed value (bottom two rows). The top two right-most panels were shown in Fig. 4; see that caption for further details.

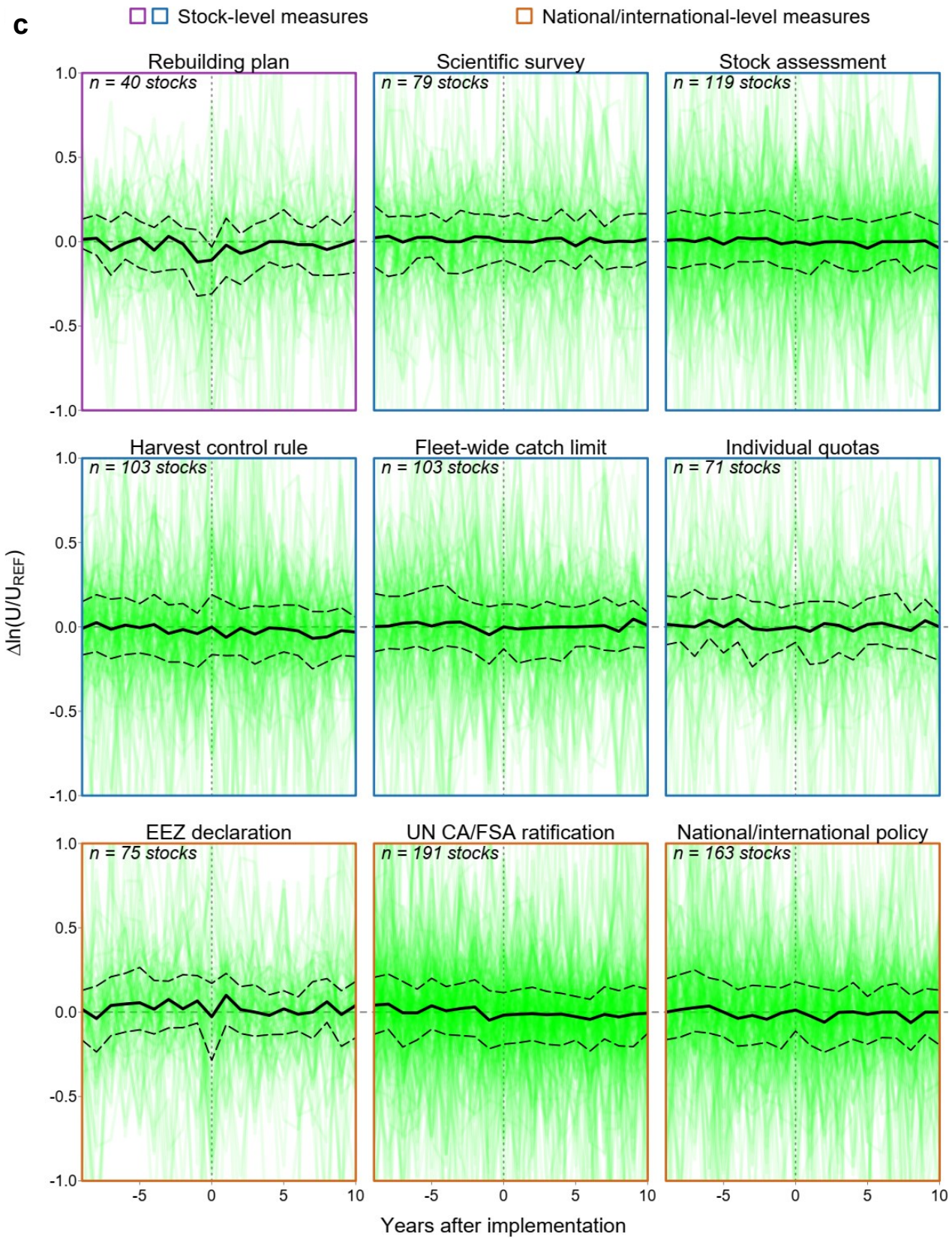
Supplementary Figure 9 (next four pages) | Time series of relative fishing pressure, relative biomass, and annual changes in these variables before and after implementation of management measures. Values of ratios (**a**) U/U_{REF}, and (**b**) B/B_{REF}, are shown on log scale. Values of annual changes in log-ratios (**c**) $\Delta\ln(U/U_{REF})$, and (**d**) $\Delta\ln(B/B_{REF})$, are shown on linear scale. The time series of each stock is shifted horizontally so the measure's implementation coincides with year 0. For (**c**) and (**d**), $\Delta\ln(U/U_{REF})$ and $\Delta\ln(B/B_{REF})$ shown at year 0 correspond to the change from year 0 to year 1. Individual measures are the same as those listed in Fig. 1 and Supplementary Table 1. For each measure, a minimum of five years of available data before year 0 and five years after year 0 were required for plotting. For rebuilding plans, year 0 represents the first year of at least five consecutive years under rebuilding and follows at least five consecutive years that were not under a rebuilding plan. Sample sizes indicated for each attribute are the number of stocks meeting these plotting requirements; sample sizes for (**c**) and (**d**) are lower than those for (**a**) and (**b**) because a minimum of six years of values are required to calculate the minimum five annual changes in values before and after year 0. The thick solid black line shows the median across stocks with available data in any given year, and thin dashed black lines show 25th and 75th percentiles. Horizontal dashed grey lines show general management targets in (**a**) and (**b**), and show the point of no annual change in the ratios in (**c**) and (**d**).



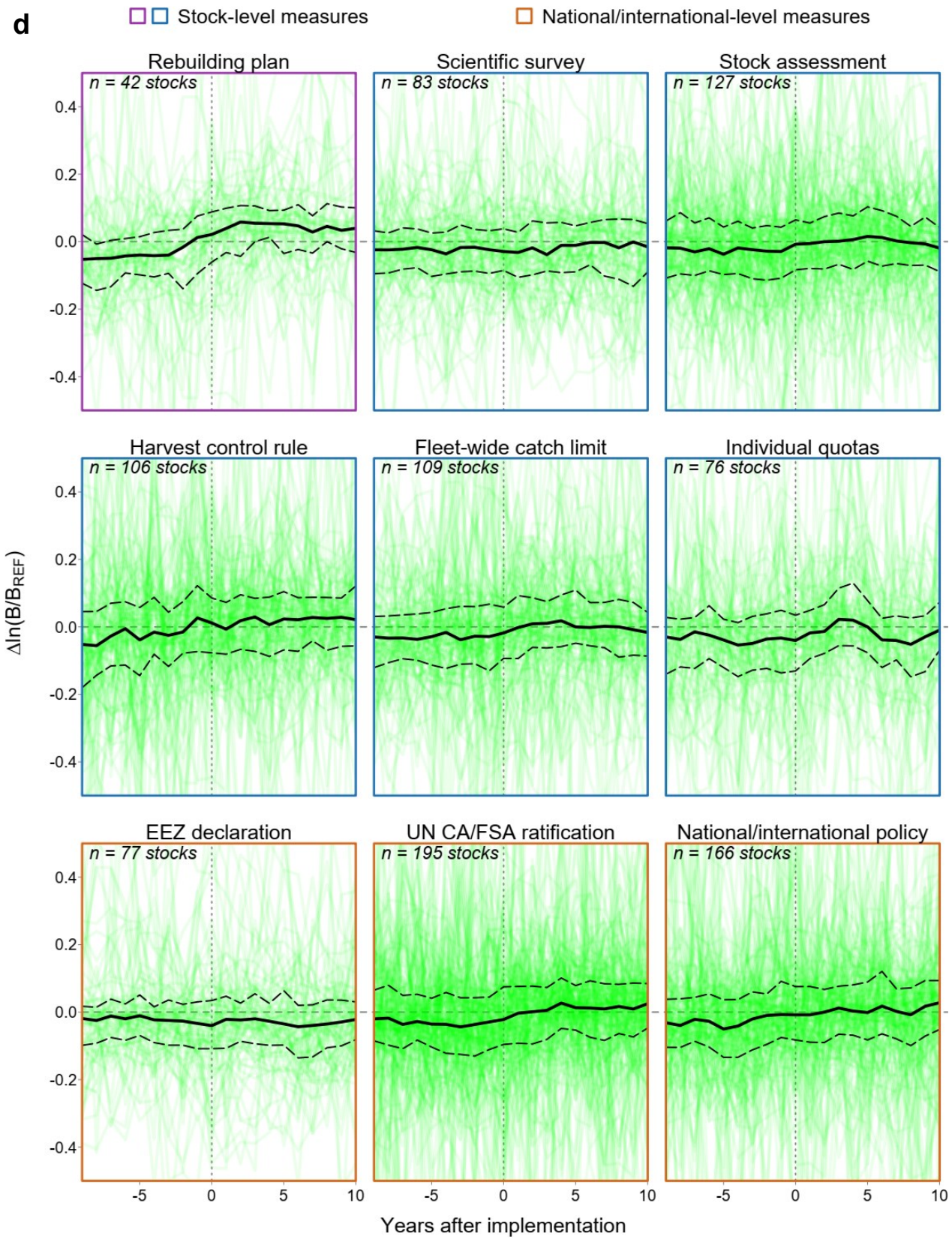
Supplementary Figure 9 continued



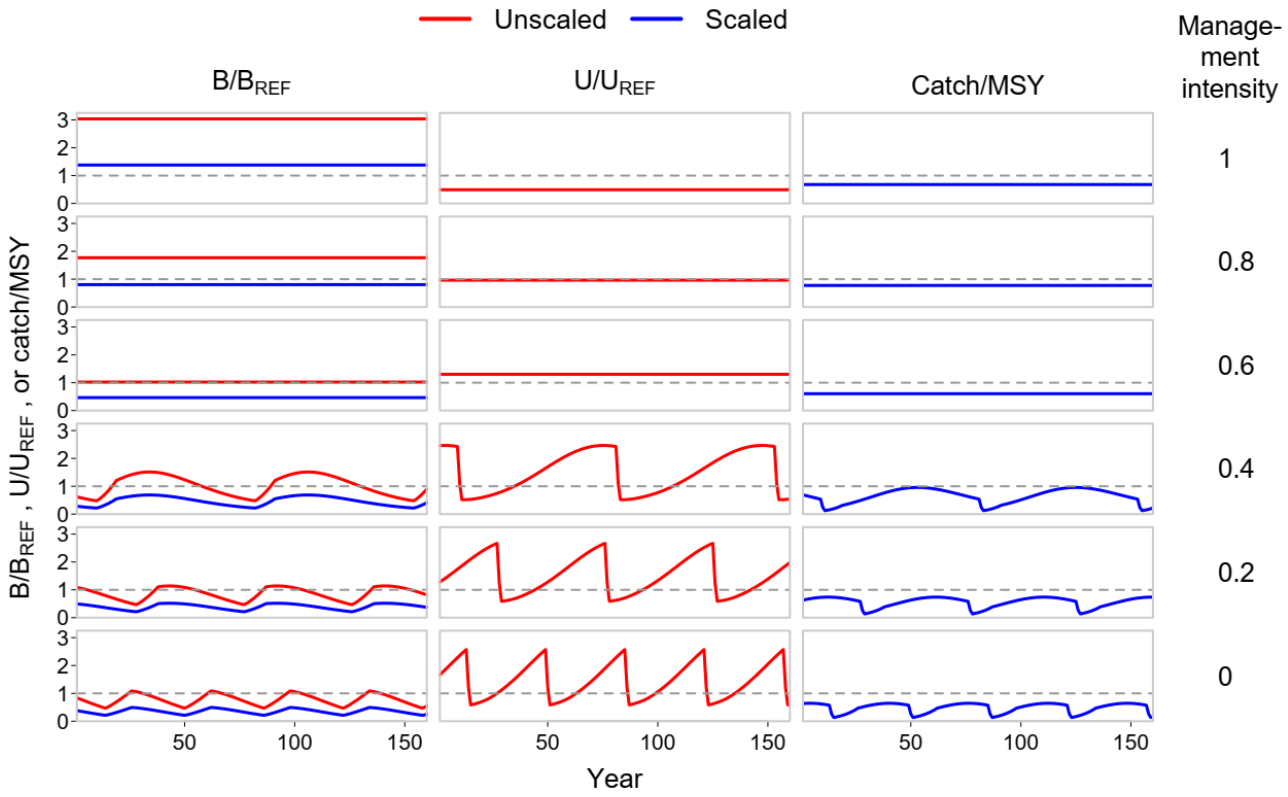
Supplementary Figure 9 continued



Supplementary Figure 9 continued



Supplementary Figure 9 continued



Supplementary Figure 10 | Time series projections at equilibrium under different levels of management intensity. Representative time series of relative fishing pressure (U/U_{REF}), relative biomass (B/B_{REF}, both unscaled and scaled values), and relative catch (catch/MSY, based on scaled biomass) are shown for an average stock. Example values assumed for management intensity apply to both stock-level and national-level indices at the combinations indicated by '×' in Fig. 5. At higher values of management intensity, rebuilding plans were never implemented, and equilibria were stable points. At lower values of management intensity, equilibria switched to stable cycles as rebuilding plans activated in response to low biomass and were then de-activated following stock recovery.

Supplementary Table 1 for

Identifying Management Actions that Promote Sustainable Fisheries

Michael C. Melnychuk, Hiroyuki Kurota, Pamela M. Mace, Maite Pons, Cóilín Minto, Giacomo Chato Osio, Olaf P. Jensen, Carryn L. de Moor, Ana M. Parma, L. Richard Little, Daniel Hively, Charmane E. Ashbrook, Nicole Baker, Ricardo O. Amoroso, Trevor A. Branch, Christopher M. Anderson, Cody S. Szuwalski, Julia K. Baum, Tim McClanahan, Yimin Ye, Alessandro Ligas, Jilali Bensbai, Grant G. Thompson, John DeVore, Arni Magnusson, Bjarte Bogstad, Edward Wort, Jake Rice, Ray Hilborn

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This PDF file is provided separately from other Supplementary Information.

Supplementary Table 1 | Management measures considered as predictor variables potentially affecting stock status.

Management measure[a]	Level[b]	Temporal effect[c]	Description
Rebuilding plan	Stock	Only when active; separate immediate and persistent effects.	Years in which the stock was placed under a formal rebuilding plan or moratorium. Criteria for implementing a rebuilding plan may vary among countries. Does not necessarily require a complete closure of a fishery, but generally involves more than slight reductions in allowable catch. May be in place for one or more years, de-activated for one or more years following stock rebuilding, and then later re-activated for one or more years.
Scientific survey	Stock	Persistent	Fishery-independent, scientific surveys that are typically used to estimate an index of abundance, which is then often used (or could be used) in stock assessments. → One of five measures comprising the stock-level management intensity index.
Stock assessment	Stock	Persistent	Scientific assessment in which an estimate of stock status (current biomass and/or fishing pressure, relative to some reference point) is provided. Usually involves a population model fit to catch and abundance index data, but approaches vary. → One of five measures comprising the stock-level management intensity index.

Management measure[a]	Level[b]	Temporal effect[c]	Description
Harvest control rule (HCR)	Stock	Persistent	Pre-specified, transparent rule for adjusting catch or fishing pressure as stock size changes. Usually involves a framework to reduce catch limits or effort in response to decreases in observed stock size. → One of five measures comprising the stock-level management intensity index.
Fleet-wide catch limit (TACs)	Stock	Persistent	Annual catch limits such as Total Allowable Catch or Guideline Harvest Levels. → One of five measures comprising the stock-level management intensity index.
Individual quotas (IQs)	Stock	Persistent	System in which quota units (or effort units) are allocated to individual fishermen, vessels, companies, or communities. Quota units are not necessarily transferable. → One of five measures comprising the stock-level management intensity index.
EEZ declaration	National/ inter-national	Persistent	Exclusive Economic Zone. → One of three measures comprising the national/ international-level management intensity index.
UN CA/FSA ratification	National/ inter-national	Persistent	First ratification of the UN FAO Compliance Agreement or UN Fish Stocks Agreement. → One of three measures comprising the national/ international-level management intensity index.
National/ regional legislative policy (varies)	National/ inter-national	Persistent	A major fisheries policy implemented by a country or a tuna Regional Fisheries Management Organisation, applying to most or all managed stocks within that jurisdiction. See Supplementary Table 2 for specific policies by country or region. → One of three measures comprising the national/ international-level management intensity index.

[a]Five of the six stock-level measures and all three national/international-level measures were used in analyses as aggregate indices of management intensity rather than as individual predictor variables.

[b]In analyses, observations are individual stocks so all management measures are technically at the stock level; here, 'level' refers to whether the measure applies to a specific stock ('stock') or to multiple stocks within the country or region ('national/international').

[c]Refers to whether the management measure is considered to have potential effect on stock status only in the years in which it is operational ('only when active') or in all years during and following its first usage ('persistent'). For rebuilding plans, the only measure with temporal effect treated as 'only when active', the modelled effect on stock status is separated into an immediate component (in the first year of implementing a rebuilding plan) and a persistent component (for all years after the first year until the end of the rebuilding plan or end of the time series).

Supplementary Table 2 for

Identifying Management Actions that Promote Sustainable Fisheries

Michael C. Melnychuk, Hiroyuki Kurota, Pamela M. Mace, Maite Pons, Cóilín Minto, Giacomo Chato Osio, Olaf P. Jensen, Carryn L. de Moor, Ana M. Parma, L. Richard Little, Daniel Hively, Charmane E. Ashbrook, Nicole Baker, Ricardo O. Amoroso, Trevor A. Branch, Christopher M. Anderson, Cody S. Szuwalski, Julia K. Baum, Tim McClanahan, Yimin Ye, Alessandro Ligas, Jilali Bensbai, Grant G. Thompson, John DeVore, Arni Magnusson, Bjarte Bogstad, Edward Wort, Jake Rice, Ray Hilborn

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This PDF file is provided separately from other Supplementary Information.

Supplementary Table 2 | National/international-level fisheries management measures treated as interventions potentially affecting stock status. Up to three measures specific to its country or region were considered for each stock: declaration of an Exclusive Economic Zone (EEZ); first ratification of either the UN FAO Compliance Agreement[a] or the UN Fish Stocks Agreement[b]; and a major piece of national or regional legislation considered as potentially-influential to stock status across most or all stocks in the country or region[c].

Country/region	Management measure	Applied to[d]	Implementation year
United States	EEZ declaration	all stocks	1976
United States	UN Compliance Agreement	all stocks	1995
United States	Sustainable Fisheries Act	all stocks	1996
Canada	EEZ declaration	all stocks	1977
Canada	UN Compliance Agreement	all stocks	1994
Canada	Fisheries Act	all stocks	1985
Europe(non-EU) NE Atl	EEZ declaration	Norway	1976
Europe(non-EU) NE Atl	UN Compliance Agreement	Norway	1994
Europe(non-EU) NE Atl	Discard Ban Package	Norway	1987
Europe(non-EU) NE Atl	EEZ declaration	Iceland	1979
Europe(non-EU) NE Atl	UN Fish Stocks Agreement	Iceland	1997
Europe(non-EU) NE Atl	Fisheries Management Act	Iceland	1990
Europe(non-EU) NE Atl	EEZ declaration	Faroe Islands	1977
Europe(non-EU) NE Atl	Commercial Fisheries Act	Faroe Islands	1994
Europe(EU) NE Atl	EEZ declaration	all stocks	1976

Country/region	Management measure	Applied to[d]	Implementation year
Europe(EU) NE Atl	UN Compliance Agreement	all stocks	1996
Europe(EU) NE Atl	2002 Reform of the Common Fisheries Policy	all stocks	2003
Europe–Med/Black Sea	EEZ declaration	France	2013
Europe–Med/Black Sea	UN Compliance Agreement	France	1996
Europe–Med/Black Sea	EEZ declaration	Spain	2013
Europe–Med/Black Sea	UN Compliance Agreement	Spain	1996
Europe–Med/Black Sea	UN Compliance Agreement	Italy	1996
Australia	EEZ declaration	all stocks	1979
Australia	UN Fish Stocks Agreement	all stocks	1999
Australia	Fisheries Management Act	all stocks	1991
New Zealand	EEZ declaration	all stocks	1978
New Zealand	Fisheries Act 1983	all stocks	1983
New Zealand	UN Fish Stocks Agreement	all stocks	2001
Japan	EEZ declaration	all stocks	1977
Japan	UN Compliance Agreement	all stocks	2000
Russia	EEZ declaration	all stocks	1977
Russia	UN Fish Stocks Agreement	all stocks	1997
Russia	Fisheries Law	all stocks	2005
South Africa	EEZ declaration	all stocks	1977
South Africa	UN Fish Stocks Agreement	all stocks	2003
South Africa	Marine Living Resources Act	all stocks	1998
West Africa	EEZ declaration	Morocco	1981
West Africa	UN Compliance Agreement	Morocco	2001
West Africa	EEZ declaration	Mauritania	1988
West Africa	UN Compliance Agreement	Mauritania	2001
West Africa	EEZ declaration	Senegal	1984
West Africa	UN Fish Stocks Agreement	Senegal	1997
South America	EEZ declaration	Argentina	1970
South America	UN Compliance Agreement	Argentina	1996
South America	Federal Fisheries Regime	Argentina	1999

Country/region	Management measure	Applied to[d]	Implementation year
South America	EEZ declaration	Chile	1947
South America	UN Compliance Agreement	Chile	2004
South America	Fishing and Aquaculture Act	Chile	1991
South America	EEZ declaration	Peru	1947
South America	UN Compliance Agreement	Peru	2001
South America	General Law of Fisheries	Peru	1993
Tuna RFMOs	UN Compliance Agreement	Japan	2000
Tuna RFMOs	UN Compliance Agreement	Spain	1996
Tuna RFMOs	UN Compliance Agreement	USA	1995
Tuna RFMOs	UN Compliance Agreement	Mexico	1999
Tuna RFMOs	UN Compliance Agreement	Ghana	2003
Tuna RFMOs	UN Fish Stocks Agreement	Brazil	2000
Tuna RFMOs	UN Fish Stocks Agreement	Indonesia	2009
Tuna RFMOs	International Convention for the Conservation of Atlantic Tunas	Atlantic	1969
Tuna RFMOs	Inter-American Tropical Tuna Commission Convention Agreement	Eastern Pacific	1950
Tuna RFMOs	Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean	Western/ Central Pacific	2004
Tuna RFMOs	Indian Ocean Tuna Commission	Indian	1996
Tuna RFMOs	Convention for the Conservation of Southern Bluefin Tuna	SBT	1994

[a]Officially, the "Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (The Compliance Agreement)", which entered into force on 24 April 2003.

[b]Officially, the "Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement)", which entered into force on 11 December 2001.

[c]If more than one major piece of fisheries legislation was implemented, the one considered to have strongest potential influence on stock status was considered. If two policies of similar perceived strength were implemented, the earlier of the two was considered.

[d]In some cases, measures listed apply to all stocks in the region, and in other cases apply to only a portion of stocks. Measures relevant to each individual stock are listed in Supplementary Figure 1. For a stock caught in multinational fisheries, the management policies included in analyses were specific to the country with the greatest proportion of catch of the stock.

Supplementary Table 8 for

Identifying Management Actions that Promote Sustainable Fisheries

Michael C. Melnychuk, Hiroyuki Kurota, Pamela M. Mace, Maite Pons, Cóilín Minto, Giacomo Chato Osio, Olaf P. Jensen, Carryn L. de Moor, Ana M. Parma, L. Richard Little, Daniel Hively, Charmane E. Ashbrook, Nicole Baker, Ricardo O. Amoroso, Trevor A. Branch, Christopher M. Anderson, Cody S. Szuwalski, Julia K. Baum, Tim McClanahan, Yimin Ye, Alessandro Ligas, Jilali Bensbai, Grant G. Thompson, John DeVore, Arni Magnusson, Bjarte Bogstad, Edward Wort, Jake Rice, Ray Hilborn

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Supplementary Table 8 | Summary of comparisons between sensitivity analyses and main run of results. See Supplementary Note 2 for details.

Analysis	Sample size (number of stocks) for analyses of U/U_{REF} and B/B_{REF}:		Coefficient estimate (SE) for: r_1, rebuilding plan (immediate) r_{2+}, rebuilding plan (persistent) s, stock-level management intensity n, national-level management intensity		Visual comparison with Figs. 3-5 and Supplementary Figure 8
	separate (Figs. 3, 4)	together (Fig. 5)	U/U_{REF}	B/B_{REF}	
Main run	288	277	r_1: –0.799 (0.039) r_{2+}: –0.022 (0.010) s: –0.030 (0.013) n: –0.045 (0.011)	r_1: –0.006 (0.015) r_{2+}: 0.064 (0.008) s: 0.012 (0.011) n: 0.022 (0.009)	
Sensitivity 1—reference points (no SP fits)	248	203	r_1: –0.196 (0.038) r_{2+}: –0.023 (0.011) s: –0.018 (0.014) n: –0.052 (0.013)	r_1: –0.003 (0.017) r_{2+}: 0.059 (0.009) s: 0.014 (0.012) n: 0.026 (0.011)	Fig. 3 similar for B/B_{REF}, differences for U/U_{REF} (see Supplementary Note 2) Fig. 4 and Supplementary Figure 8 similar for B/B_{REF}, differences for U/U_{REF} (see Supplementary Note 2) Fig. 5 differences (see Supplementary Note 2)
Sensitivity 2—time series length (min. 20 yrs)	254	242	r_1: –0.791 (0.039) r_{2+}: –0.023 (0.010) s: –0.030 (0.013) n: –0.042 (0.011)	r_1: 0.005 (0.014) r_{2+}: 0.063 (0.008) s: 0.010 (0.011) n: 0.023 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar

Analysis	Sample size (number of stocks) for analyses of U/U_{REF} and B/B_{REF}:		Coefficient estimate (SE) for: r_1, rebuilding plan (immediate) r_{2+}, rebuilding plan (persistent) s, stock-level management intensity n, national-level management intensity		Visual comparison with Figs. 3-5 and Supplementary Figure 8
	separate (Figs. 3, 4)	together (Fig. 5)	U/U_{REF}	B/B_{REF}	
Sensitivity 3a—ARIMA structure (p=0, q=0)	288	277	r_1: –0.788 (0.041) r_{2+}: –0.008 (0.020) s: –0.042 (0.026) n: –0.042 (0.022)	r_1: –0.010 (0.016) r_{2+}: 0.064 (0.007) s: 0.012 (0.010) n: 0.022 (0.009)	Fig. 3 similar (wider confidence limits) Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar
Sensitivity 3b—ARIMA structure (p=1, q=0)	288	277	r_1: –0.800 (0.041) r_{2+}: –0.007 (0.016) s: –0.040 (0.021) n: –0.045 (0.018)	r_1: –0.003 (0.015) r_{2+}: 0.063 (0.008) s: 0.012 (0.011) n: 0.022 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar
Sensitivity 3c—ARIMA structure (p=2, q=0)	288	277	r_1: –0.829 (0.040) r_{2+}: –0.010 (0.015) s: –0.035 (0.019) n: –0.048 (0.016)	r_1: –0.004 (0.015) r_{2+}: 0.063 (0.008) s: 0.012 (0.011) n: 0.022 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar
Sensitivity 3d—ARIMA structure (p=0, q=1)	288	277	r_1: –0.816 (0.040) r_{2+}: –0.009 (0.014) s: –0.036 (0.019) n: –0.047 (0.016)	r_1: –0.004 (0.015) r_{2+}: 0.063 (0.008) s: 0.012 (0.011) n: 0.022 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar

Analysis	Sample size (number of stocks) for analyses of U/U_{REF} and B/B_{REF}:		Coefficient estimate (SE) for: r_1, rebuilding plan (immediate) r_{2+}, rebuilding plan (persistent) s, stock-level management intensity n, national-level management intensity		Visual comparison with Figs. 3-5 and Supplementary Figure 8
	separate (Figs. 3, 4)	together (Fig. 5)	U/U_{REF}	B/B_{REF}	
Sensitivity 4a—regional weighting (proportional to $n_{r,RAMLDBfull}$)	288	277	r_1: –0.843 (0.040) r_{2+}: –0.029 (0.011) s: –0.030 (0.013) n: –0.045 (0.012)	r_1: –0.008 (0.016) r_{2+}: 0.075 (0.009) s: 0.005 (0.011) n: 0.022 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar
Sensitivity 4b—regional weighting (proportional to $n_{r,RAMLDBsub}$)	288	277	r_1: –0.903 (0.040) r_{2+}: –0.031 (0.011) s: –0.031 (0.013) n: –0.042 (0.011)	r_1: –0.010 (0.017) r_{2+}: 0.077 (0.009) s: 0.004 (0.011) n: 0.022 (0.010)	Fig. 3 similar Fig. 4 and Supplementary Figure 8 similar Fig. 5 similar

Supplementary Figure 1 for

Identifying Management Actions that Promote Sustainable Fisheries

Michael C. Melnychuk, Hiroyuki Kurota, Pamela M. Mace, Maite Pons, Cóilín Minto, Giacomo Chato Osio, Olaf P. Jensen, Carryn L. de Moor, Ana M. Parma, L. Richard Little, Daniel Hively, Charmane E. Ashbrook, Nicole Baker, Ricardo O. Amoroso, Trevor A. Branch, Christopher M. Anderson, Cody S. Szuwalski, Julia K. Baum, Tim McClanahan, Yimin Ye, Alessandro Ligas, Jilali Bensbai, Grant G. Thompson, John DeVore, Arni Magnusson, Bjarte Bogstad, Edward Wort, Jake Rice, Ray Hilborn

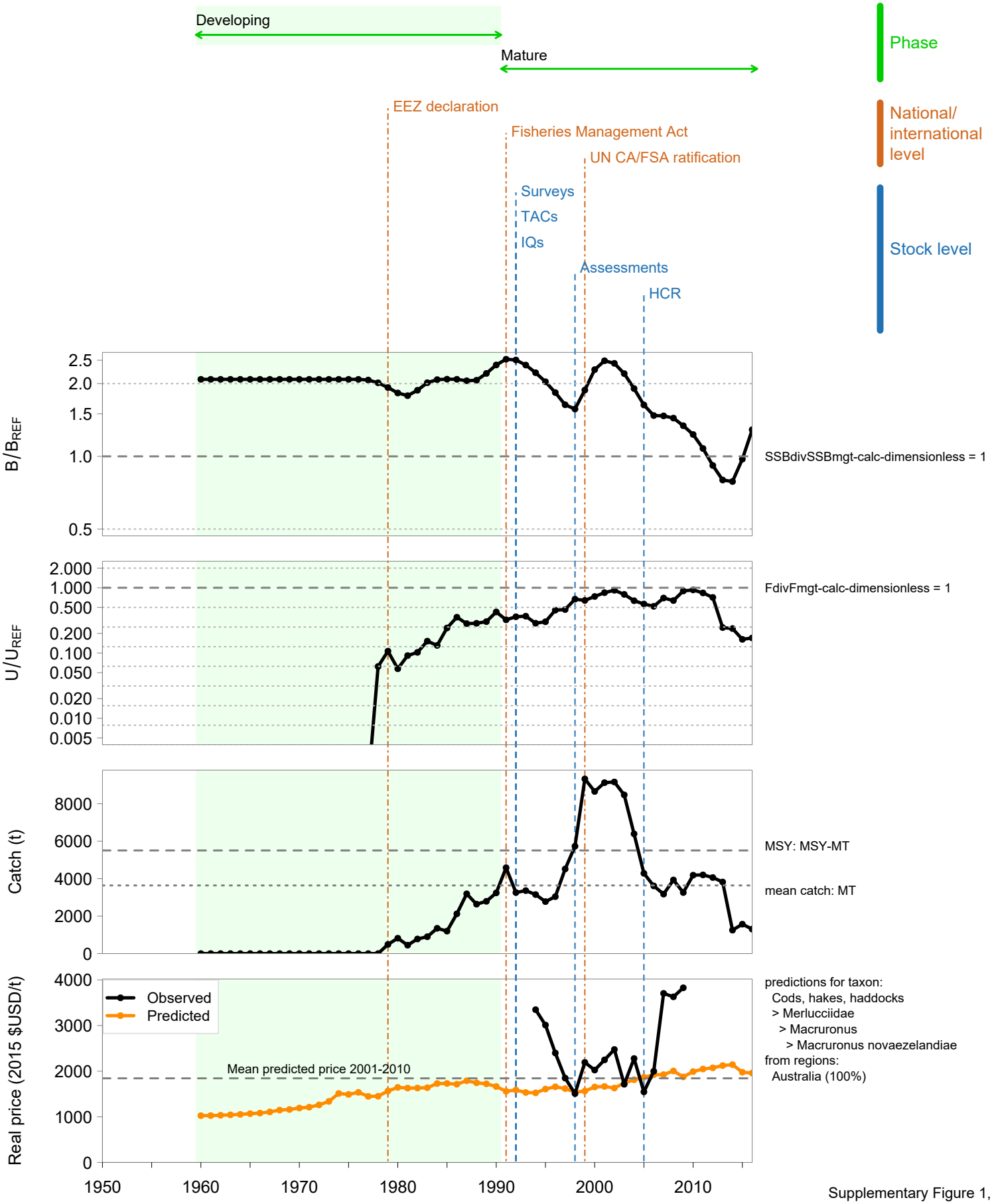
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This PDF file is provided separately from other Supplementary Information.

Supplementary Figure 1 (next 288 pages) | Stock status history relative to the timing of fisheries management interventions for 288 individual stocks included in analyses. Four panels show: stock biomass relative to target reference point (B/B_{REF}, on log scale); fishing pressure relative to target reference point (U/U_{REF}, on log scale); catch; and real ex-vessel price (predicted price and, if available, also observed price). Horizontal dashed grey lines in each panel show: target ratio of $B/B_{REF} = 1$; target ratio of $U/U_{REF} = 1$; mean catch excluding leading zeros (short dash) and, if available, best estimate of maximum sustainable yield (MSY, long dash); and mean predicted price from 2001-2010. In panels for B/B_{REF} and U/U_{REF}, horizontal dotted grey lines show successive doubling or halving of target levels. Catch consists of at least commercial landings and, if available, also estimates of recreational catch, discards, and/or illegal or unreported catch. If applicable, the years in which the stock was under a rebuilding plan are shown with purple hatching. Years in which other management measures were first implemented are shown by vertical dashed lines, with measures labelled above the top panel. Management measures are grouped at the stock level (scientific surveys; stock assessments; harvest control rules (HCR); total allowable catches or other fleet-wide catch limits (TAC); individual quotas (IQ); and rebuilding plans), and at the national/international level (declaration of Exclusive Economic Zones (EEZ); first ratification of either the United Nations Food and Agriculture Organization Compliance Agreement or the United Nations Fish Stocks Agreement (UN CA/FSA); and a major national or international fisheries policy implementation). Stock histories are partitioned into 'developing' (shaded green, if applicable) and 'mature' fishery phases based on values of biomass, fishing pressure, and catch relative to reference points. Years during which relative biomass was depleted below 0.5 (one of many typical thresholds used around the world for defining 'overfished', $B/B_{REF} < 0.5$) are shaded red, if applicable. Notes to the right of the top three panels list details about the type of B/B_{REF}, U/U_{REF}, and MSY estimates available (taken from the RAM Legacy Stock Assessment Database, RAMLDB). Notes to the right of the bottom panel list the taxonomic groups and regions used for predicting ex-vessel prices for the stock (notes with 'from region: none (100%)' signify that region-specific prices were not available for the species, so predicted prices were drawn instead from the global mean price for the species). Page titles list the region, RAMLDB 'stockid' code, and stock name. Notes under page titles list the stock's categorised taxonomic group, fishery type, and primary country. See Supplementary Table 1 for descriptions of management measures.

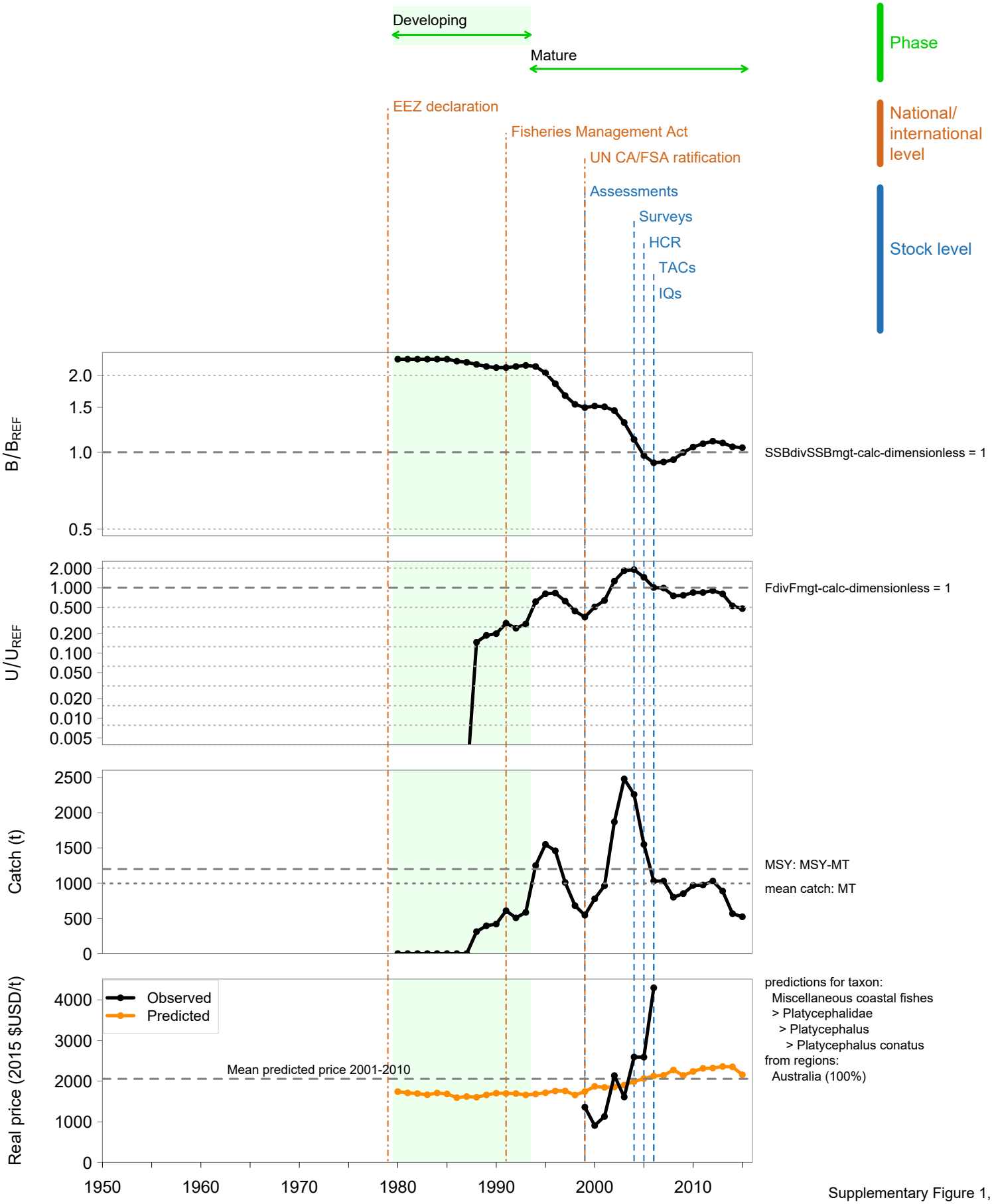
Australia -- BGRDRNSWWA -- Blue grenadier New South Wales to Western Australia

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Australia



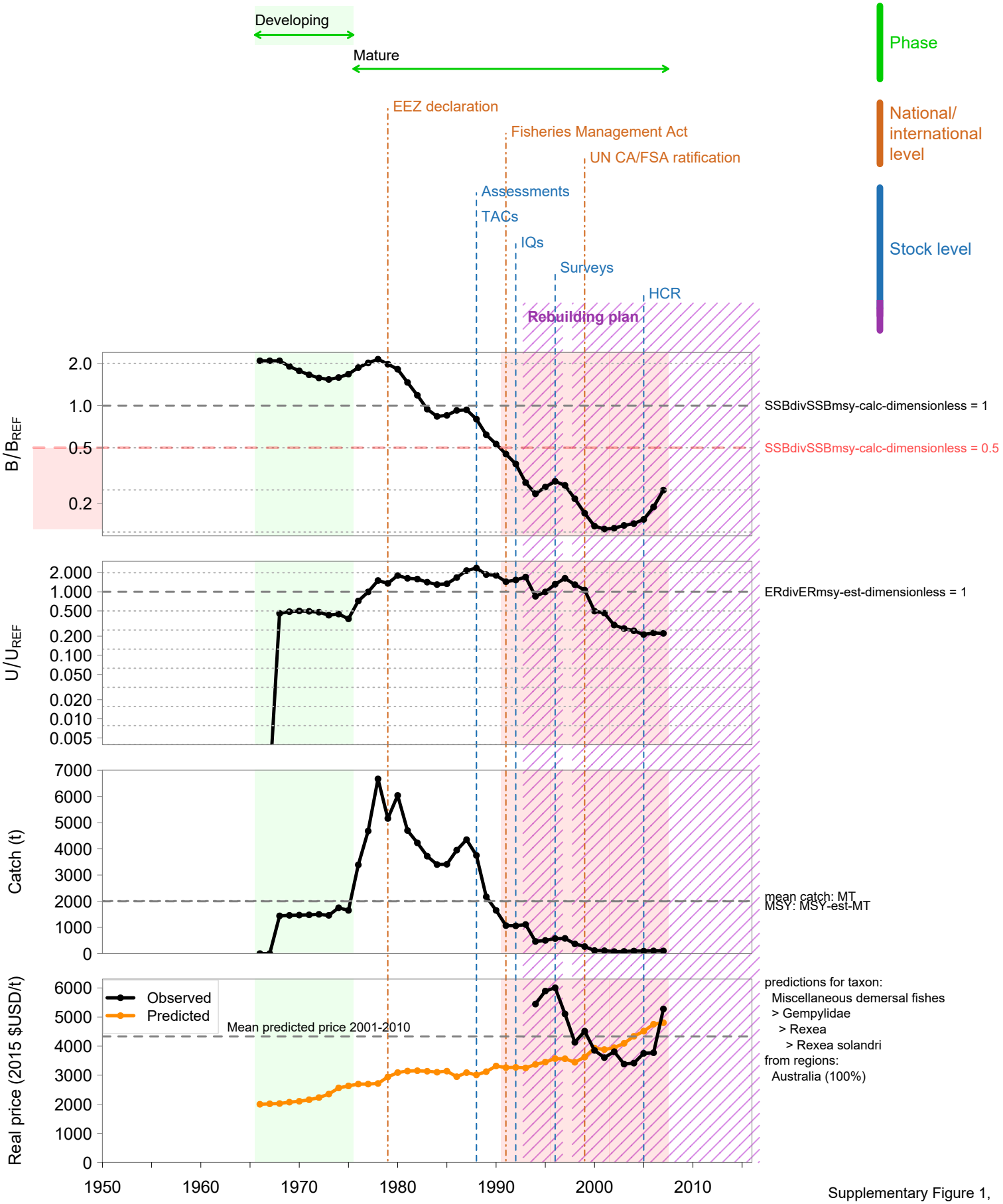
Australia -- DEEPFLATHEADSE -- Deepwater flathead Southeast Australia

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Australia



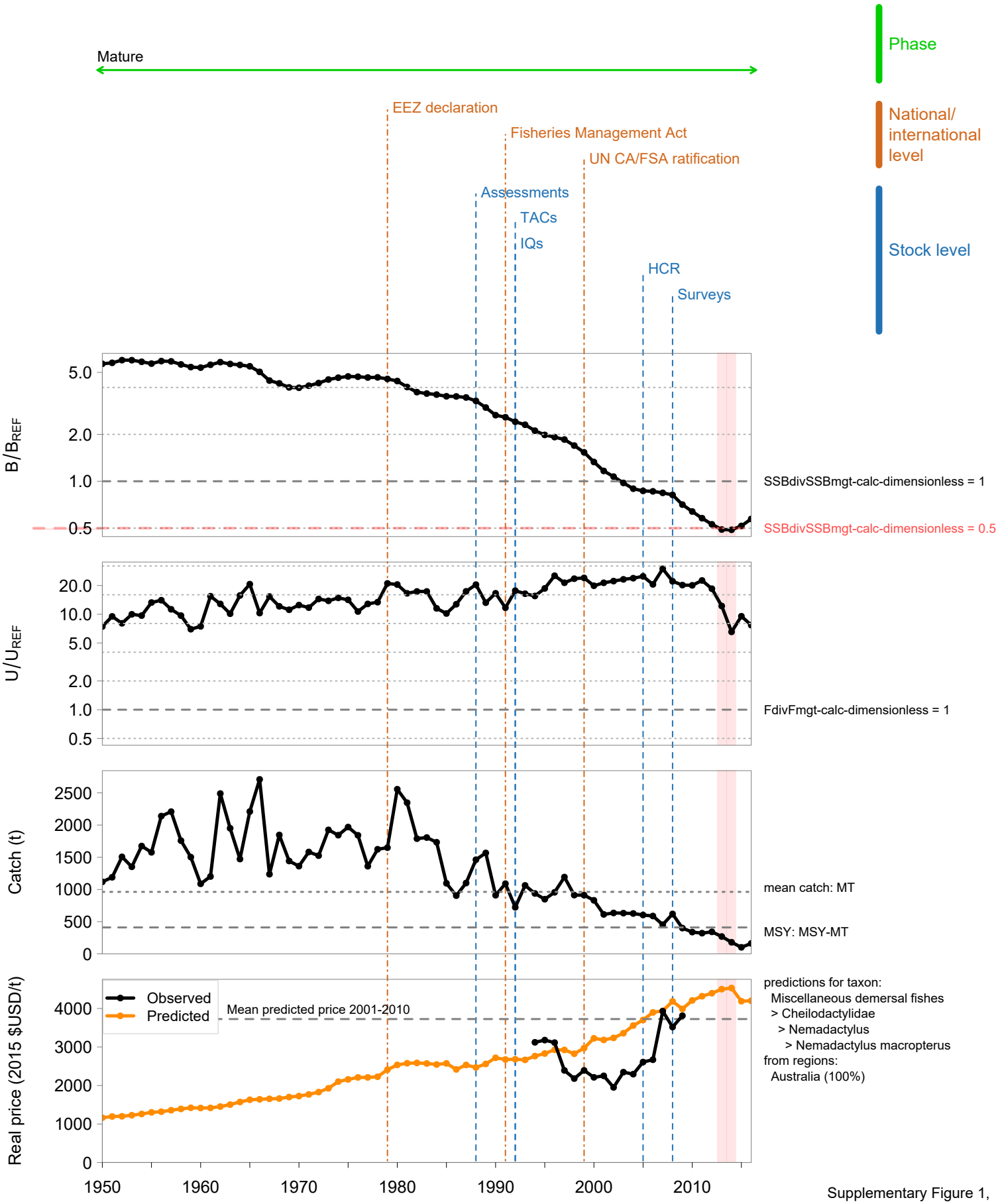
Australia -- GEMFISHSE -- Common gemfish Southeast Australia

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Australia



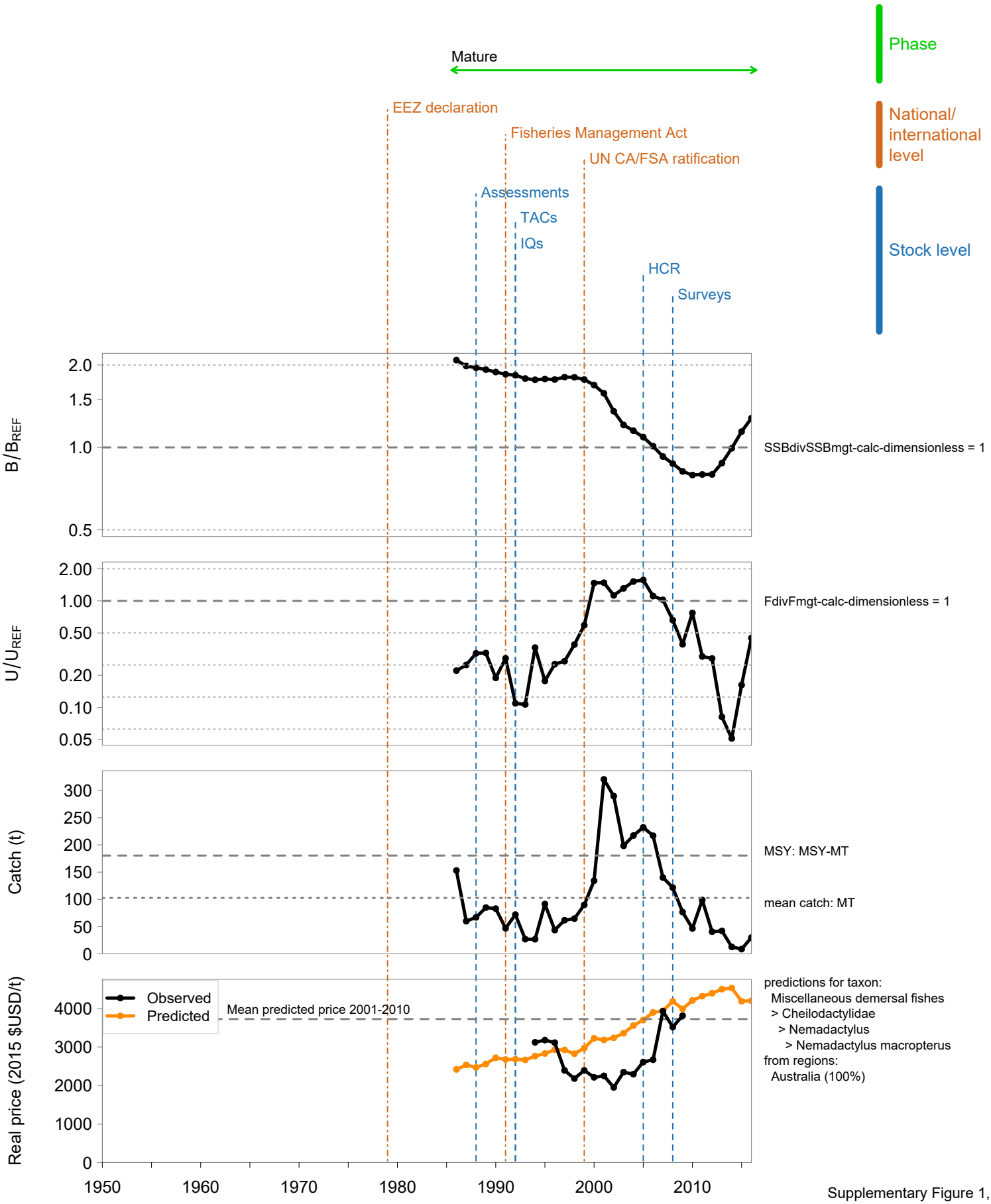
Australia -- MORWONGESE -- Jackass morwong Eastern half of Southeast Australia

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Australia



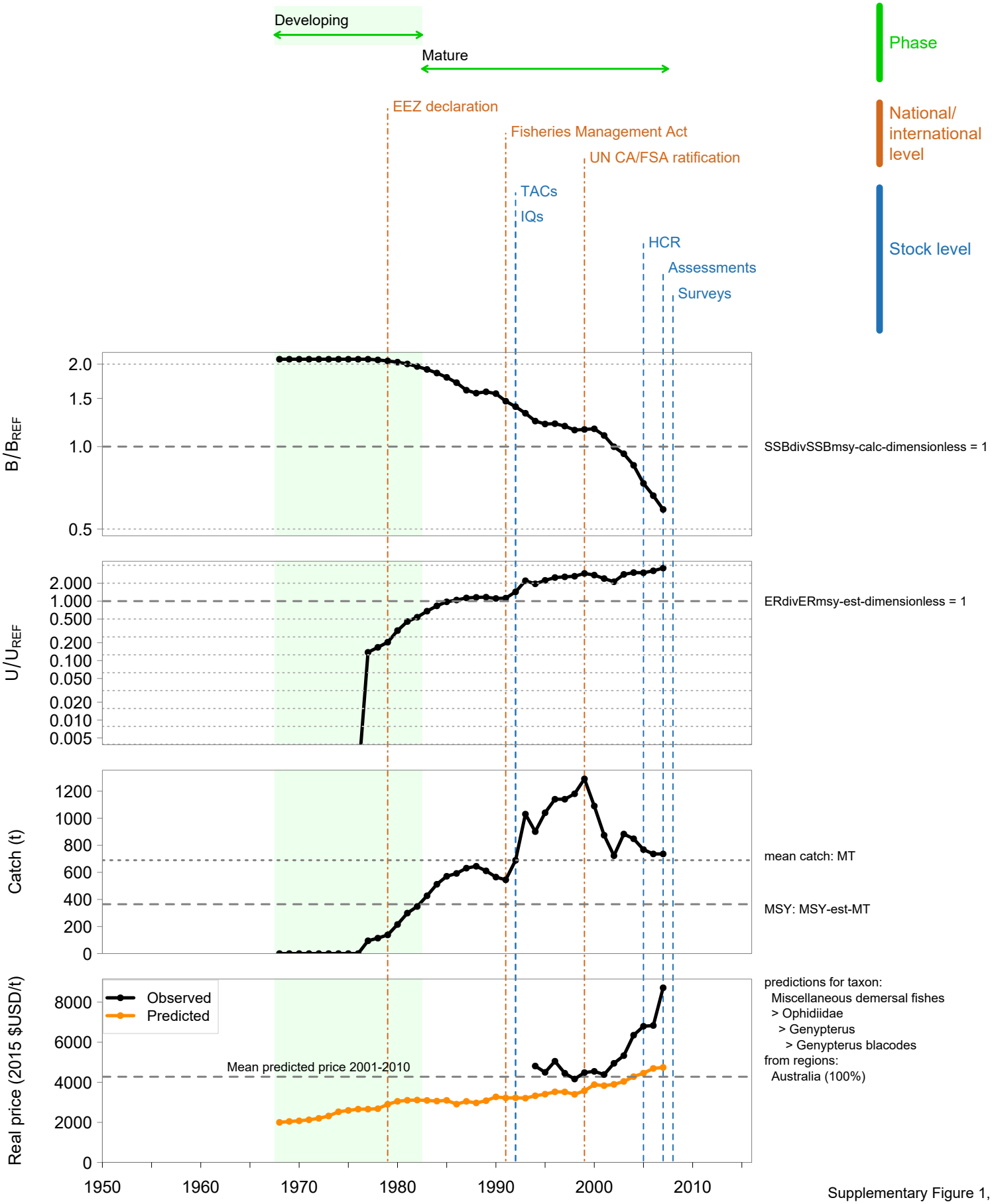
Australia -- MORWONGWSE -- Jackass morwong Western half of Southeast Australia

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Australia



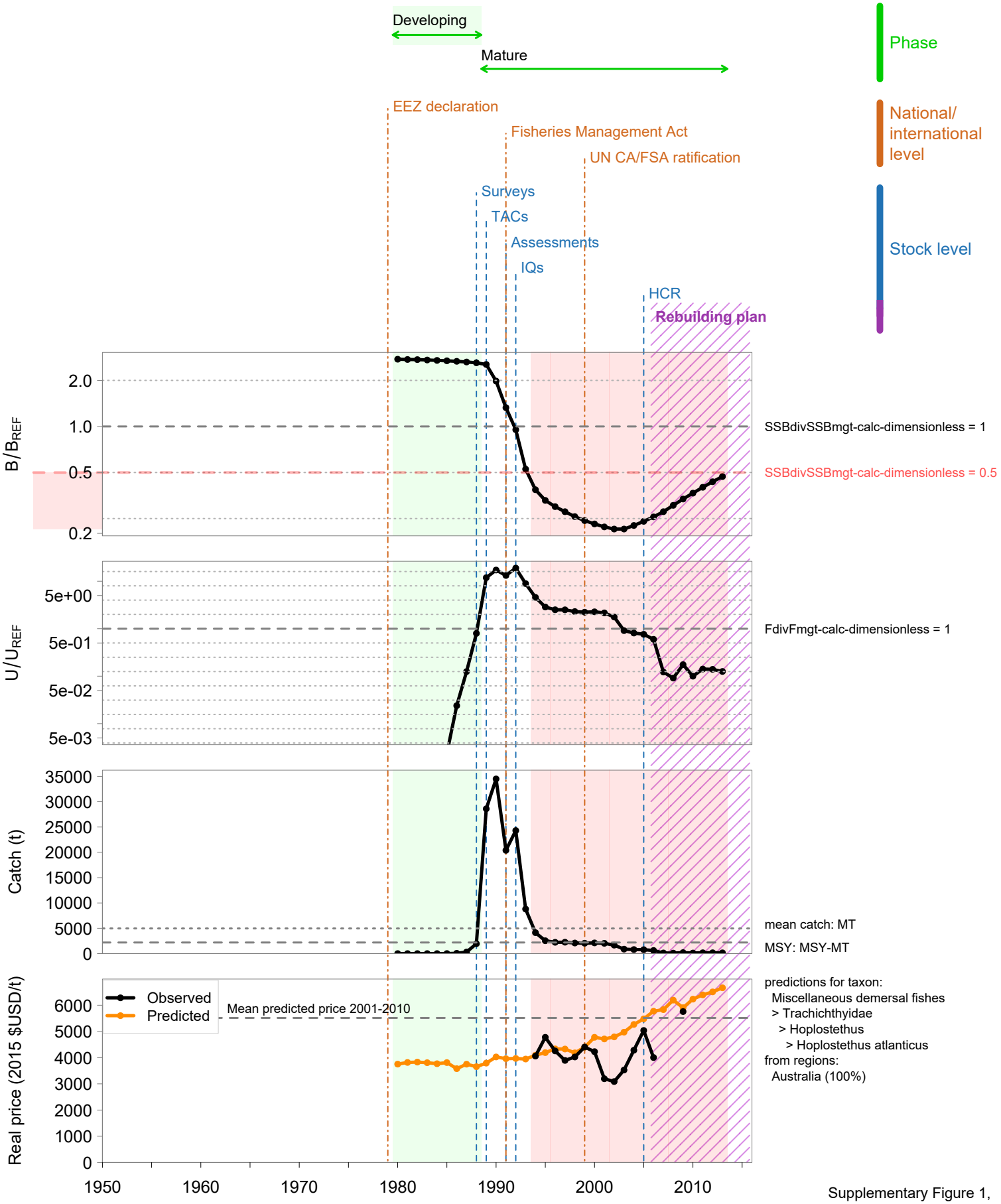
Australia -- NZLINGESE -- Ling Southeast Australia

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Australia



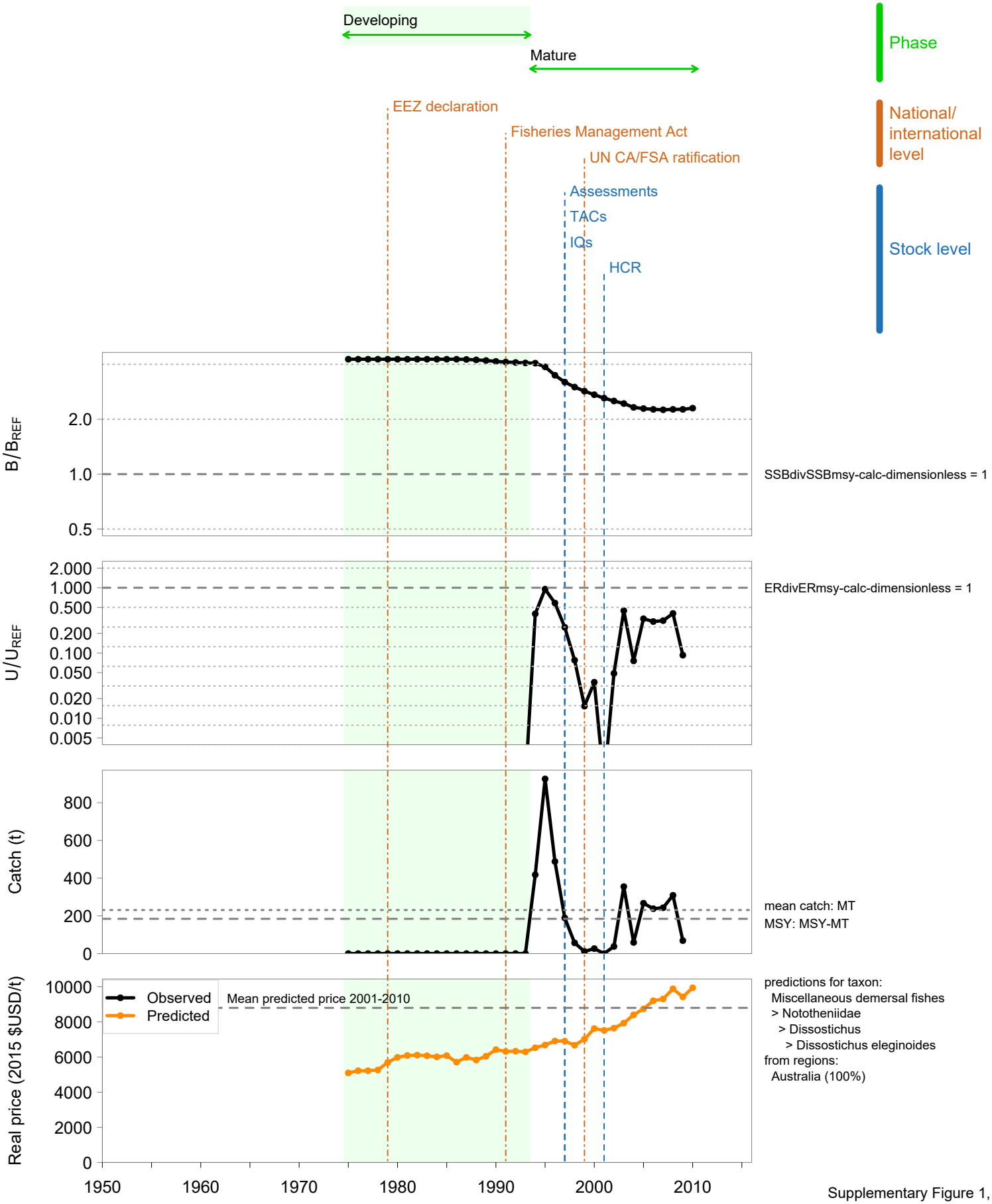
Australia -- OROUGHYSE -- Orange roughy Southeast Australia

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: Australia



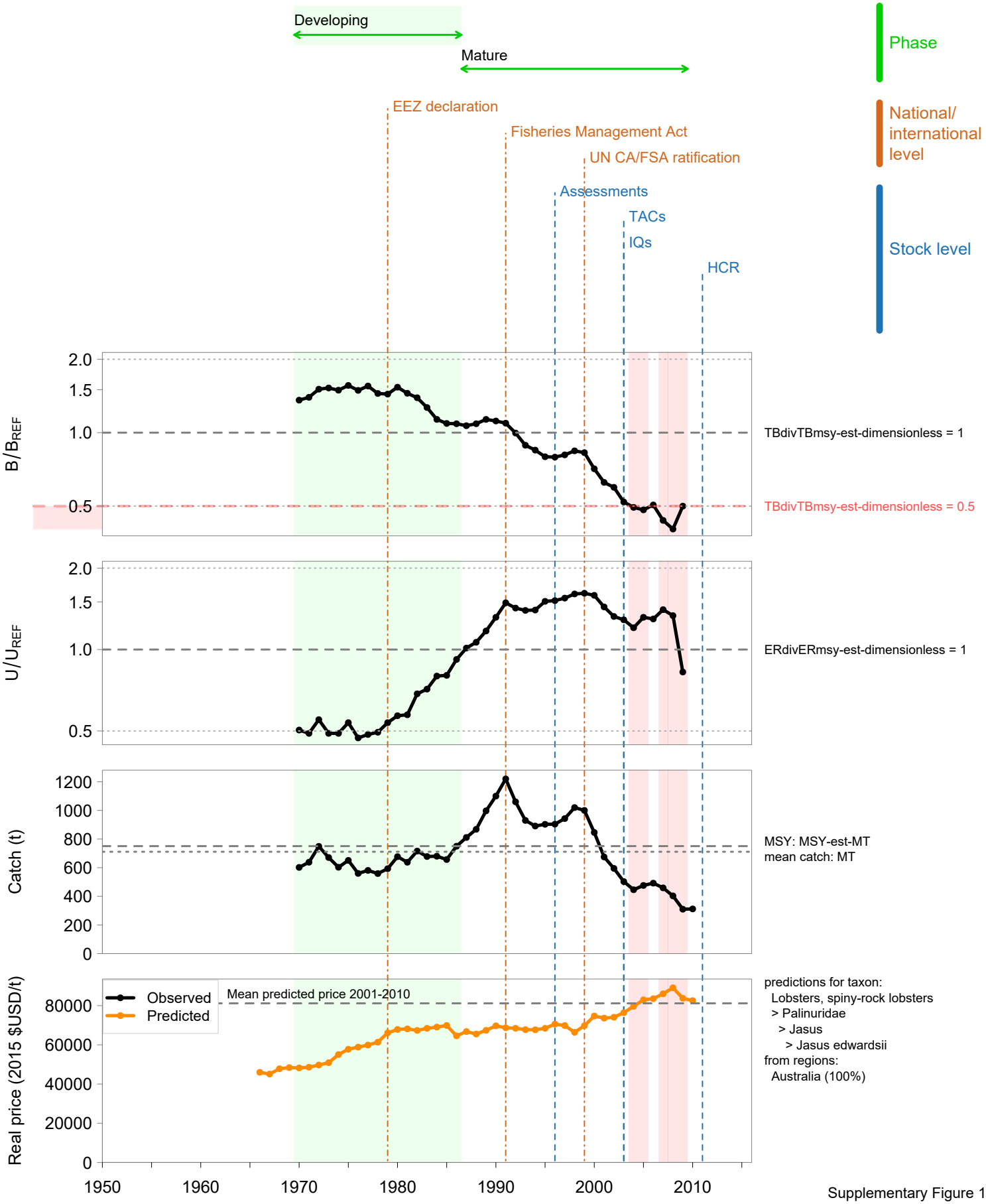
Australia -- PTOOTHFISHMI -- Patagonian toothfish Macquarie Island

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: Australia



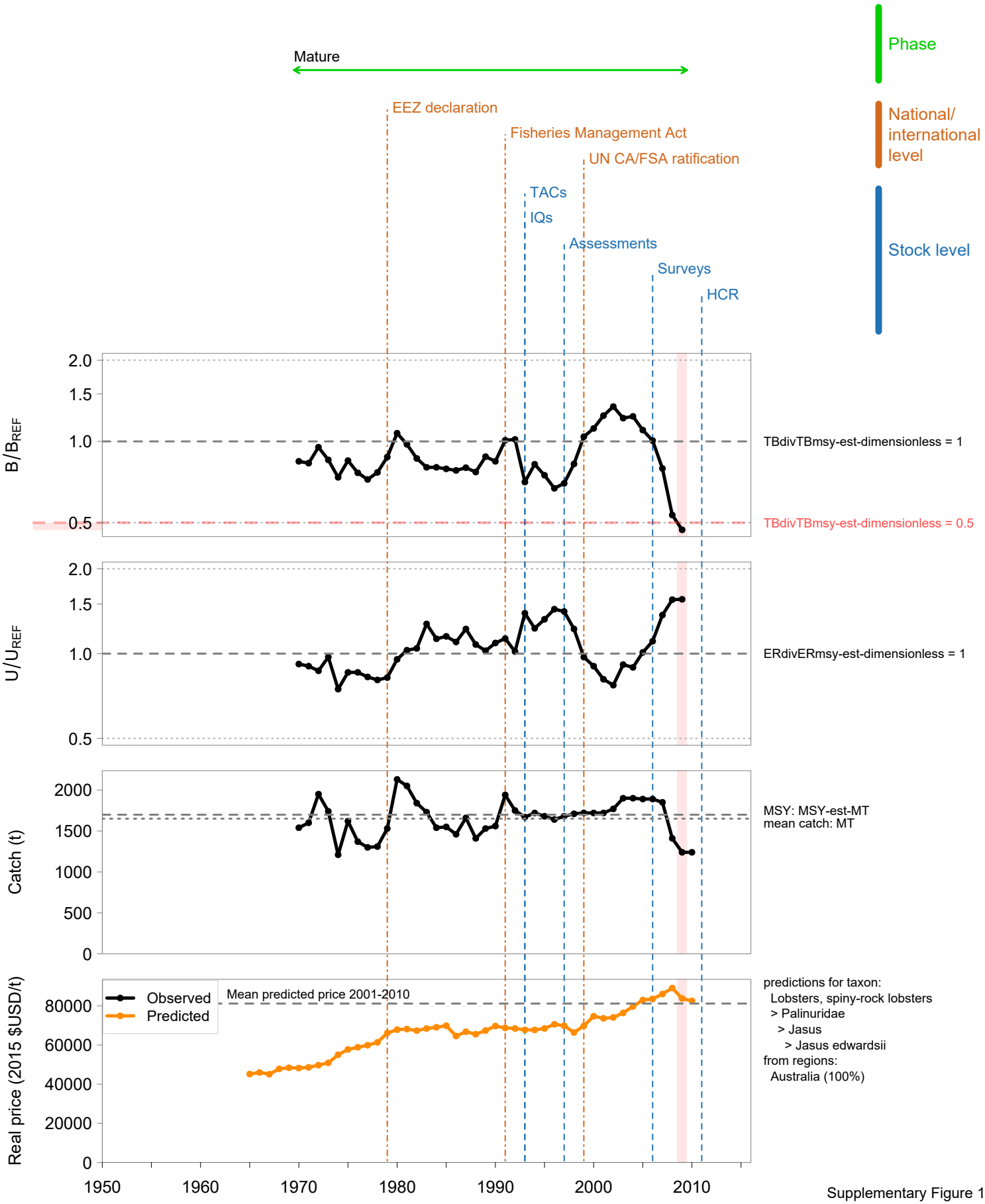
Australia -- RROCKLOBSTERSAUSNZ -- Rock lobster South Australia Northern Zone

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: Australia



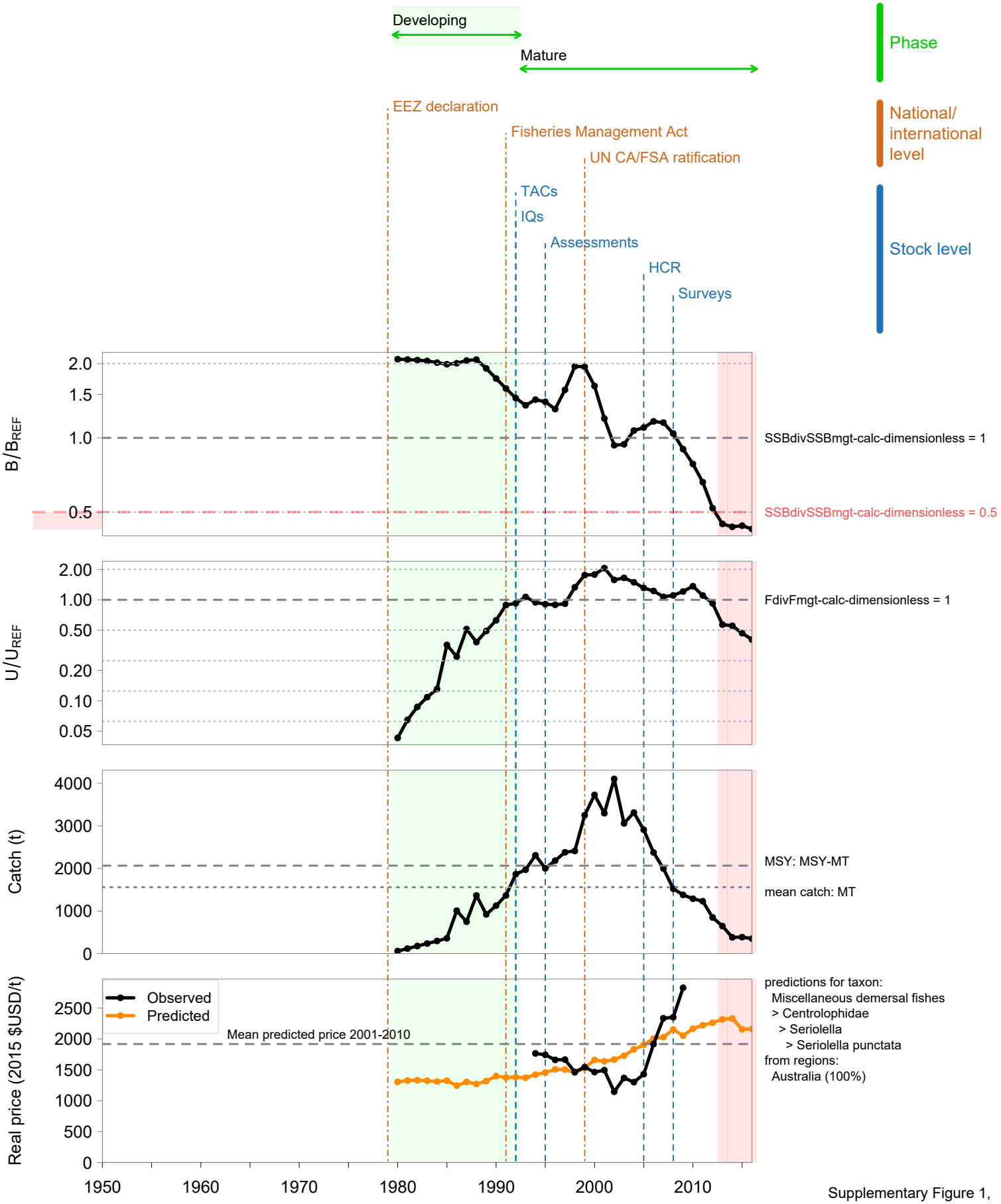
Australia -- RROCKLOBSTERSAUSSZ -- Rock lobster South Australia Southern Zone

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: Australia



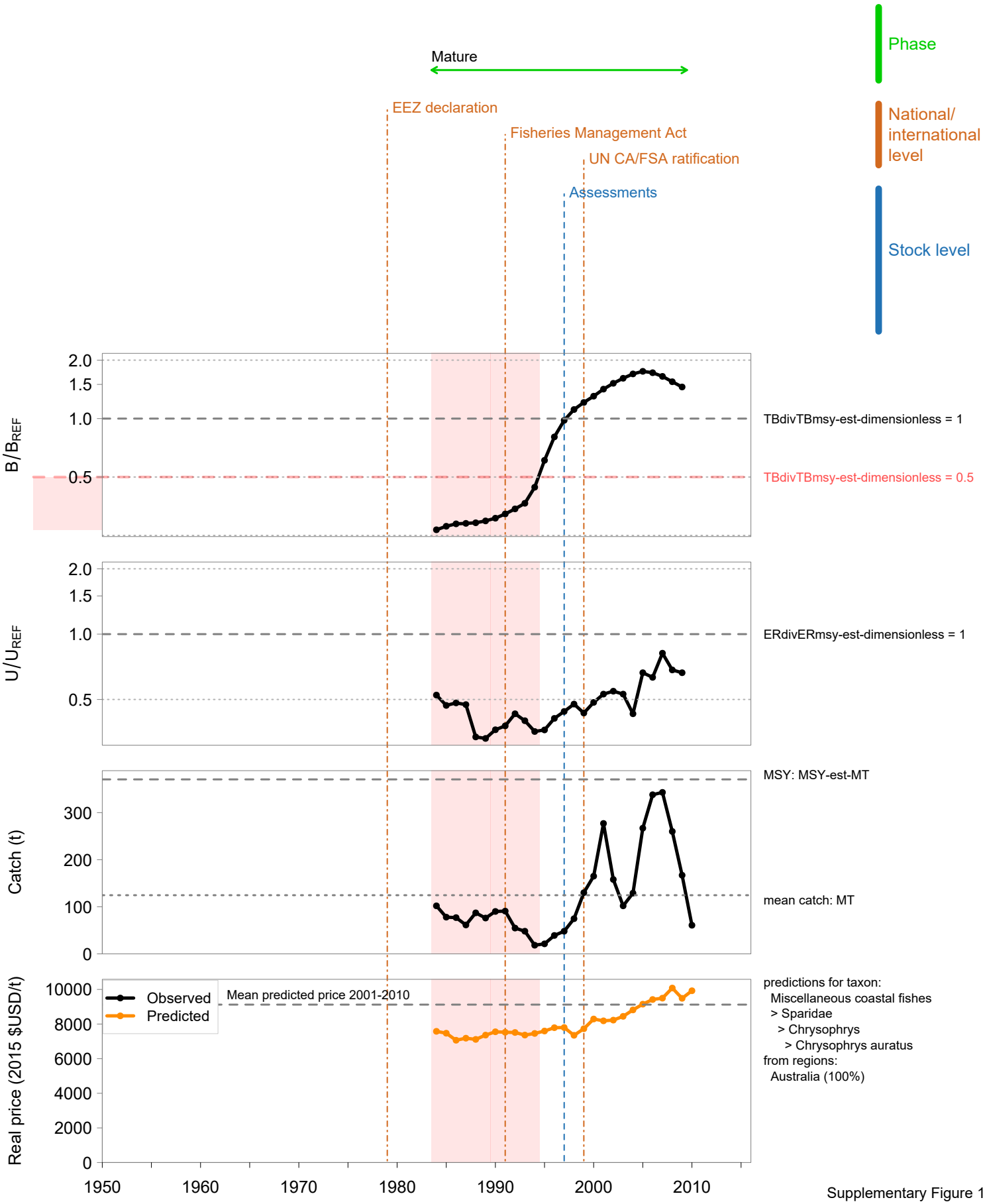
Australia -- SILVERFISHSE -- Silverfish Southeast Australia

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Australia



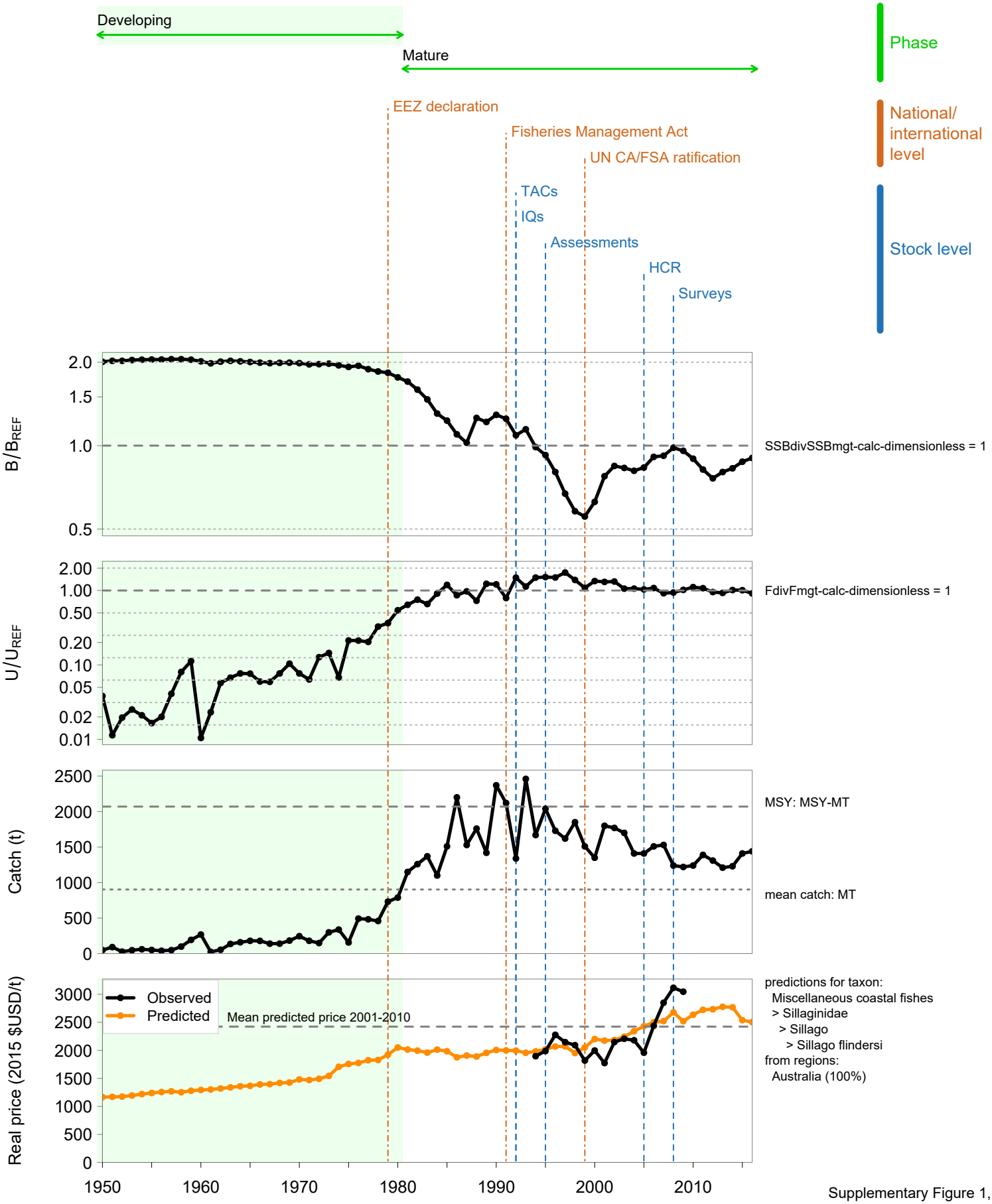
Australia -- SNAPSAUSSSG -- Snapper Southern Spencer Gulf

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: single-species, primary country: Australia



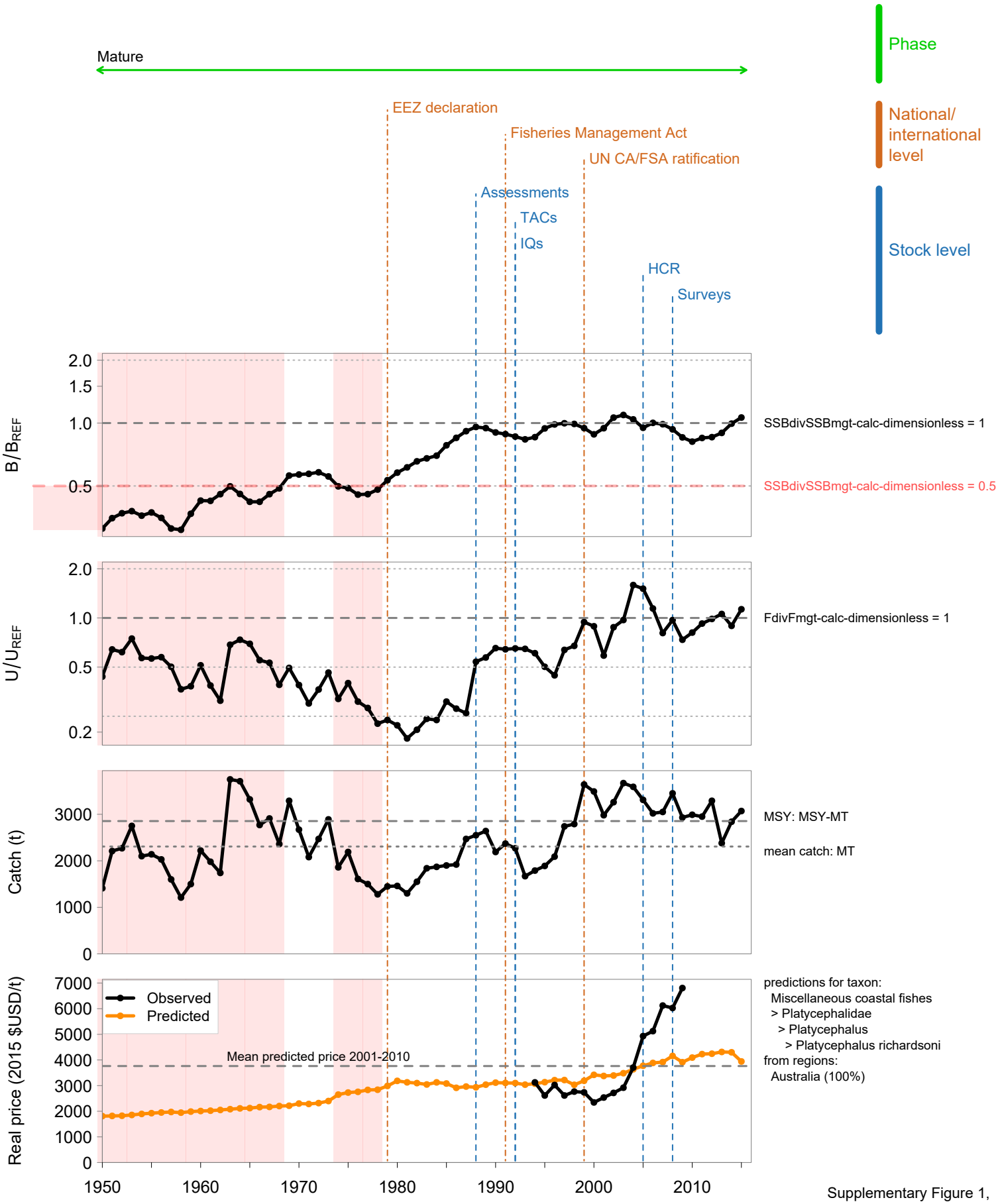
Australia -- SWHITSE -- School whiting Southeast Australia

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Australia



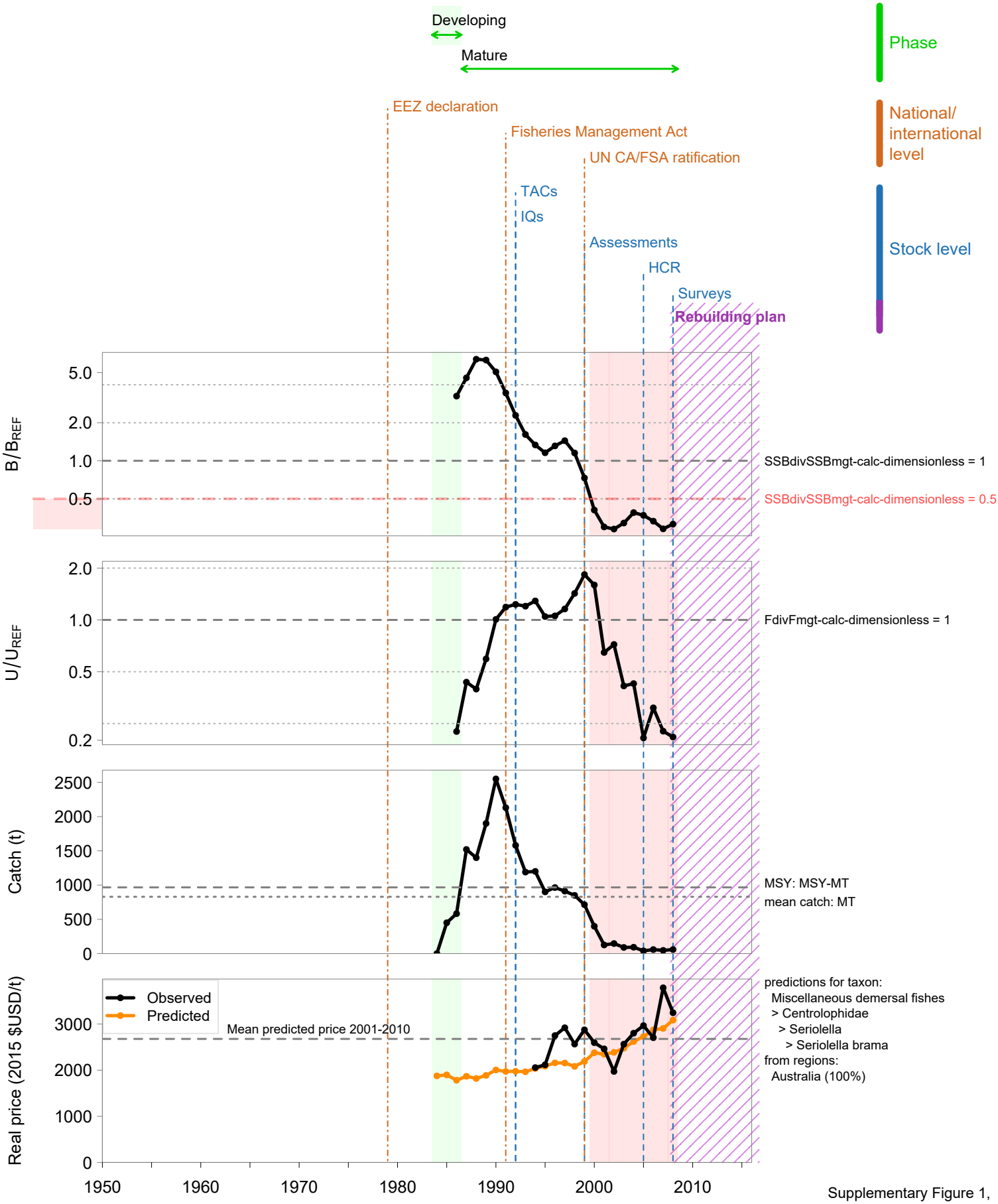
Australia -- TIGERFLATSE -- Tiger flathead Southeast Australia

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Australia



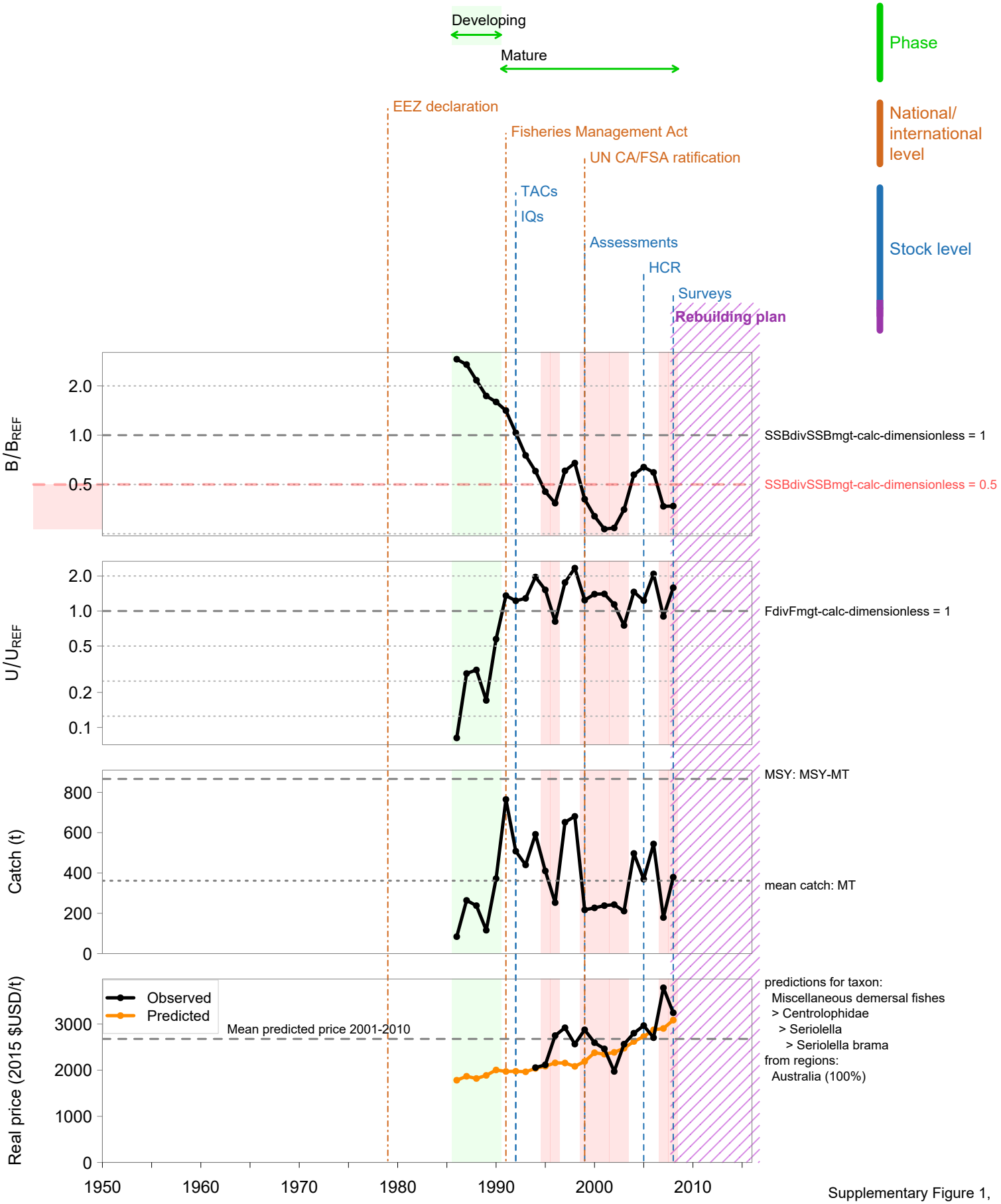
Australia -- WAREHOUESE -- Blue warehou Eastern half of Southeast Australia

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Australia



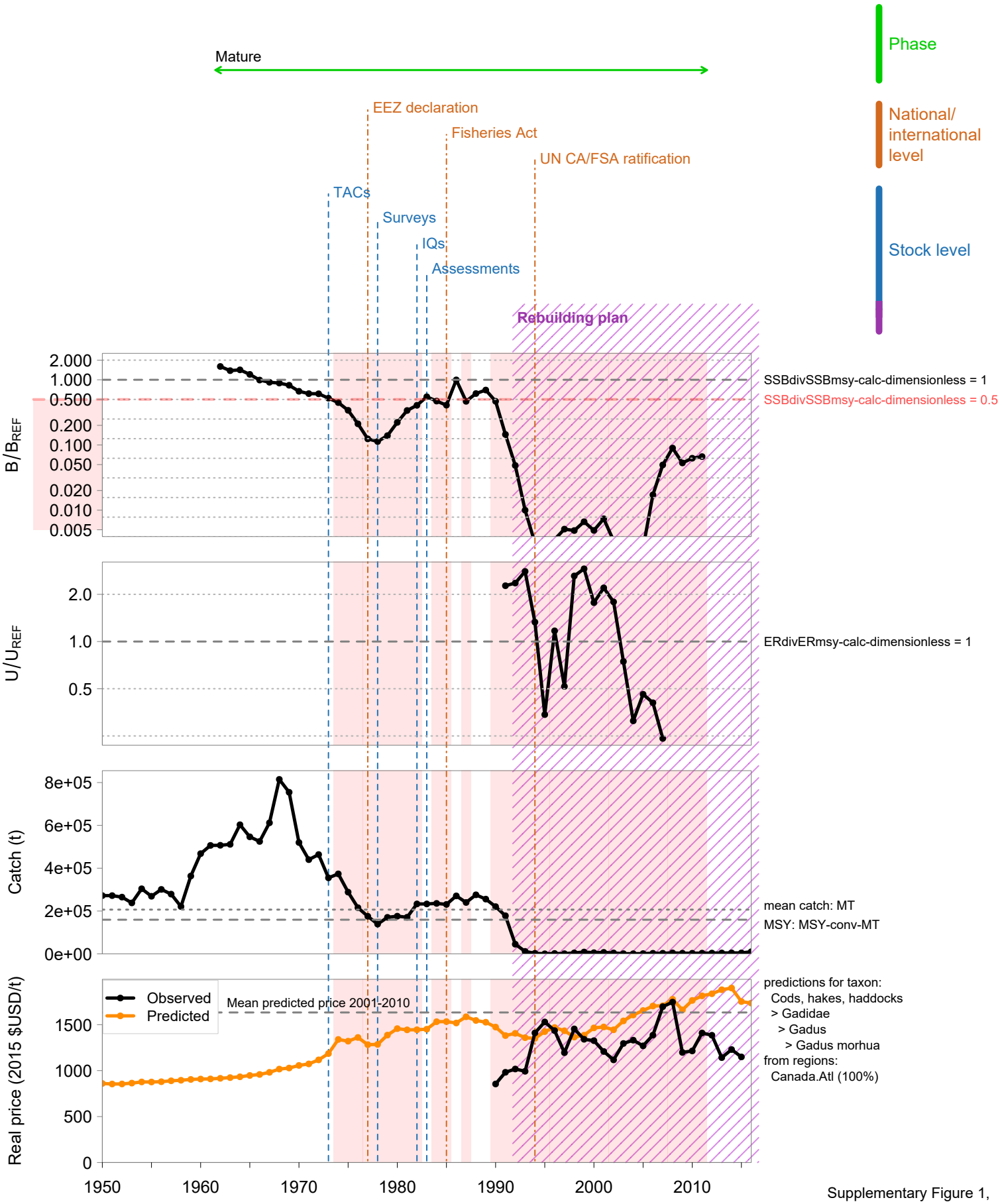
Australia -- WAREHOUWSE -- Blue warehou Western half of Southeast Australia

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Australia



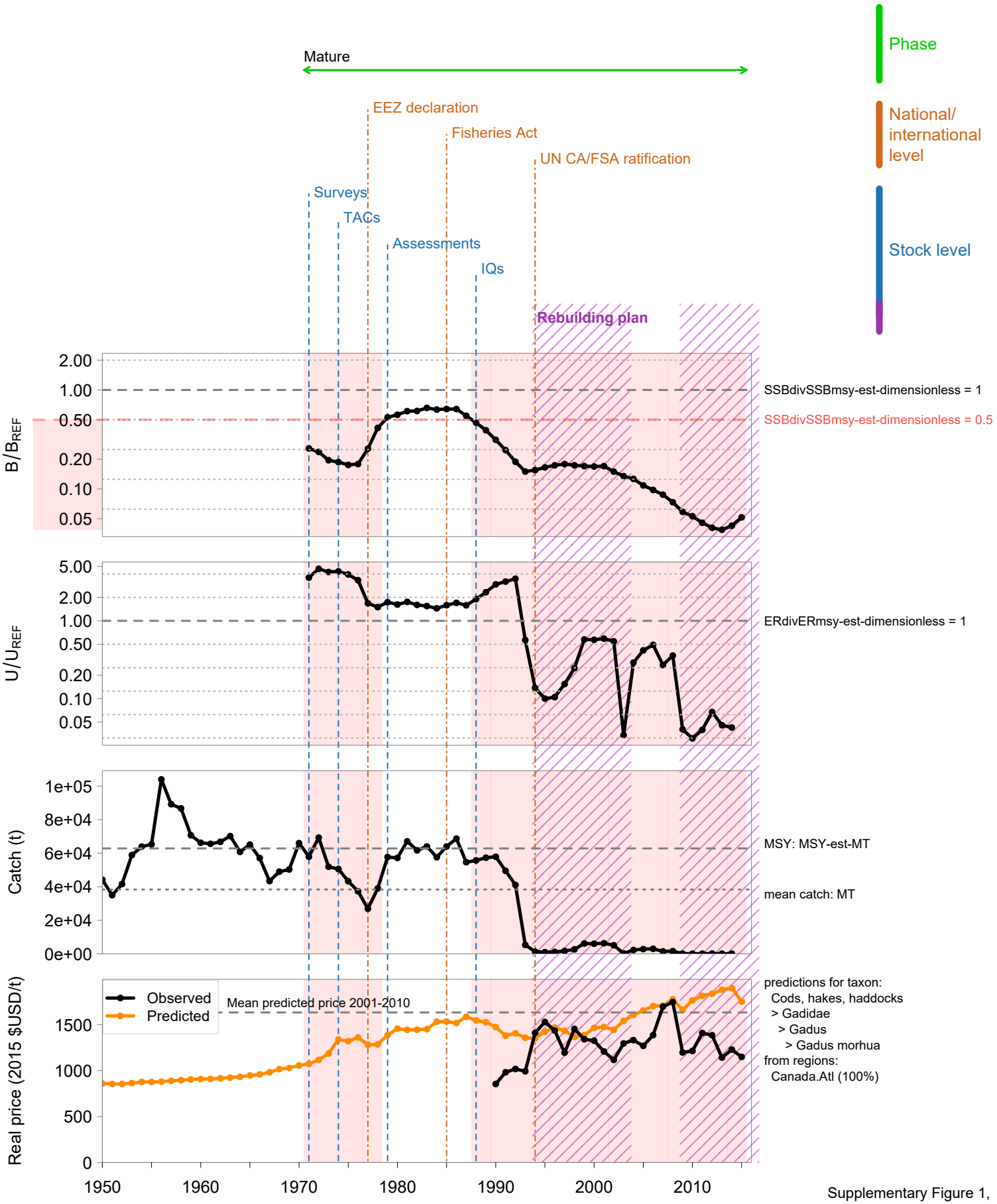
Canada-East Coast -- COD2J3KL -- Atlantic cod Southern Labrador-Eastern Newfoundland

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Canada



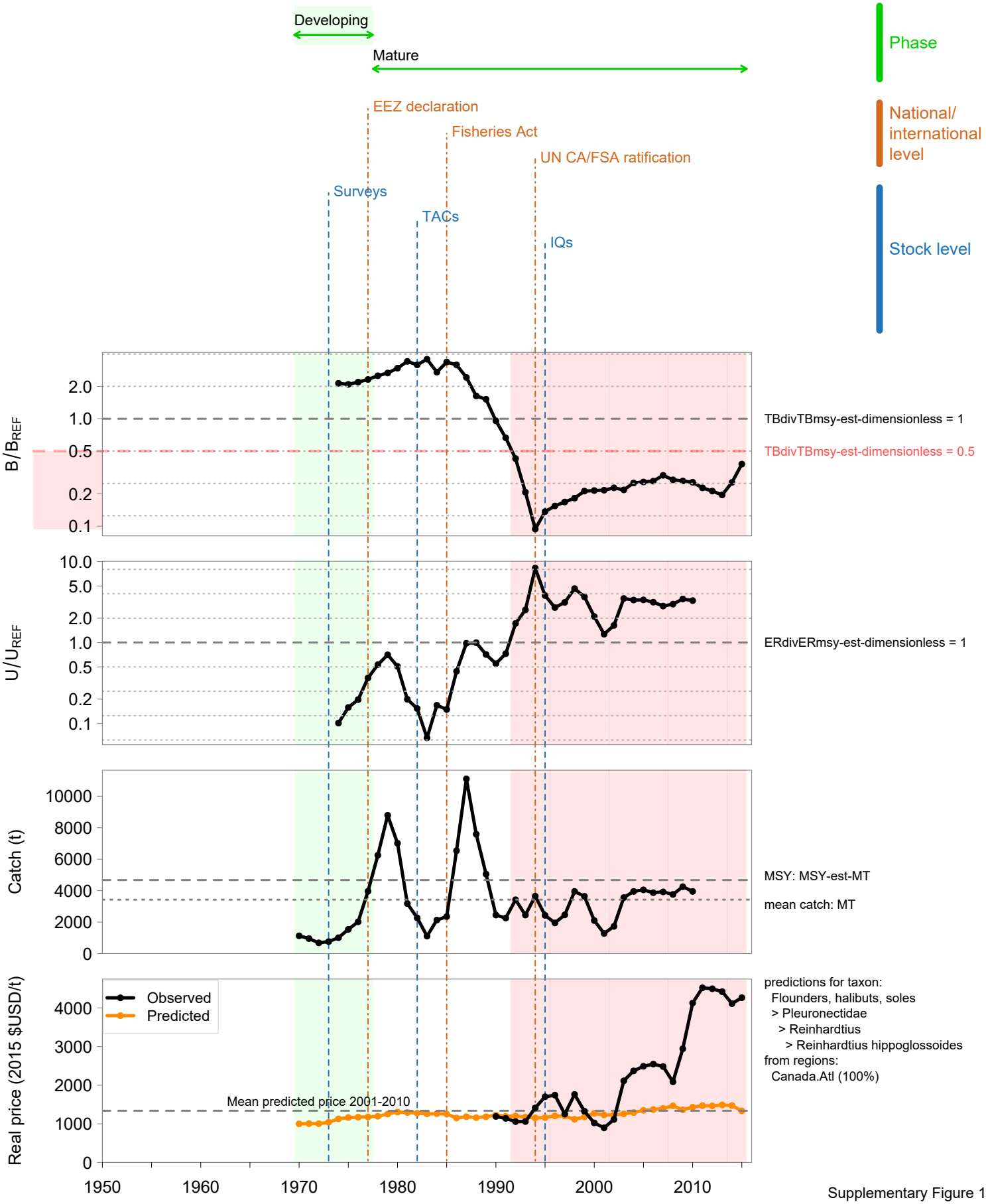
Canada-East Coast -- COD4TVn -- Atlantic cod Southern Gulf of St. Lawrence

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Canada



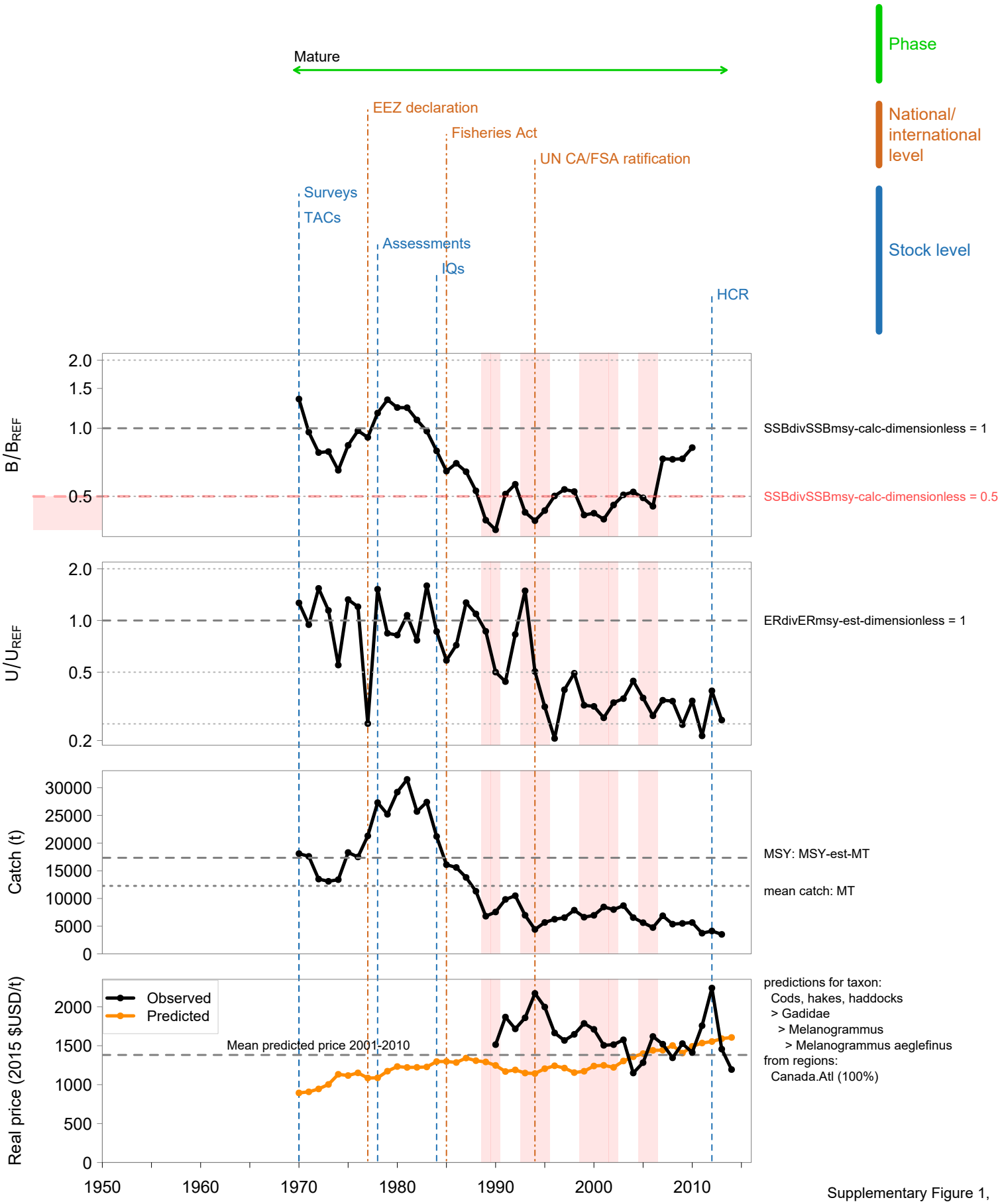
Canada-East Coast -- GHAL4RST -- Greenland halibut Gulf of St. Lawrence

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: single-species, primary country: Canada



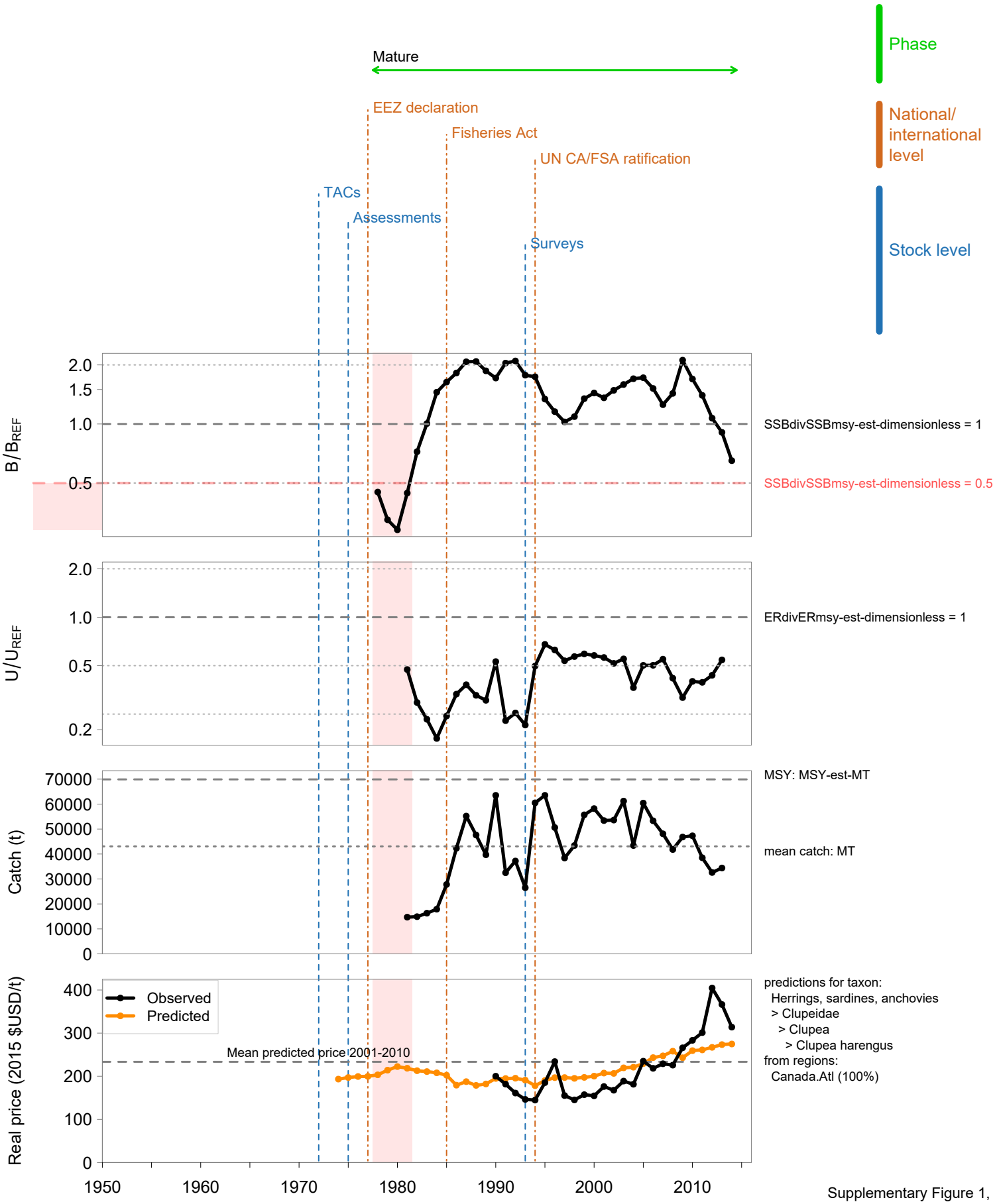
Canada-East Coast -- HAD4X5Y -- Haddock Western Scotian Shelf, Bay of Fundy and Gulf of Maine

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Canada



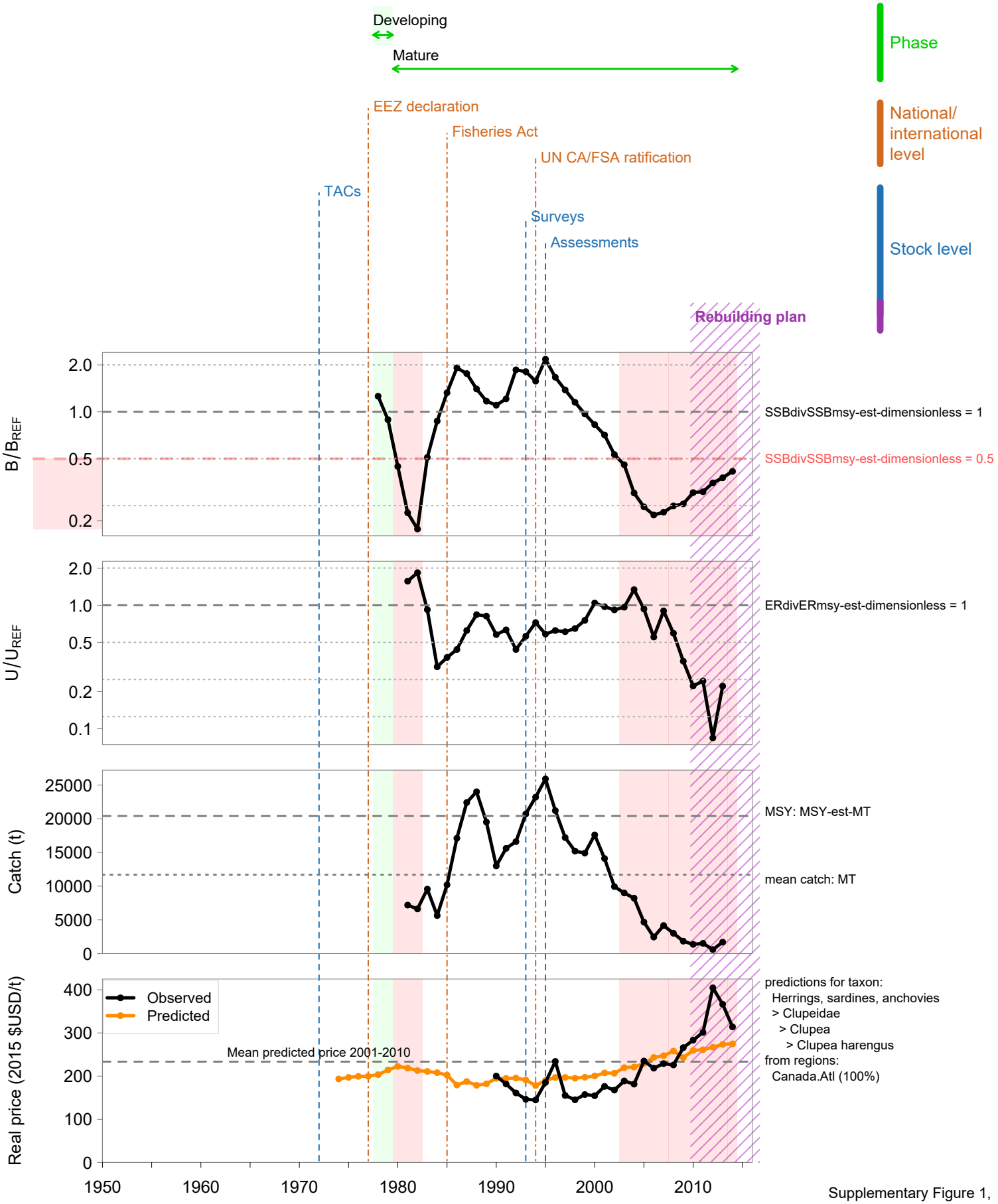
Canada-East Coast -- HERR4TFA -- Herring Southern Gulf of St. Lawrence (Fall spawners)

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



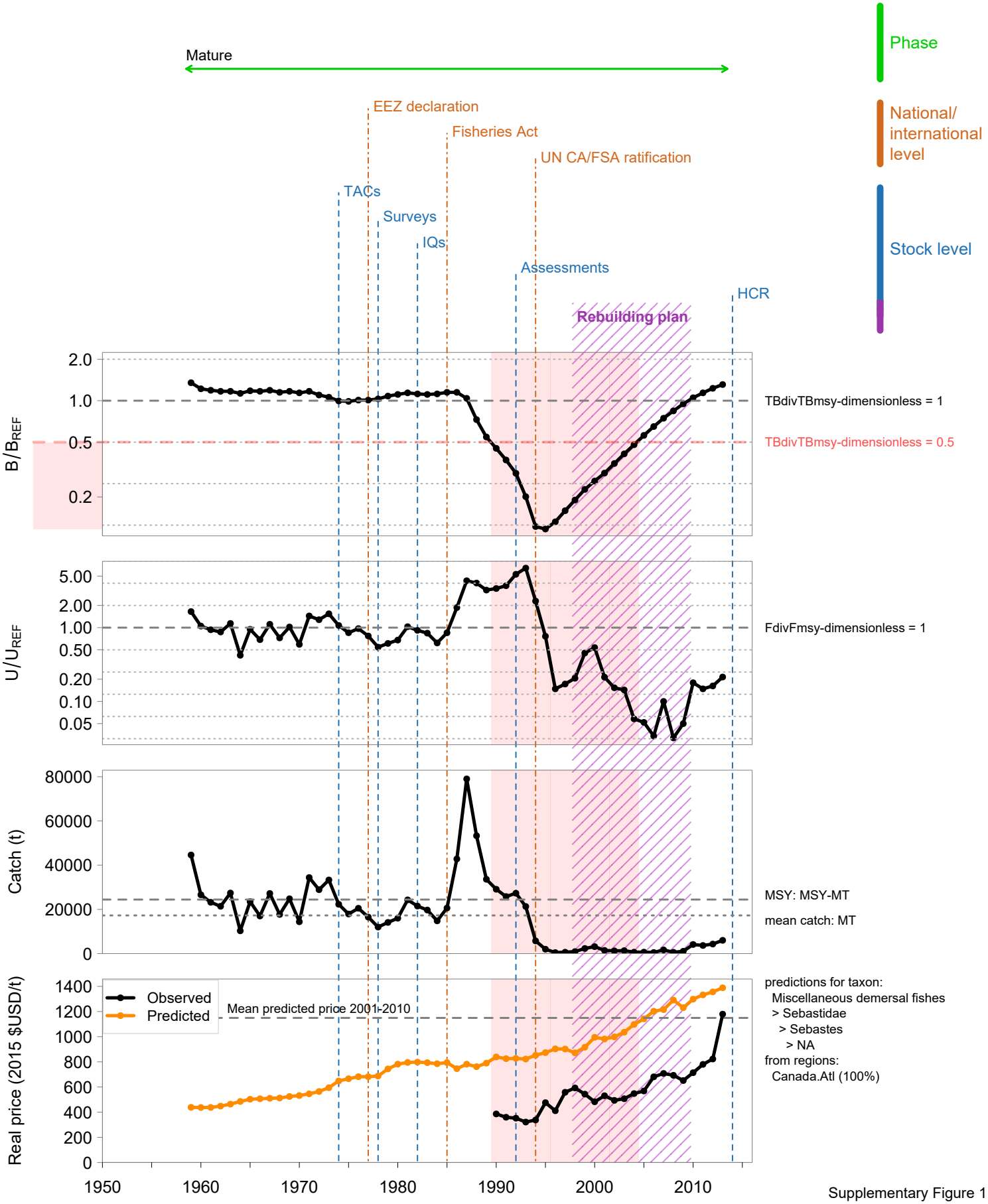
Canada-East Coast -- HERR4TSP -- Herring Southern Gulf of St. Lawrence (Spring spawners)

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



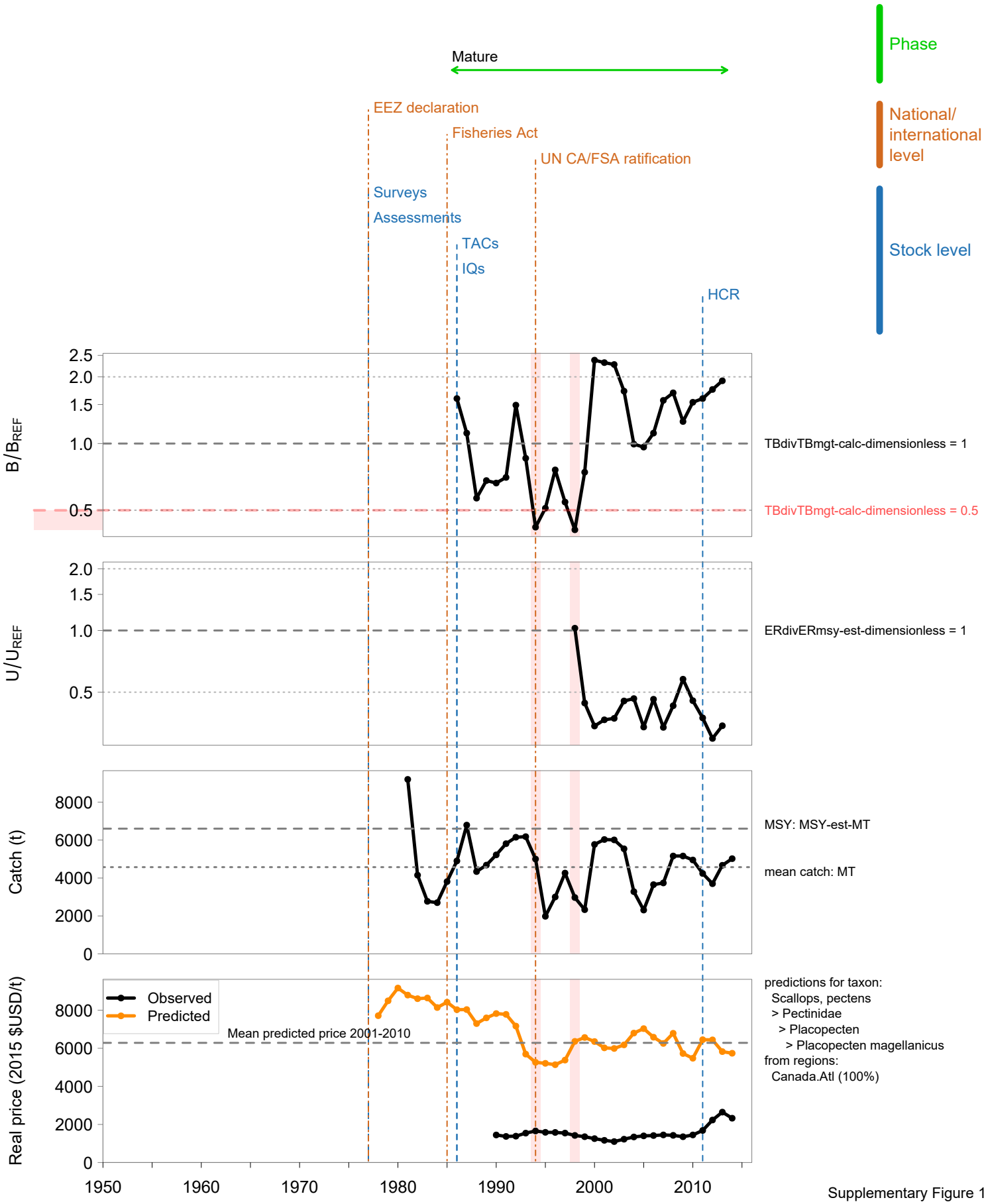
Canada-East Coast -- REDFISHSPP3LN -- Redfish species N and SW Grand Banks

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Canada



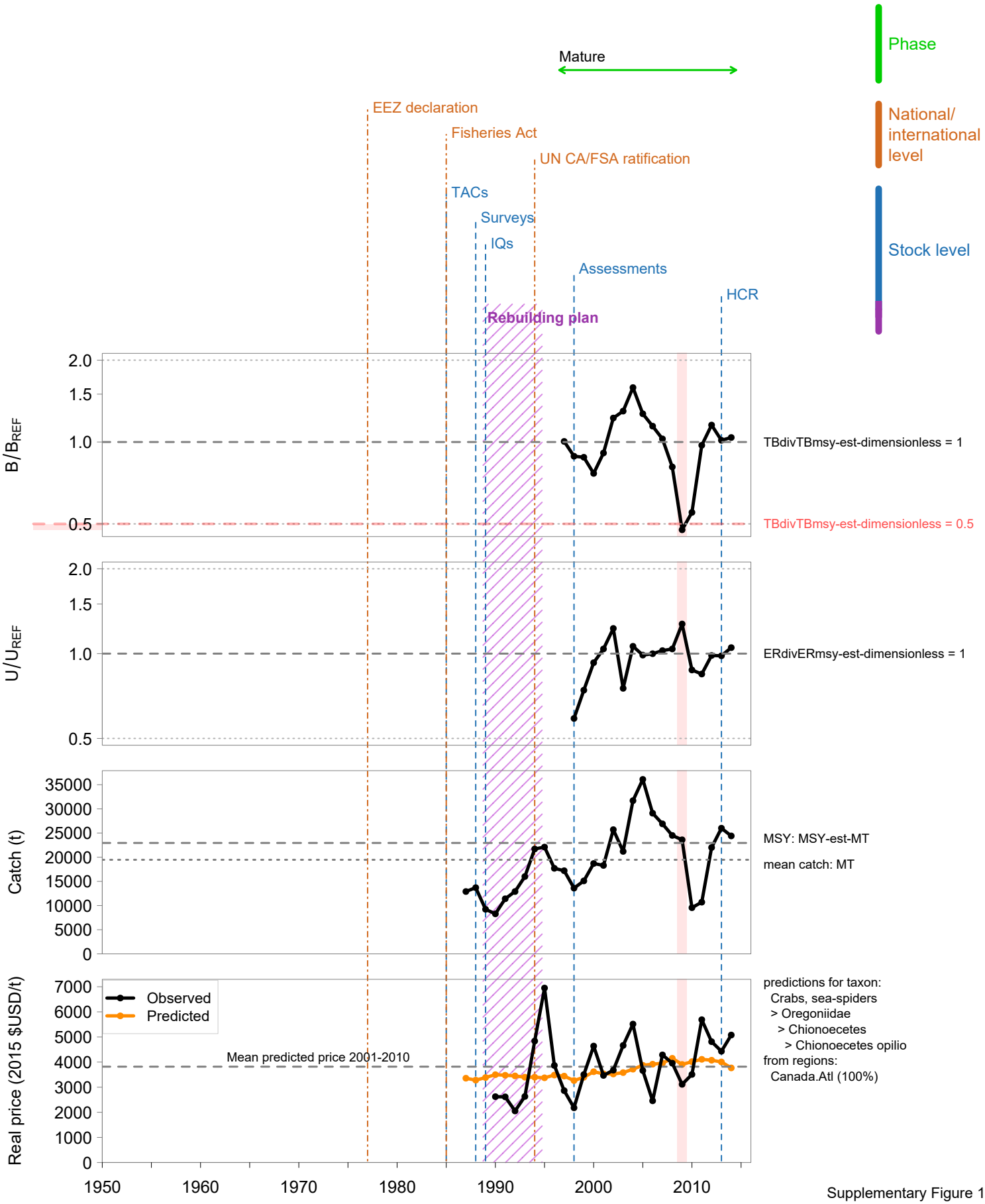
Canada-East Coast -- SCALLGB -- Sea scallop Georges Bank

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: Canada



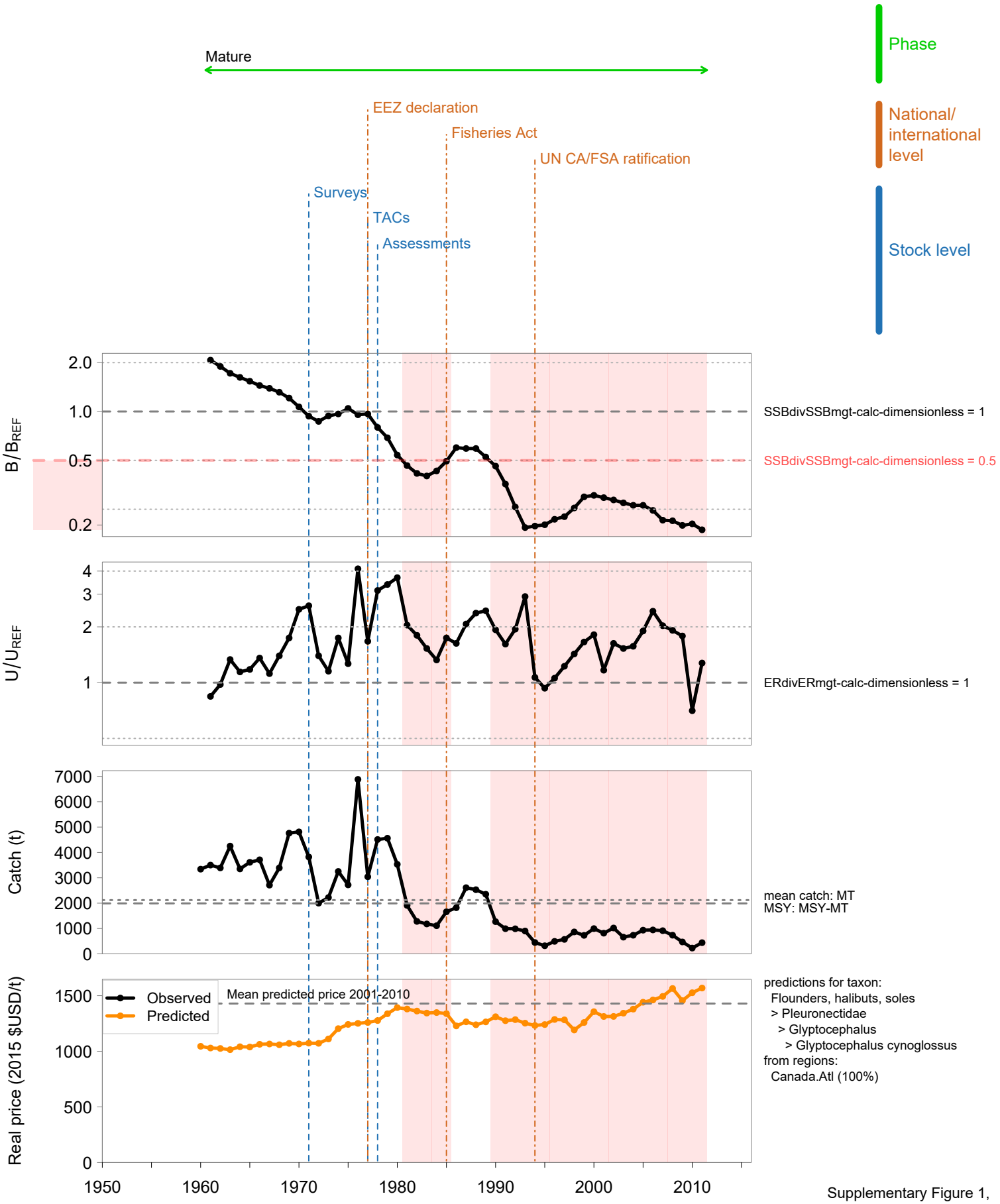
Canada-East Coast -- SNOWCRABSGSL -- Snow crab Southern Gulf of St. Lawrence

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: Canada



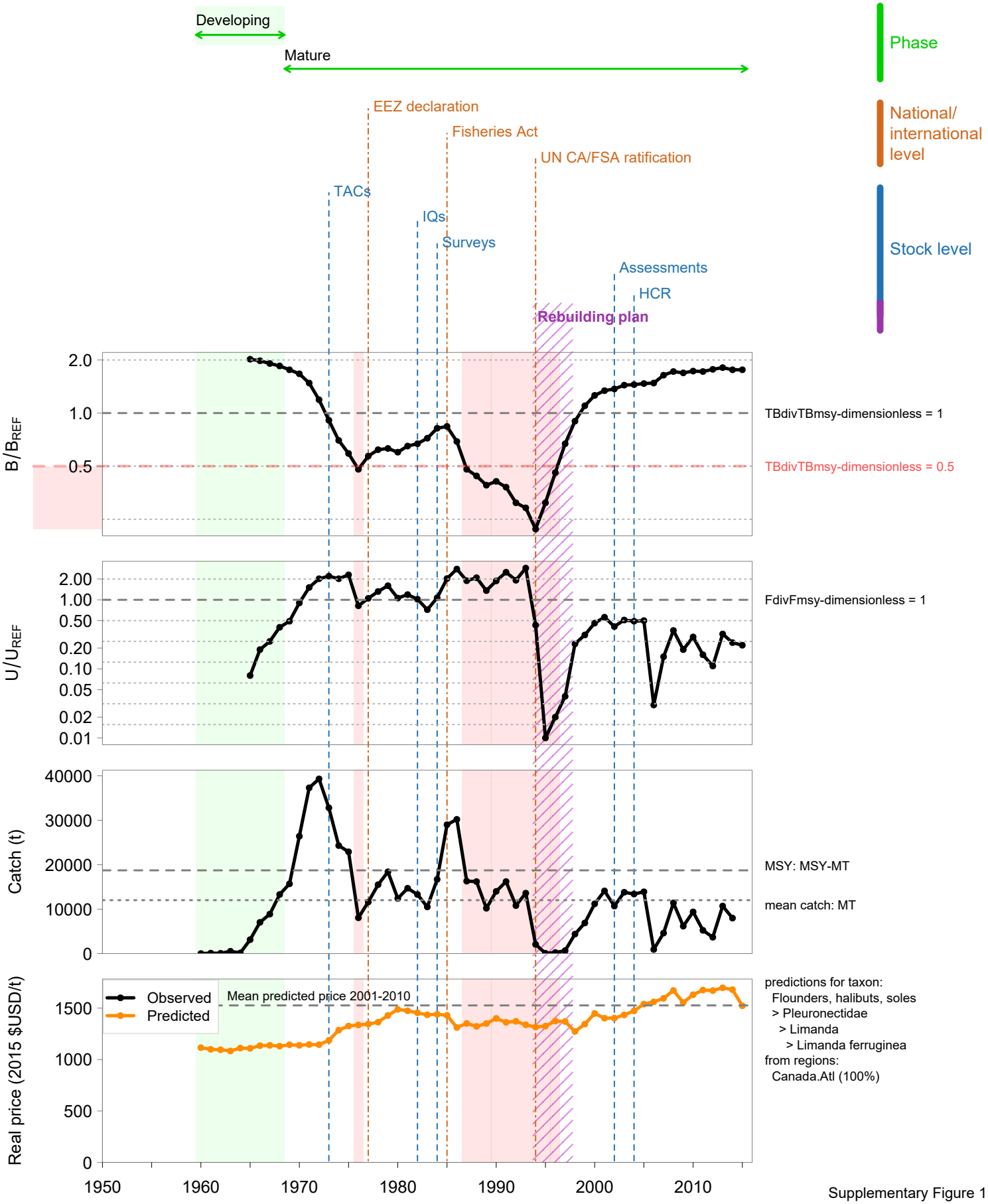
Canada-East Coast -- WITFLOUN4RST -- Witch flounder Gulf of St. Lawrence

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Canada



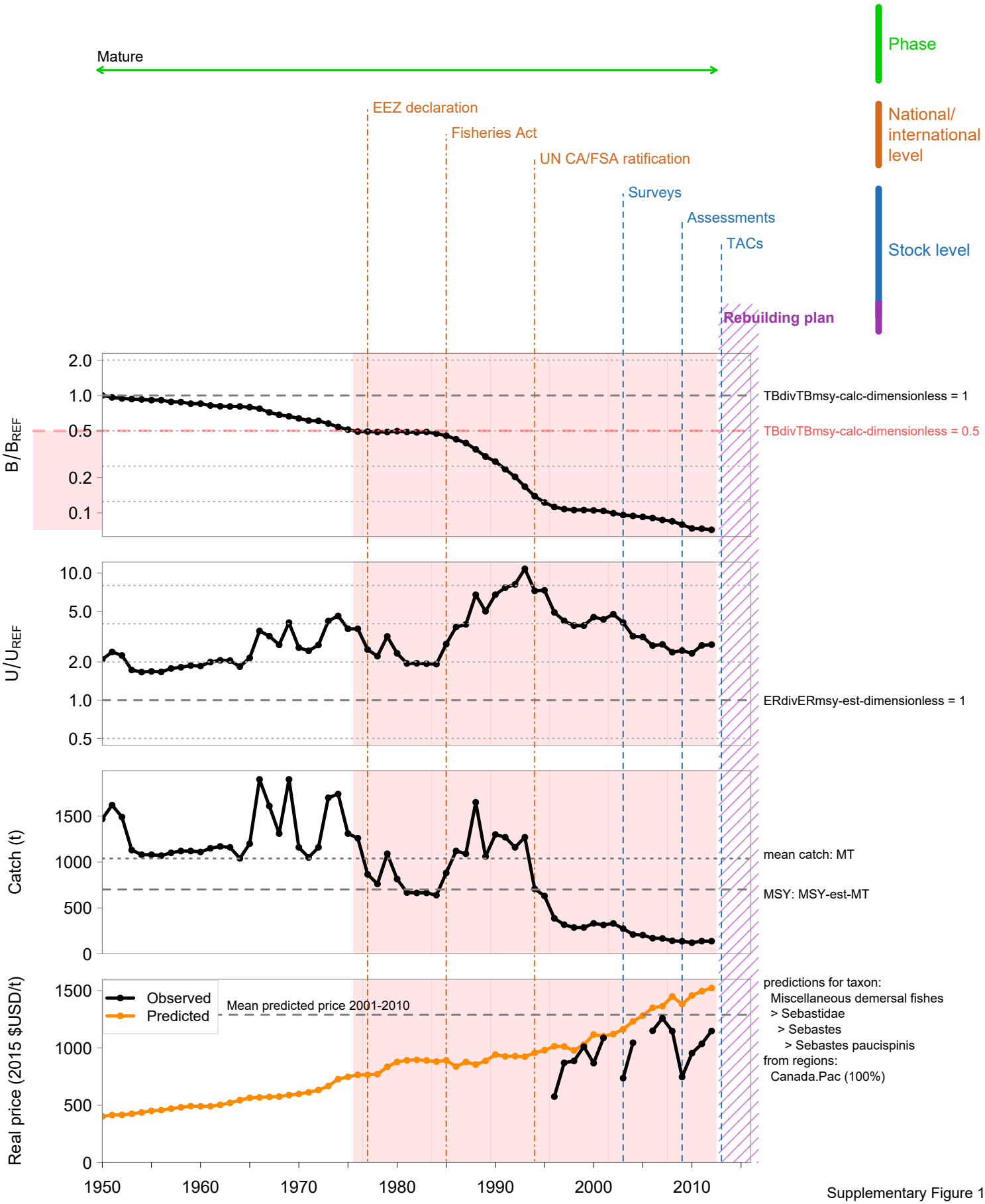
Canada-East Coast -- YELL3LNO -- Yellowtail flounder Grand Banks

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Canada



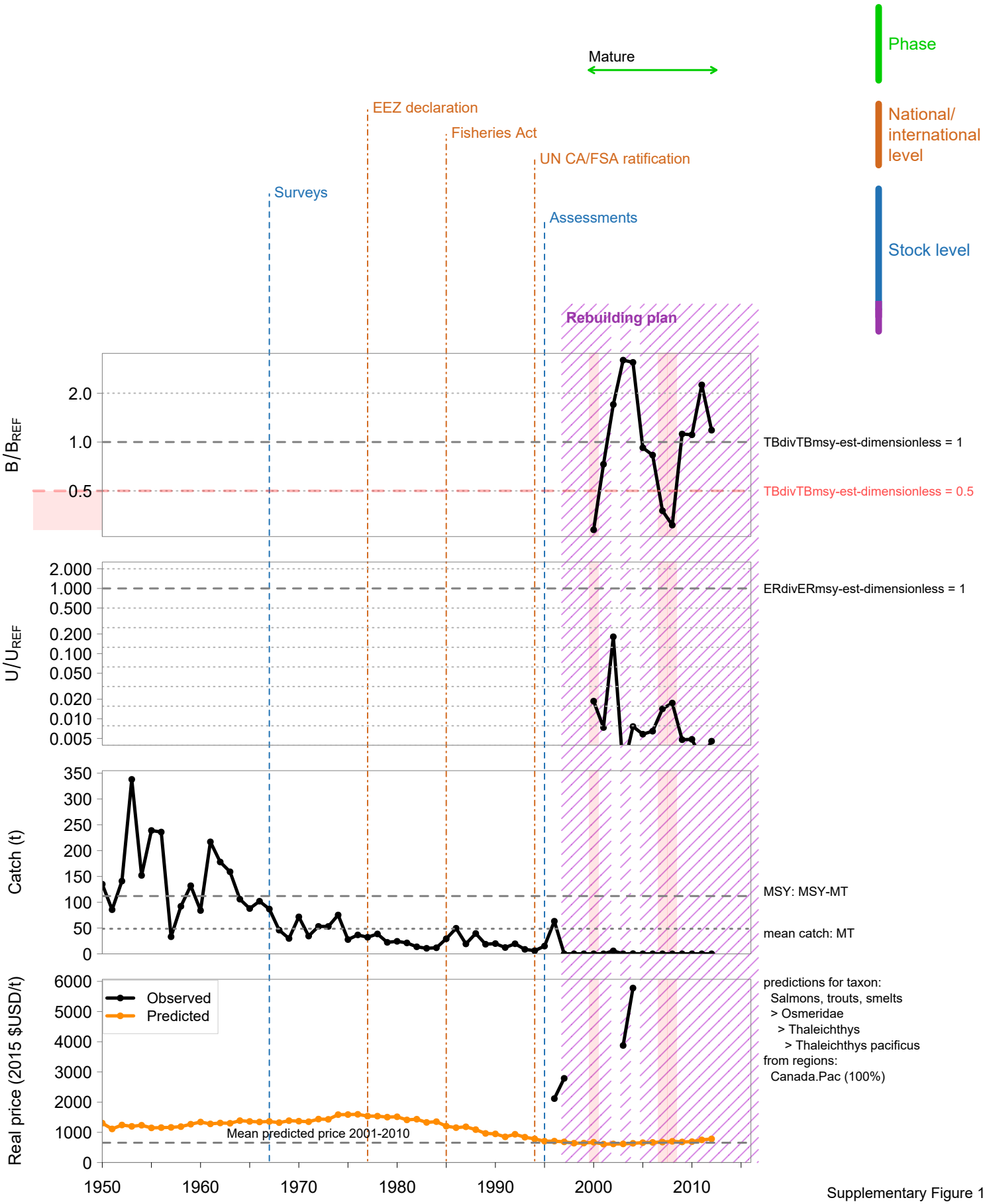
Canada-West Coast -- BOCACCBCW -- Bocaccio British Columbia Waters

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Canada



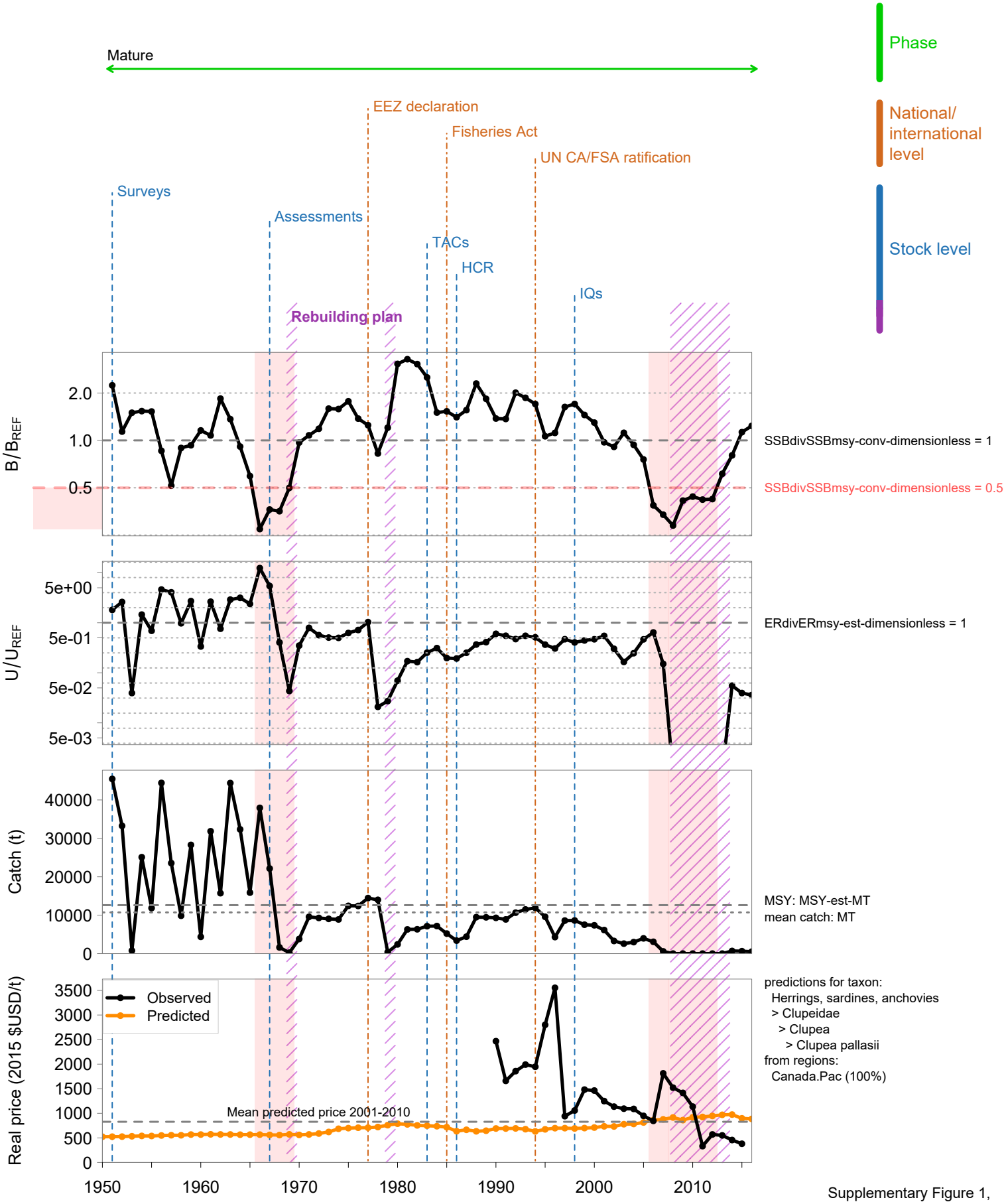
Canada-West Coast -- EULAPCOASTFRDU -- Eulachon Pacific Coast of Canada Fraser River Designatable Unit

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Canada



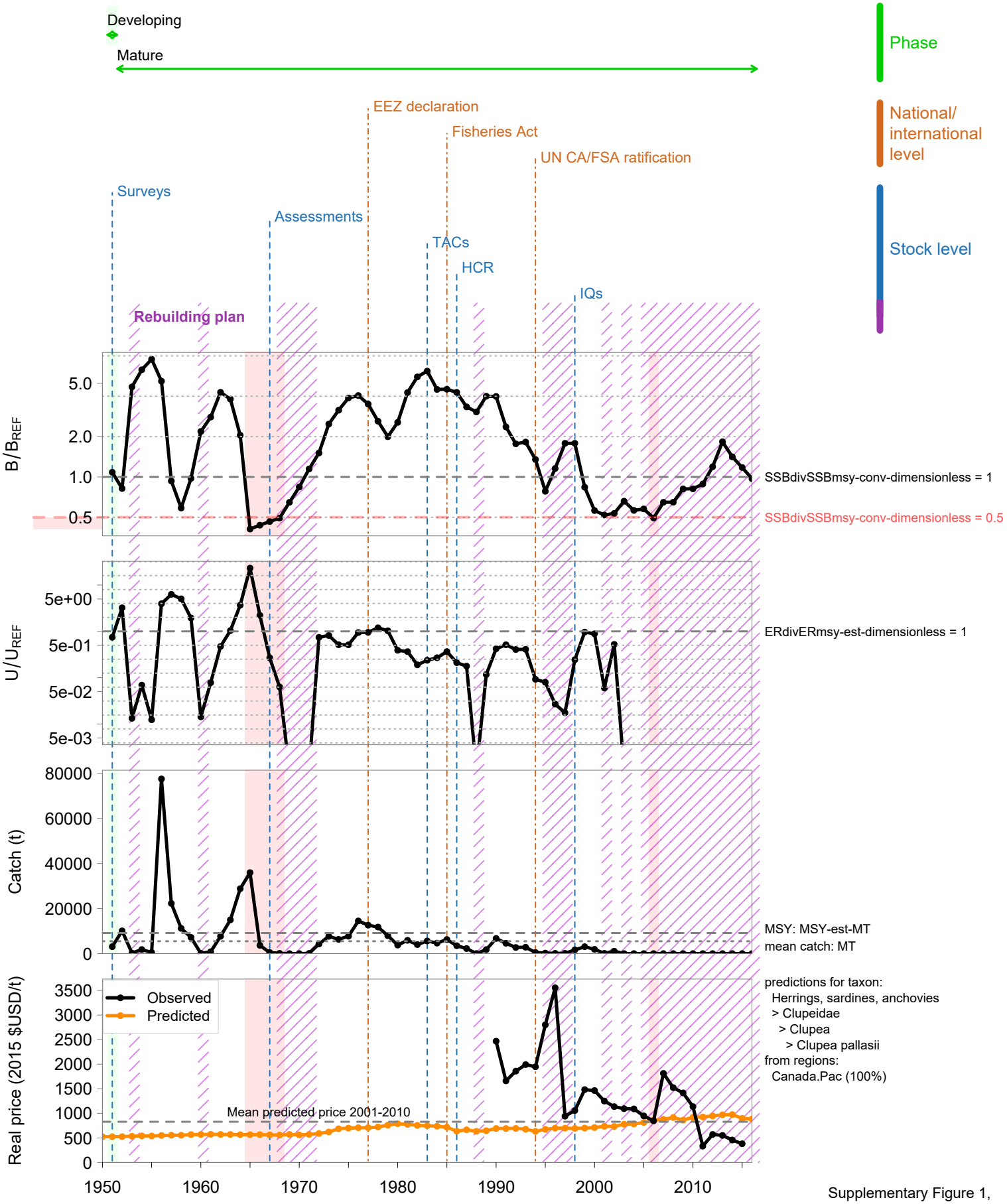
Canada-West Coast -- HERRCC -- Pacific herring Central Coast

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



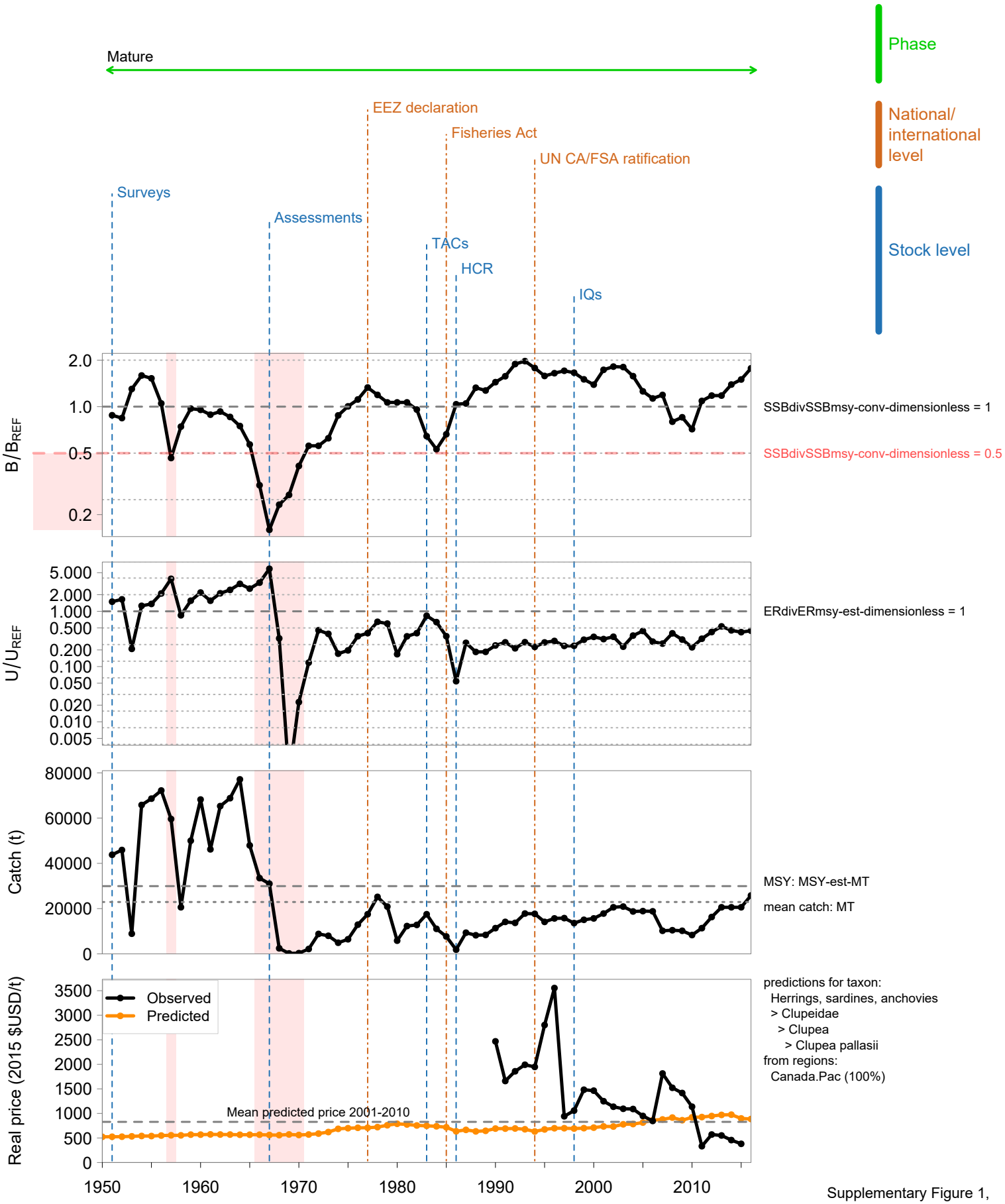
Canada-West Coast -- HERRQCI -- Pacific herring Queen Charlotte Islands

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



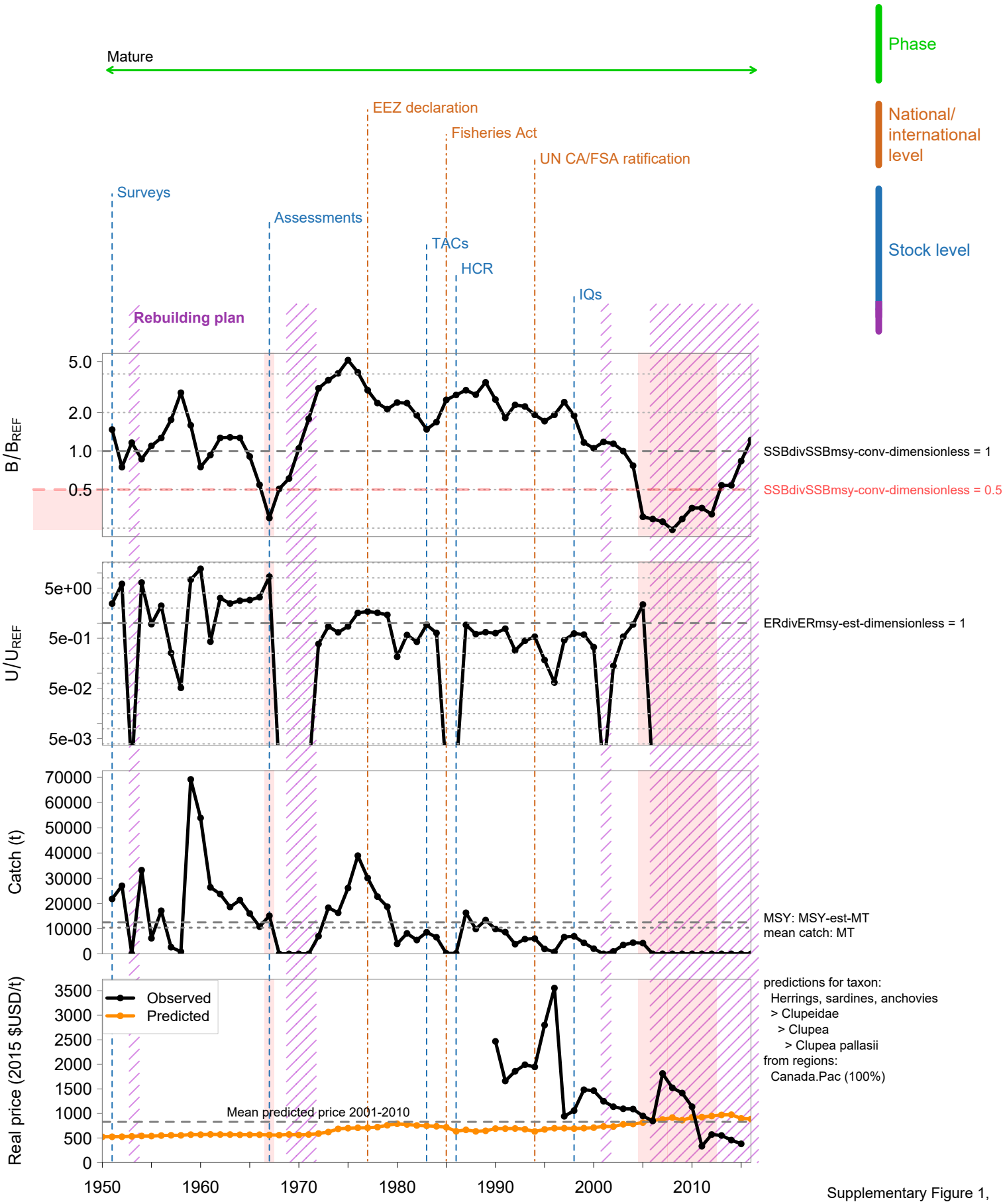
Canada-West Coast -- HERRSOG -- Pacific herring Strait of Georgia

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



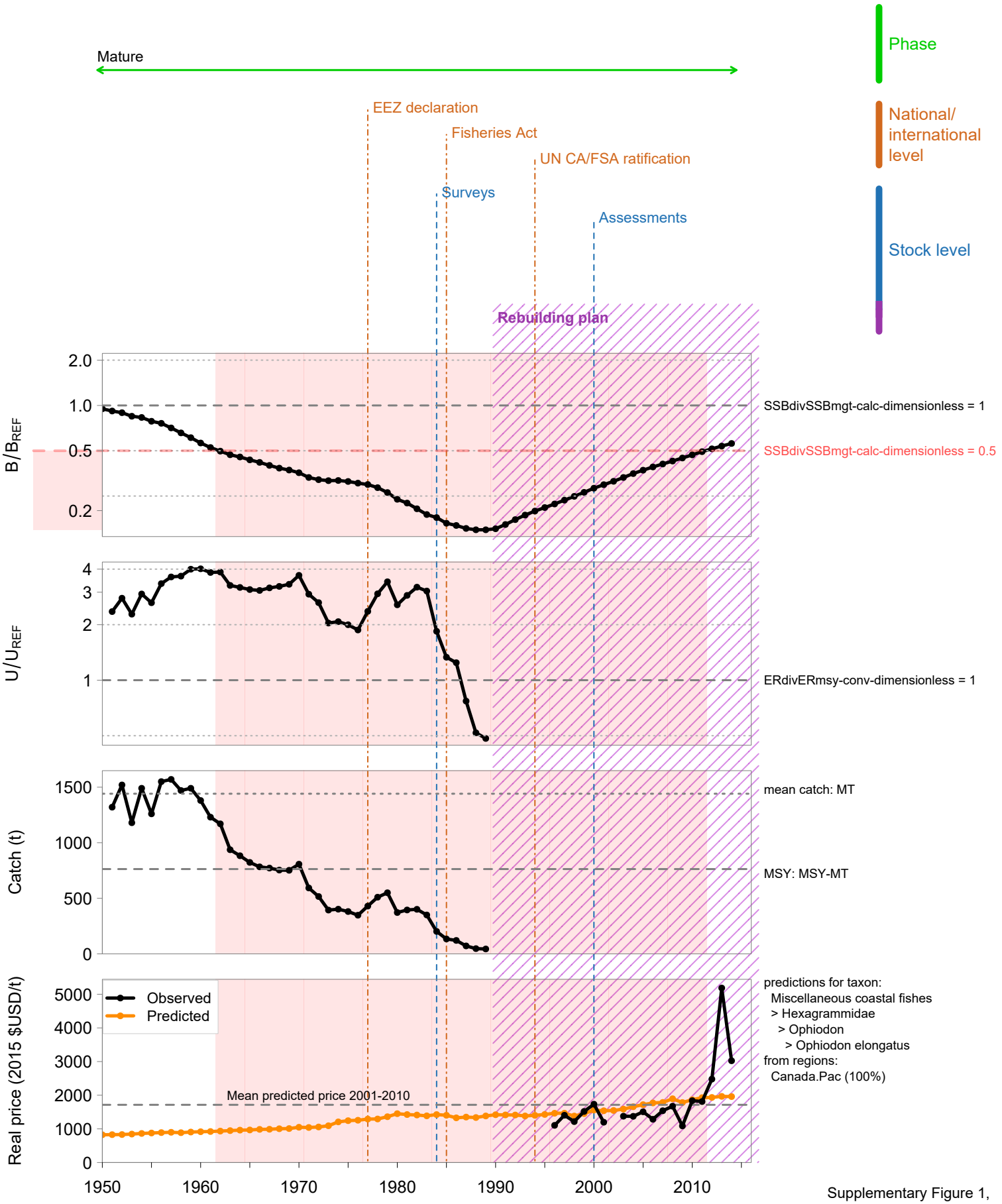
Canada-West Coast -- HERRWCVANI -- Pacific herring West Coast of Vancouver Island

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Canada



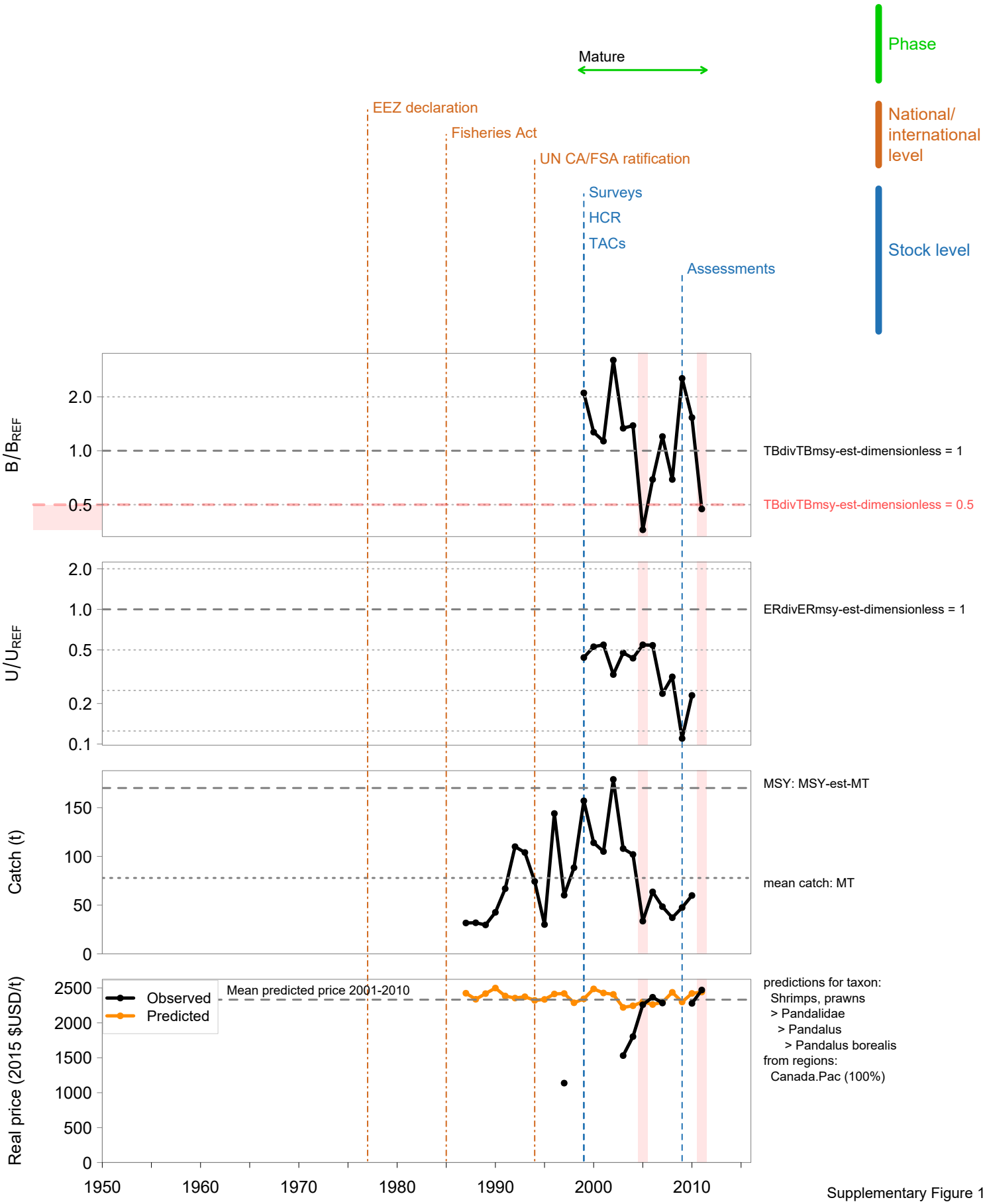
Canada-West Coast -- LINGCODSOG -- Lingcod Strait of Georgia

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Canada



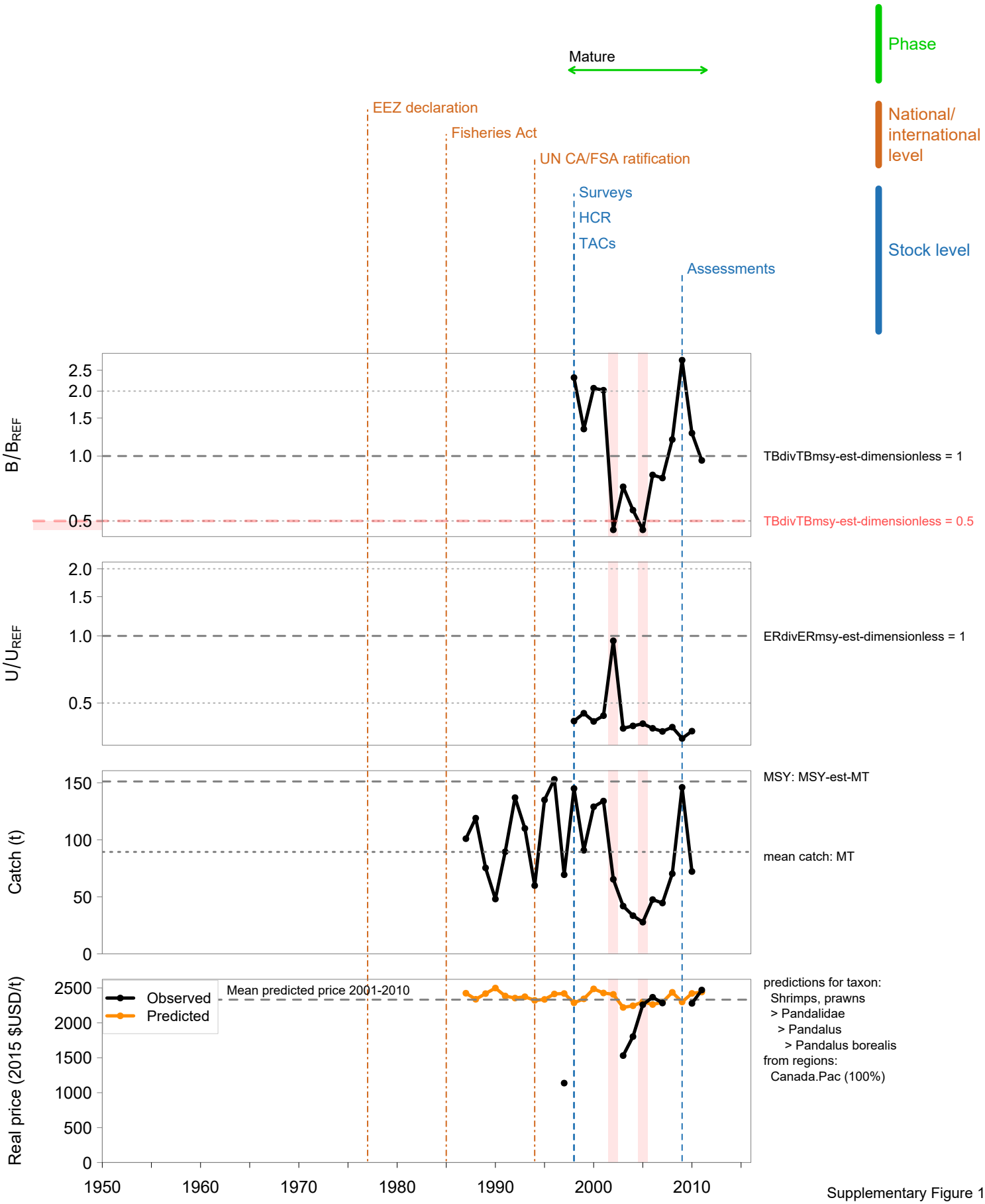
Canada-West Coast -- PANDALSMA14 -- Northern shrimp Shrimp Management Area 14

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Canada



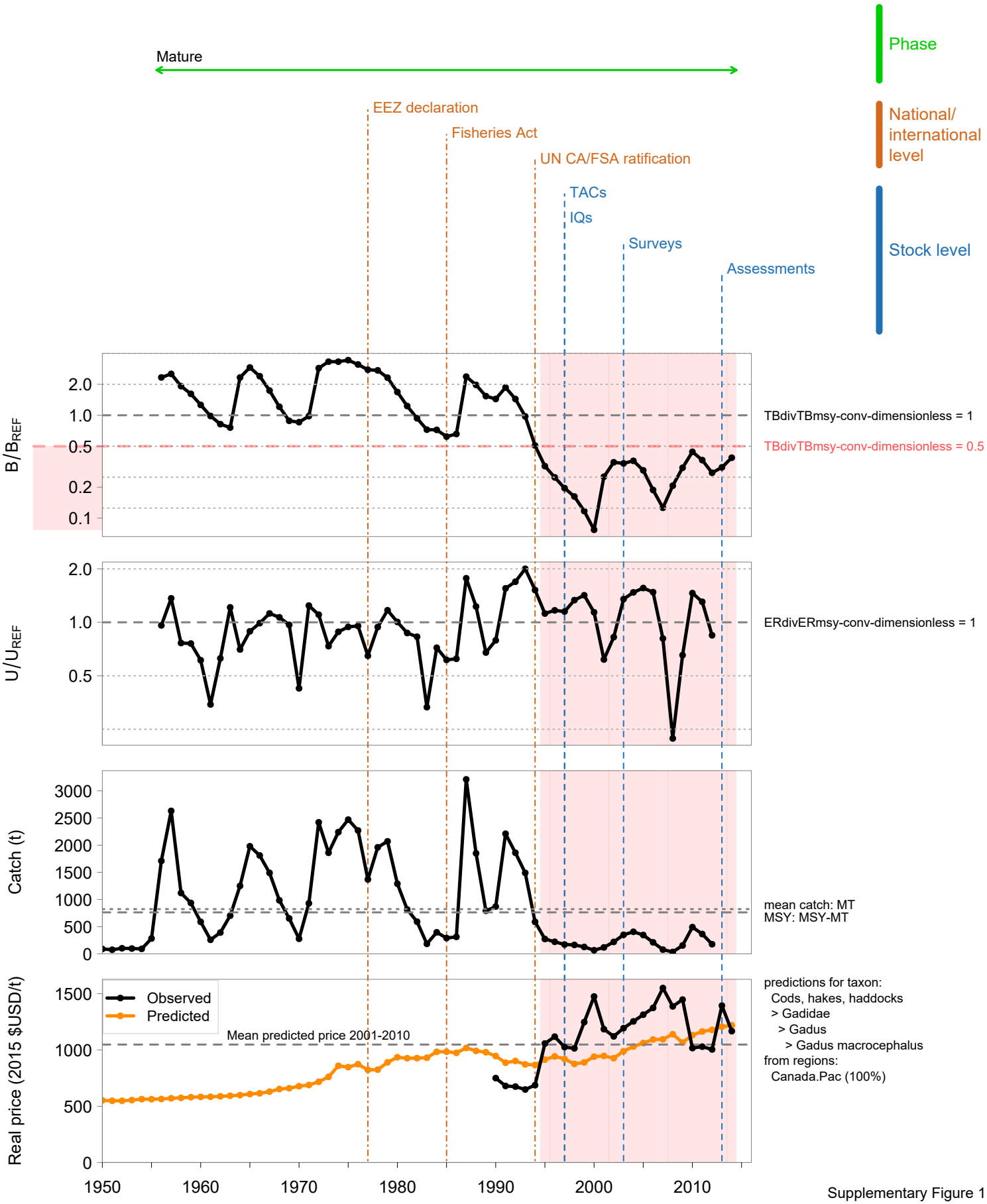
Canada-West Coast -- PANDALSMAFR -- Northern shrimp Shrimp Management Area FR

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Canada



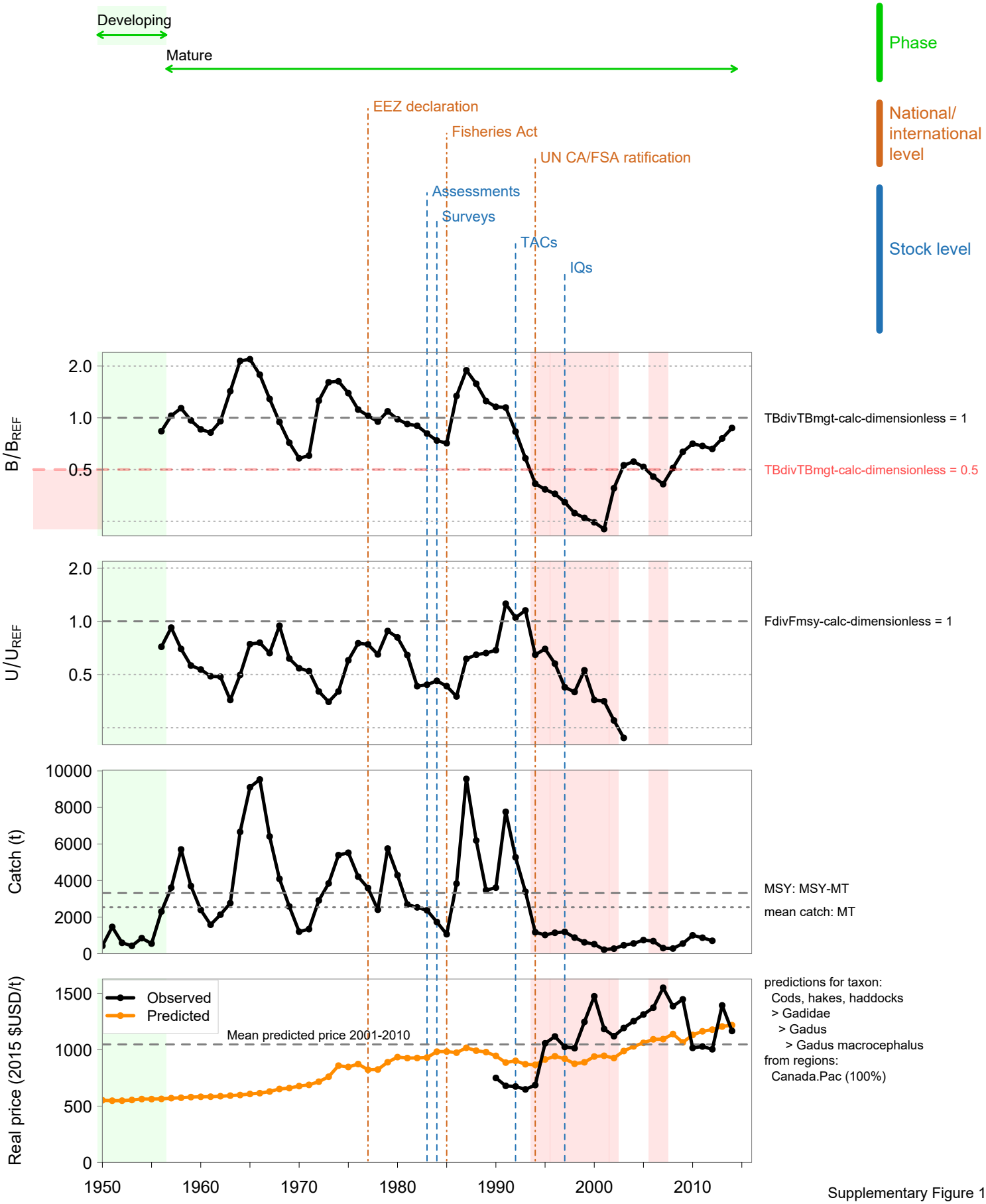
Canada-West Coast -- PCOD5AB -- Pacific cod Queen Charlotte Sound

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Canada



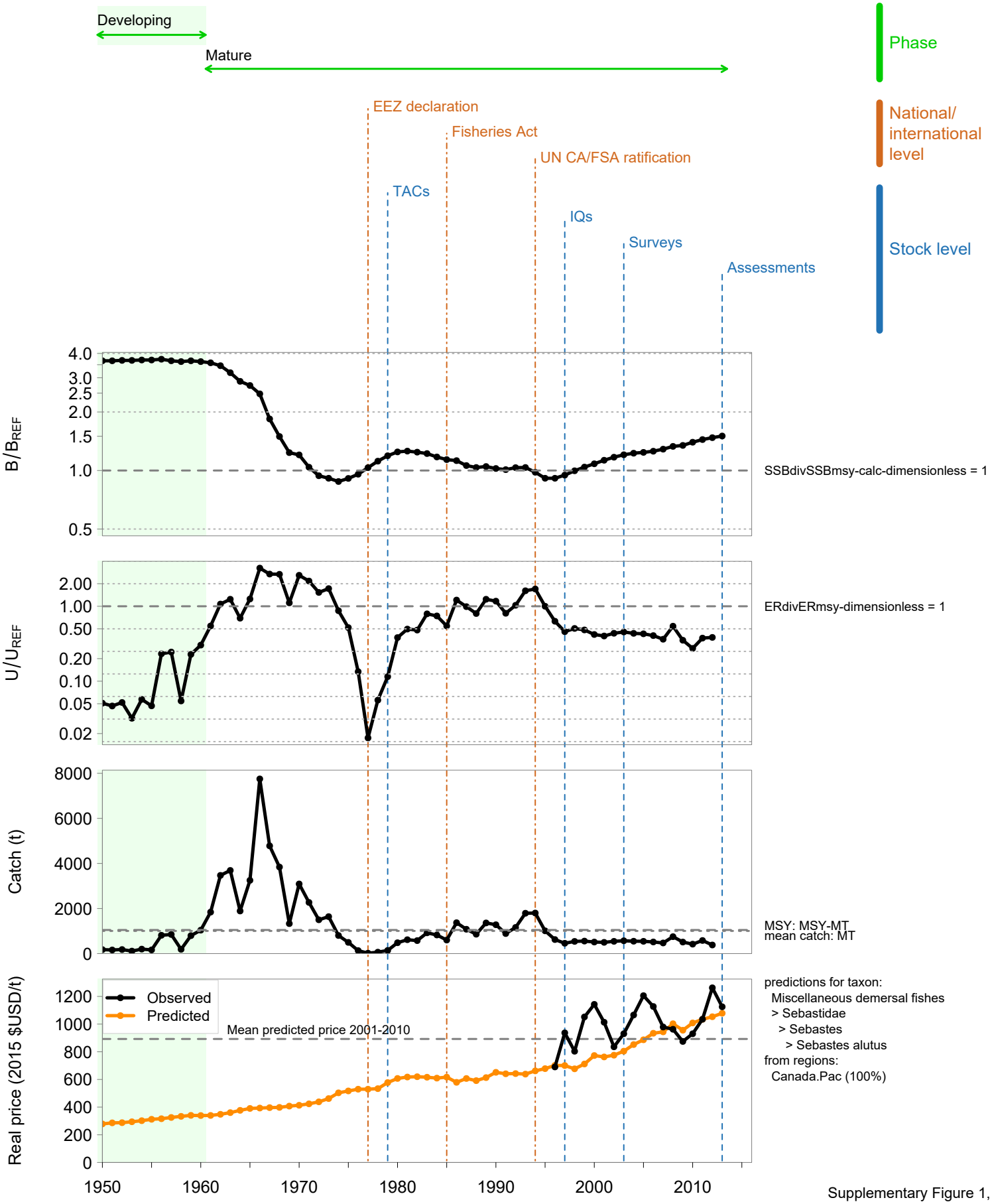
Canada-West Coast -- PCODHS -- Pacific cod Hecate Strait

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Canada



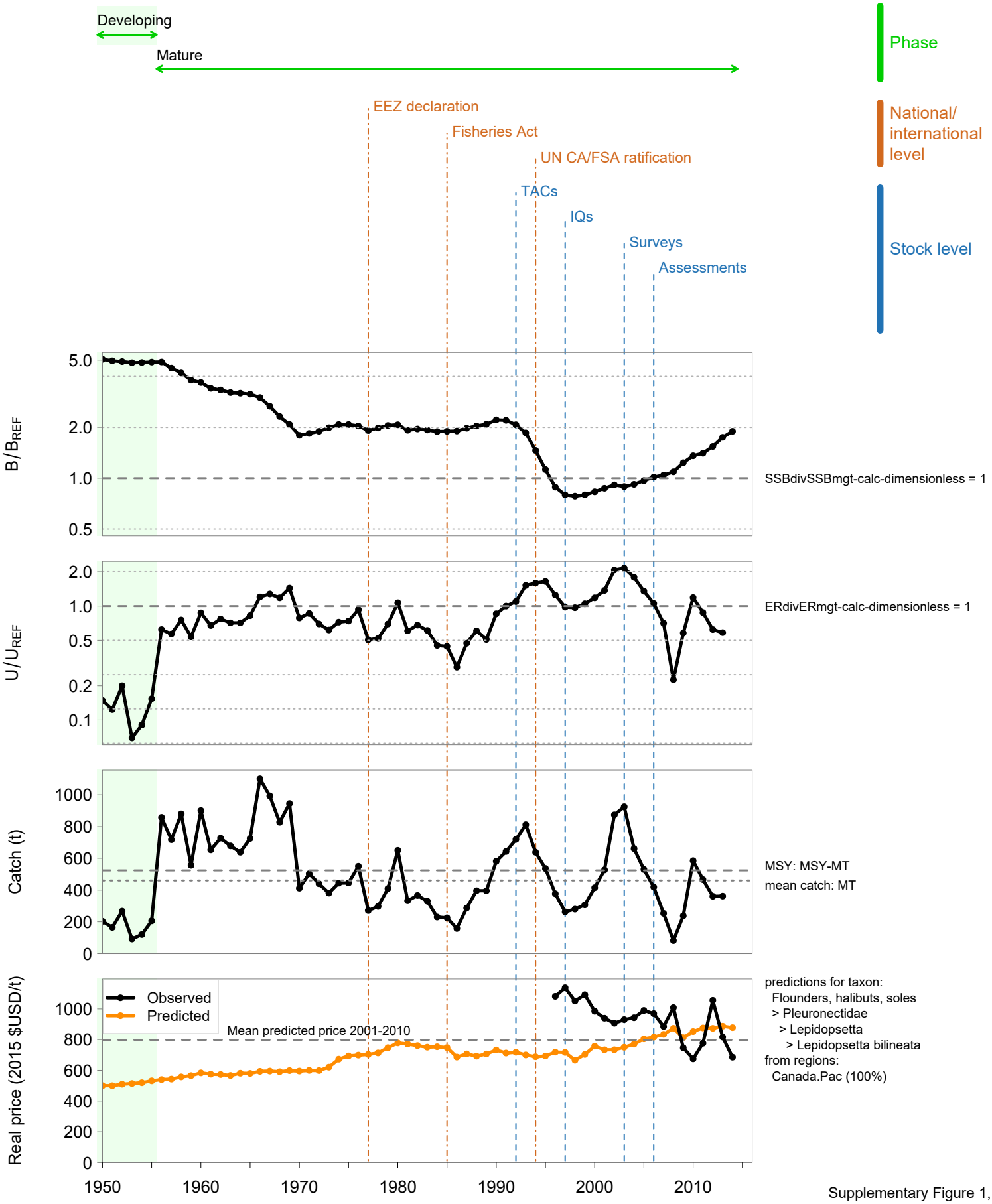
Canada-West Coast -- PERCHWCVANI -- Pacific ocean perch West Coast of Vancouver Island

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Canada



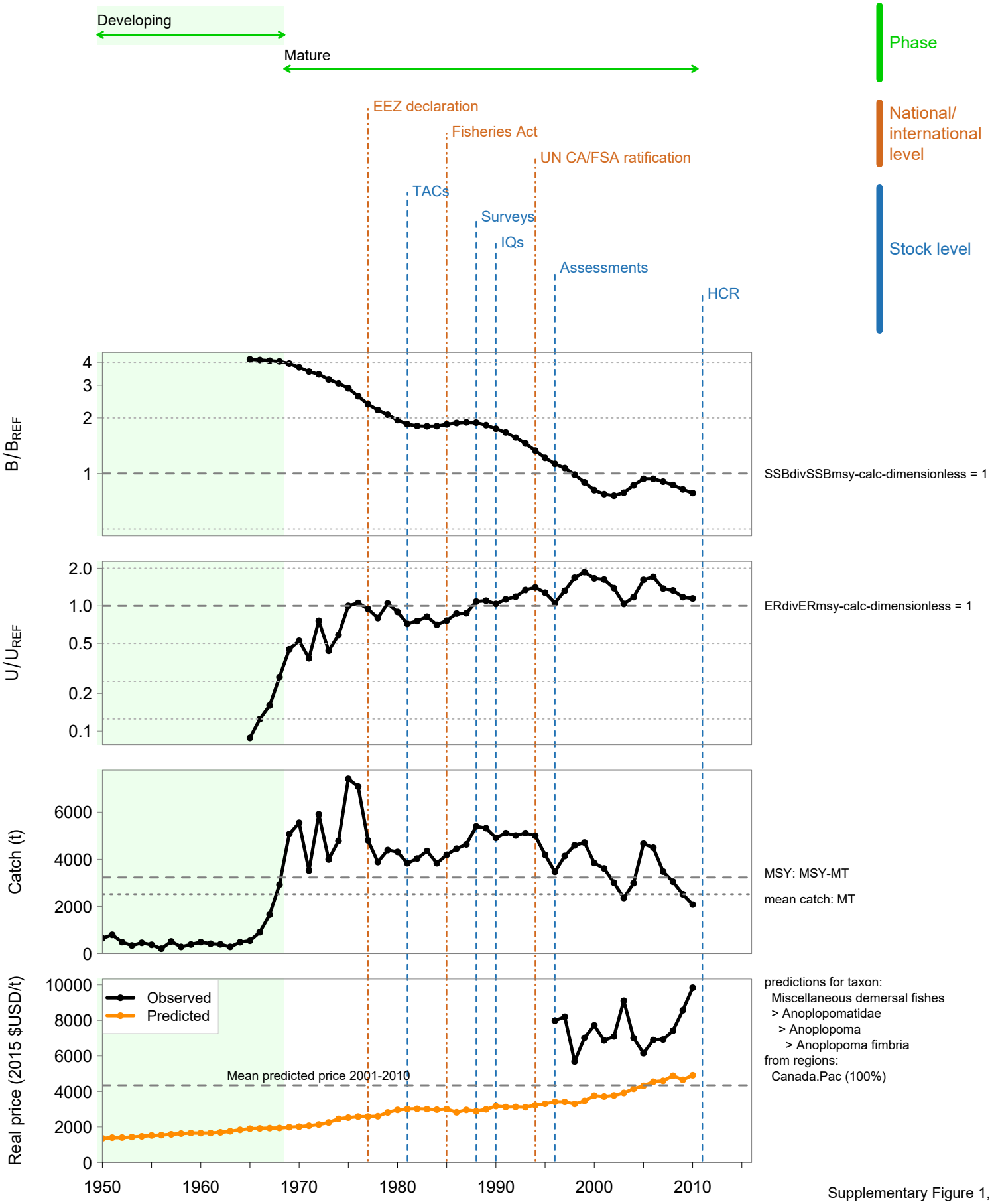
Canada-West Coast -- RSOLE5AB -- Rock sole Queen Charlotte Sound

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Canada



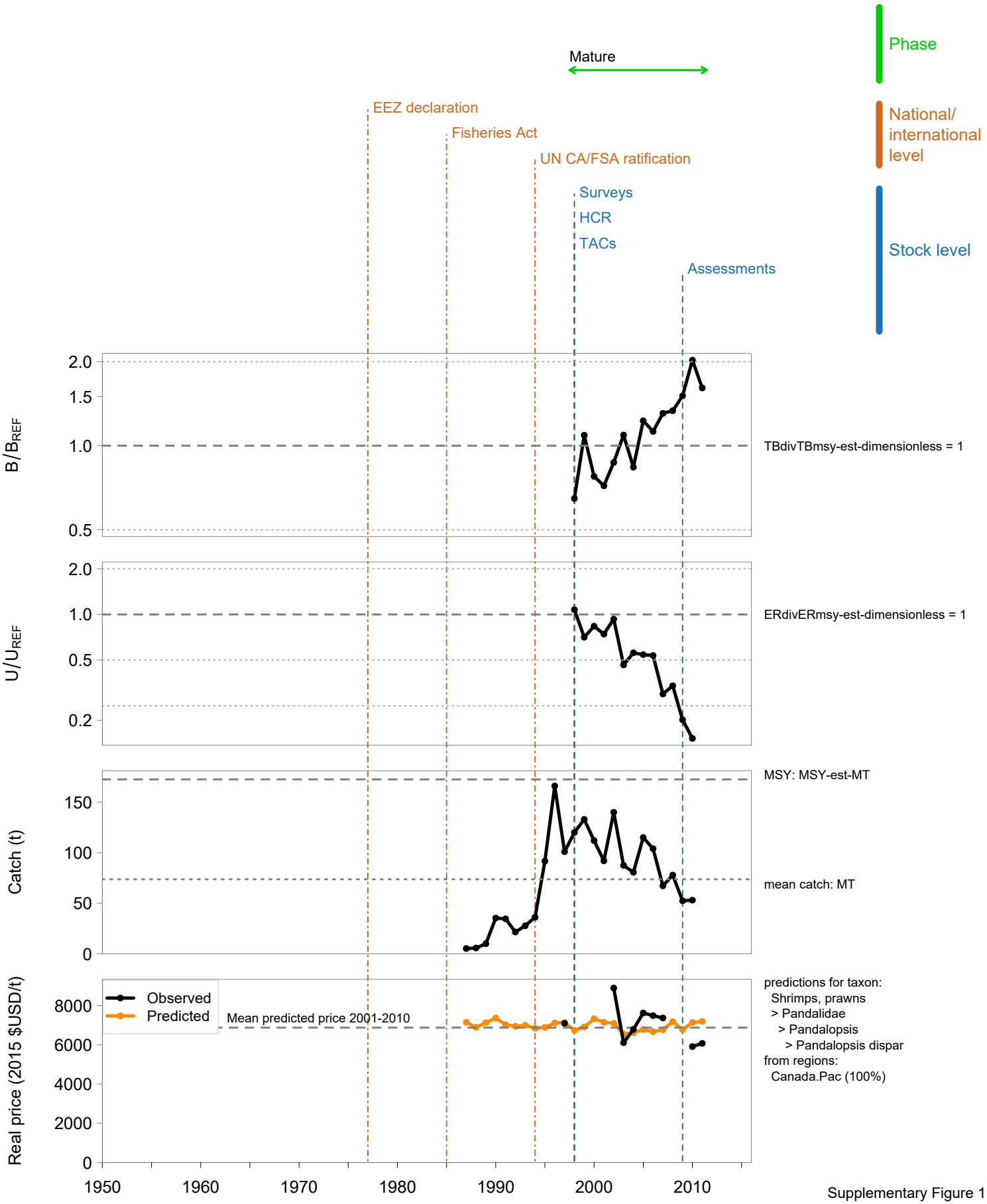
Canada-West Coast -- SABLEFPCAN -- Sablefish Pacific Coast of Canada

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: single-species, primary country: Canada



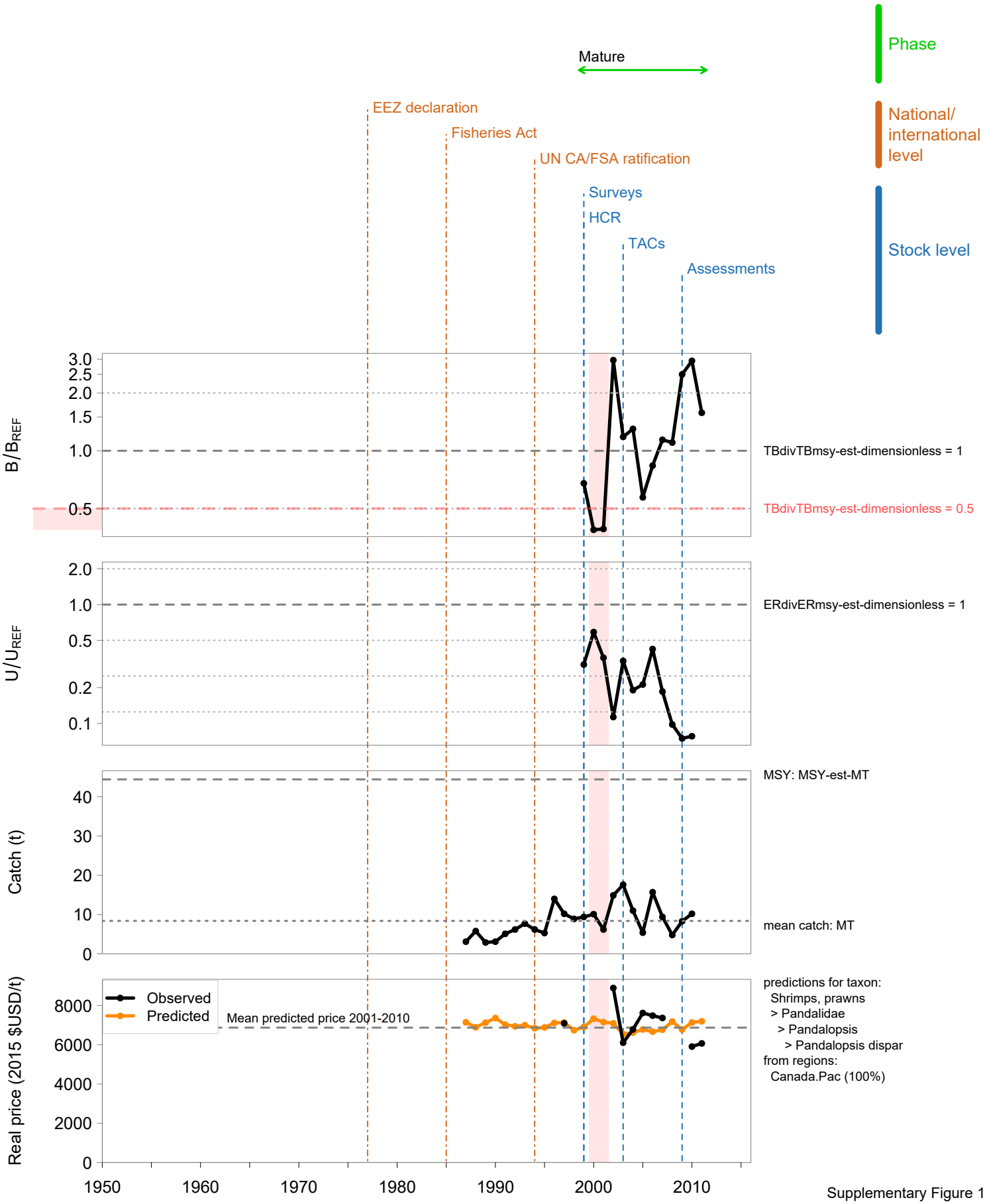
Canada-West Coast -- SSHRIMPSMAPRD -- Sidestripe shrimp Shrimp Management Area PRD

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Canada



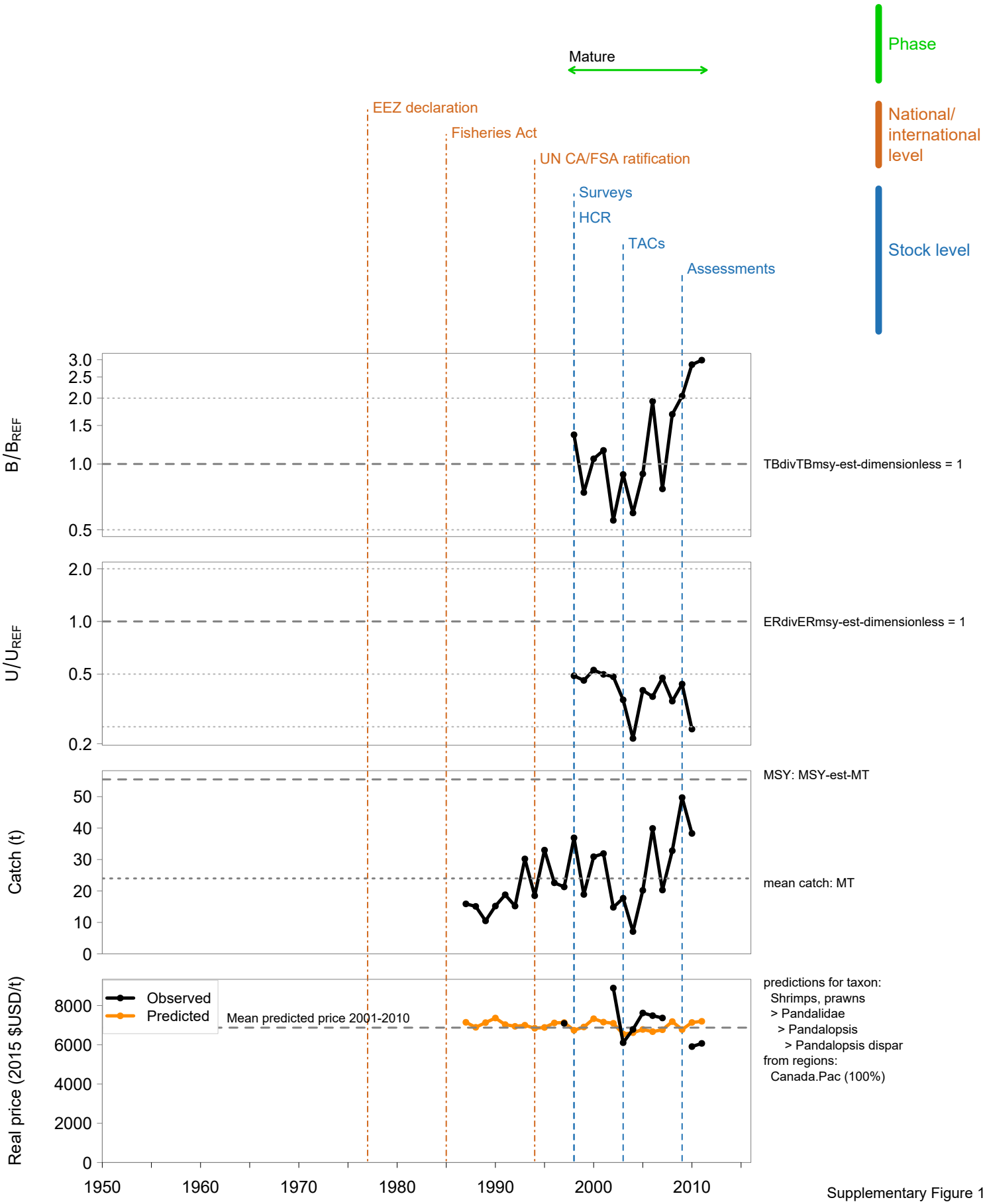
Canada-West Coast -- SSSHRIMPSMA14 -- Sidestripe shrimp Shrimp Management Area 14

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Canada



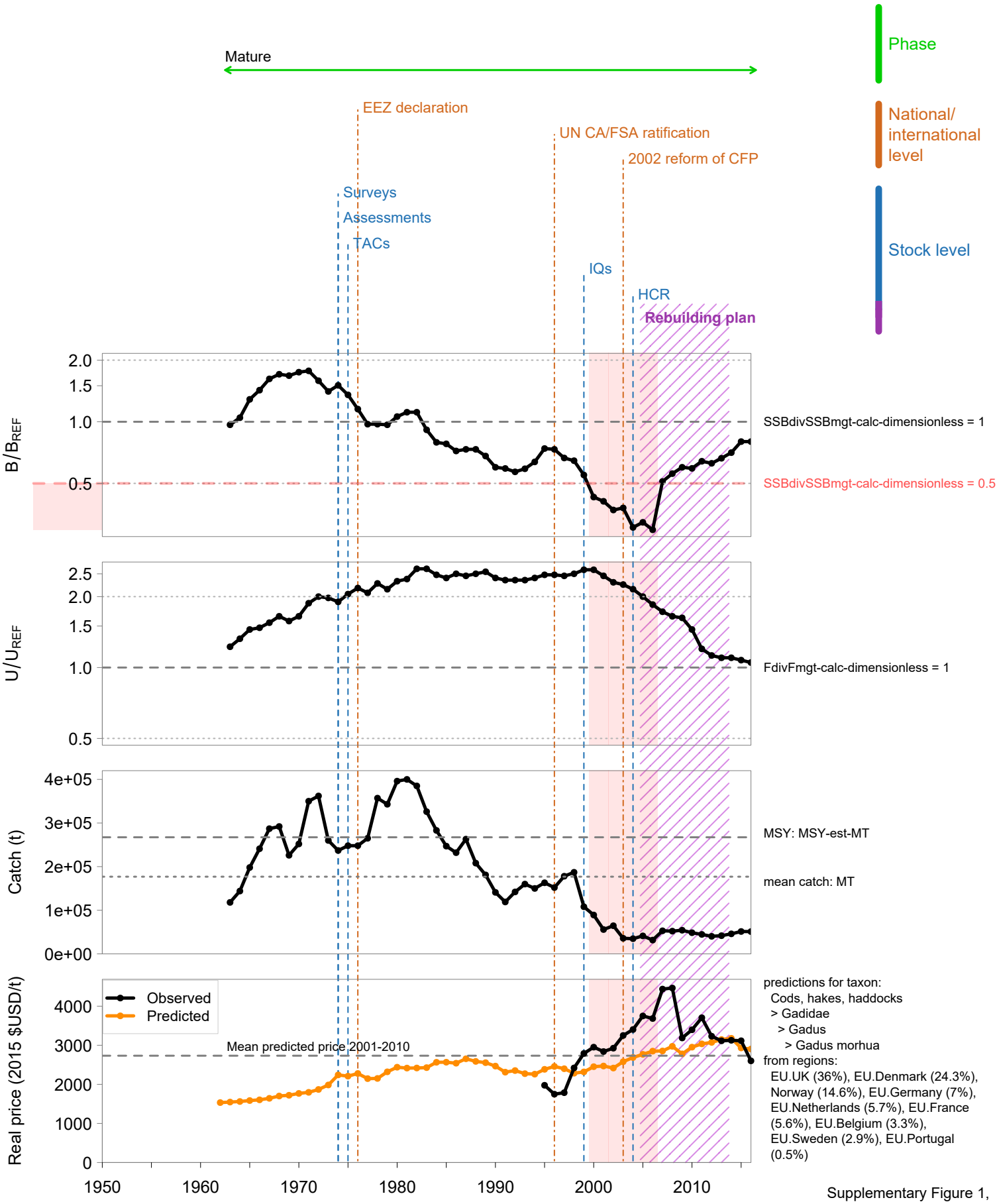
Canada-West Coast -- SSSHRIMPSMAFR -- Sidestripe shrimp Shrimp Management Area FR

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Canada



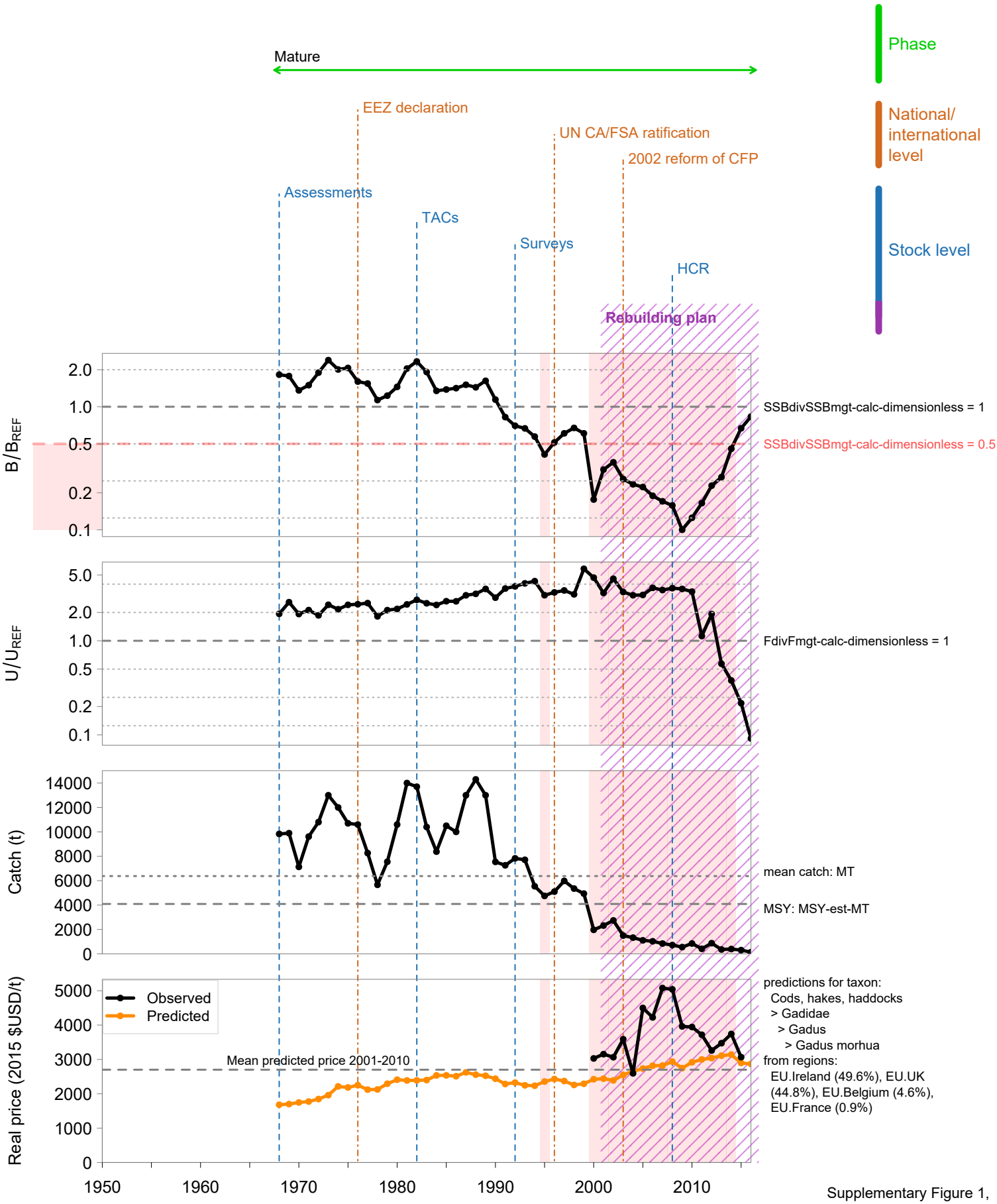
Europe(EU) NE Atl -- CODIIIaW-IV-VIId -- Atlantic cod ICES 3a(west)-4-7d

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Great Britain



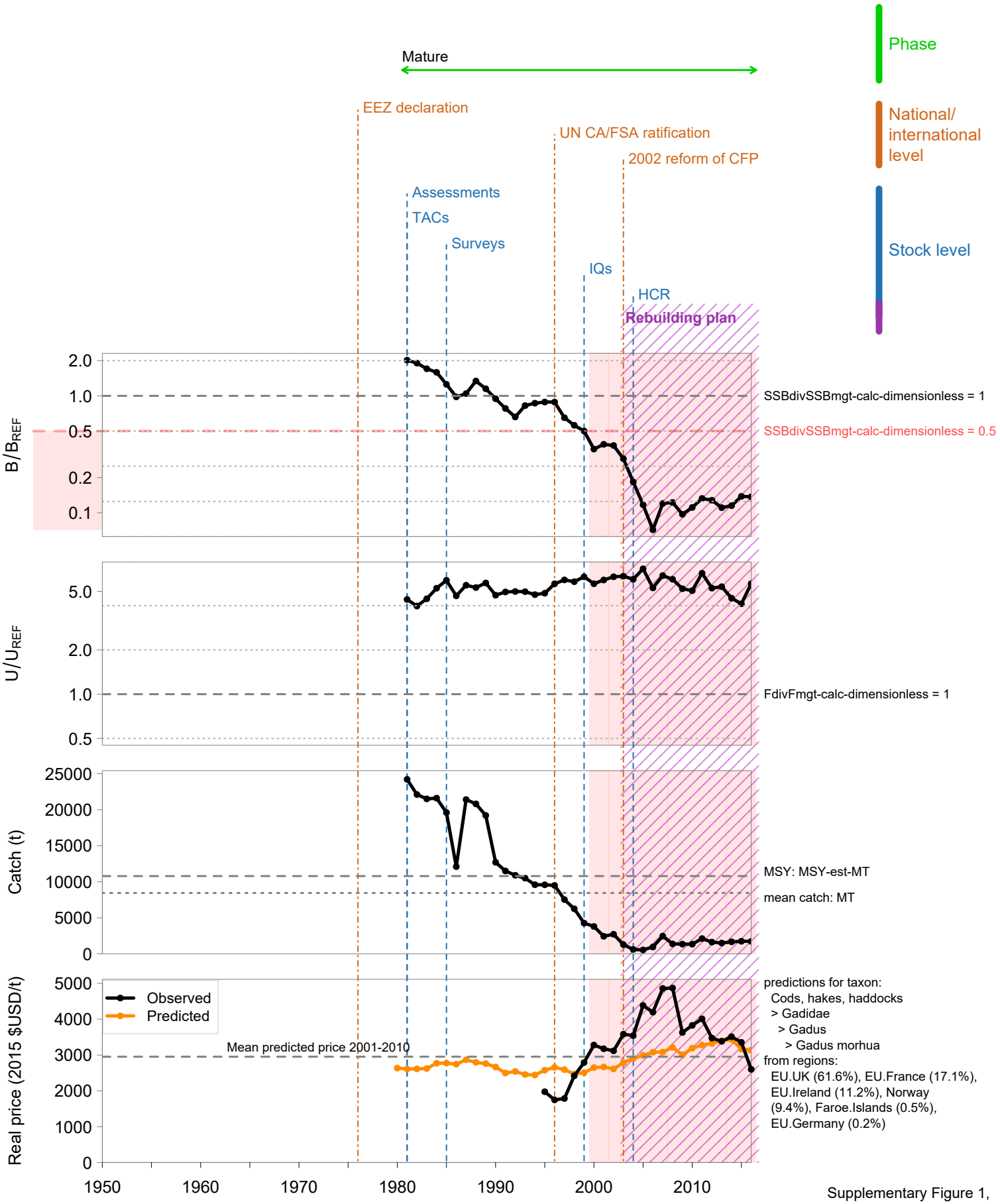
Europe(EU) NE Atl -- CODIS -- Atlantic cod Irish Sea

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Ireland



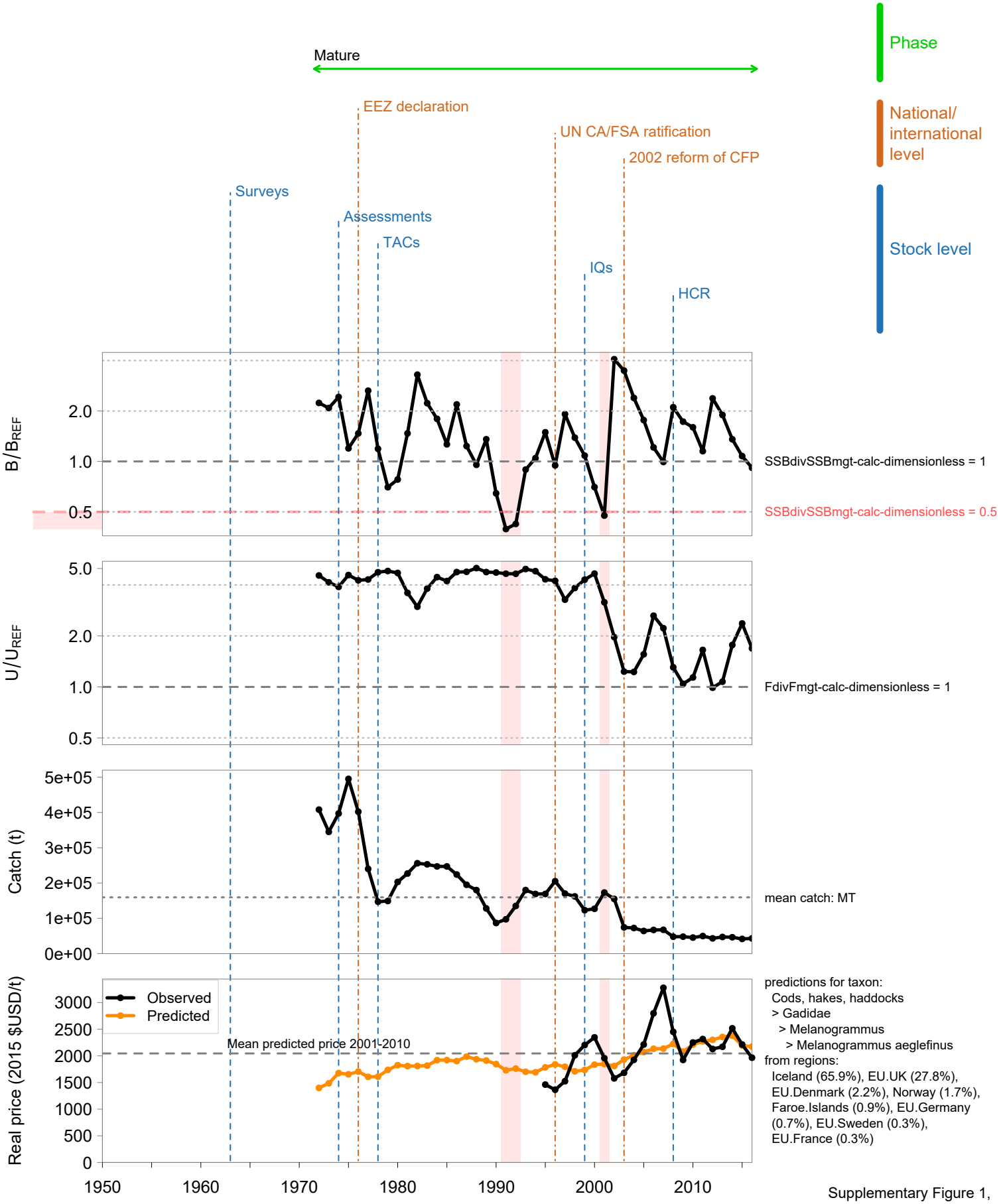
Europe(EU) NE Atl -- CODVIa -- Atlantic cod West of Scotland

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Great Britain



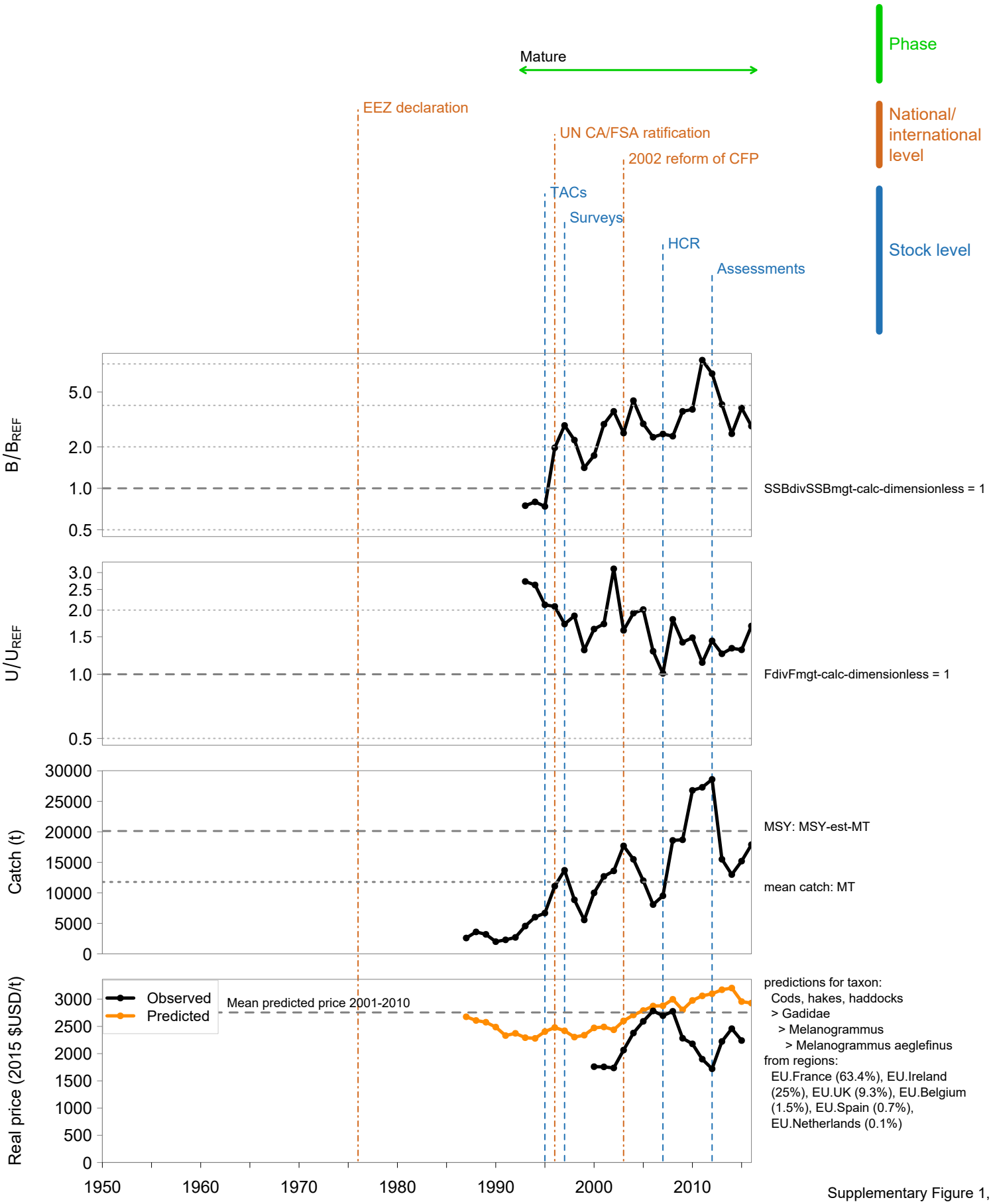
Europe(EU) NE Atl -- HADNS-IIIa-VIa -- Haddock ICES 3a-4-6a

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Iceland



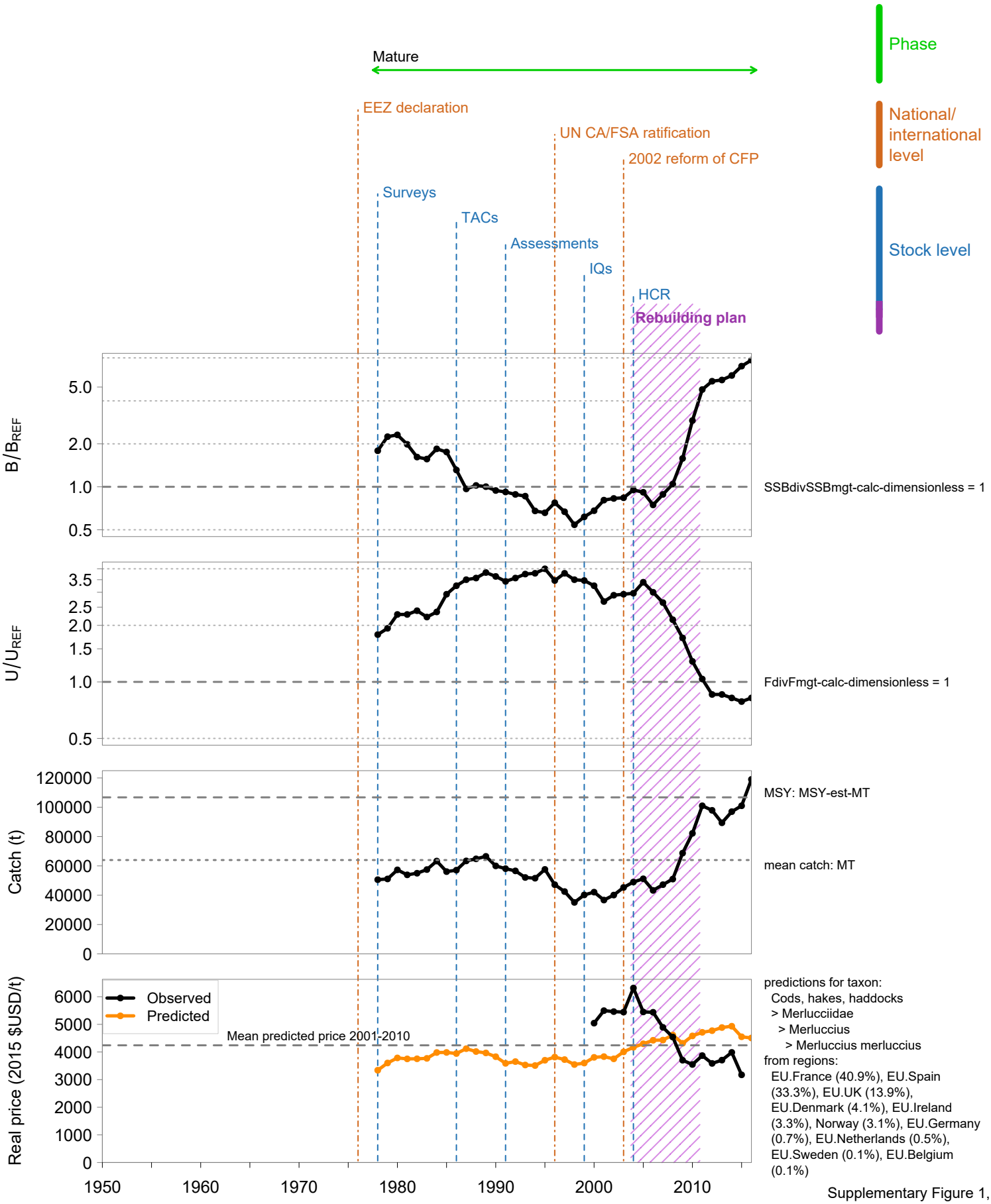
Europe(EU) NE Atl -- HADVIIb-k -- Haddock ICES 7b-k

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: France



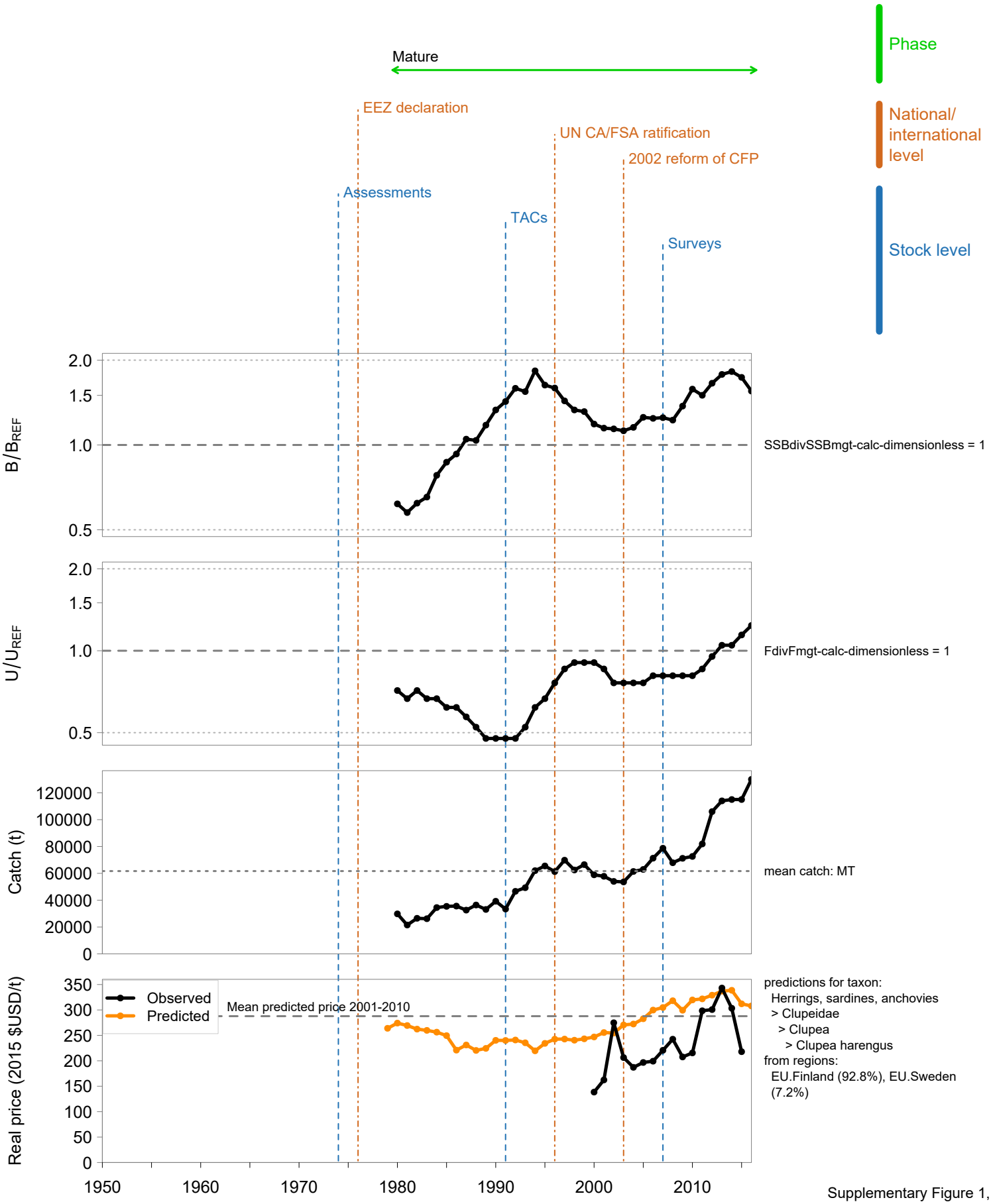
Europe(EU) NE Atl -- HAKENRTN -- Hake ICES 3a-4-6-7-8abd

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: France



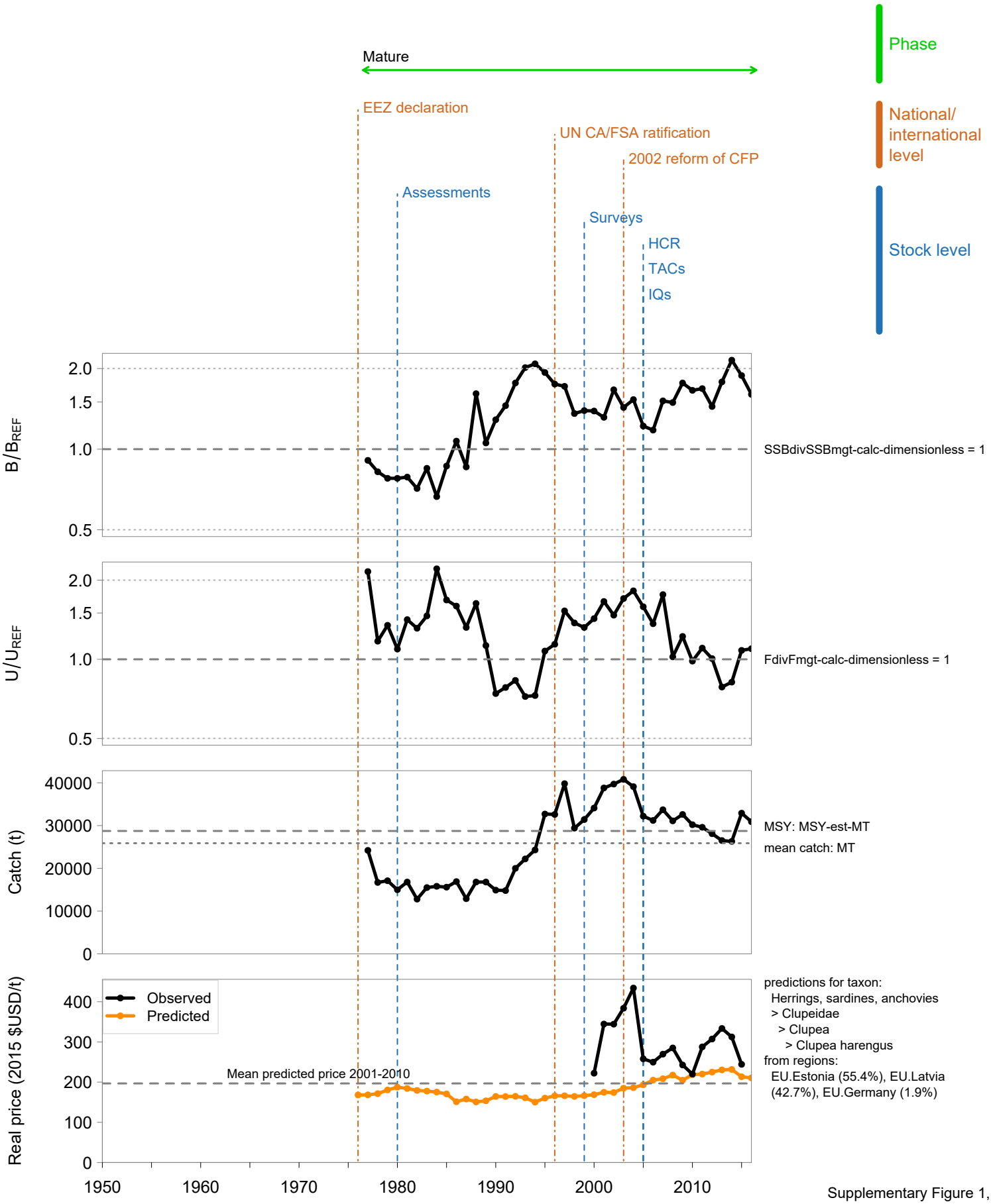
Europe(EU) NE Atl -- HERR30-31 -- Herring Subdivisions 30-31

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Finland



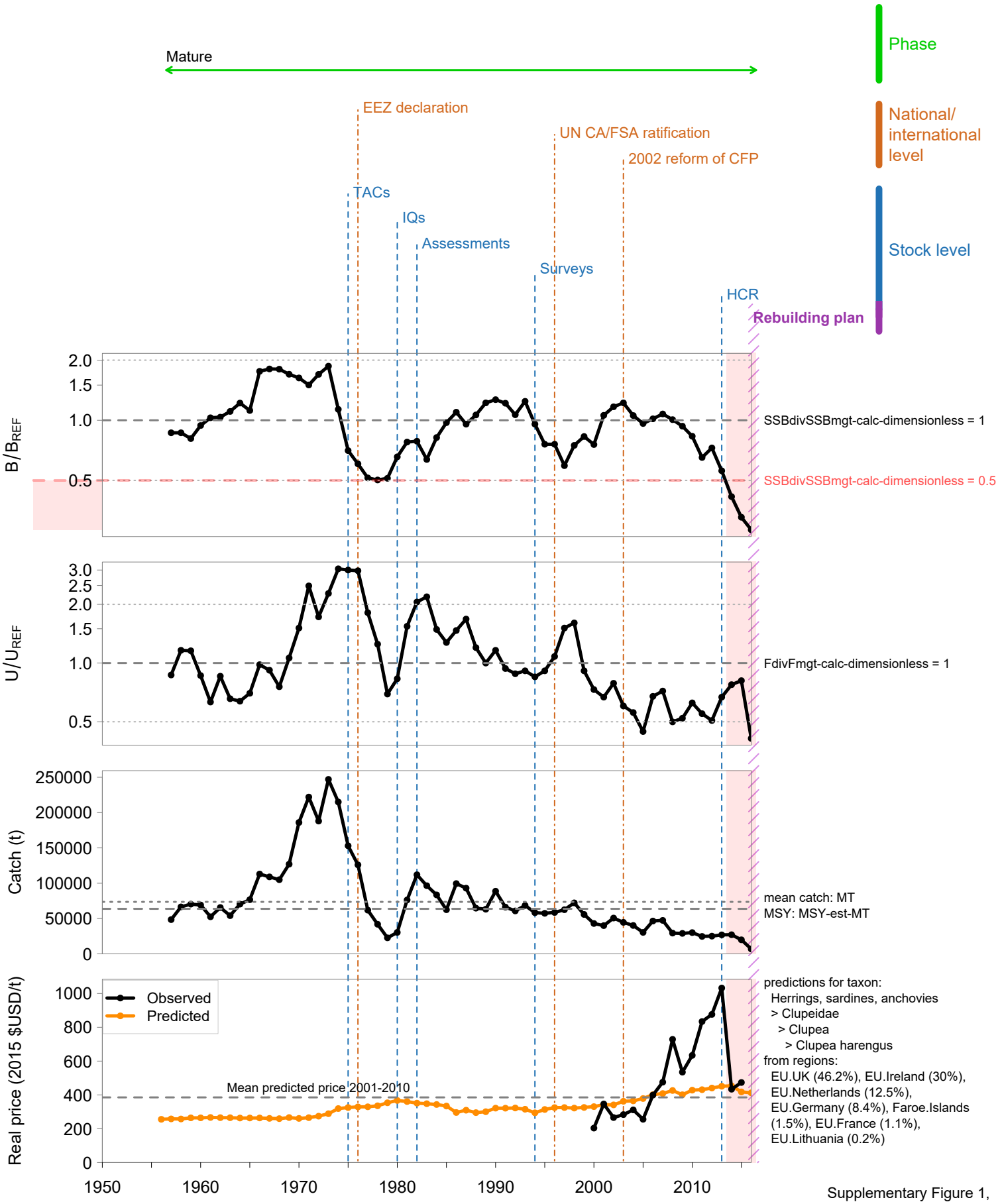
Europe(EU) NE Atl -- HERRRIGA -- Herring Gulf of Riga East of Gotland

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Estonia



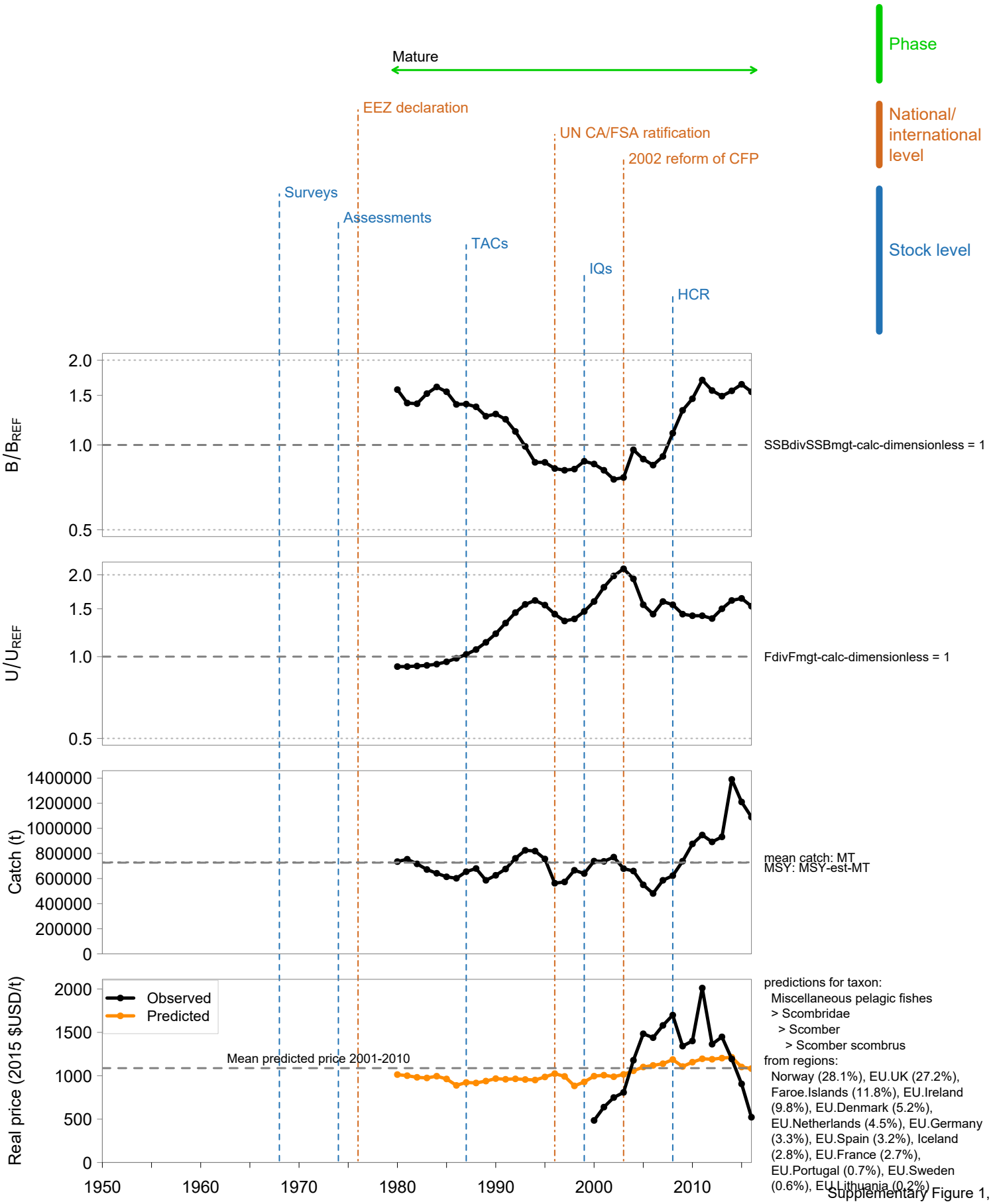
Europe(EU) NE Atl -- HERRVIaVIIbc -- Herring ICES 5a-7bc

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Great Britain



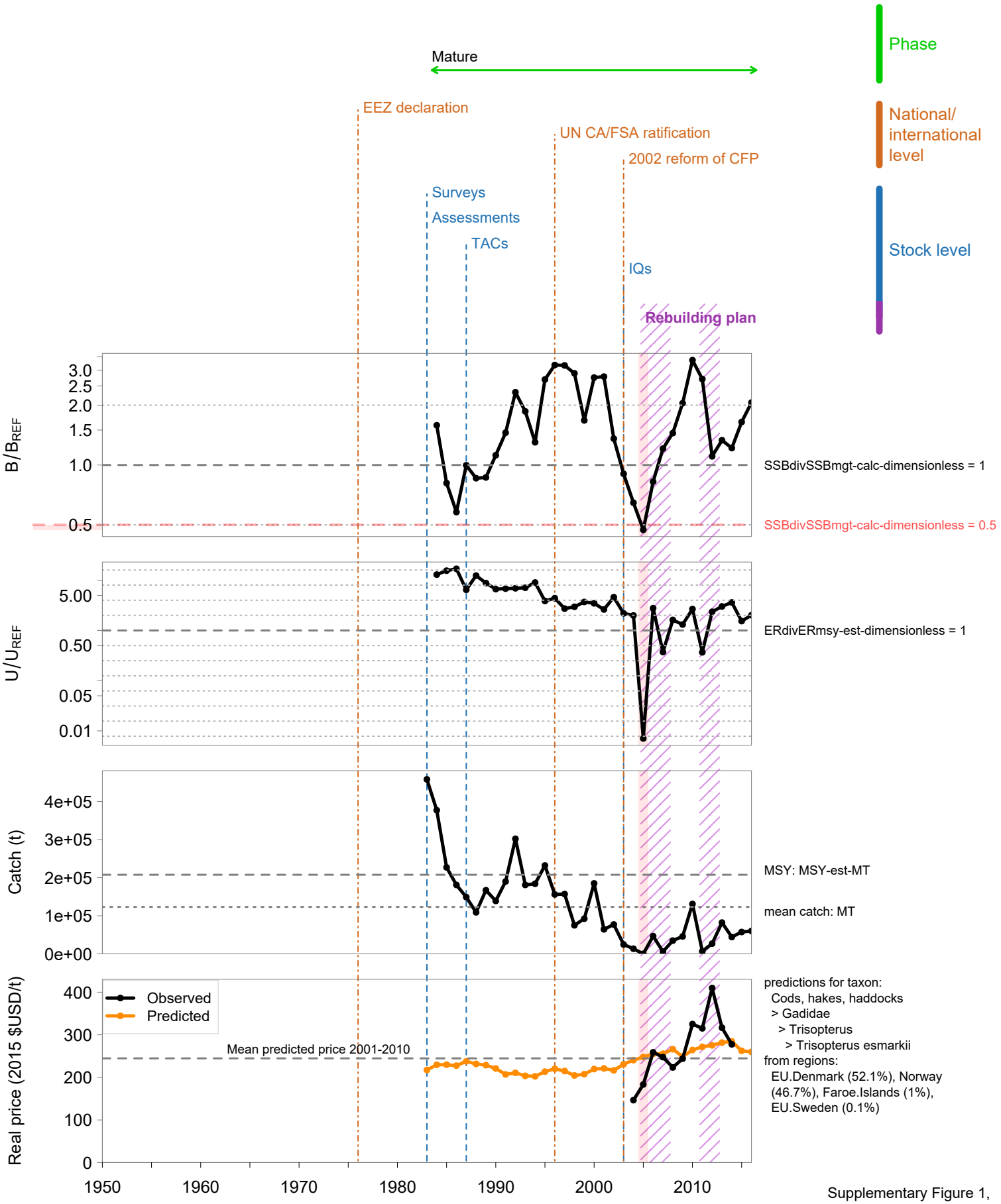
Europe(EU) NE Atl -- MACKNEICES -- Mackerel ICES Northeast Atlantic

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: single-species, primary country: Norway



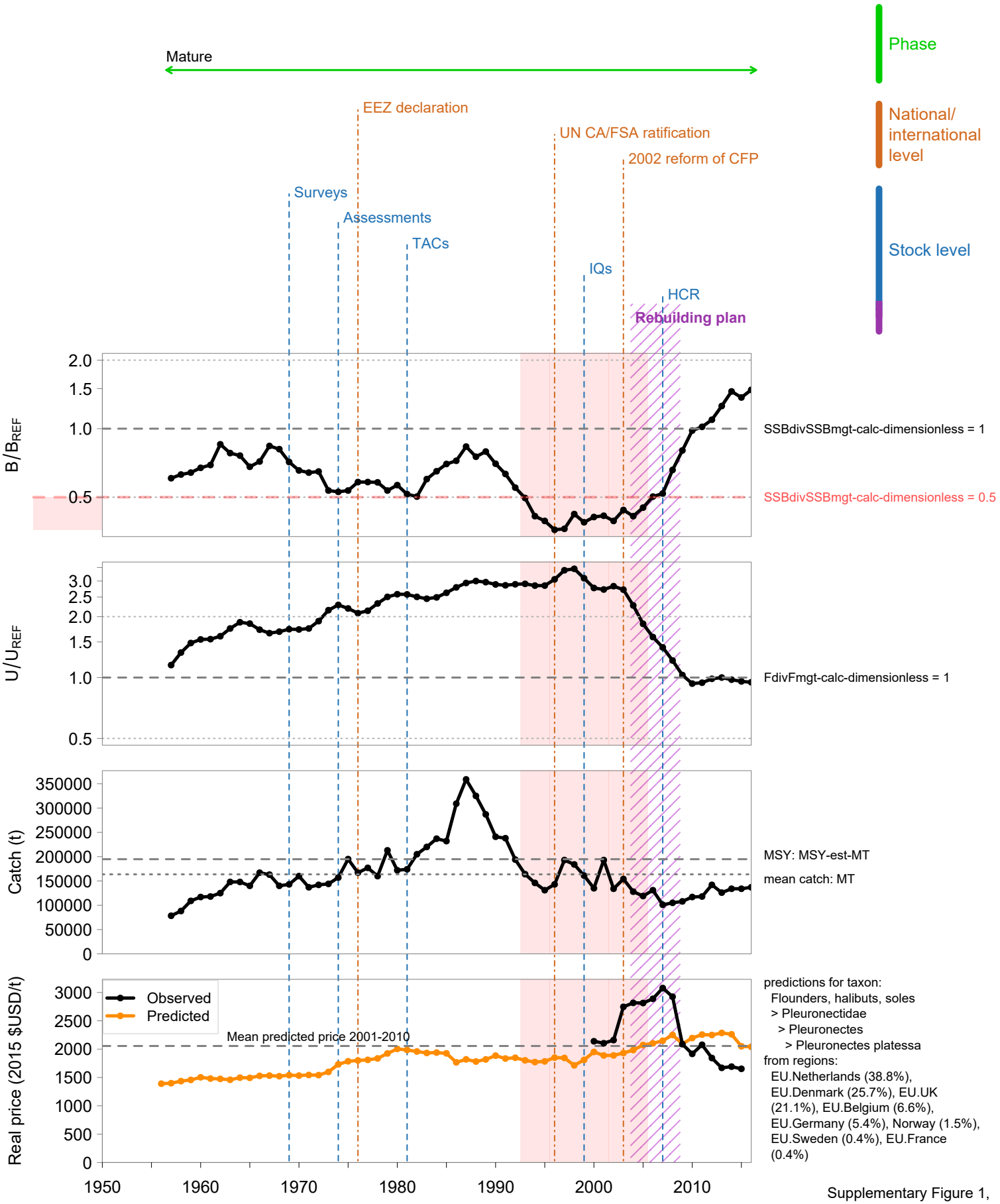
Europe(EU) NE Atl -- NPOUTIIIa-IV -- Norway pout ICES 3a-4

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Denmark



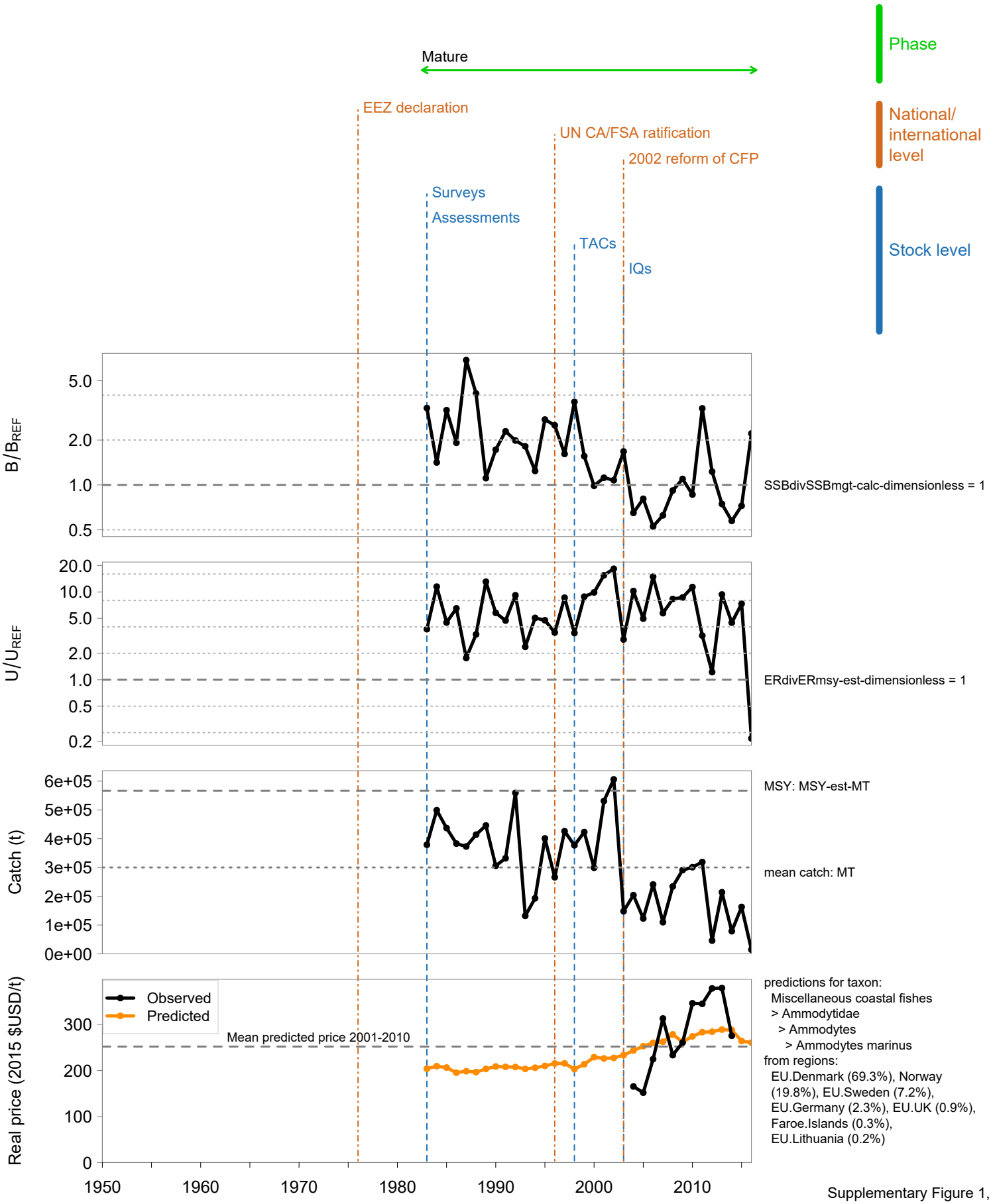
Europe(EU) NE Atl -- PLAICNS -- European plaice North Sea

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Netherlands



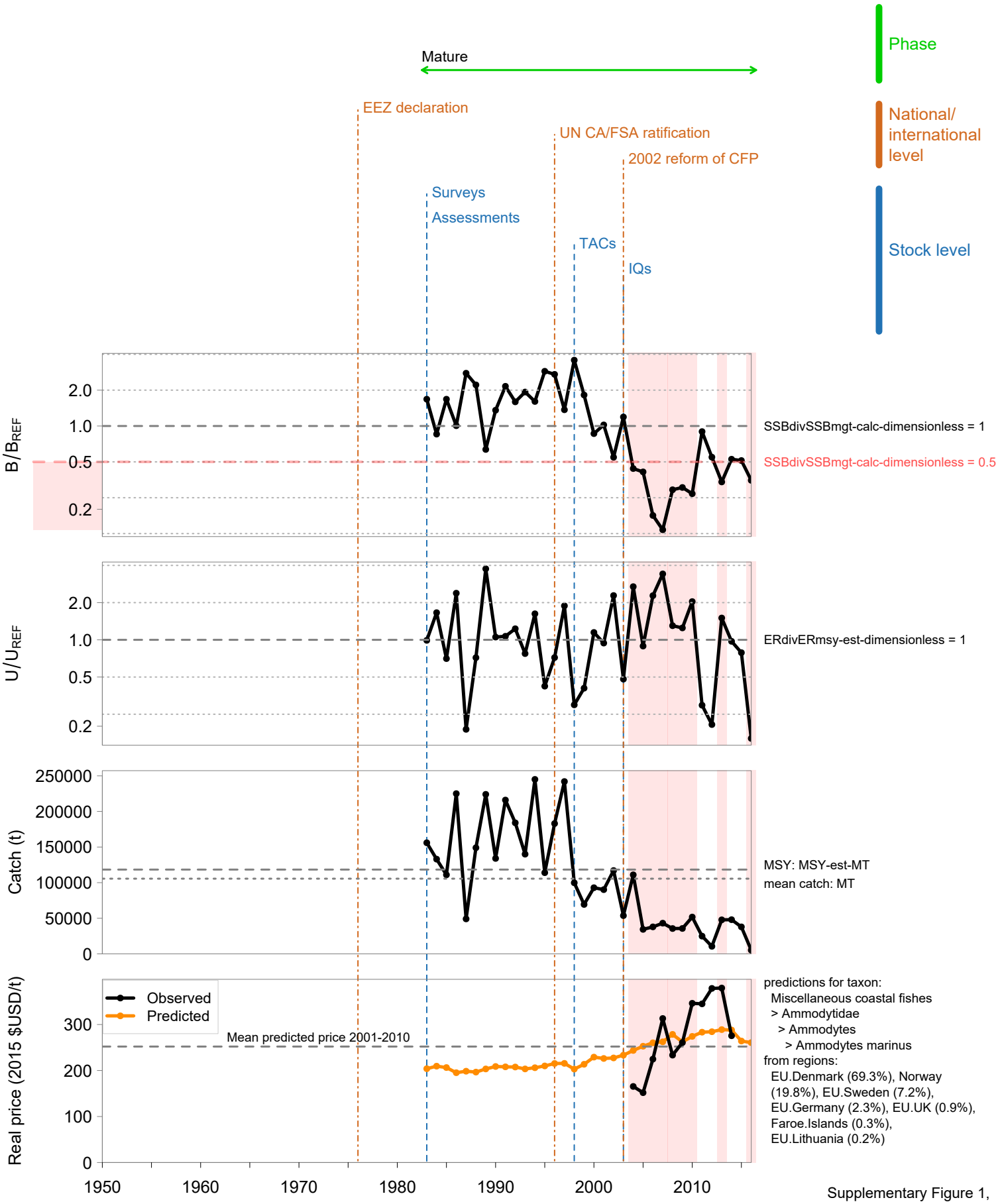
Europe(EU) NE Atl -- SEELNSSA1 -- Sand eel Sandeel Area 1

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Denmark



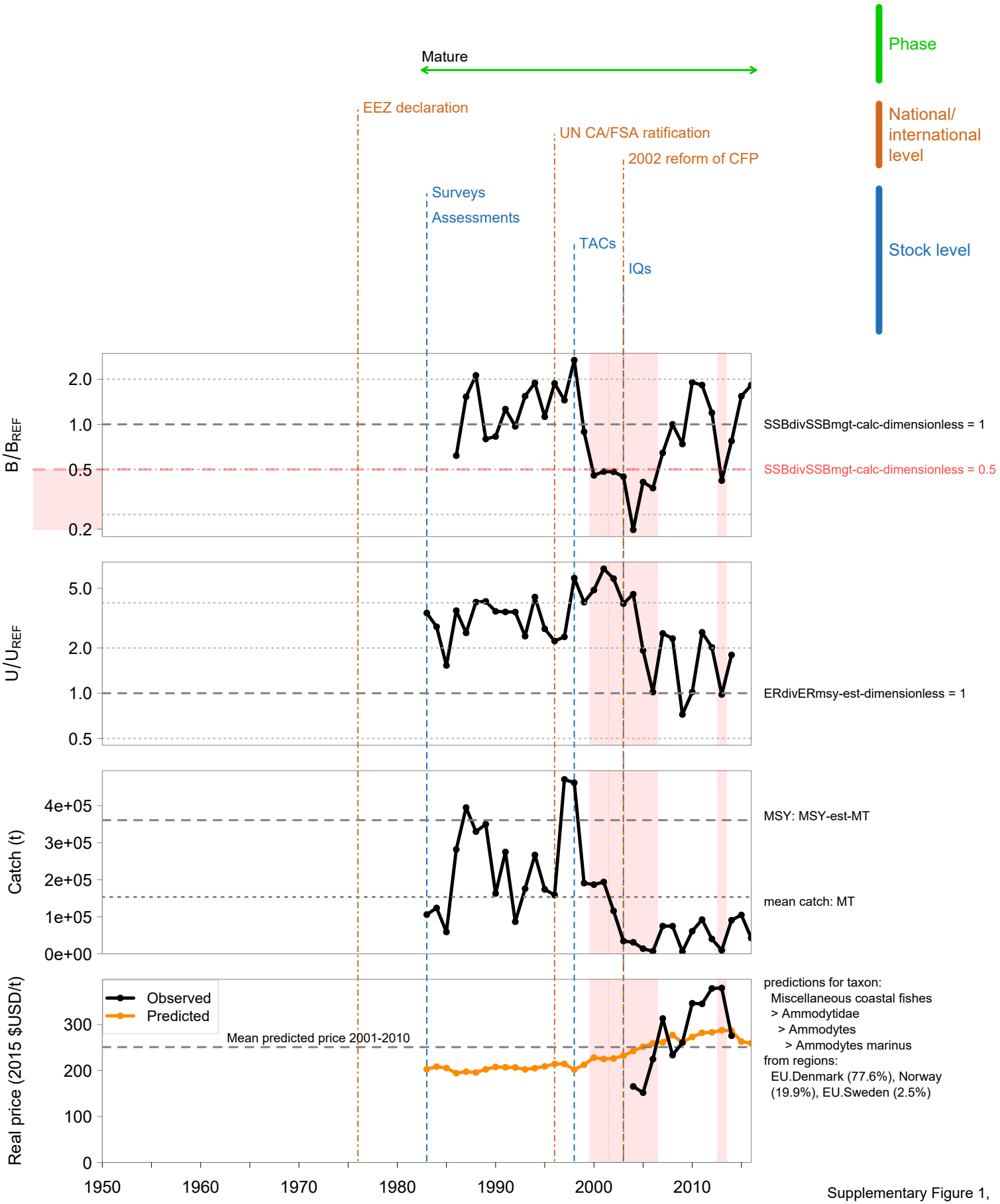
Europe(EU) NE Atl -- SEELNSSA2 -- Sand eel Sandeel Area 2

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Denmark



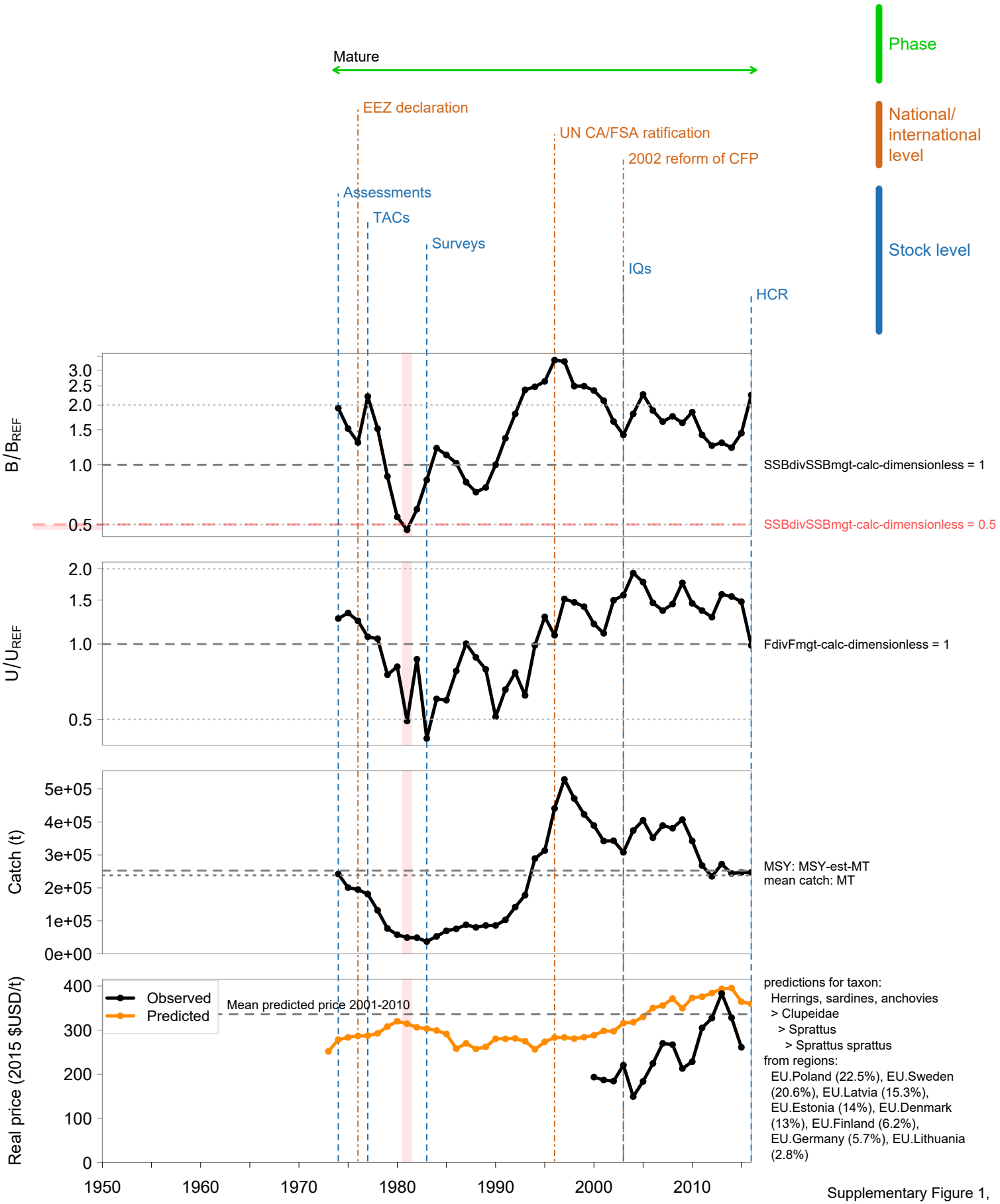
Europe(EU) NE Atl -- SEELNSSA3 -- Sand eel Sandeel Area 3

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Denmark



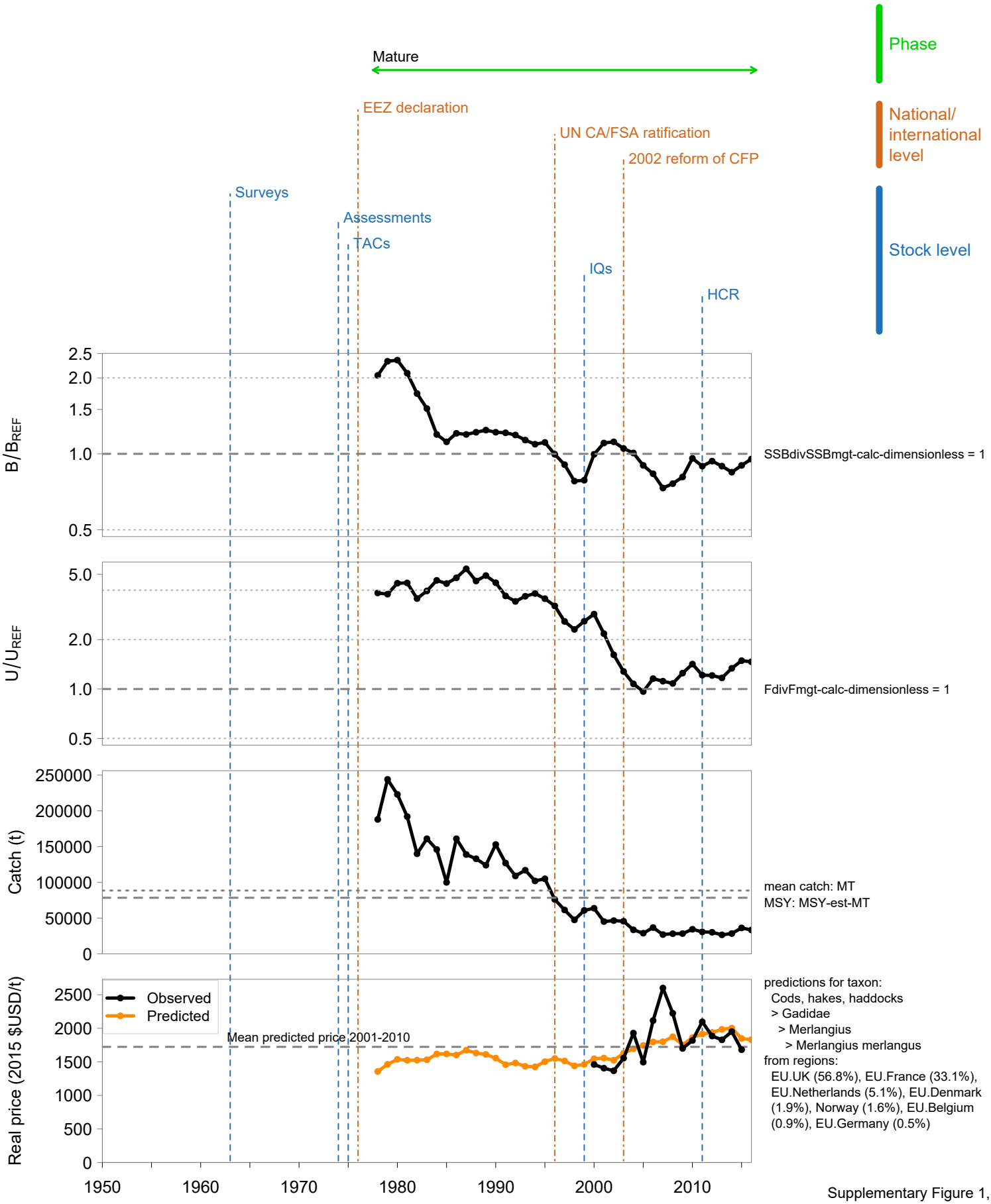
Europe(EU) NE Atl -- SPRAT22-32 -- Sprat Baltic Areas 22-32

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Poland



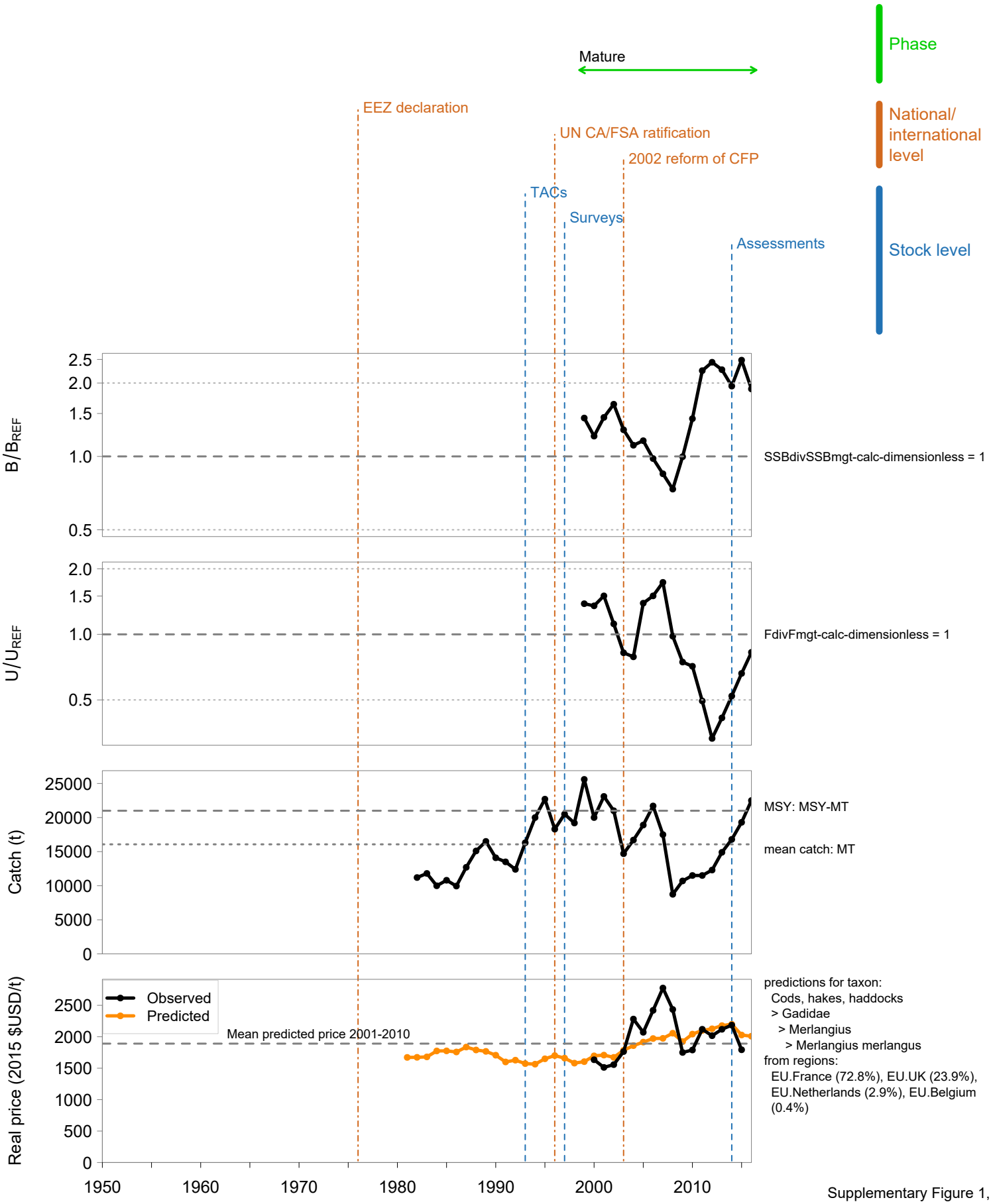
Europe(EU) NE Atl -- WHITNS-VIId -- Whiting ICES 4-7d

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Great Britain



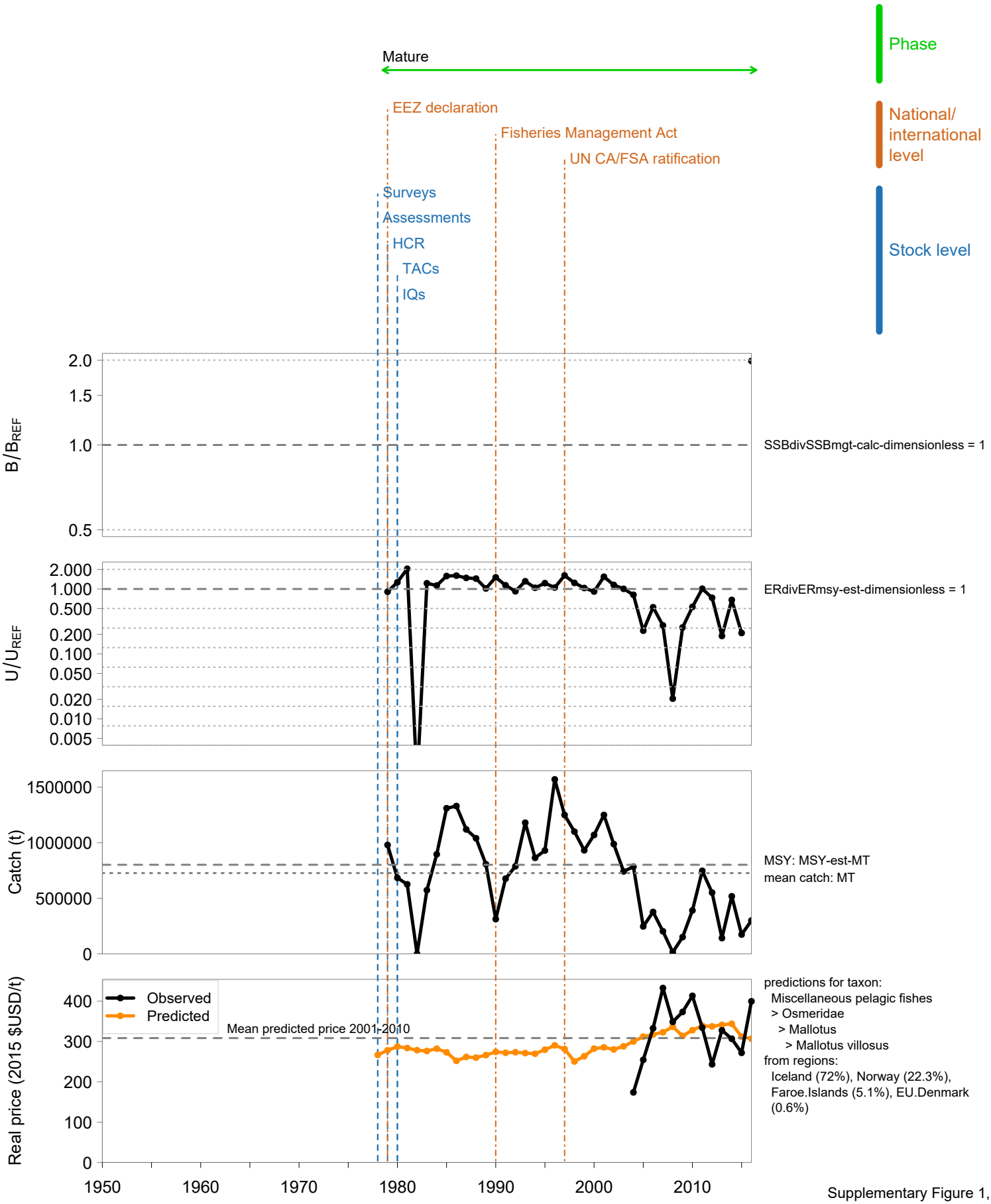
Europe(EU) NE Atl -- WHITVIIek -- Whiting Celtic Sea

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: France



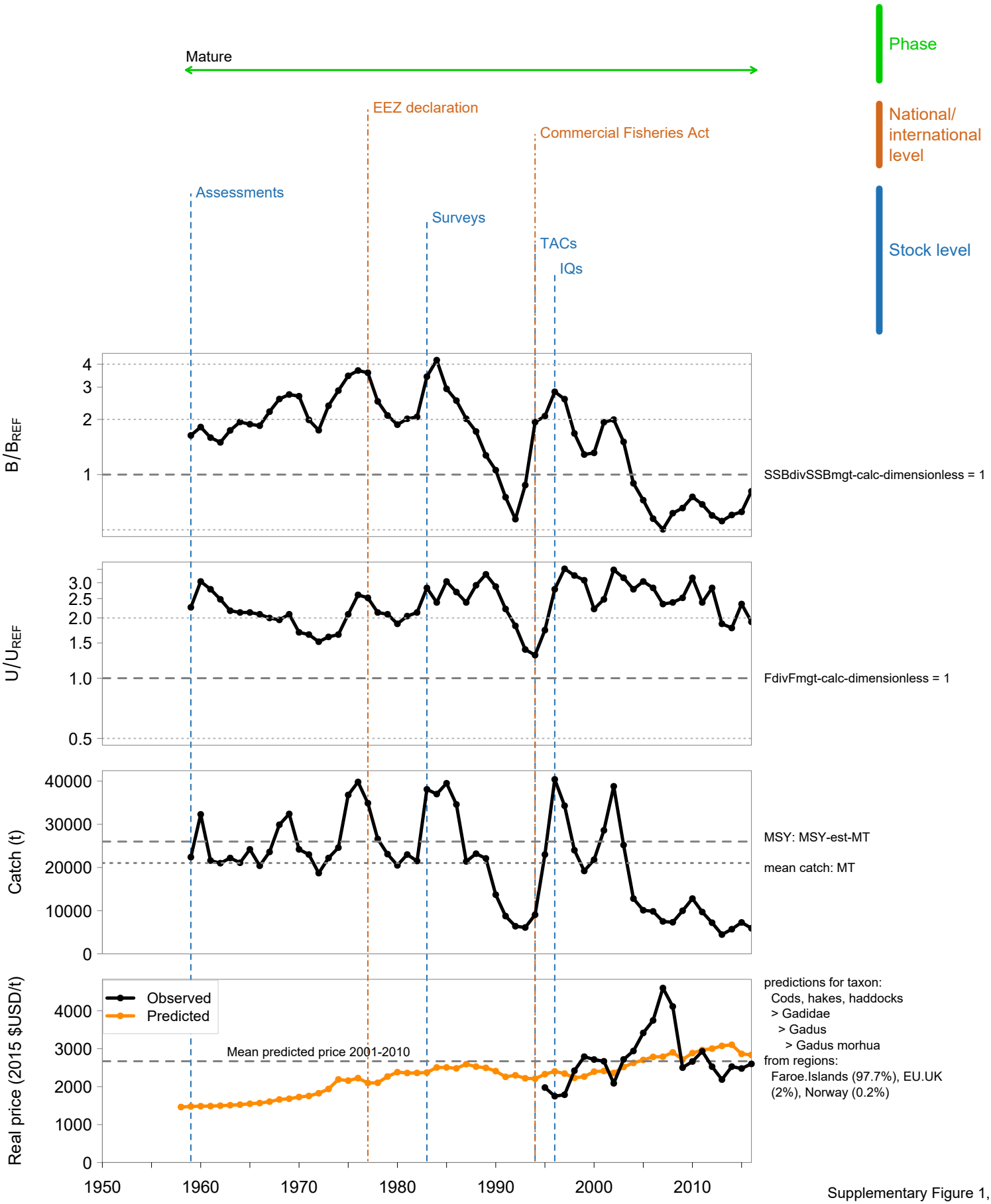
Europe(non-EU) NE Atl -- CAPEIIa-V-XIV -- Capelin ICES 2a-5-14

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Iceland



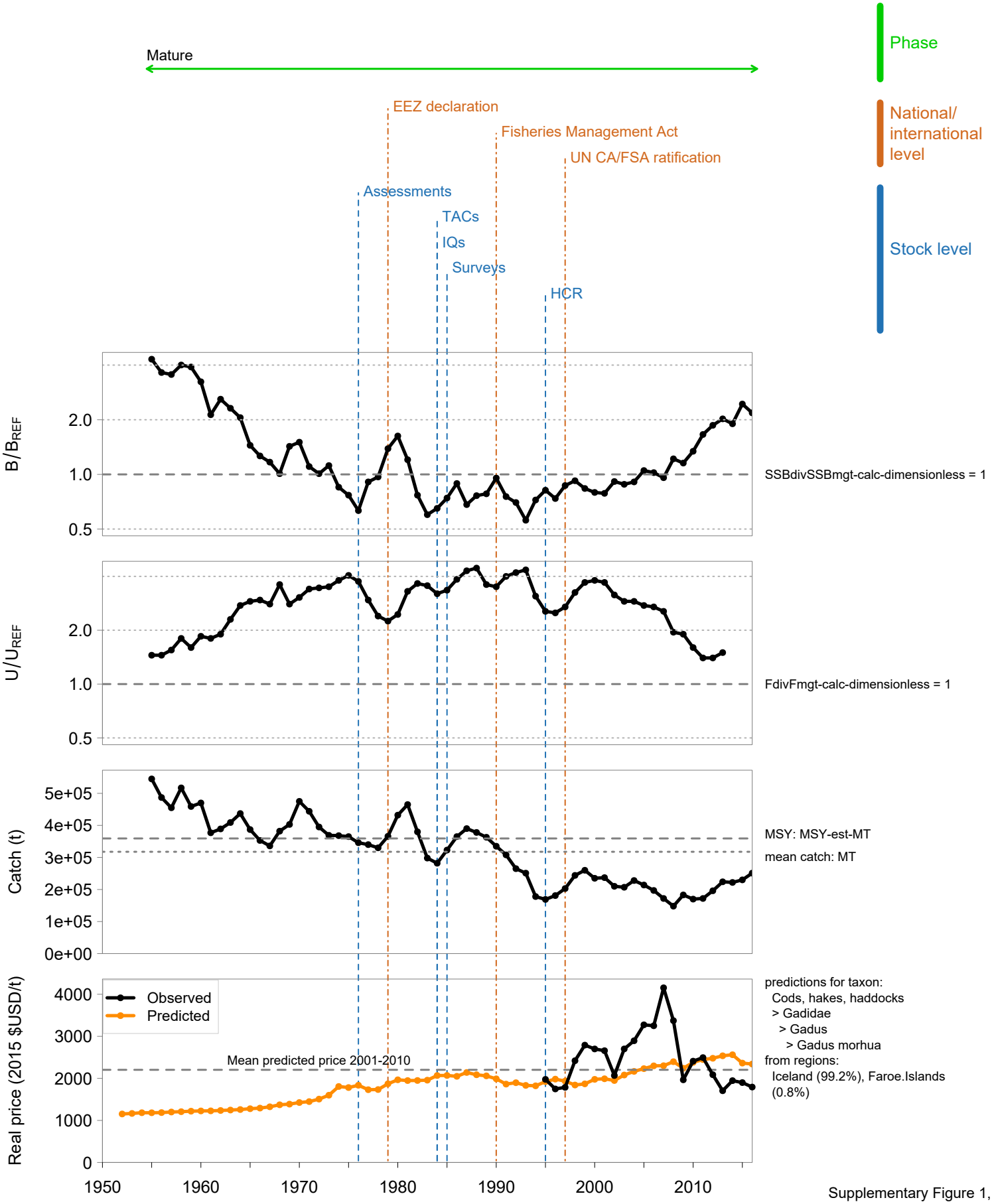
Europe(non-EU) NE Atl -- CODFAPL -- Atlantic cod Faroe Plateau

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Faroe Islands



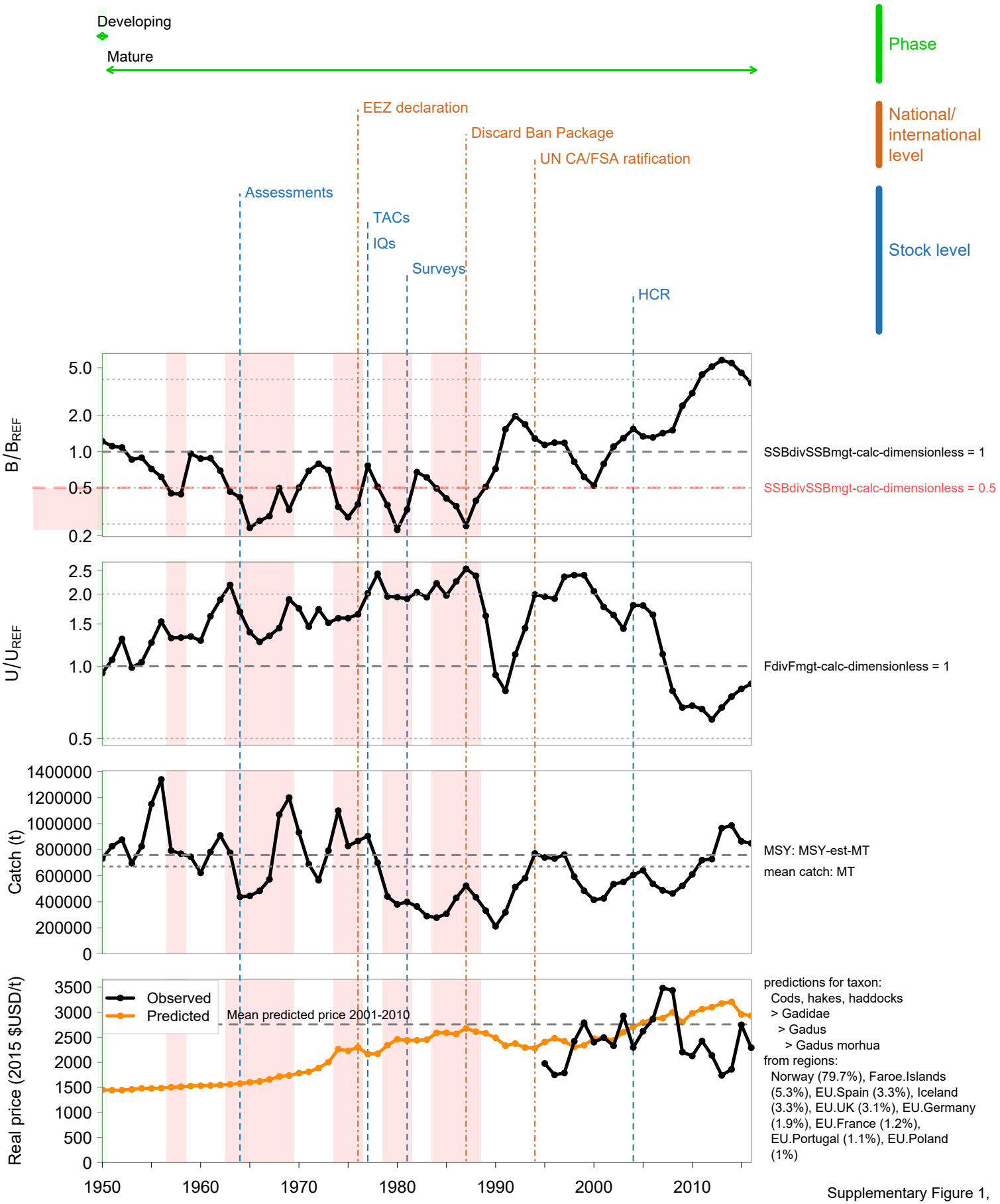
Europe(non-EU) NE Atl -- CODICE -- Atlantic cod Iceland Grounds

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Iceland



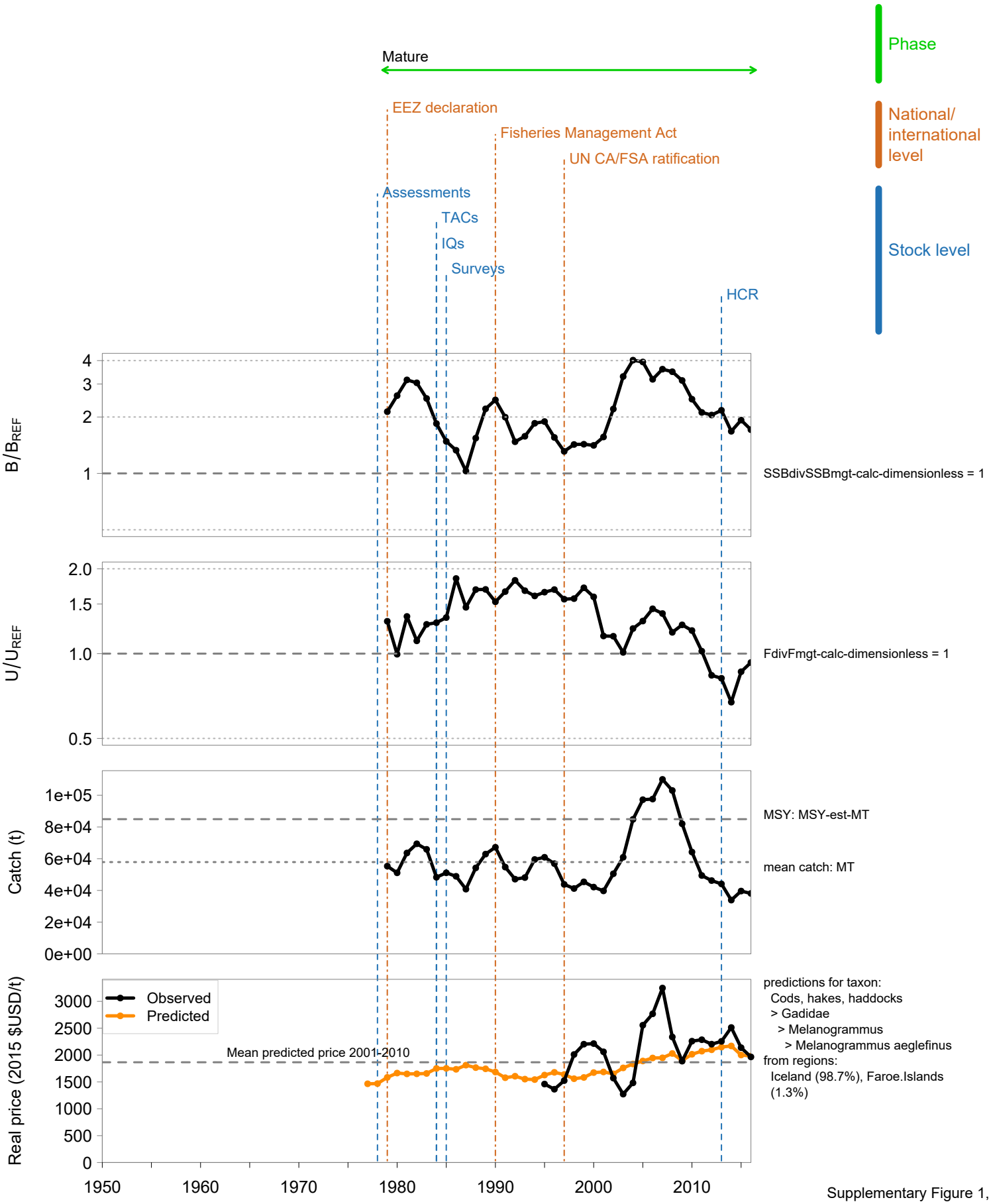
Europe(non-EU) NE Atl -- CODNEAR -- Atlantic cod North-East Arctic

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Norway



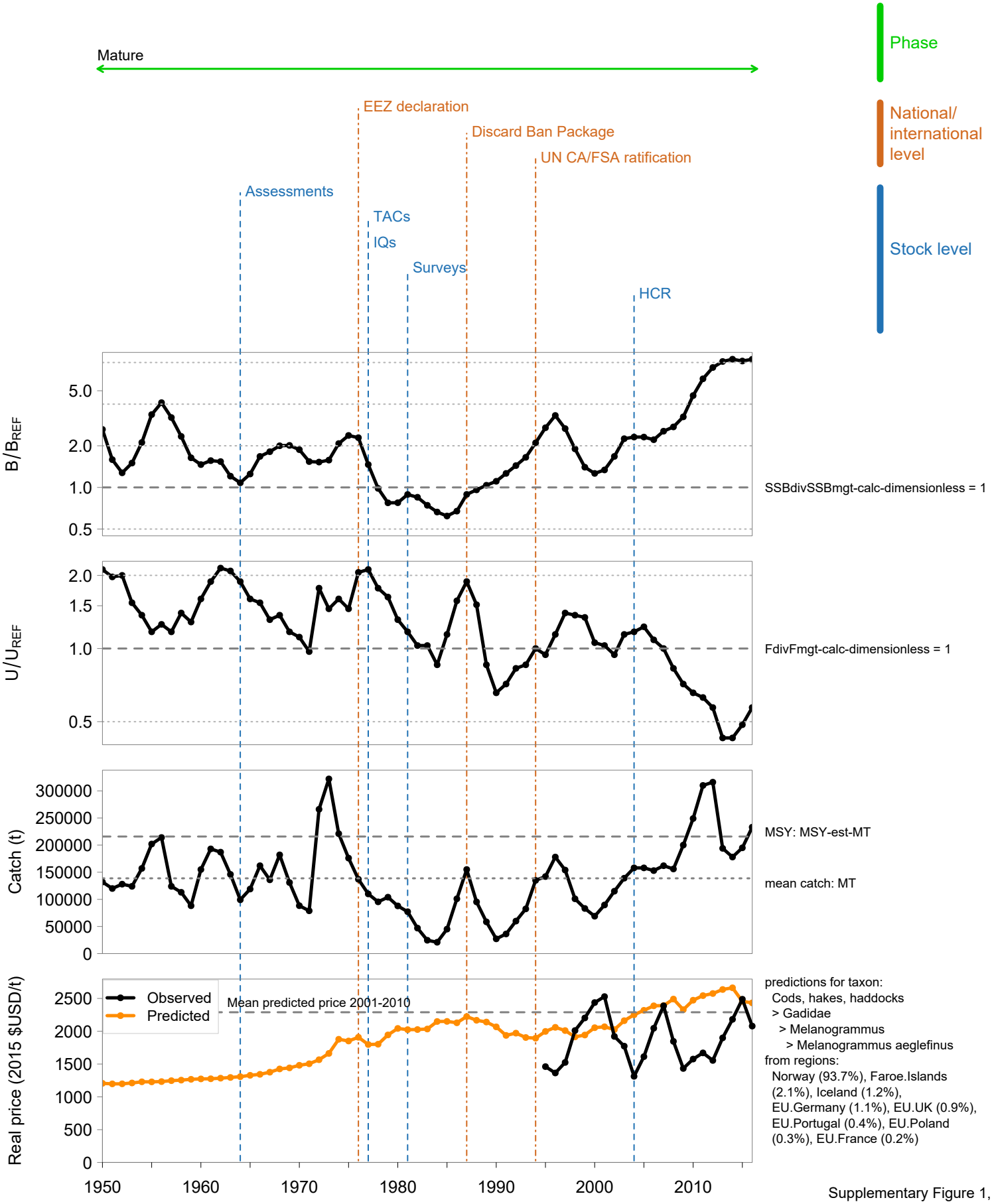
Europe(non-EU) NE Atl -- HADICE -- Haddock Iceland Grounds

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Iceland



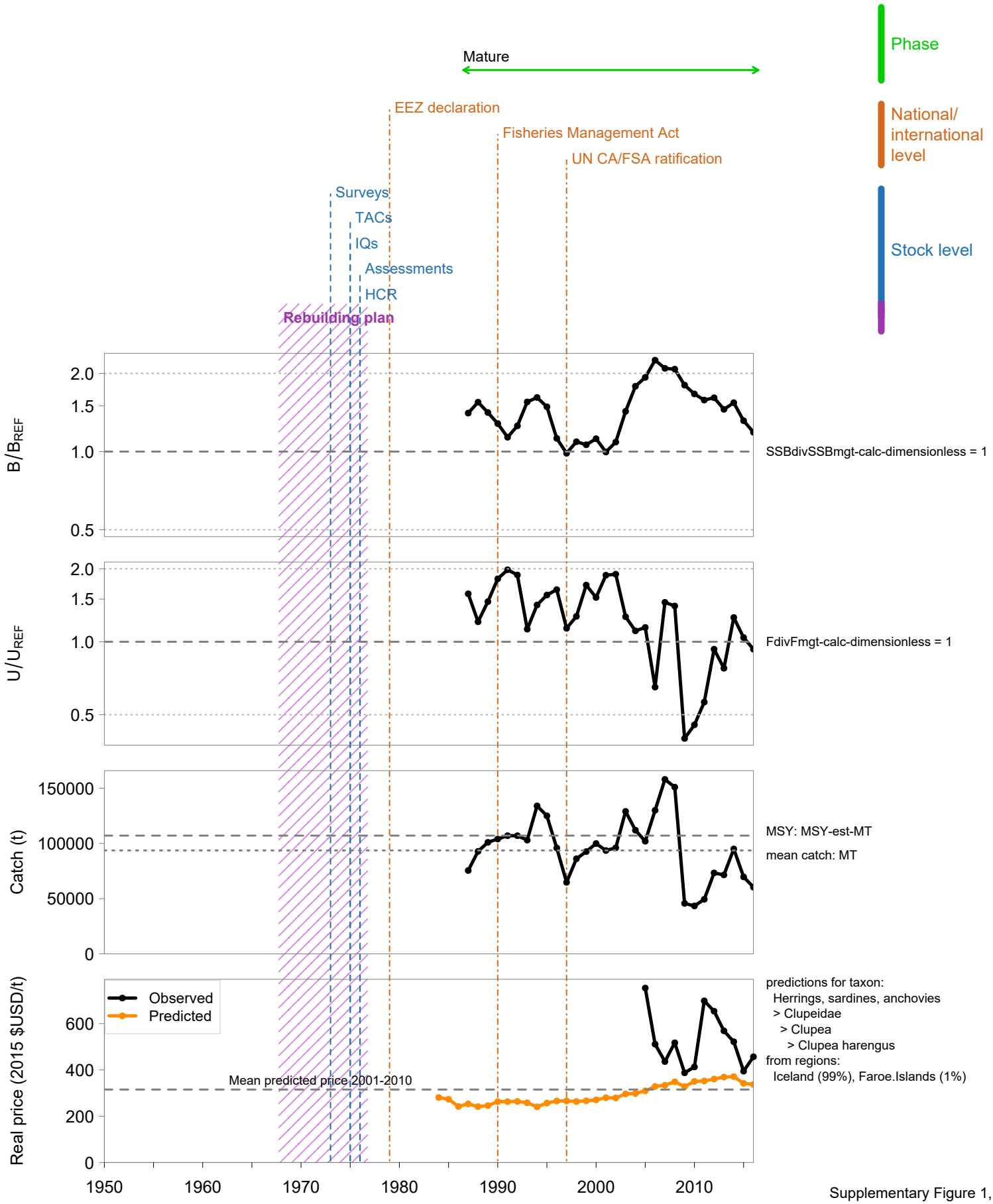
Europe(non-EU) NE Atl -- HADNEAR -- Haddock North-East Arctic

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Norway



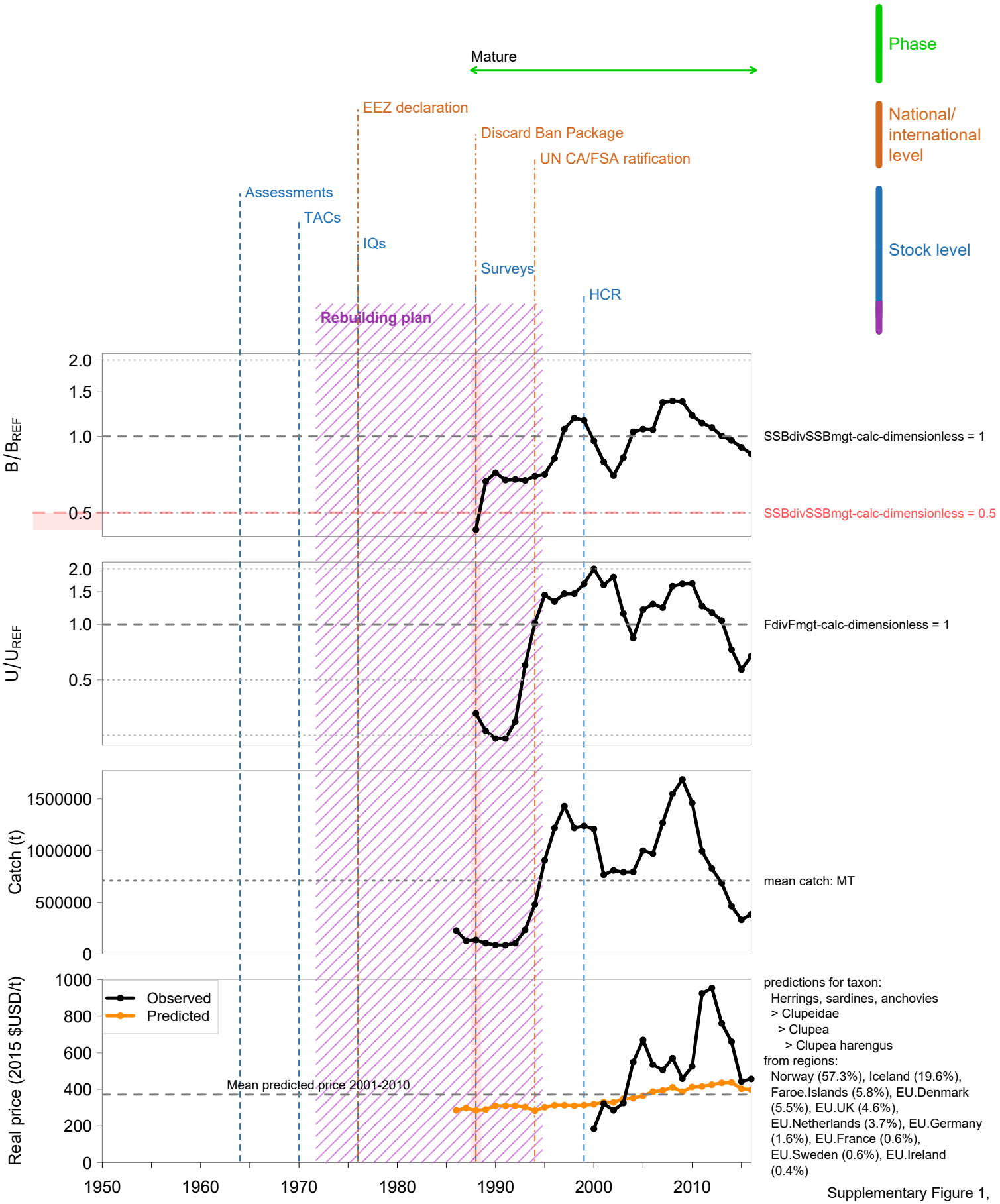
Europe(non-EU) NE Atl -- HERRIsum -- Herring Iceland (Summer spawners)

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Iceland



Europe(non-EU) NE Atl -- HERRNORSS -- Herring ICES 1-2-4a-5-14a (Norwegian Spring Spawners)

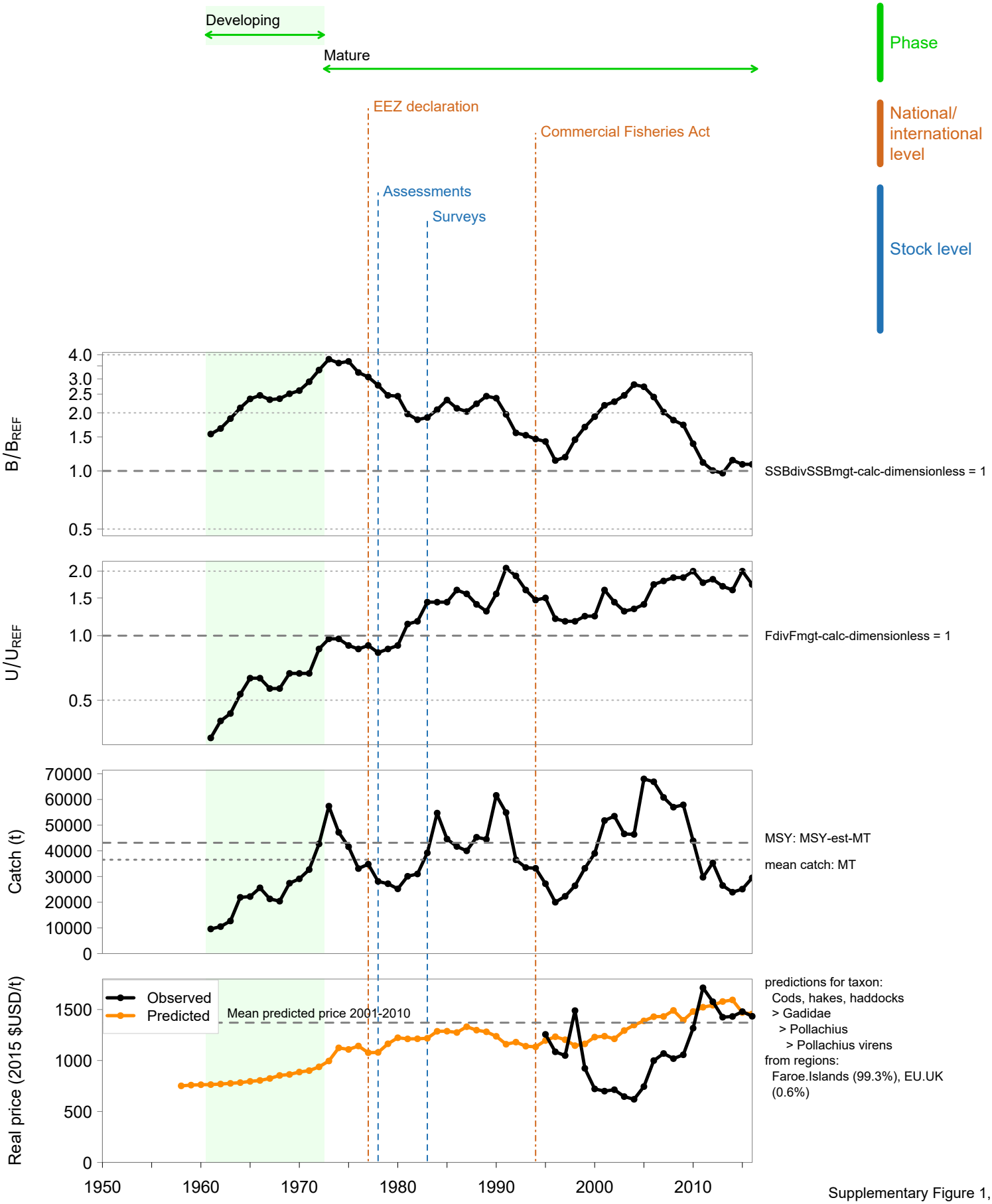
taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Norway



predictions for taxon:
Herrings, sardines, anchovies
> Clupeidae
> Clupea
> Clupea harengus
from regions:
Norway (57.3%), Iceland (19.6%), Faroe.Islands (5.8%), EU.Denmark (5.5%), EU.UK (4.6%), EU.Netherlands (3.7%), EU.Germany (1.6%), EU.France (0.6%), EU.Sweden (0.6%), EU.Ireland (0.4%)

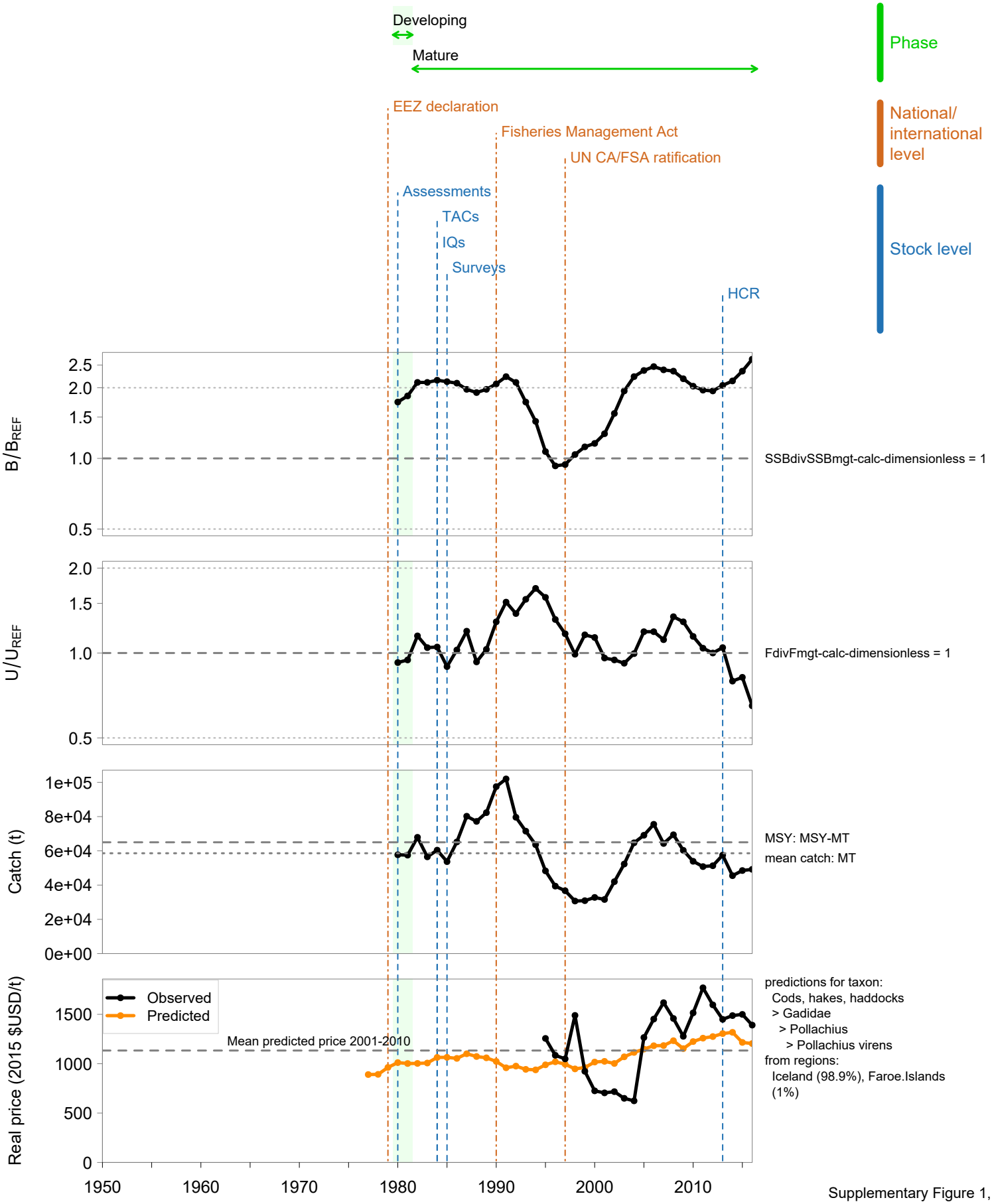
Europe(non-EU) NE Atl -- POLLFAPL -- Pollock Faroe Plateau

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Faroe Islands



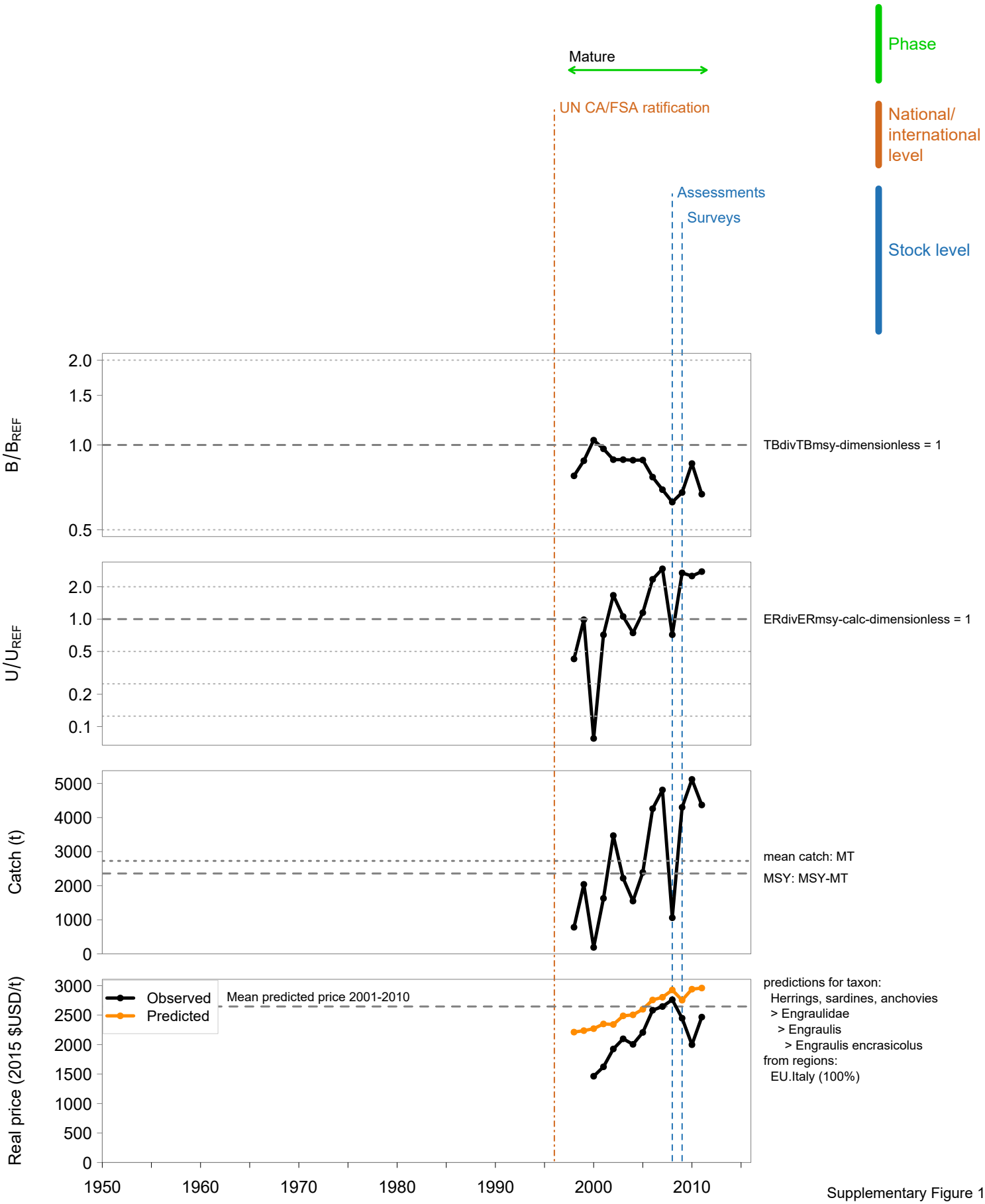
Europe(non-EU) NE Atl -- POLLIEG -- Pollock Iceland Grounds

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Iceland



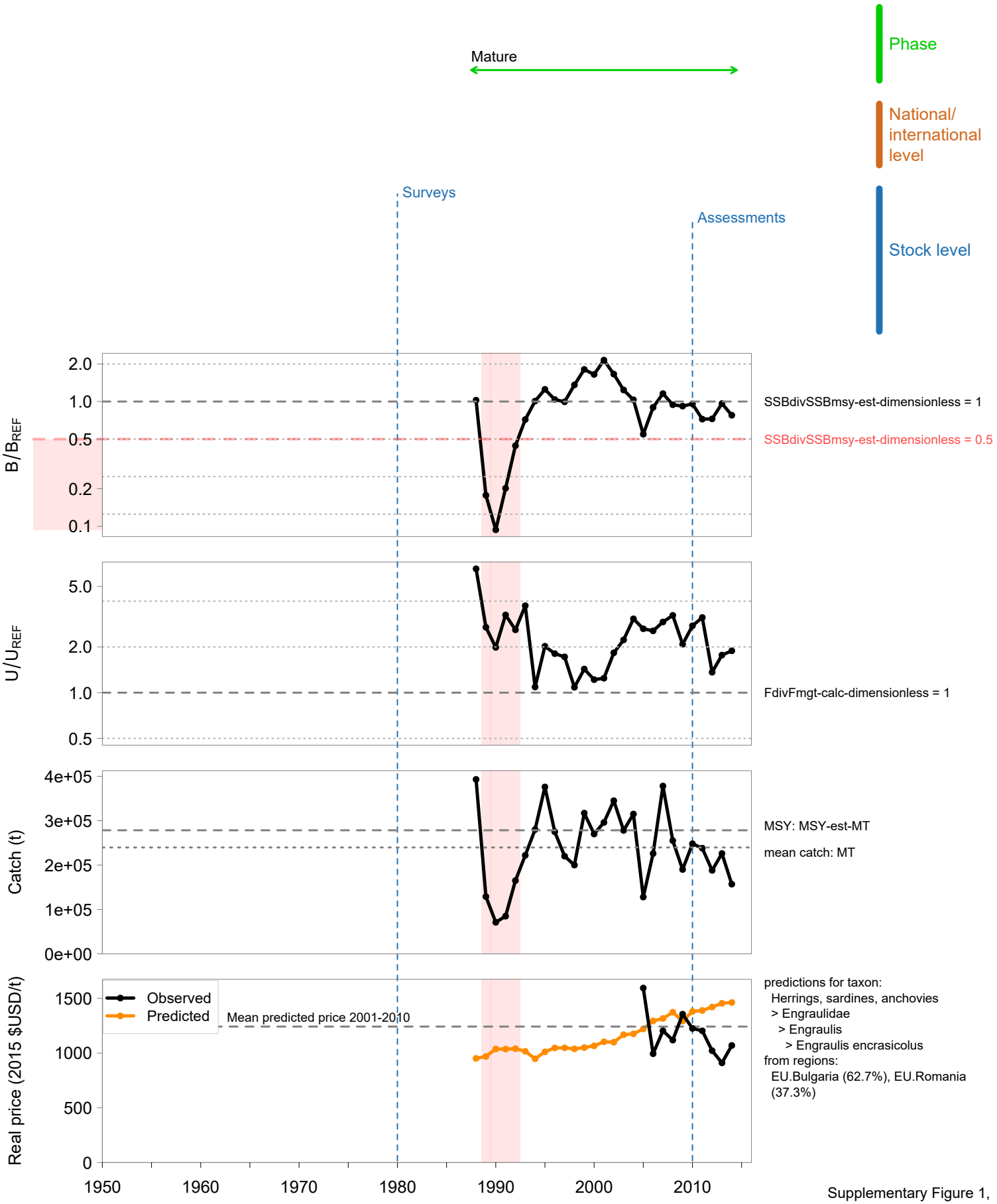
Europe-Med/Black Sea -- ANCHMEDGSA16 -- Anchovy South of Sicily

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Italy



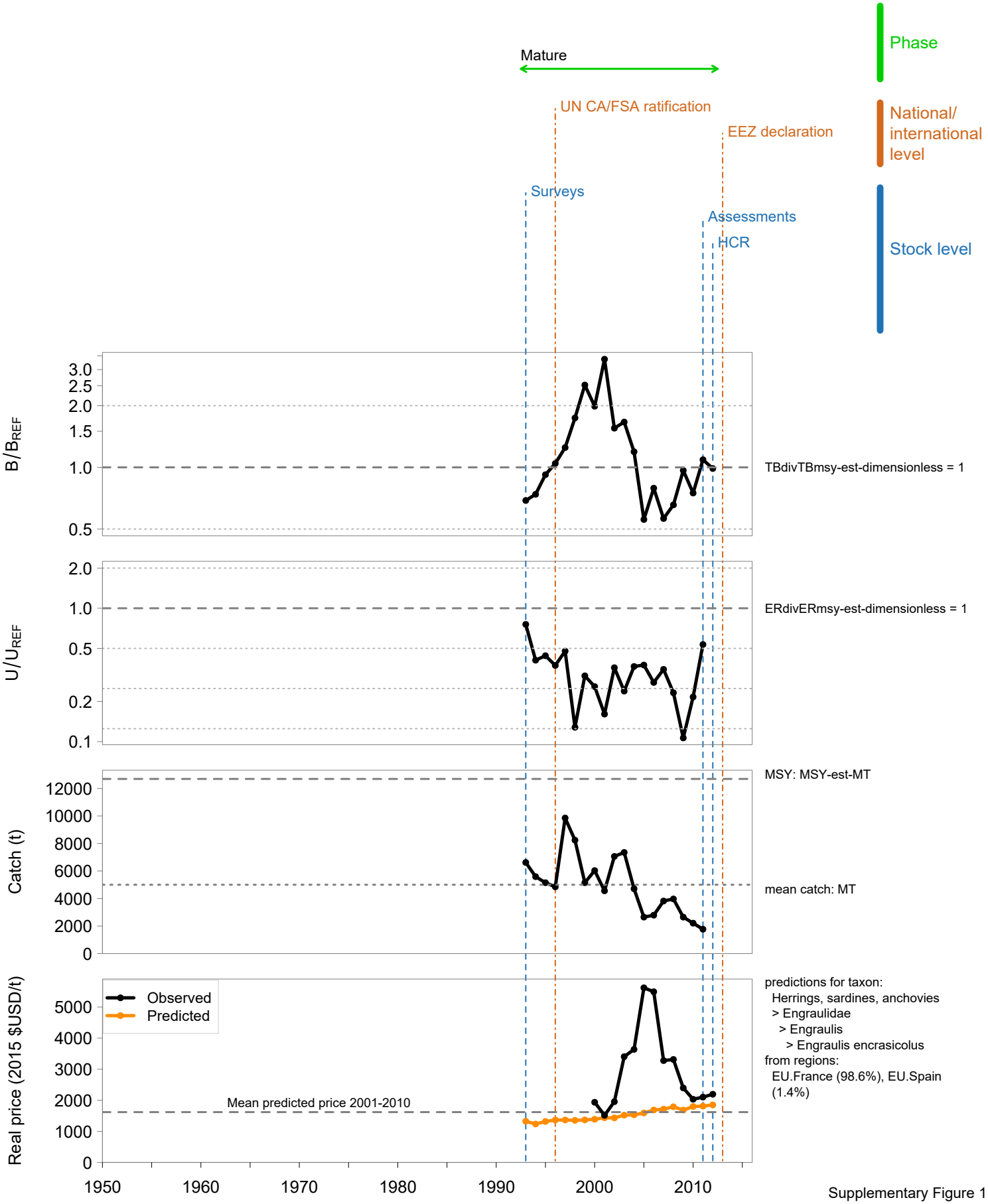
Europe-Med/Black Sea -- ANCHMEDGSA29 -- Anchovy Black Sea

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Turkey



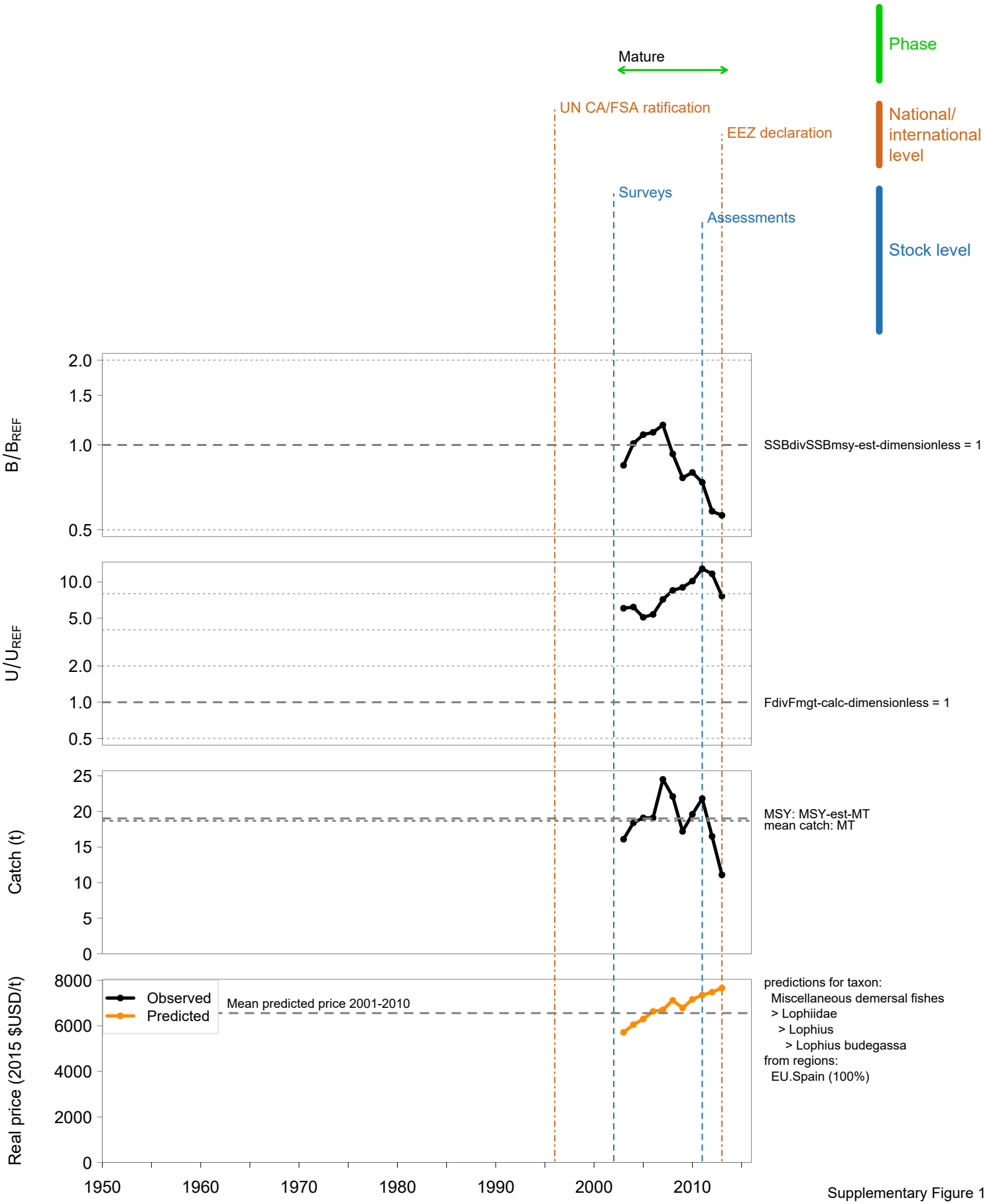
Europe-Med/Black Sea -- ANCHMEDGSA7 -- Anchovy Gulf of Lions

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: France



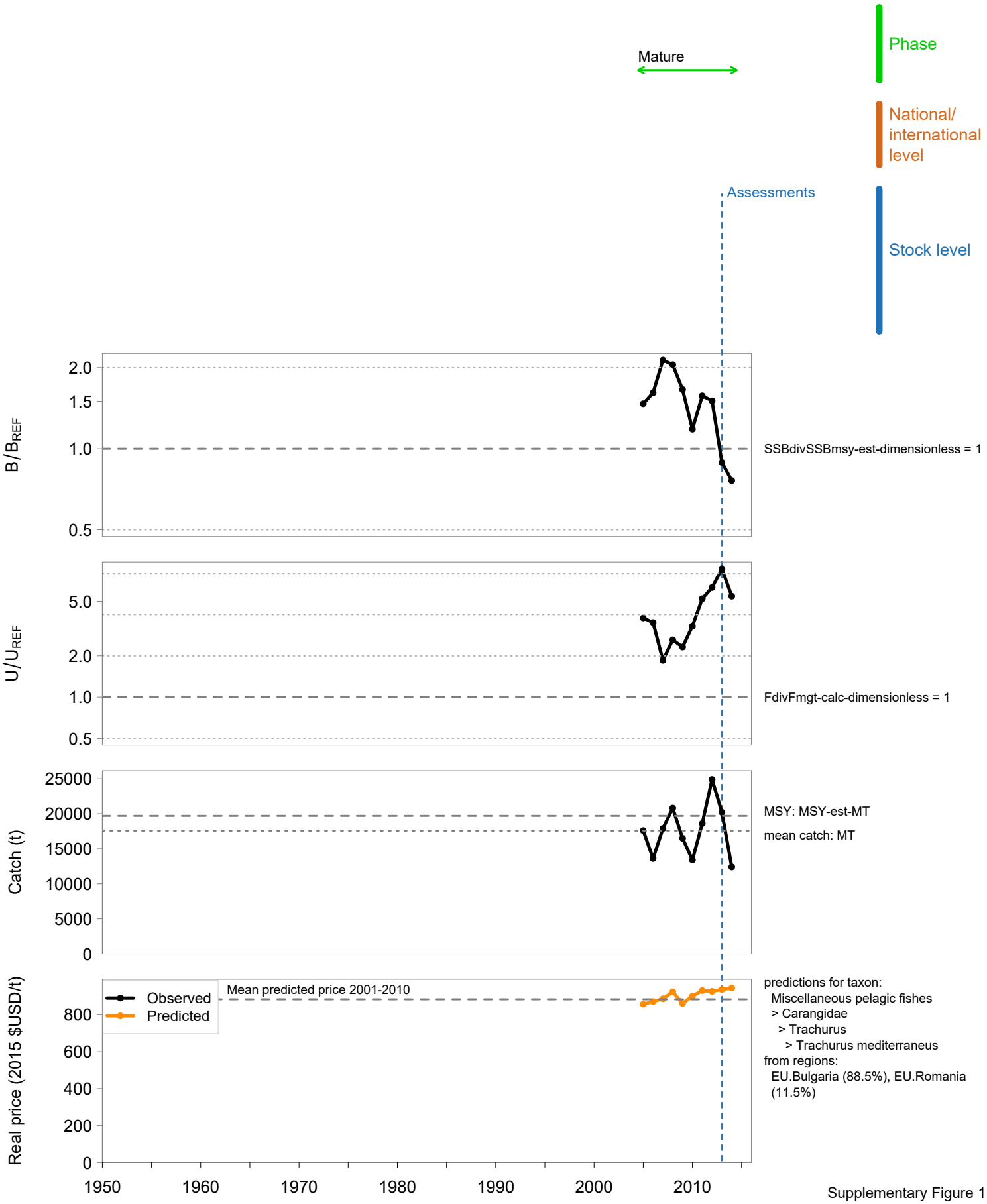
Europe-Med/Black Sea -- ANGLMEDGSA5 -- Black bellied angler Balearic Island

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Spain



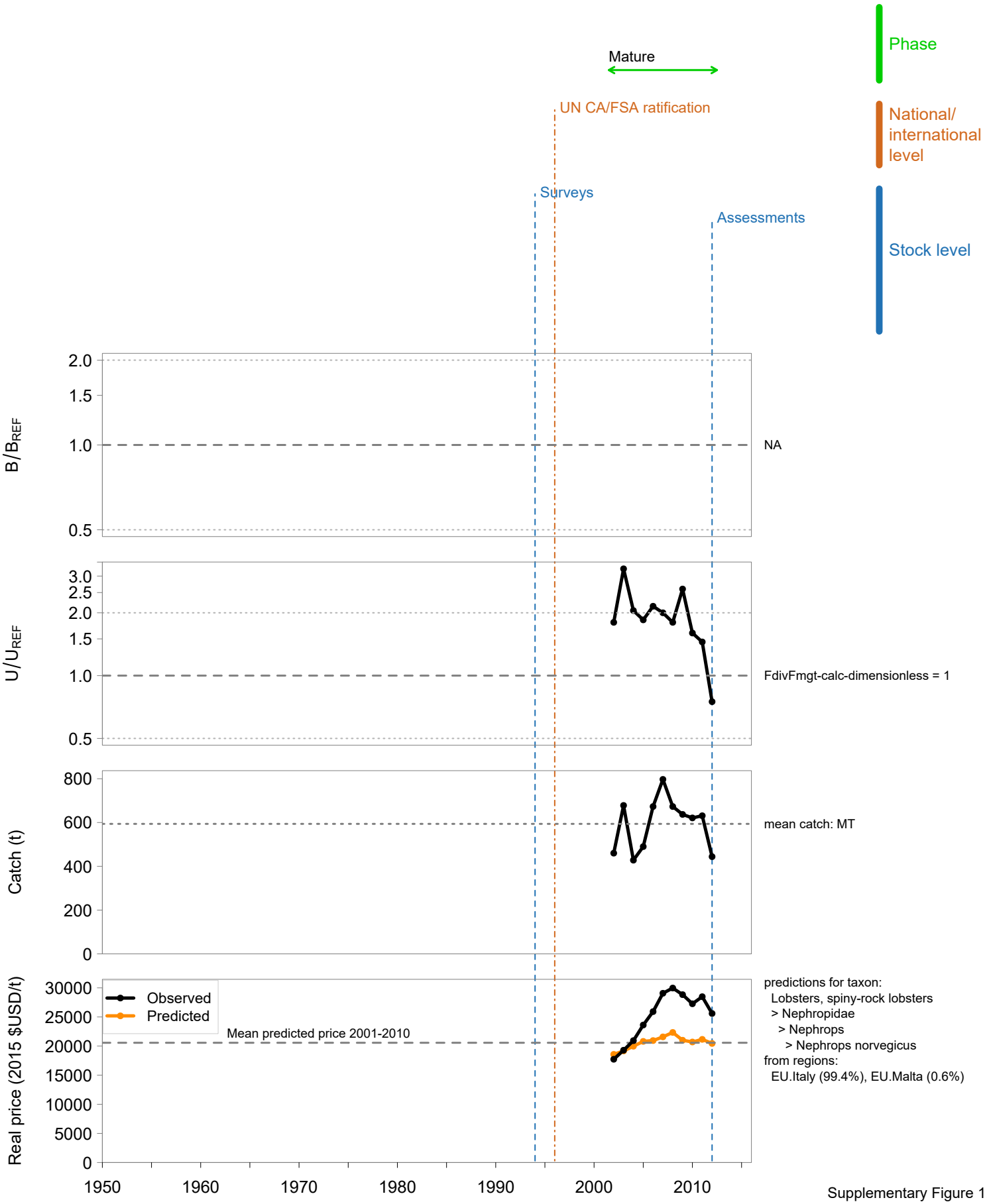
Europe-Med/Black Sea -- MHMACKMEDGSA29 -- Mediterranean horse mackerel Black Sea

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Turkey



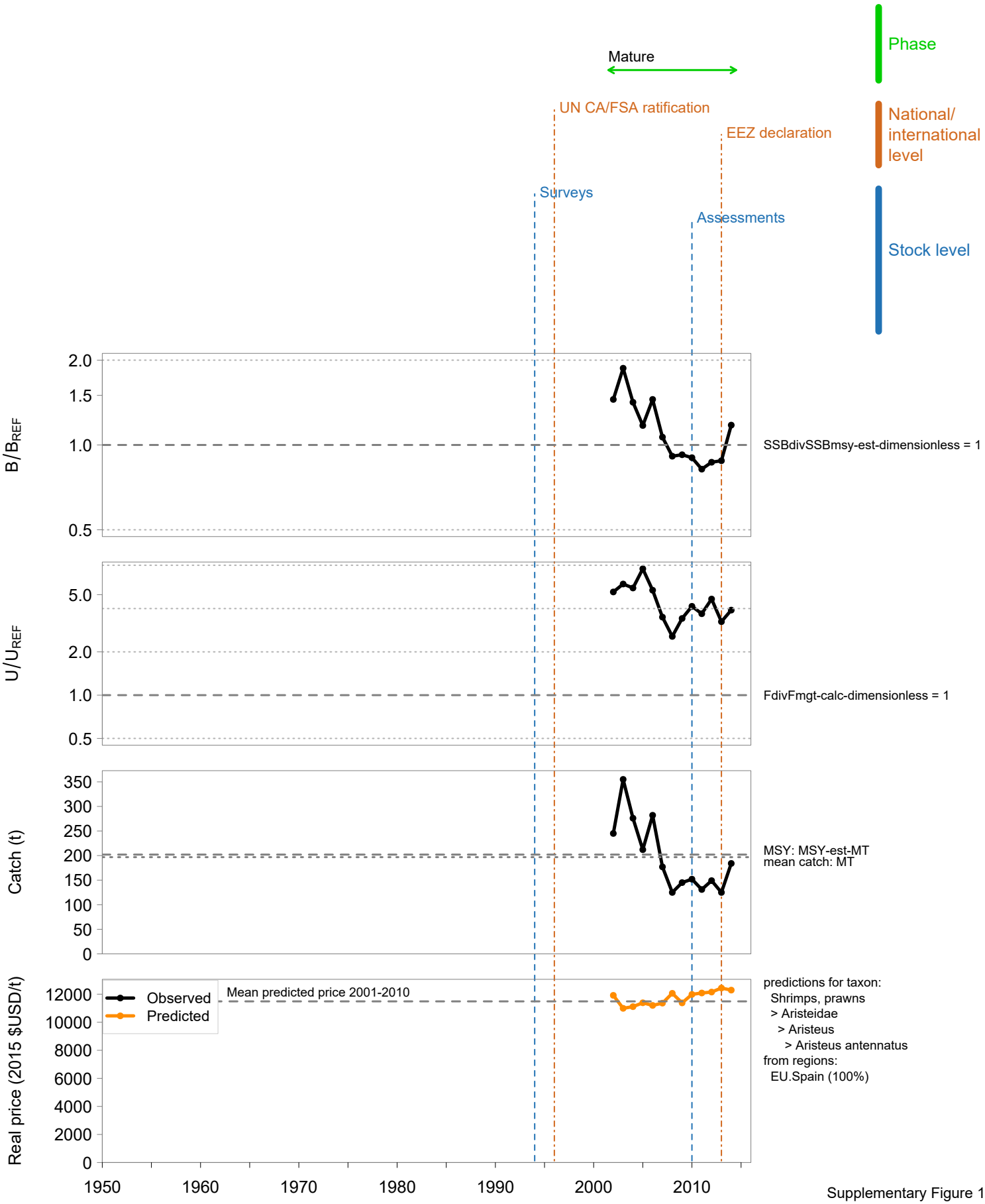
Europe-Med/Black Sea -- NEPHMEDGSA15-16 -- Norway lobster Malta Island and South of Sicily (GSA 15, 16)

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Italy



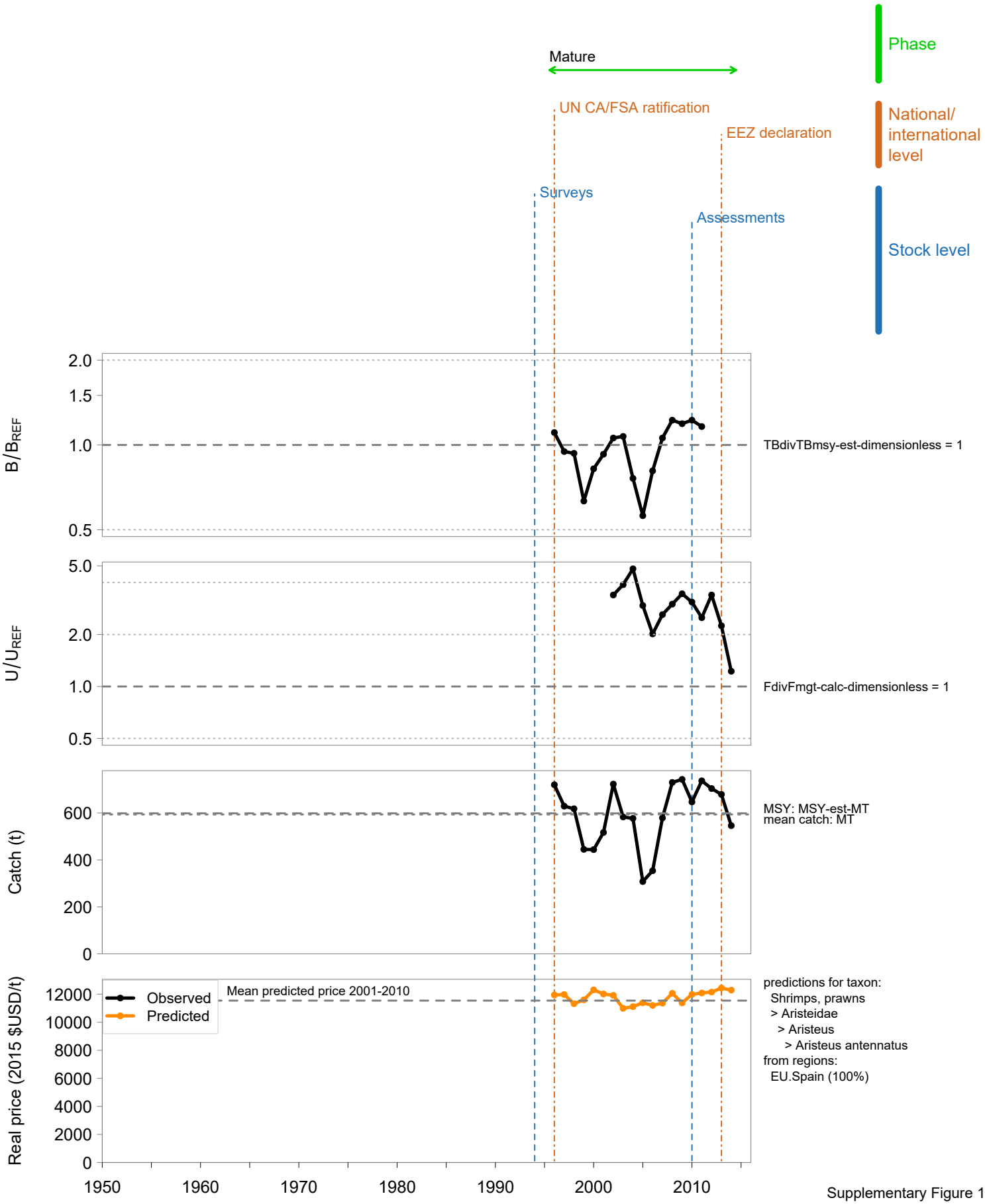
Europe-Med/Black Sea -- RDSHRMPMEDGSA1 -- Red shrimp Northern Alboran Sea

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Spain



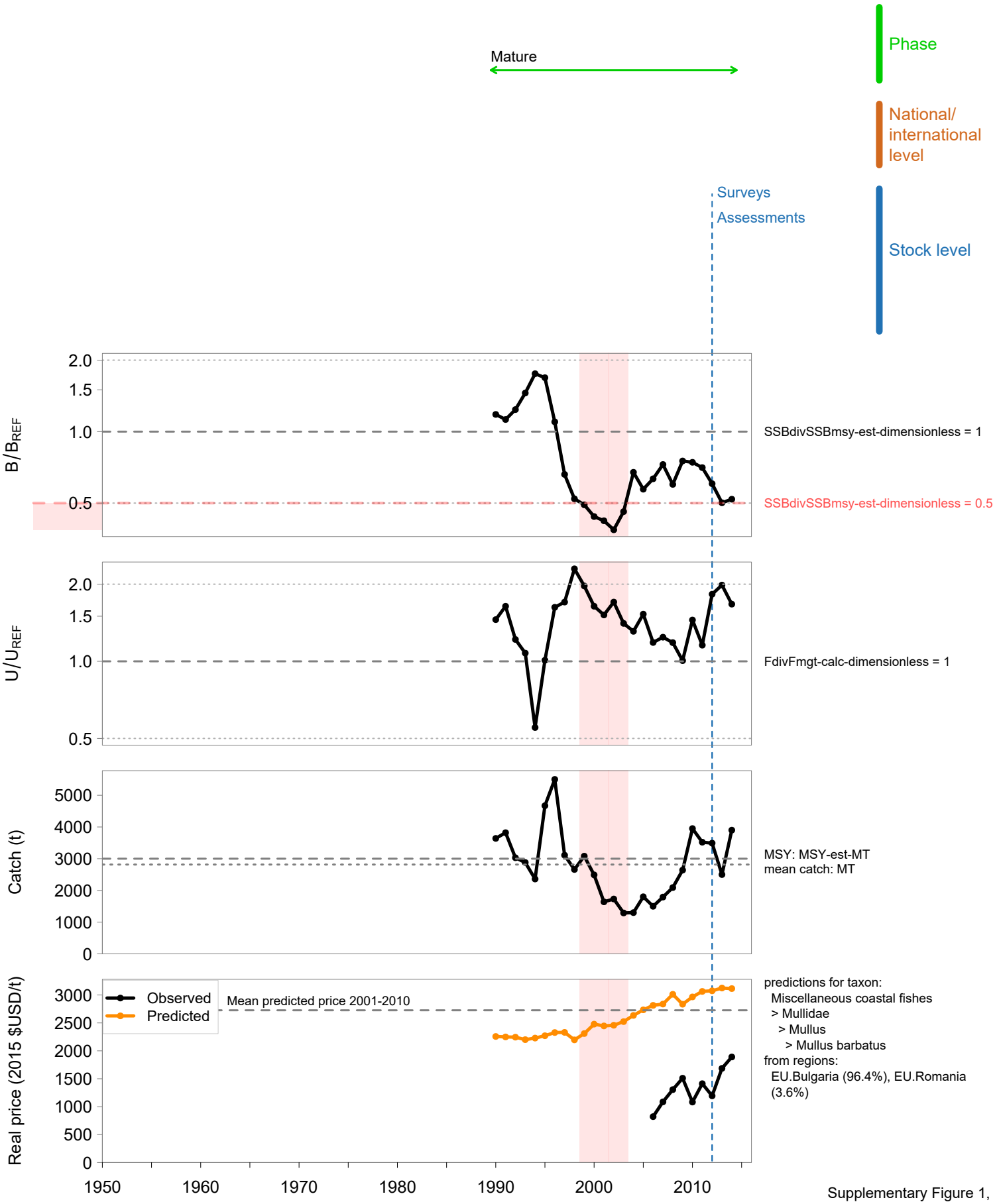
Europe-Med/Black Sea -- RDSHRMPMEDGSA6 -- Red shrimp Northern Spain

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Spain



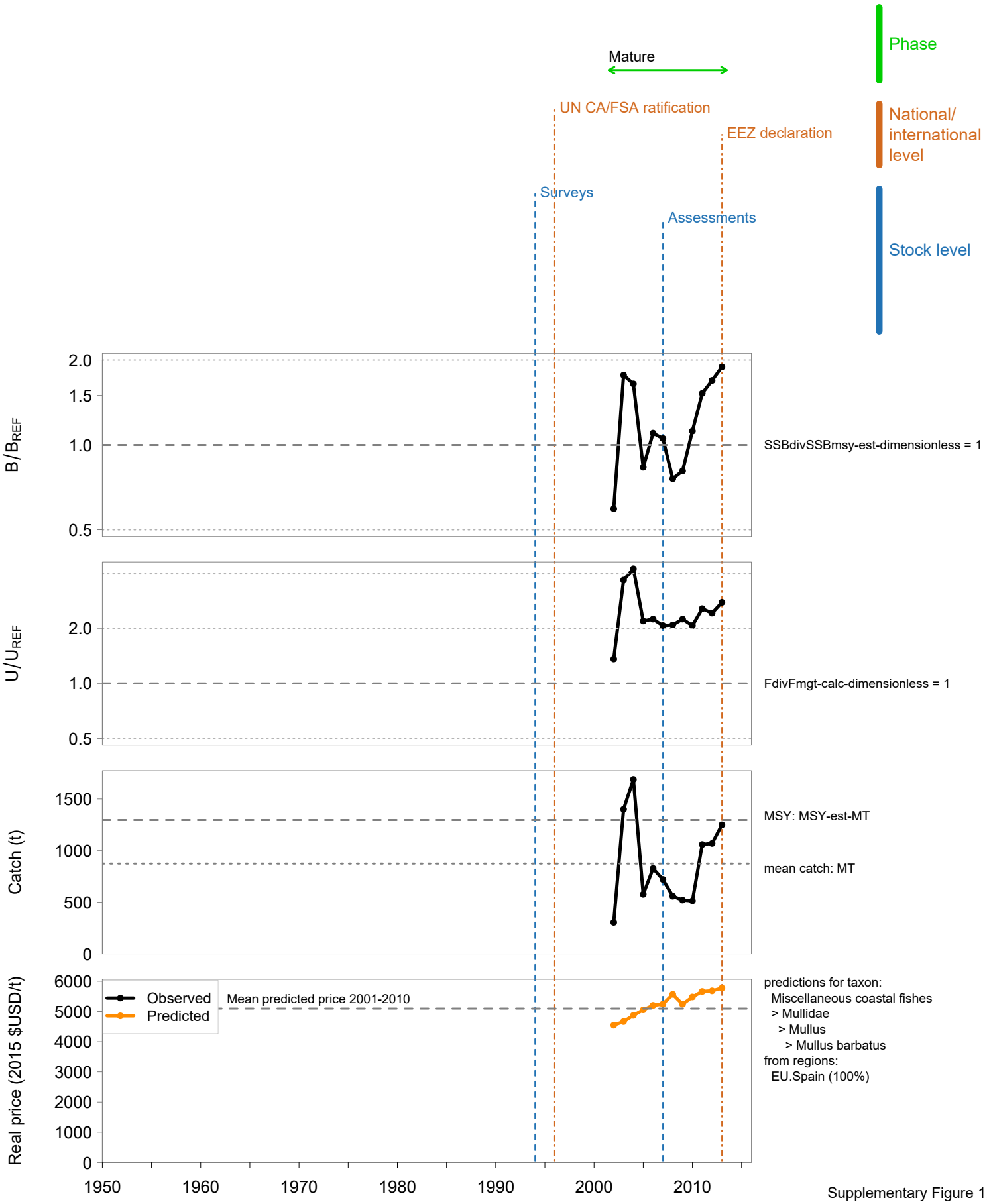
Europe-Med/Black Sea -- RMULLMEDGSA29 -- Red mullet Black Sea

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Turkey



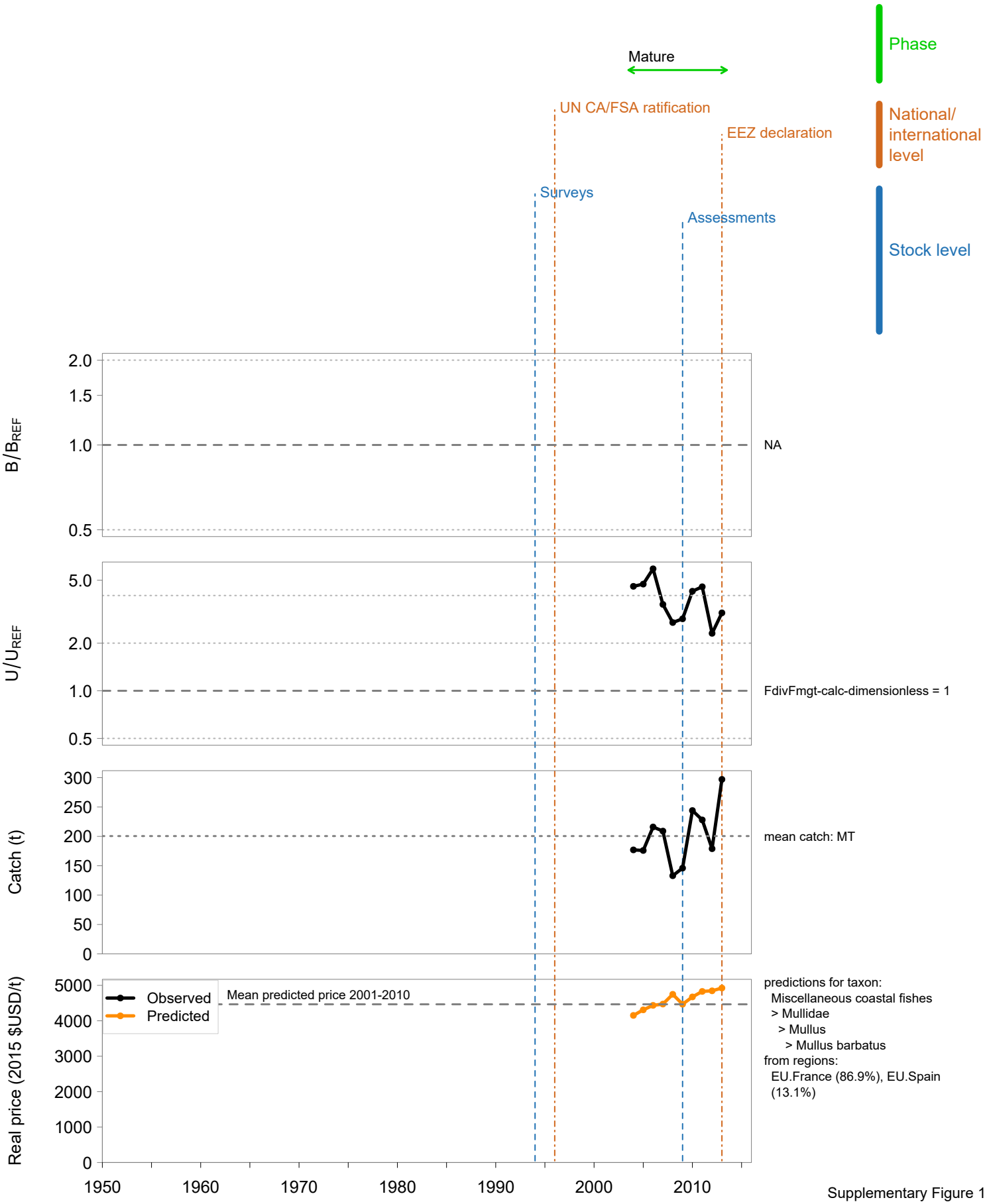
Europe-Med/Black Sea -- RMULLMEDGSA6 -- Red mullet Northern Spain

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Spain



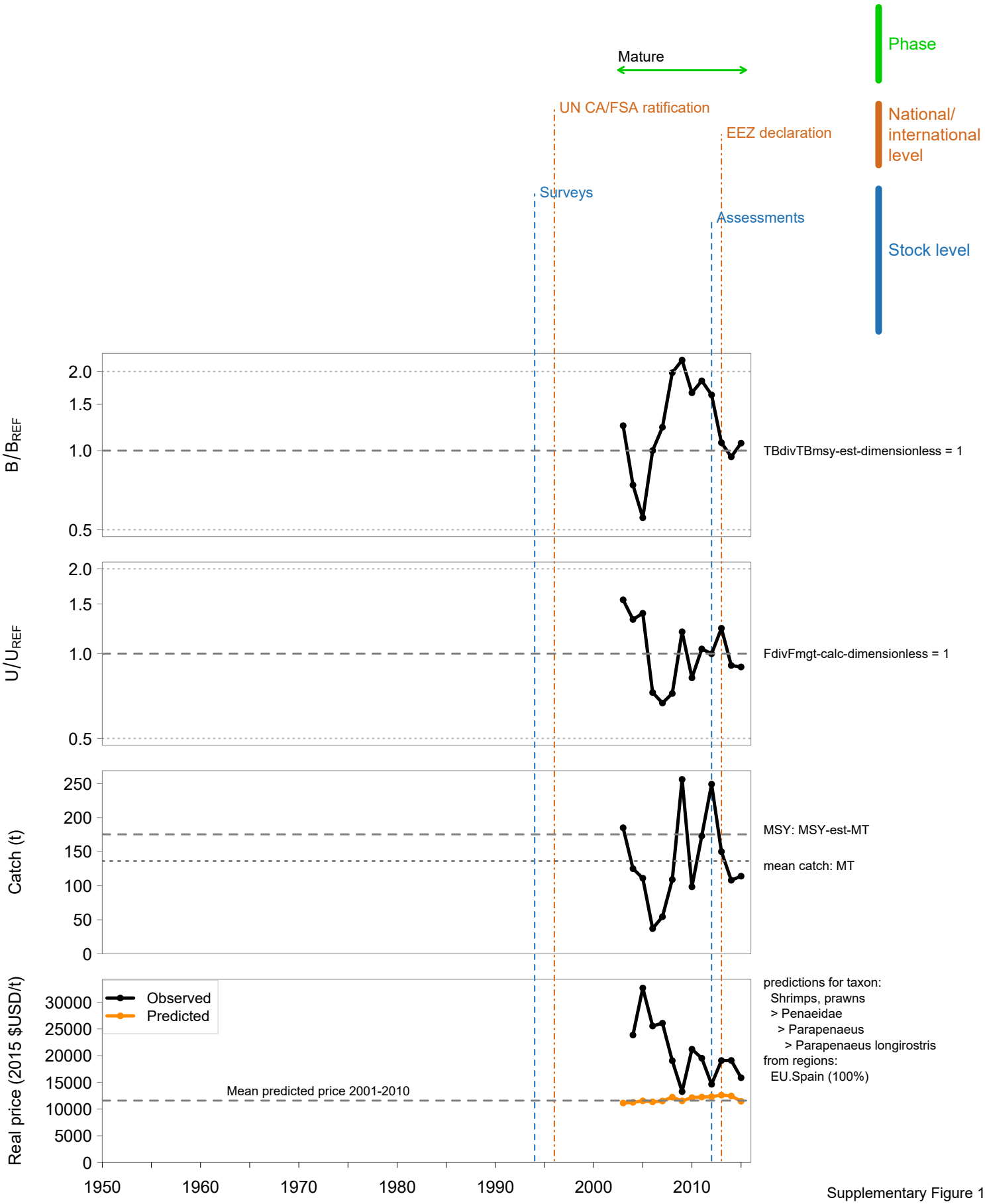
Europe-Med/Black Sea -- RMULLMEDGSA7 -- Red mullet Gulf of Lions

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: France



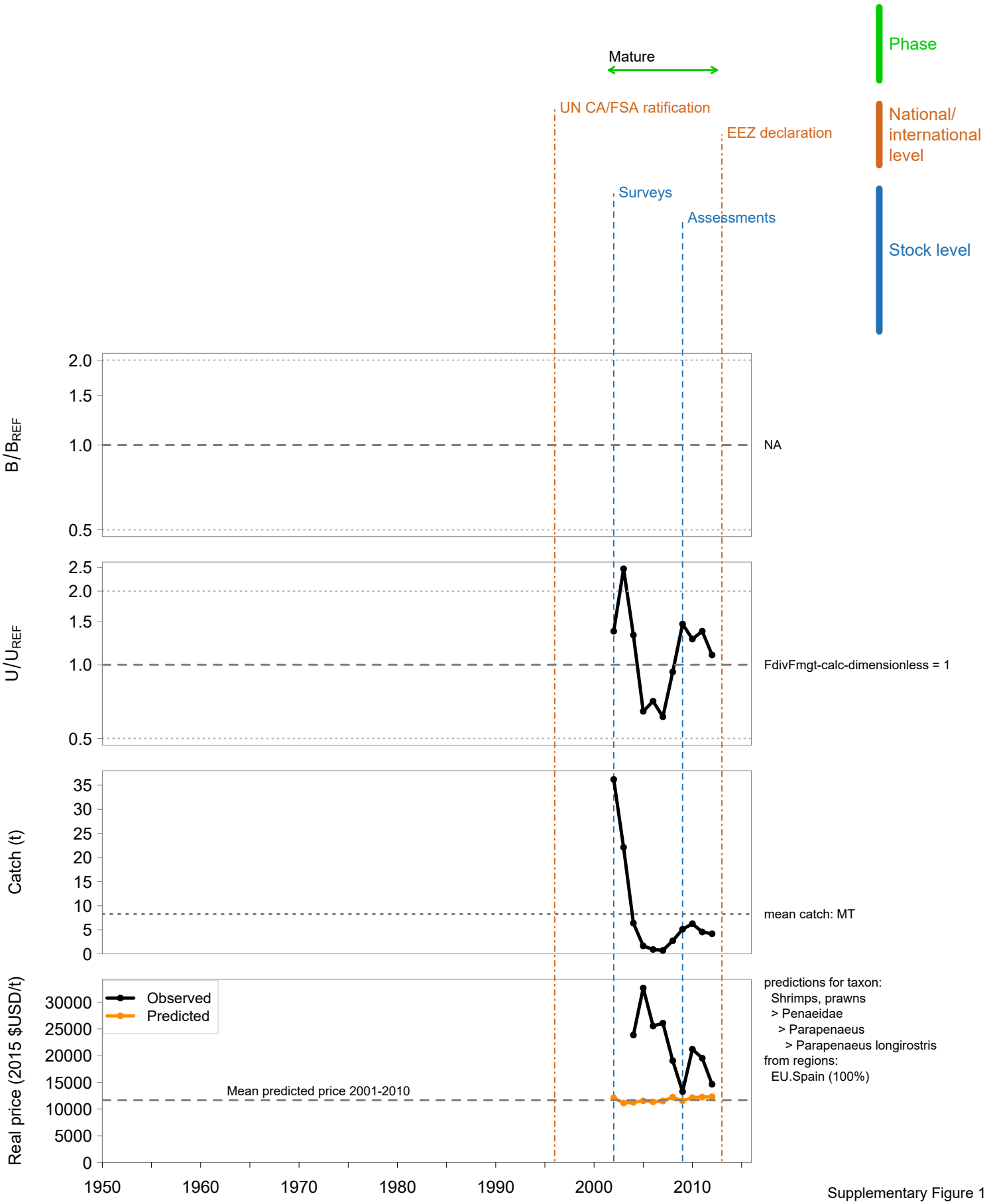
Europe-Med/Black Sea -- RSHRMPMEDGSA1 -- Deep water rose shrimp Northern Alboran Sea

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Spain



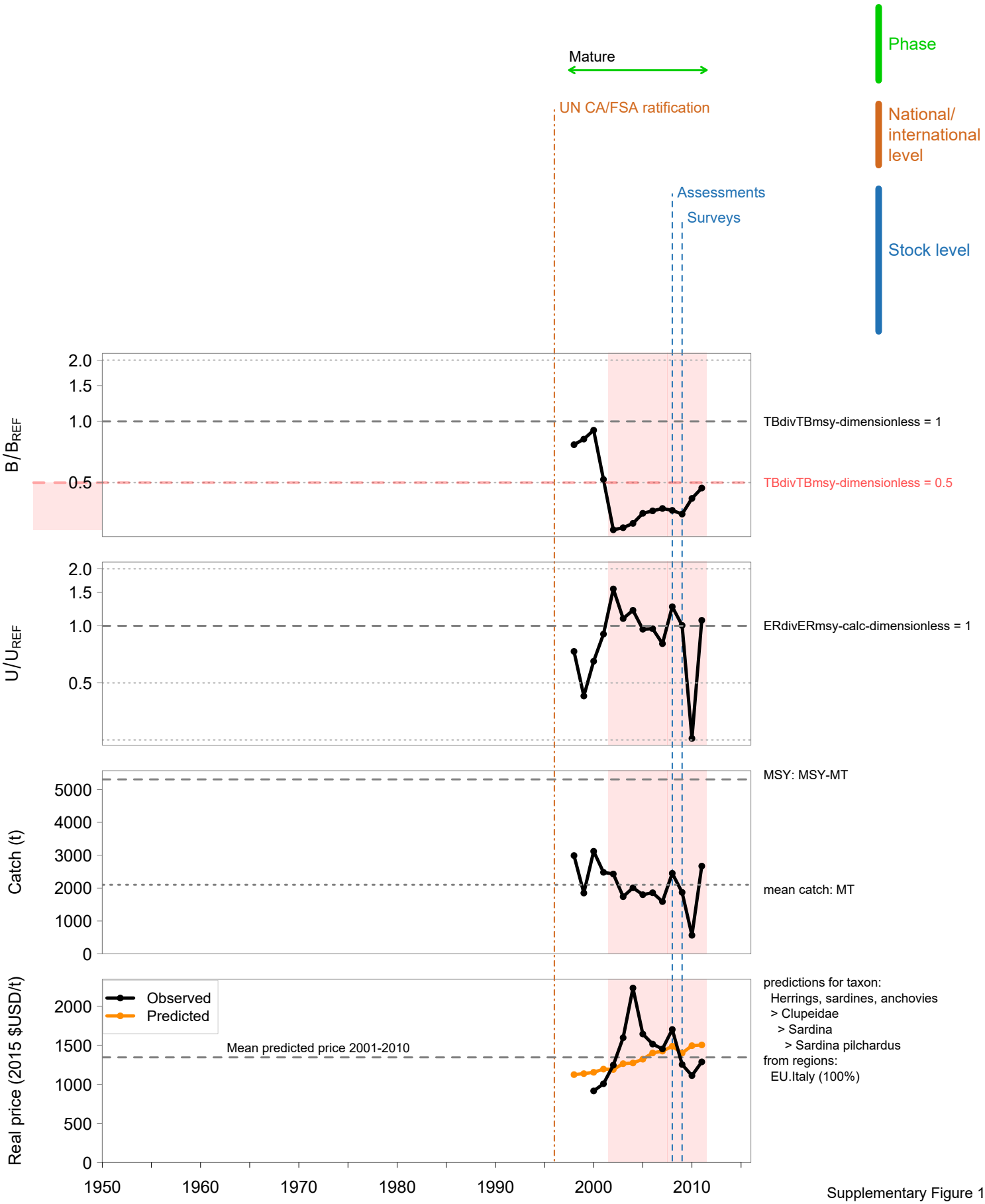
Europe-Med/Black Sea -- RSHRMPMEDGSA5 -- Deep water rose shrimp Balearic Island

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Spain



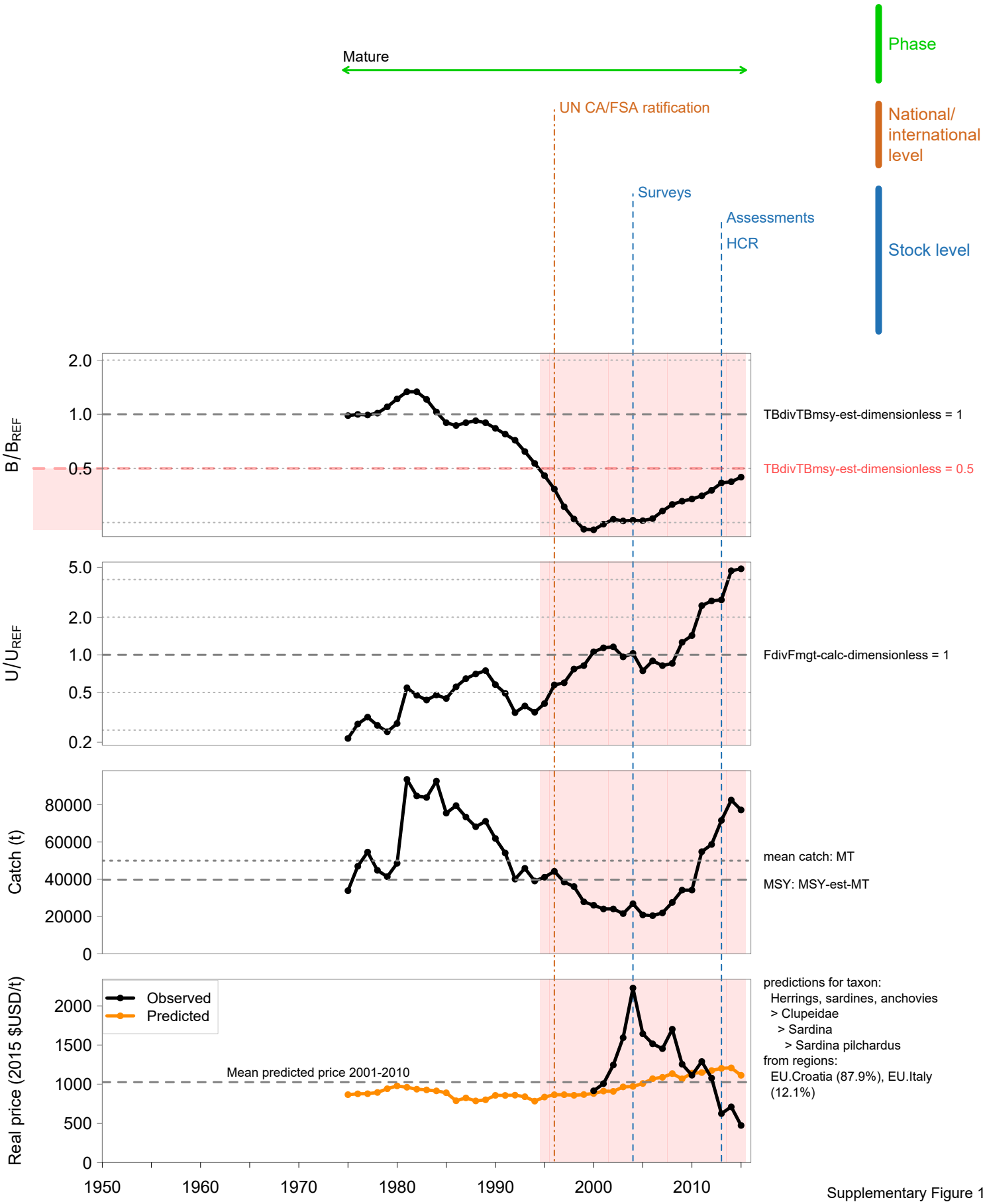
Europe-Med/Black Sea -- SARDMEDGSA16 -- Sardine South of Sicily

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Italy



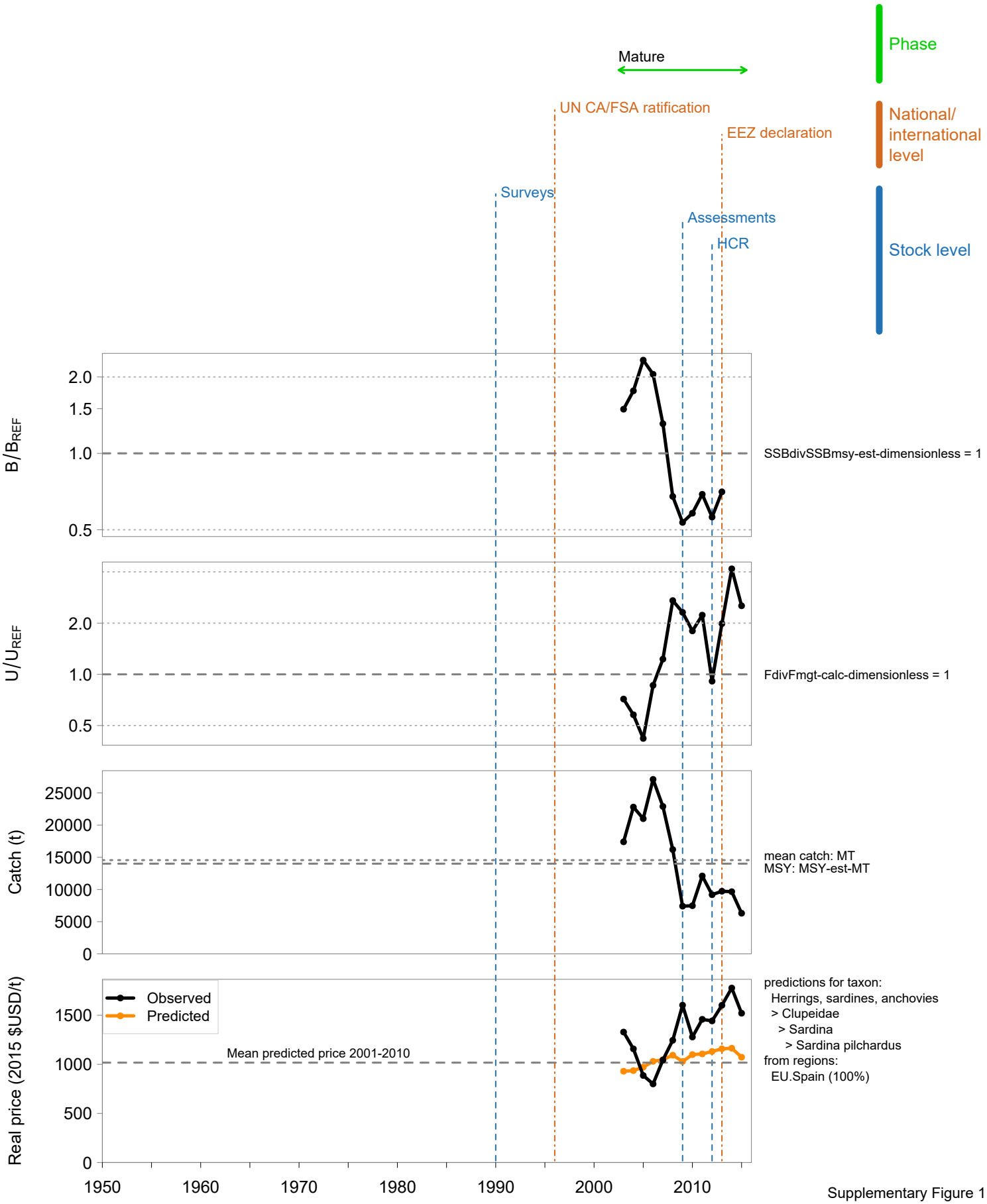
Europe-Med/Black Sea -- SARDMEDGSA17-18 -- Sardine Adriatic Sea (GSA 17,18)

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Italy



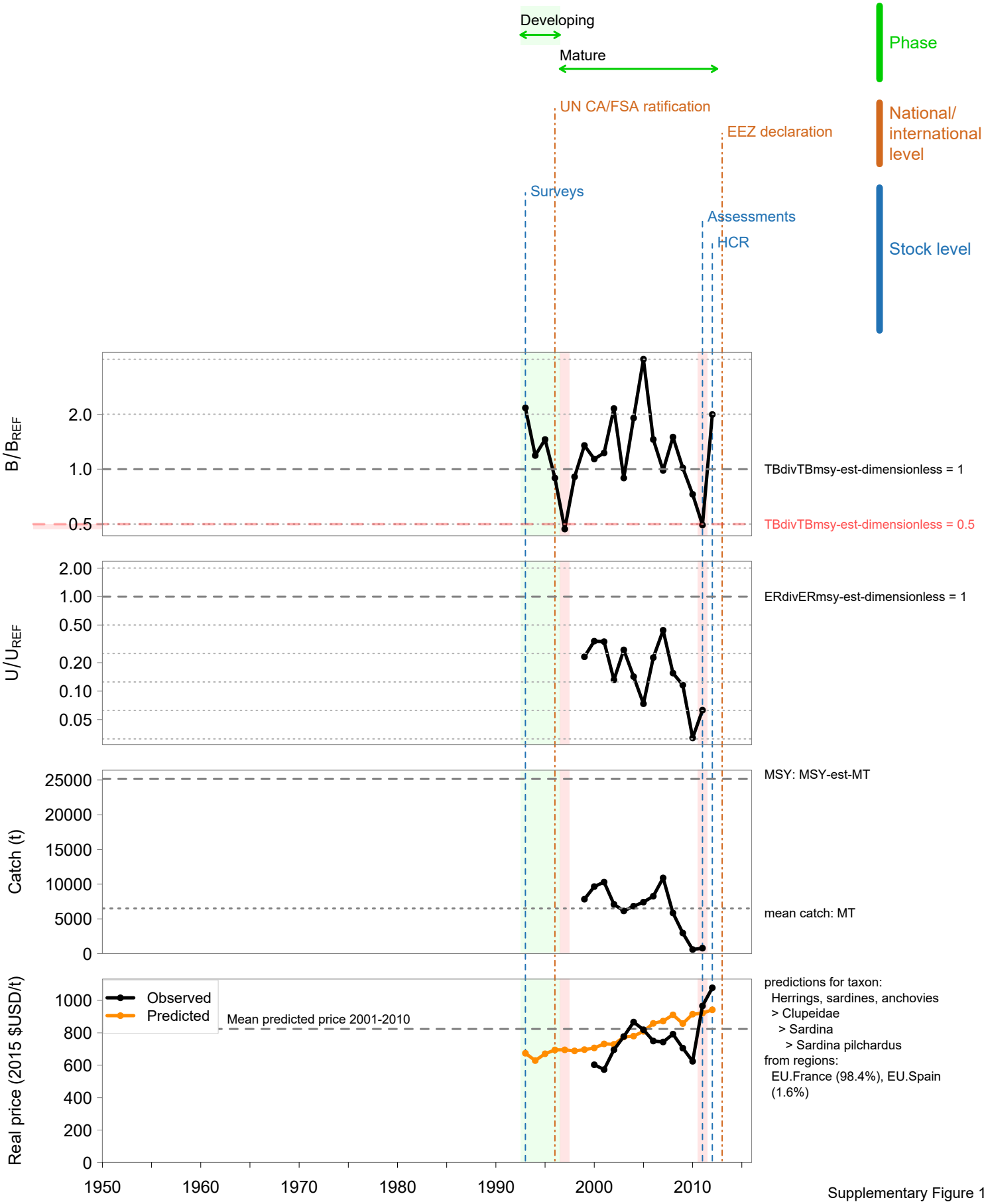
Europe-Med/Black Sea -- SARDMEDGSA6 -- European pilchard Northern Spain

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Spain



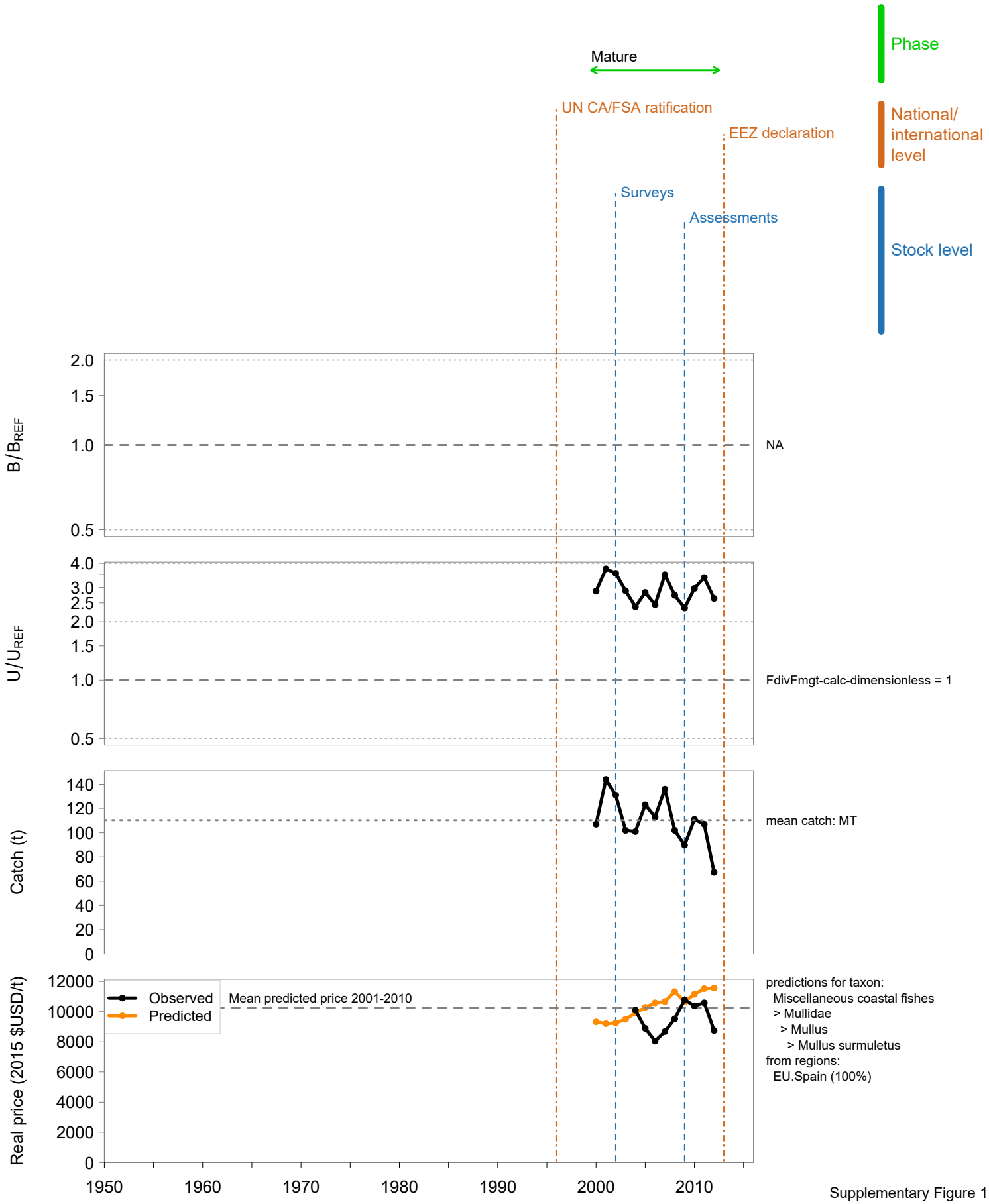
Europe-Med/Black Sea -- SARDMEDGSA7 -- Sardine Gulf of Lions

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: France



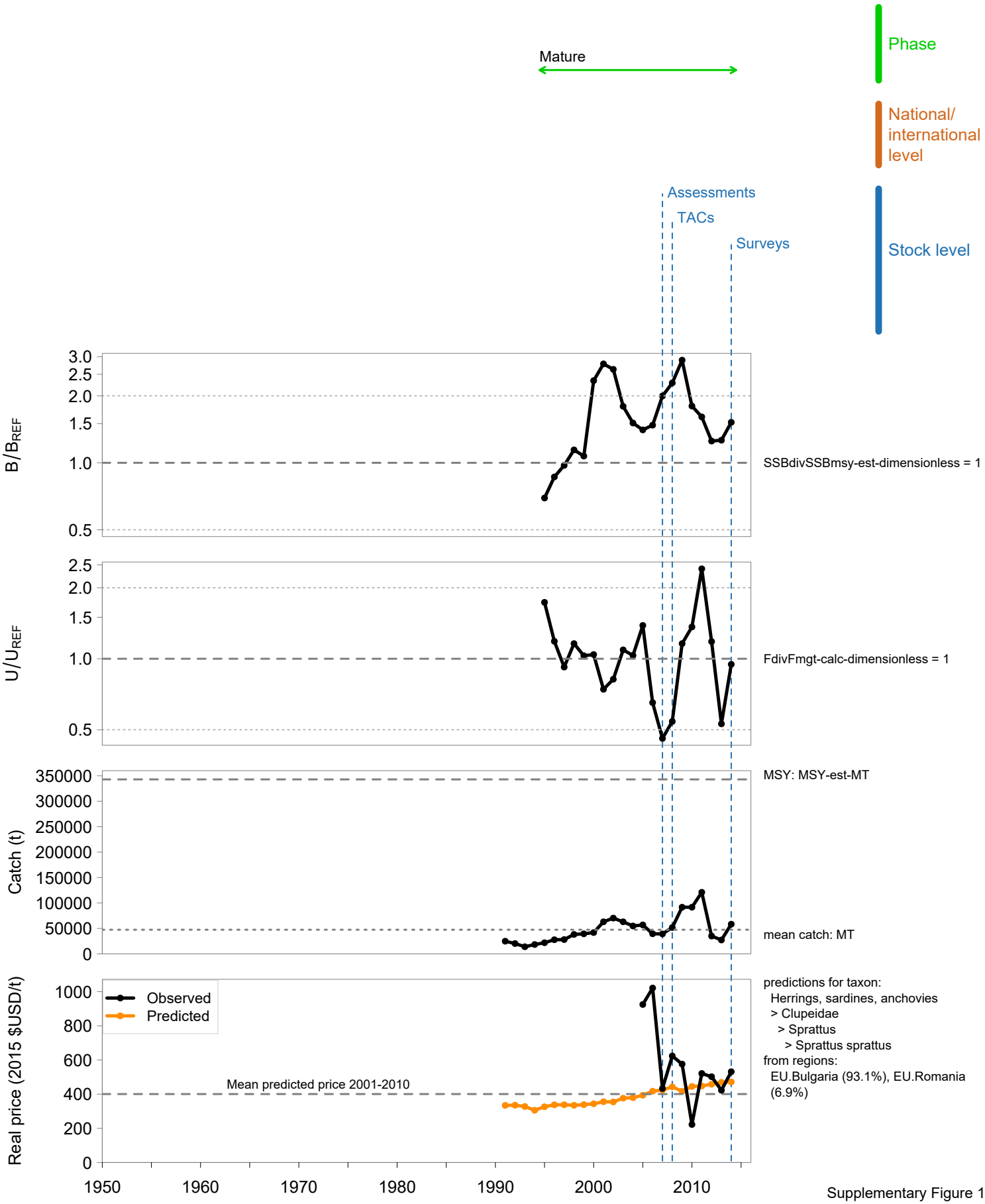
Europe-Med/Black Sea -- SMULLMEDGSA5 -- Surmullet Balearic Island

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: Spain



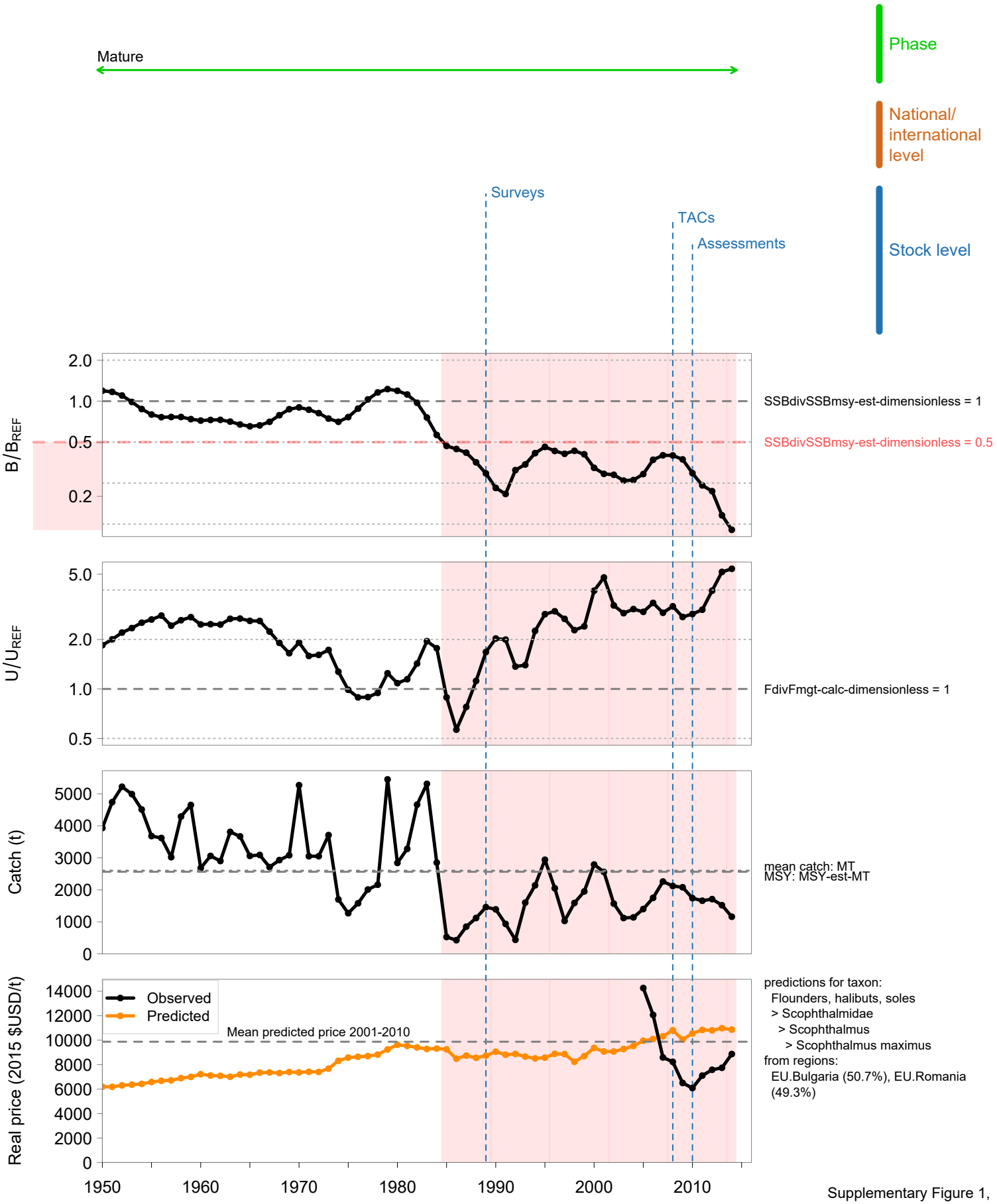
Europe-Med/Black Sea -- SPRBLKGSA29 -- Sprat Black Sea

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Ukraine



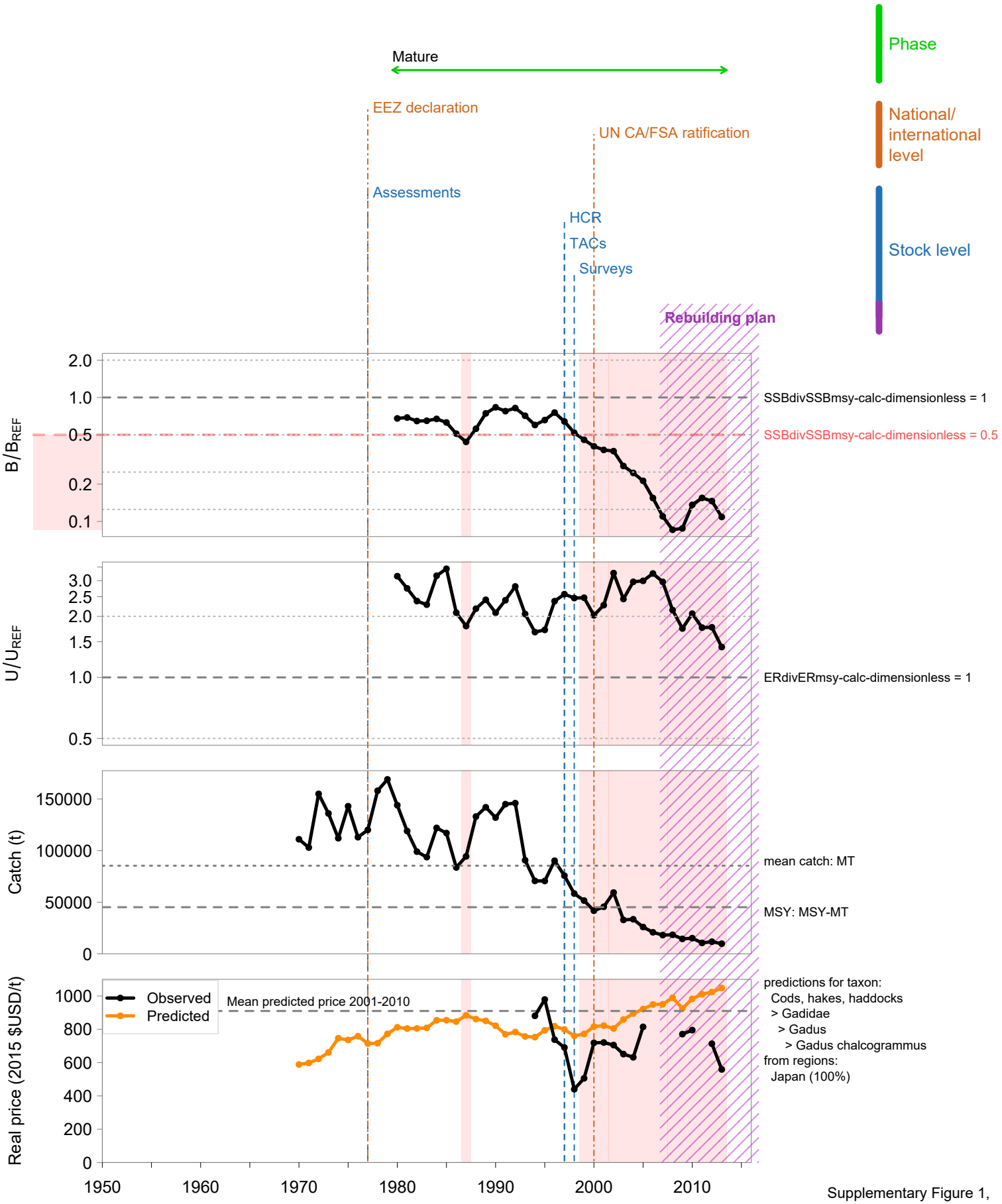
Europe-Med/Black Sea -- TURBLKGSA29 -- Turbot Black Sea

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Turkey



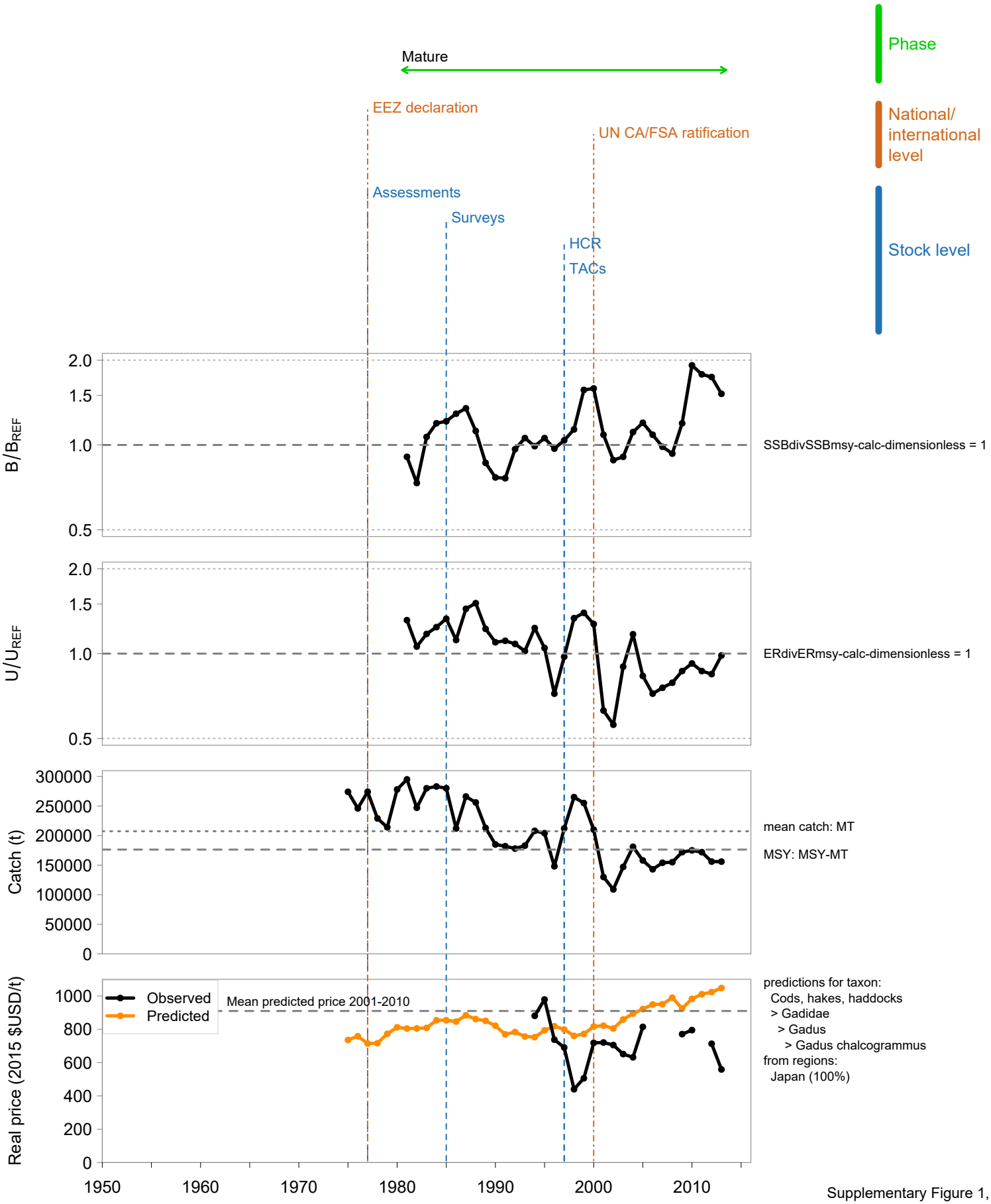
Japan -- APOLLNSJ -- Walleye pollock Sea of Japan North

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Japan



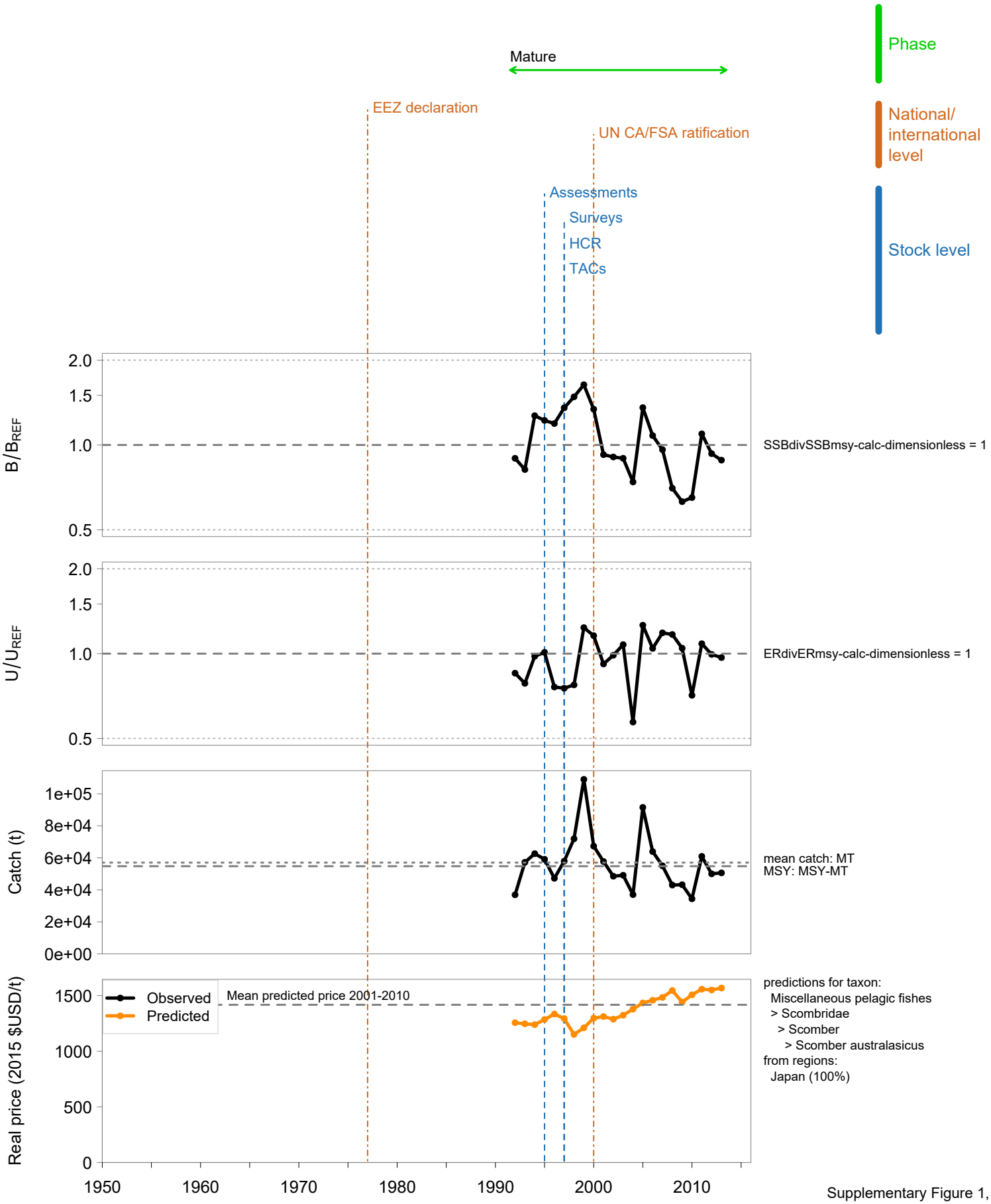
Japan -- APOLLPJPN -- Walleye pollock Pacific Coast of Japan

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Japan



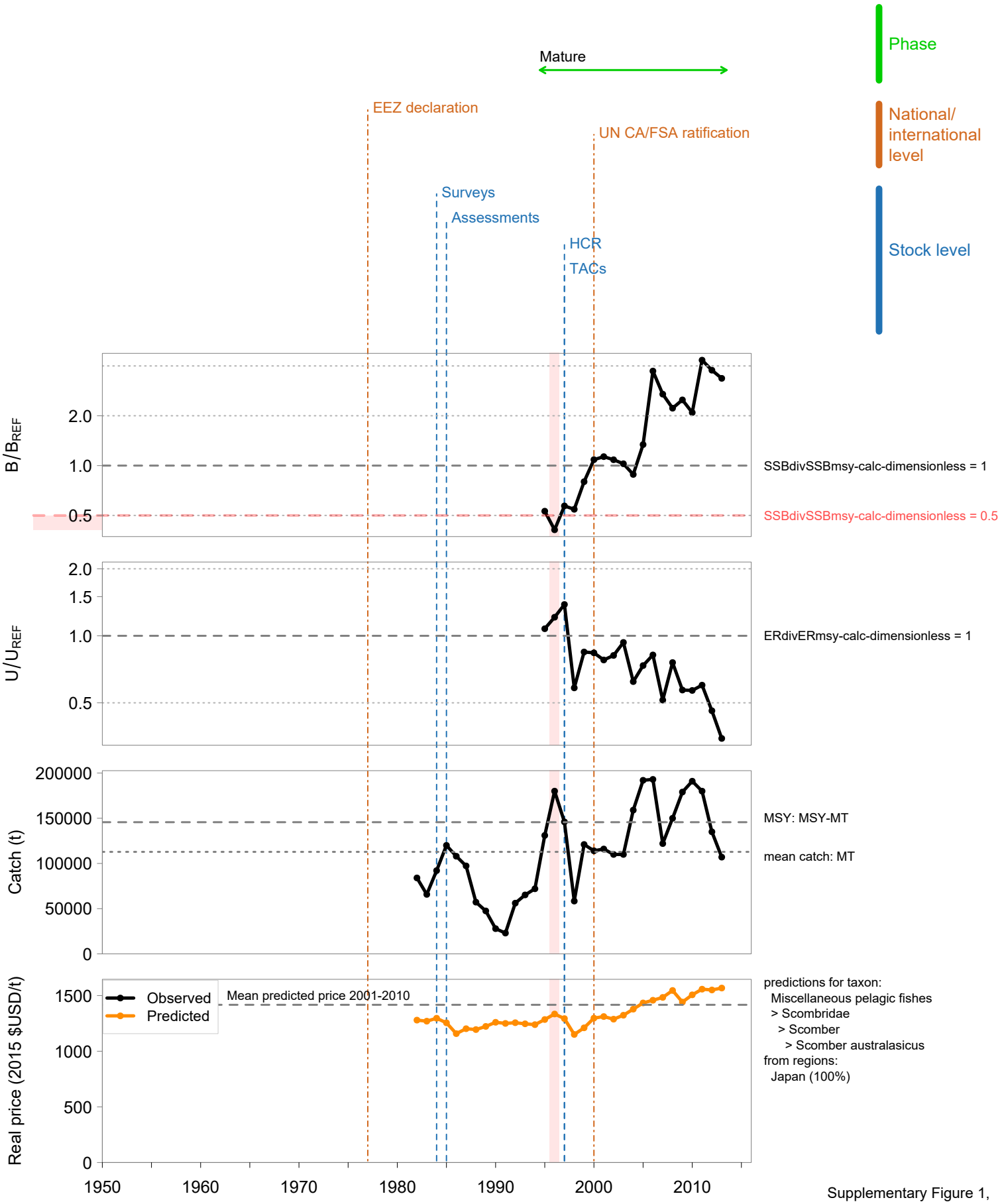
Japan -- BMACKECS -- Spotted mackerel East China Sea

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



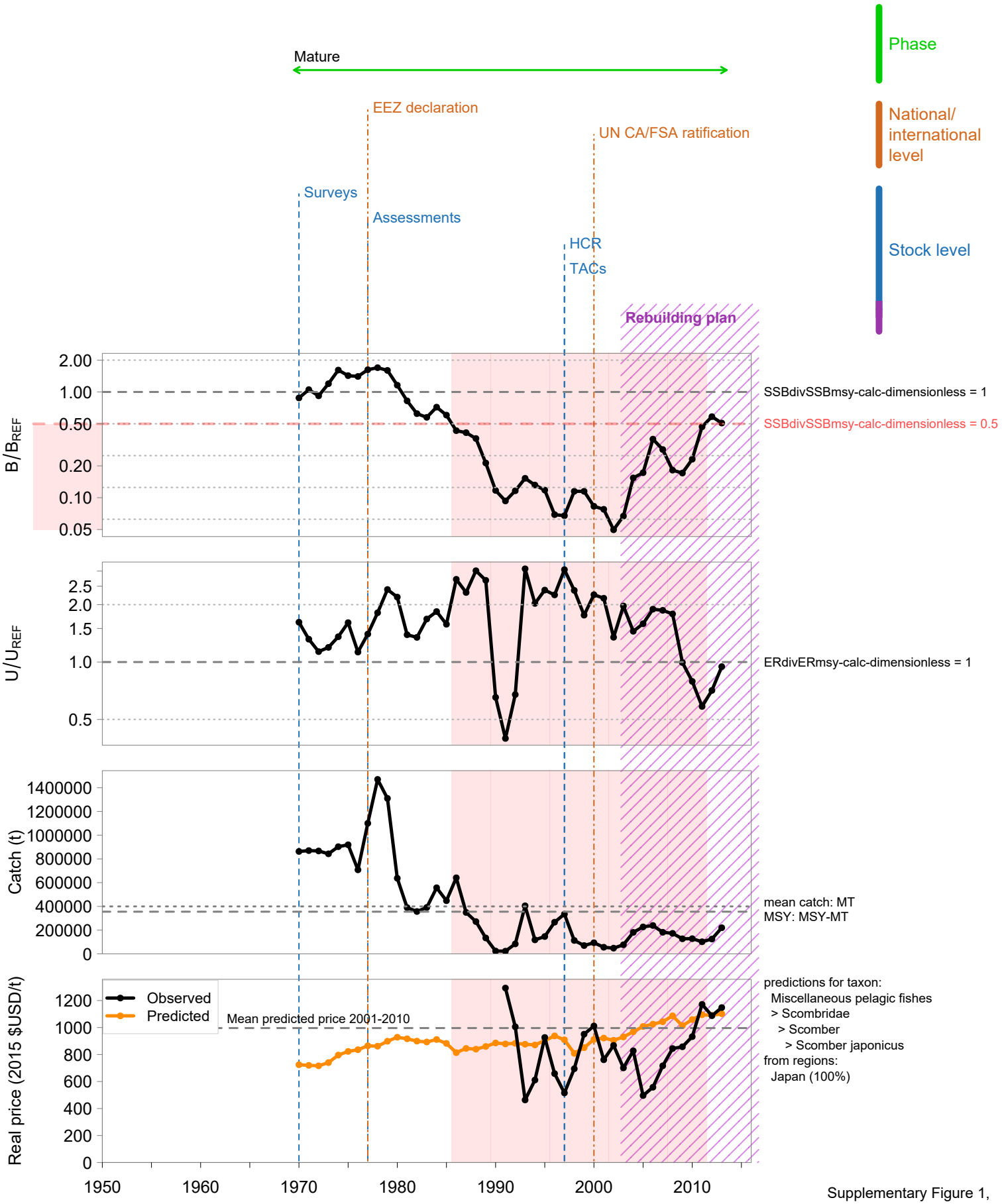
Japan -- BMACKPJPN -- Spotted mackerel Pacific Coast of Japan

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



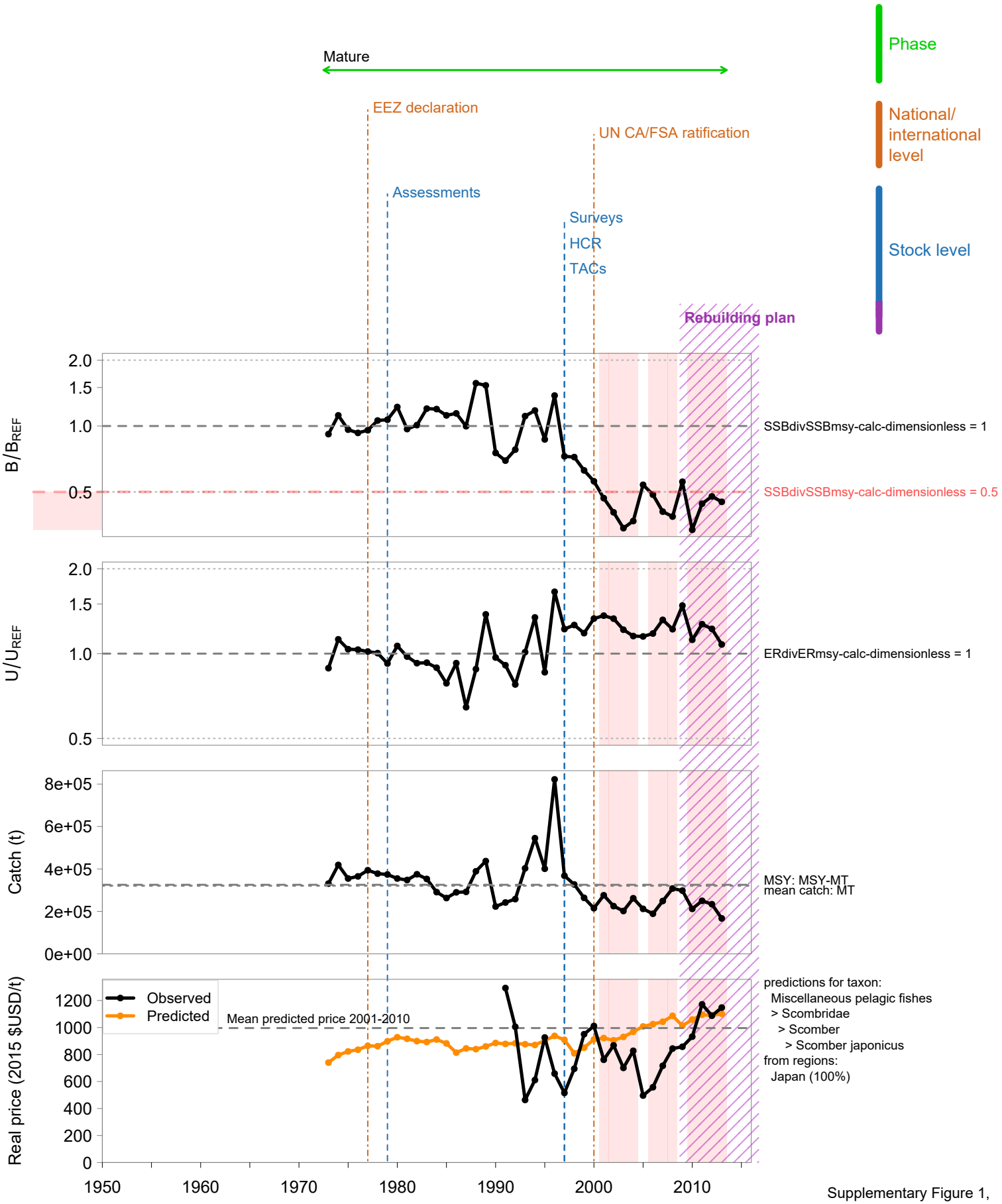
Japan -- CMACKPJPN -- Chub mackerel Pacific Coast of Japan

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



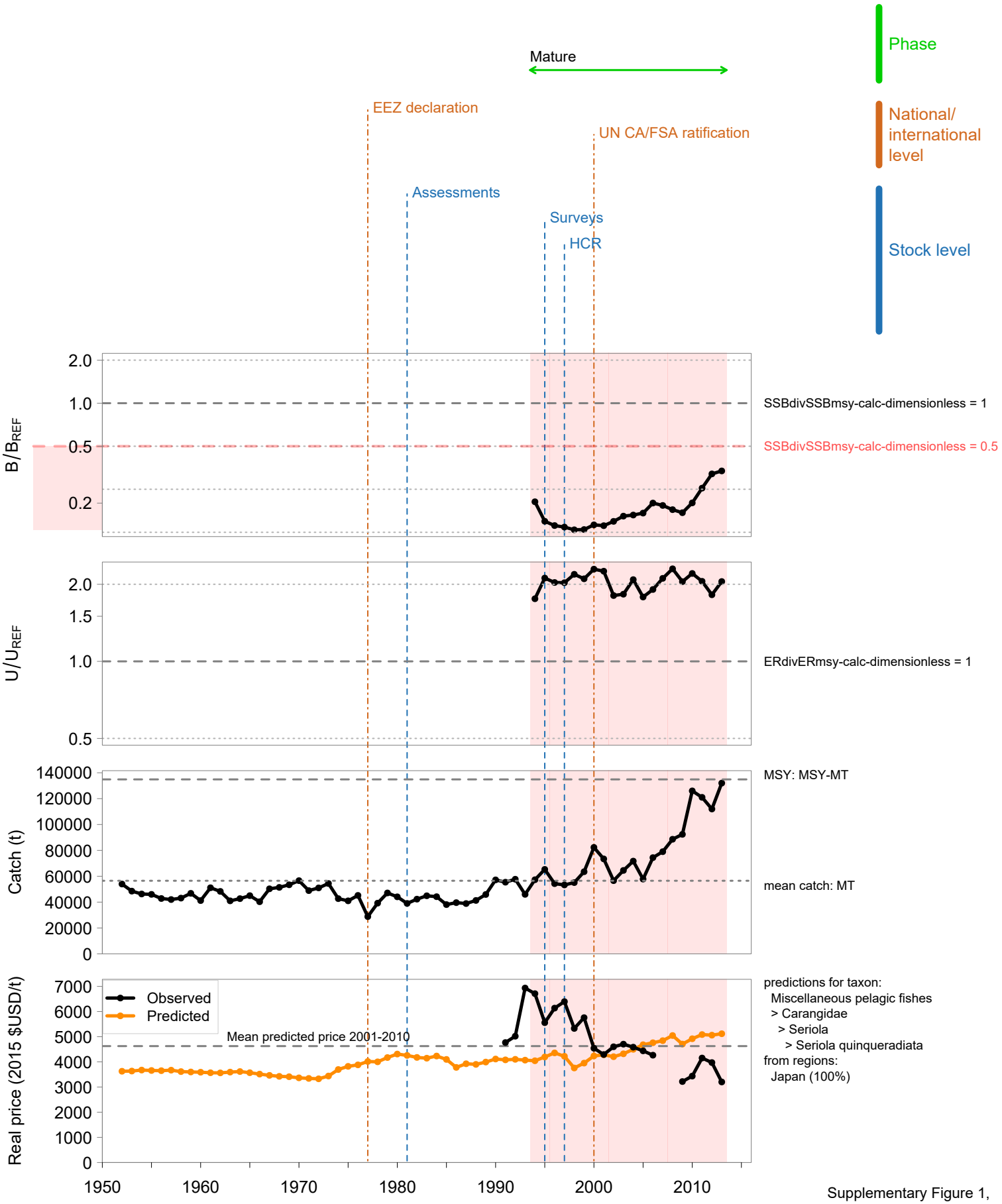
Japan -- CMACKTSST -- Chub mackerel Tsushima Strait

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



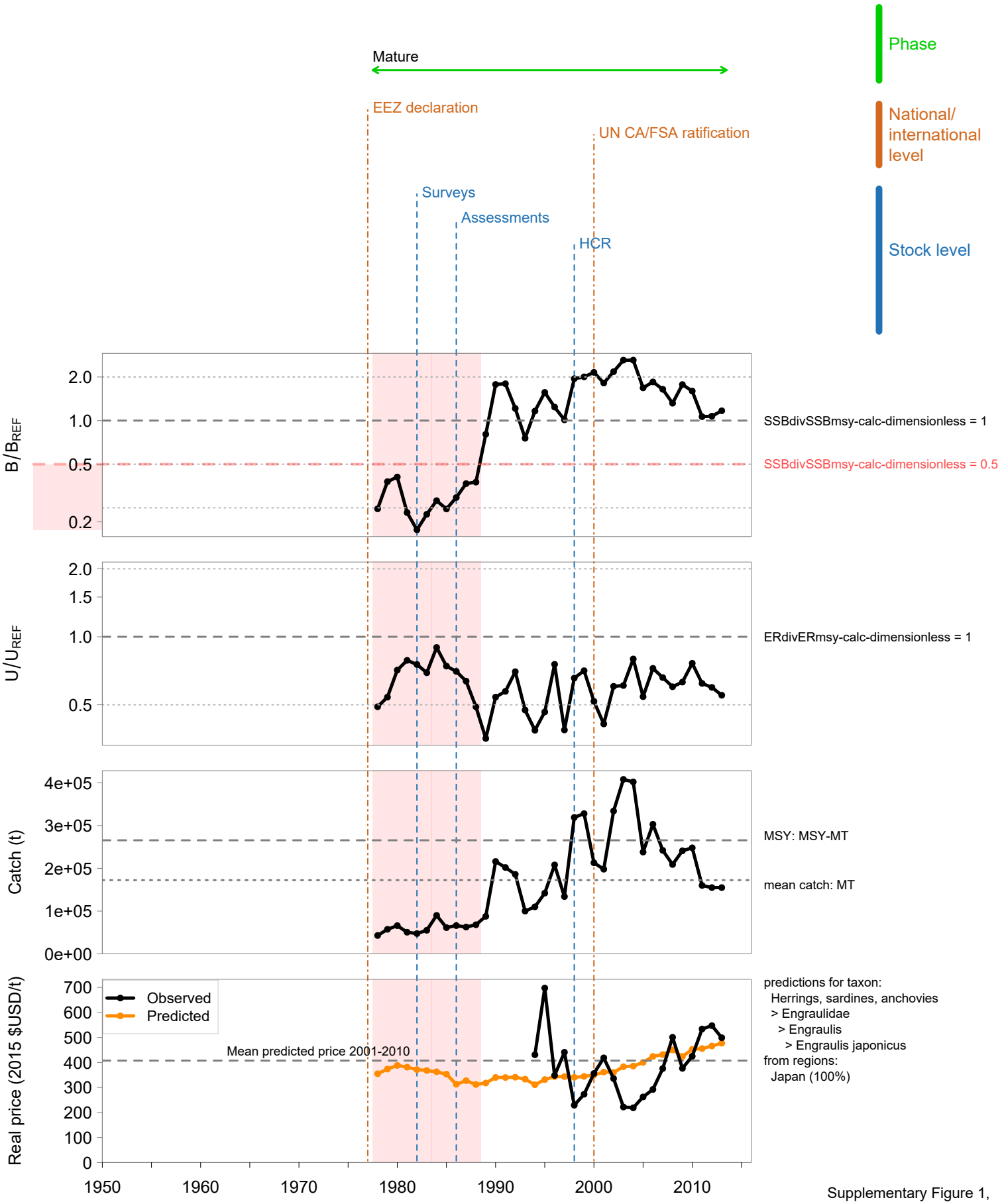
Japan -- JAMBERJPN -- Japanese amberjack Japan

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



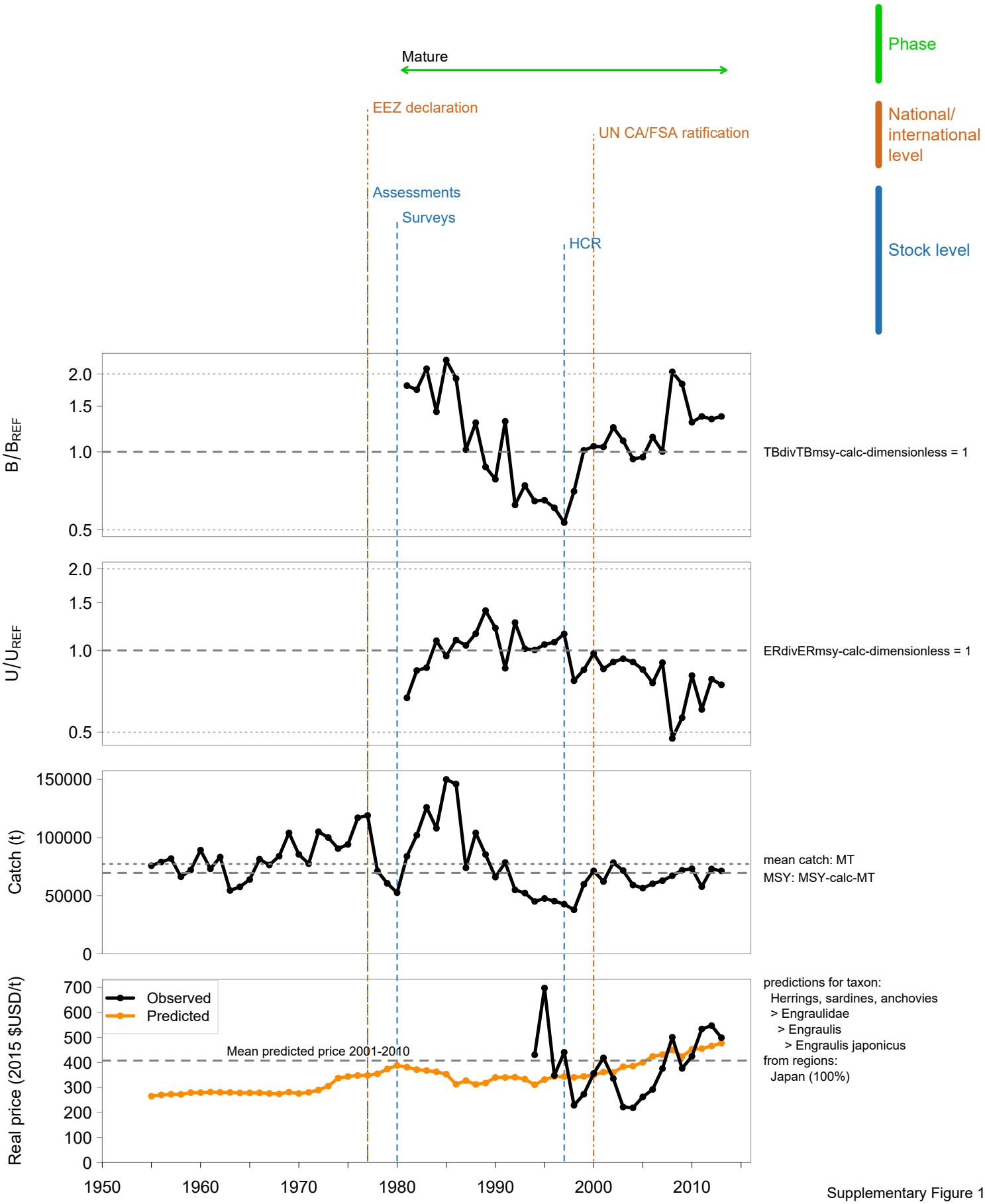
Japan -- JANCHOPJPN -- Japanese anchovy Pacific Coast of Japan

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Japan



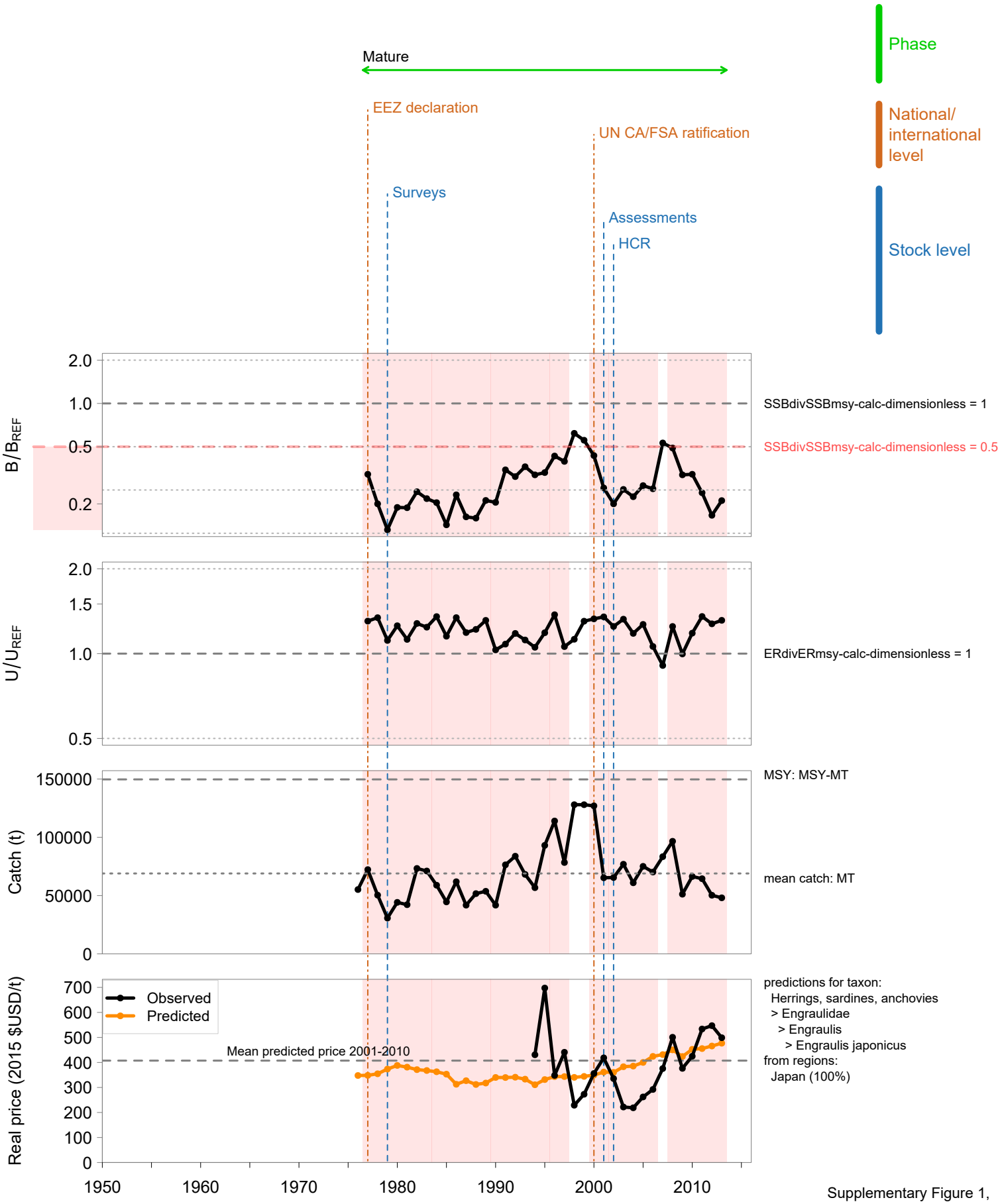
Japan -- JANCHOSETO -- Japanese anchovy Inland Sea of Japan

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Japan



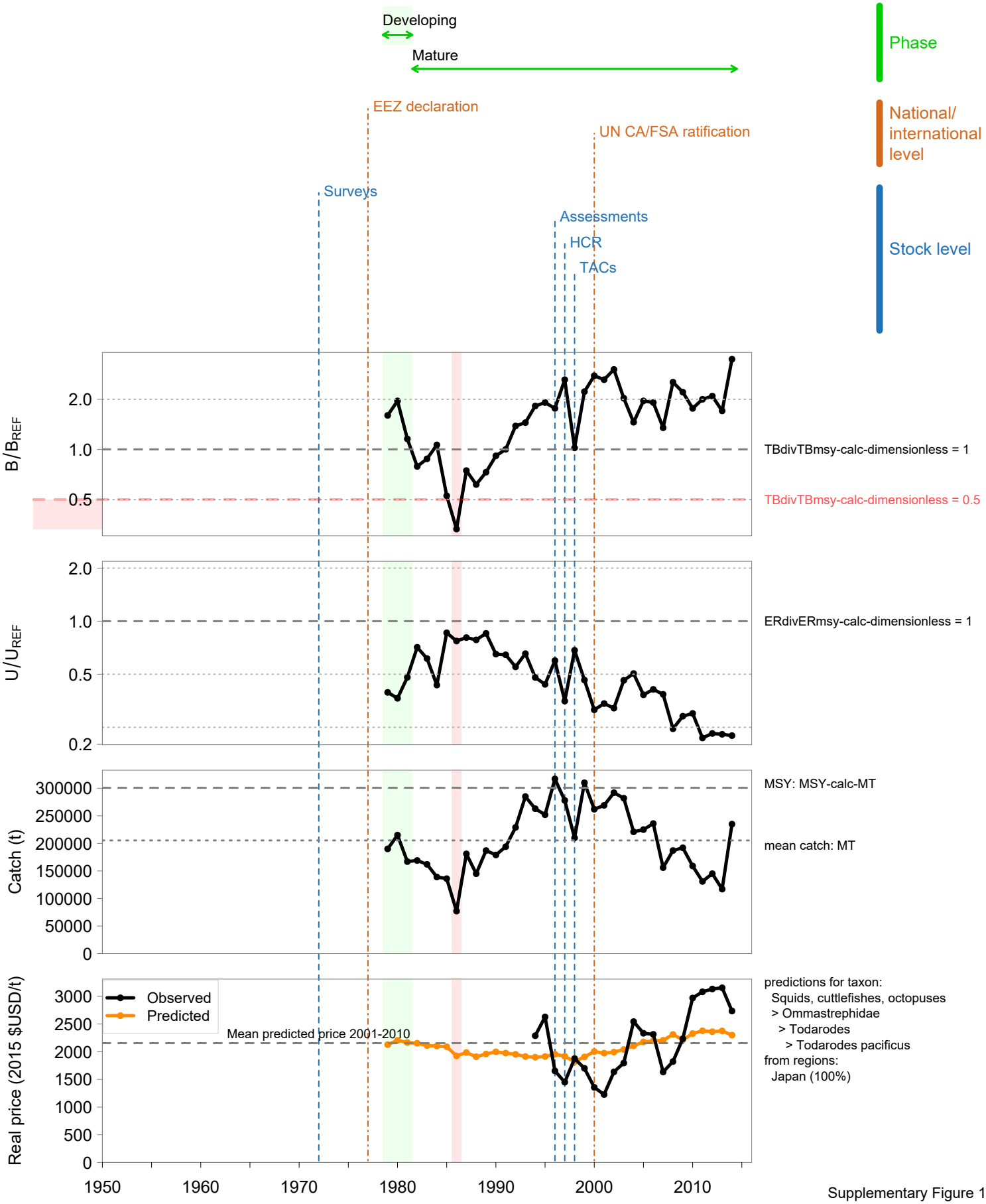
Japan -- JANCHOTSST -- Japanese anchovy Tsushima Strait

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Japan



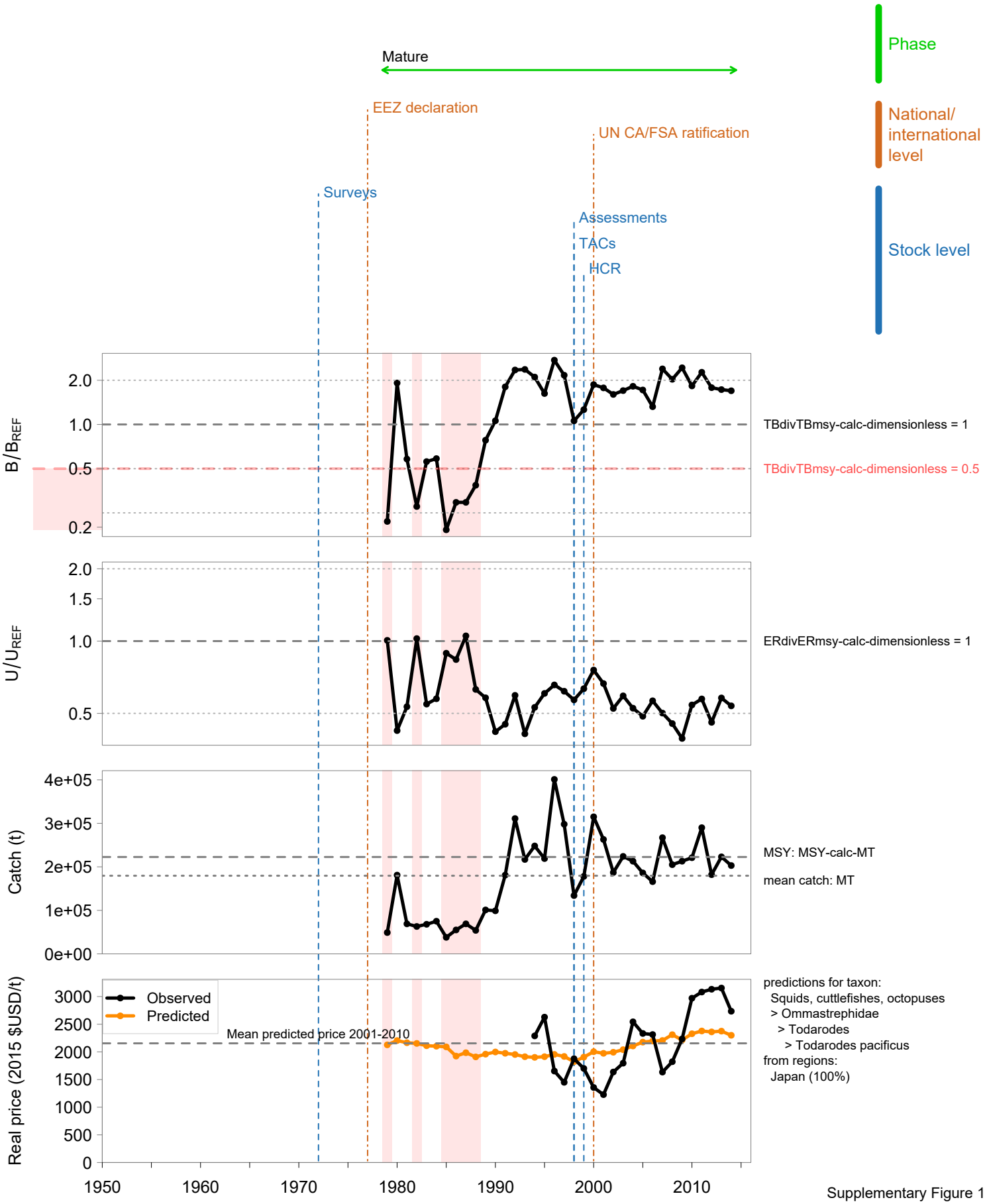
Japan -- JCSQUIDJPNAR -- Japanese flying squid Japan Autumn recruitment

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: Japan



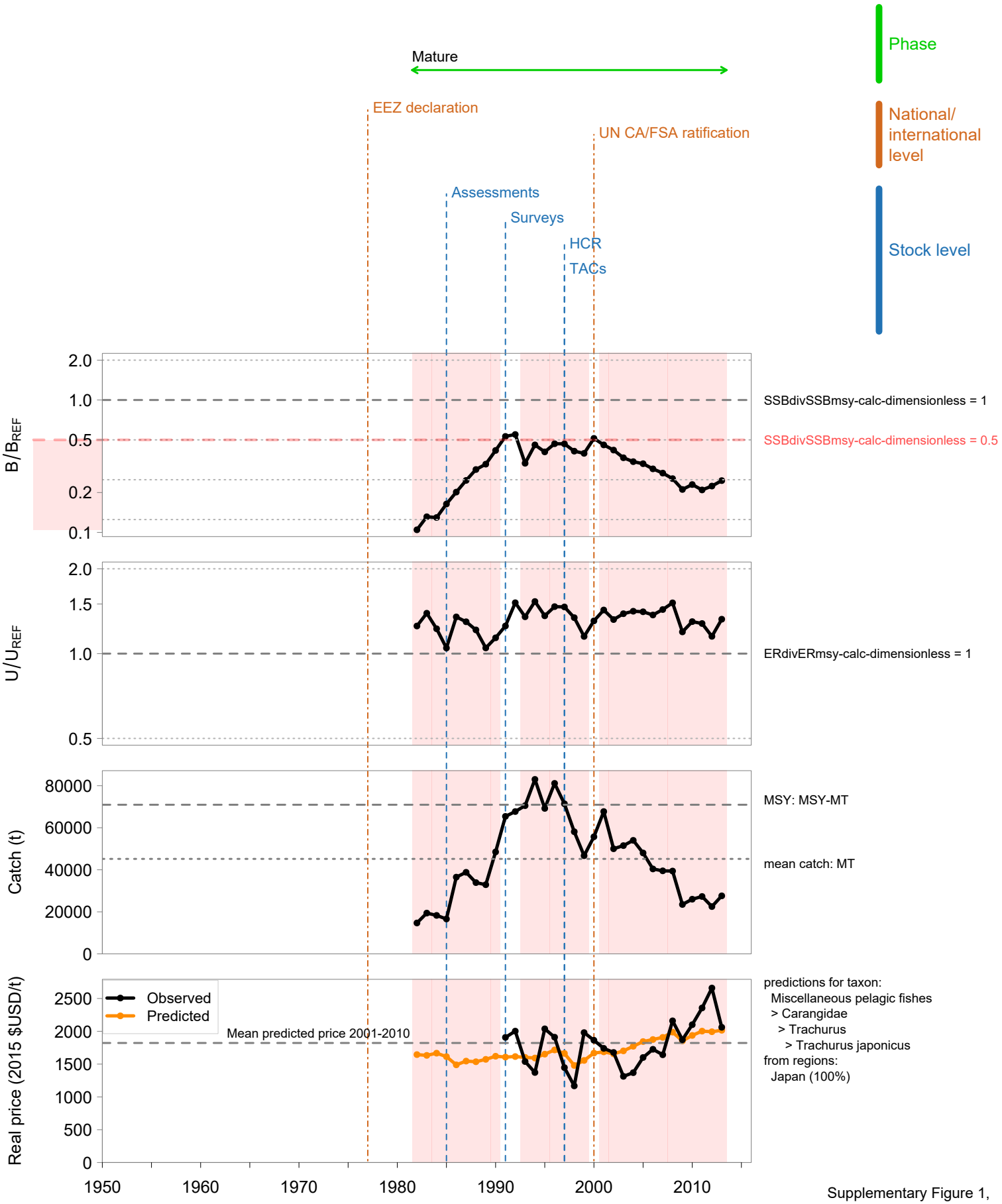
Japan -- JCSQUIDJPNWR -- Japanese flying squid Japan Winter recruitment

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: Japan



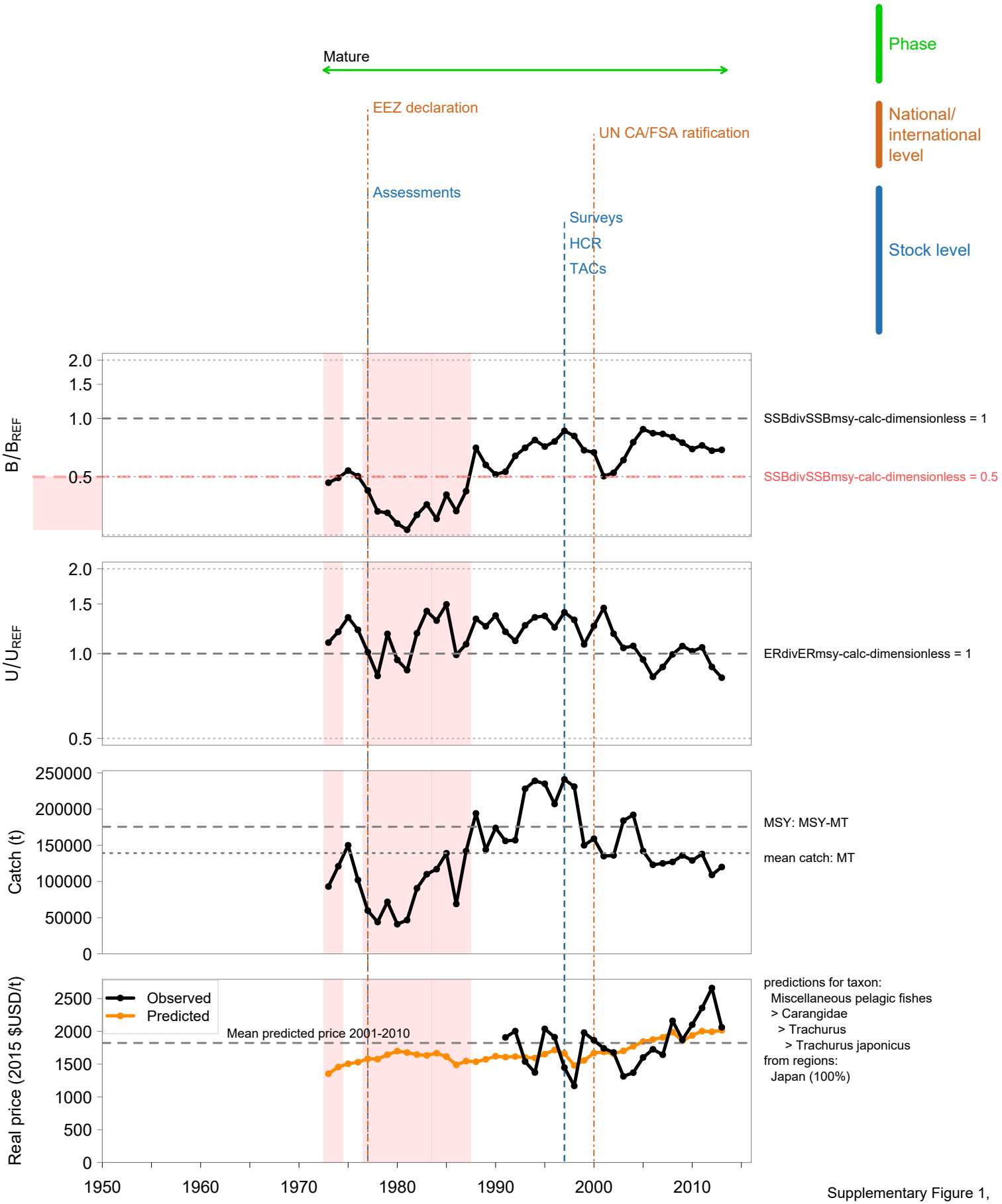
Japan -- JMACKPJPN -- Japanese jack mackerel Pacific Coast of Japan

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



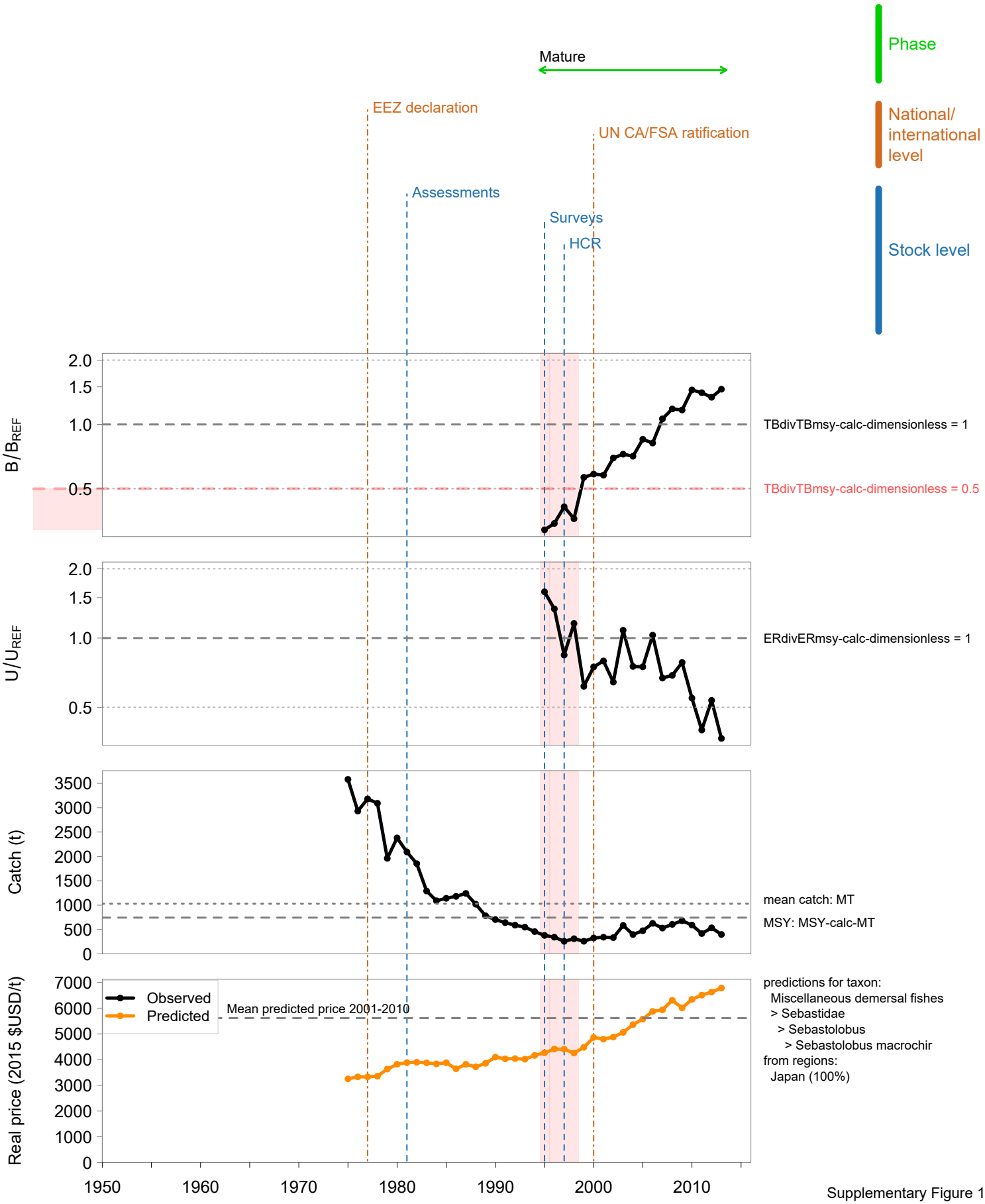
Japan -- JMACKTSST -- Japanese jack mackerel Tsushima Strait

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Japan



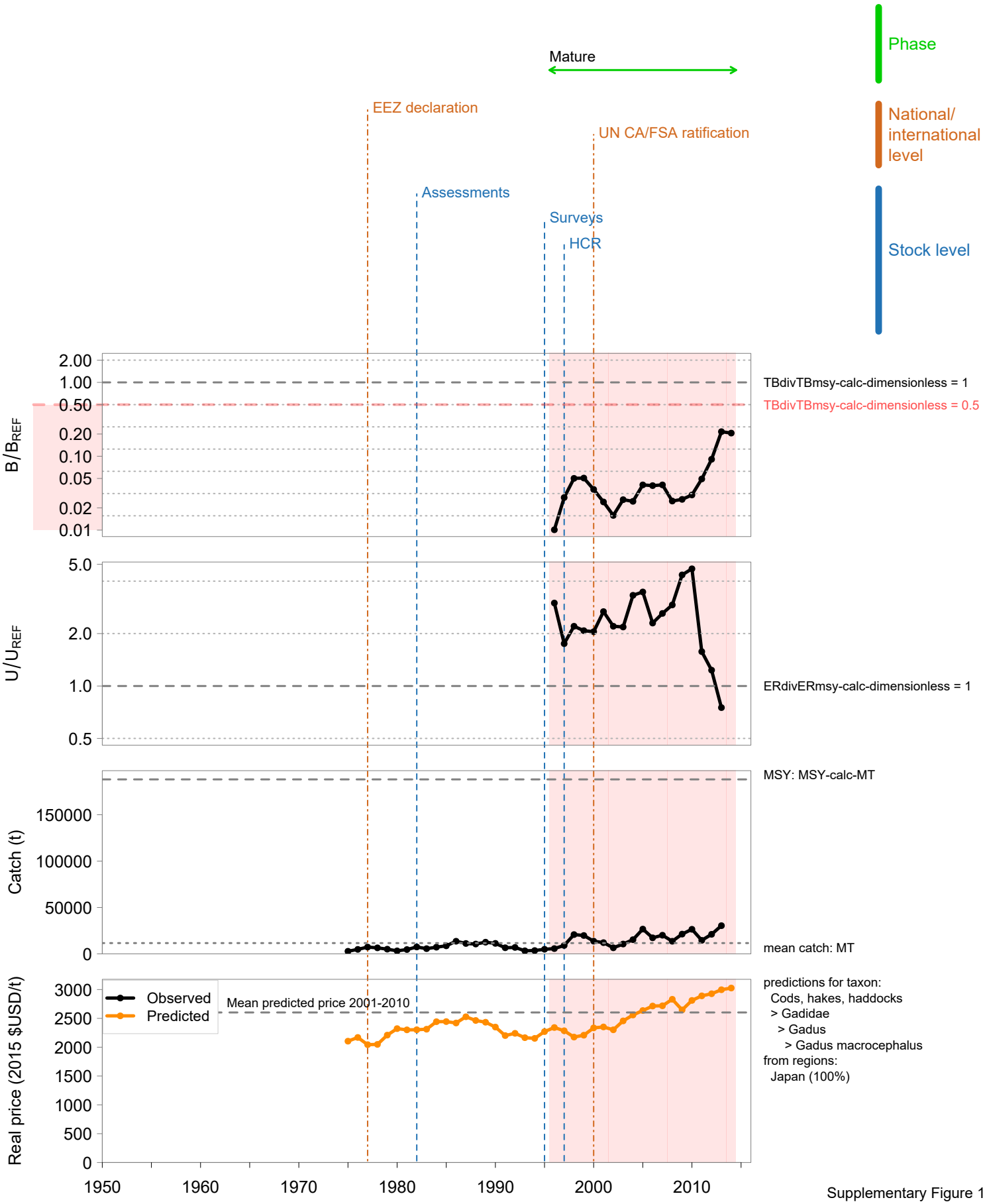
Japan -- KCROCKNPAC -- Kichiji rockfish North Pacific

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: Japan



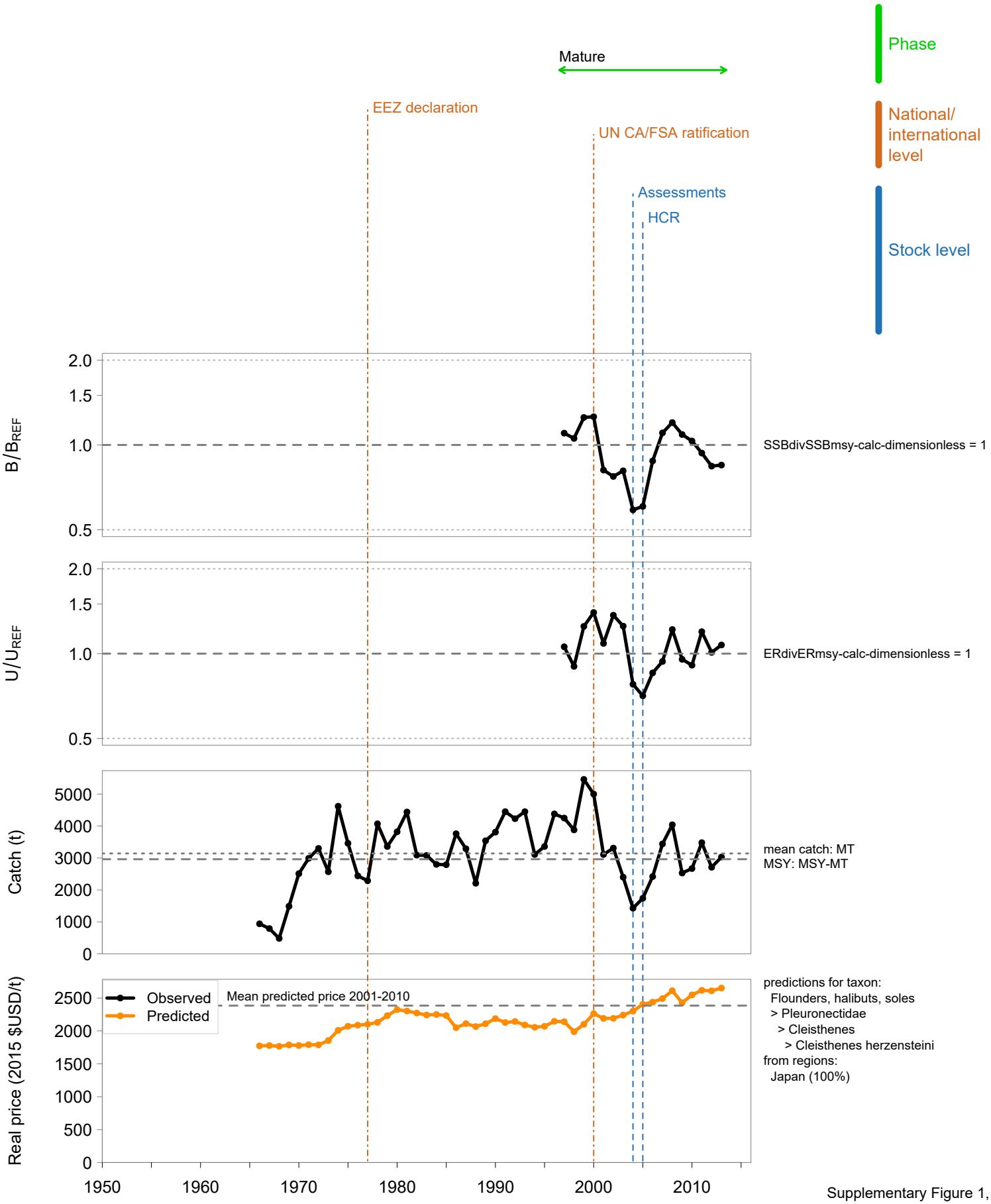
Japan -- PCODNPAC -- Pacific cod North Pacific

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Japan



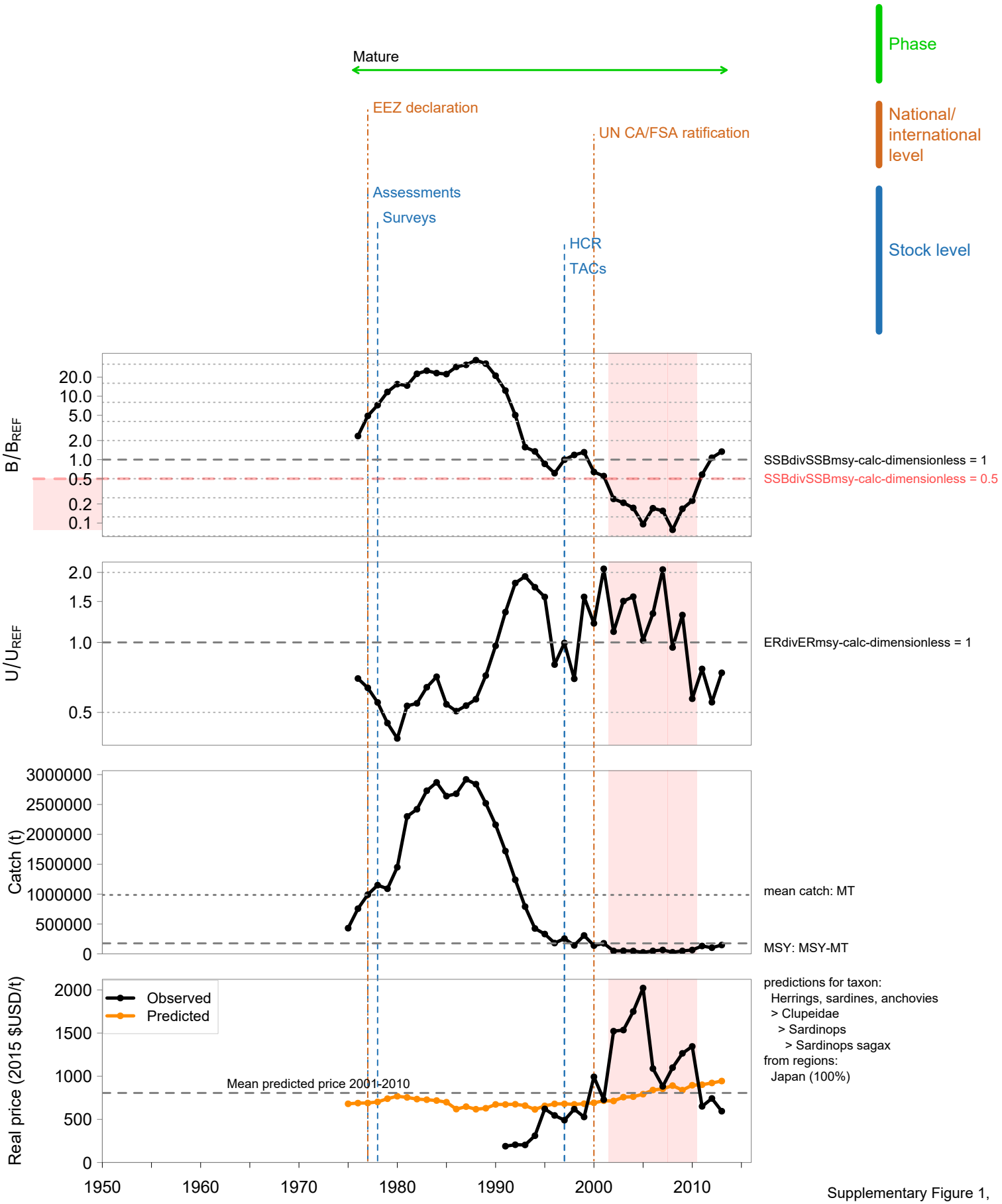
Japan -- PHFLOUNSOJ -- Pointhead flounder Sea of Japan

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Japan



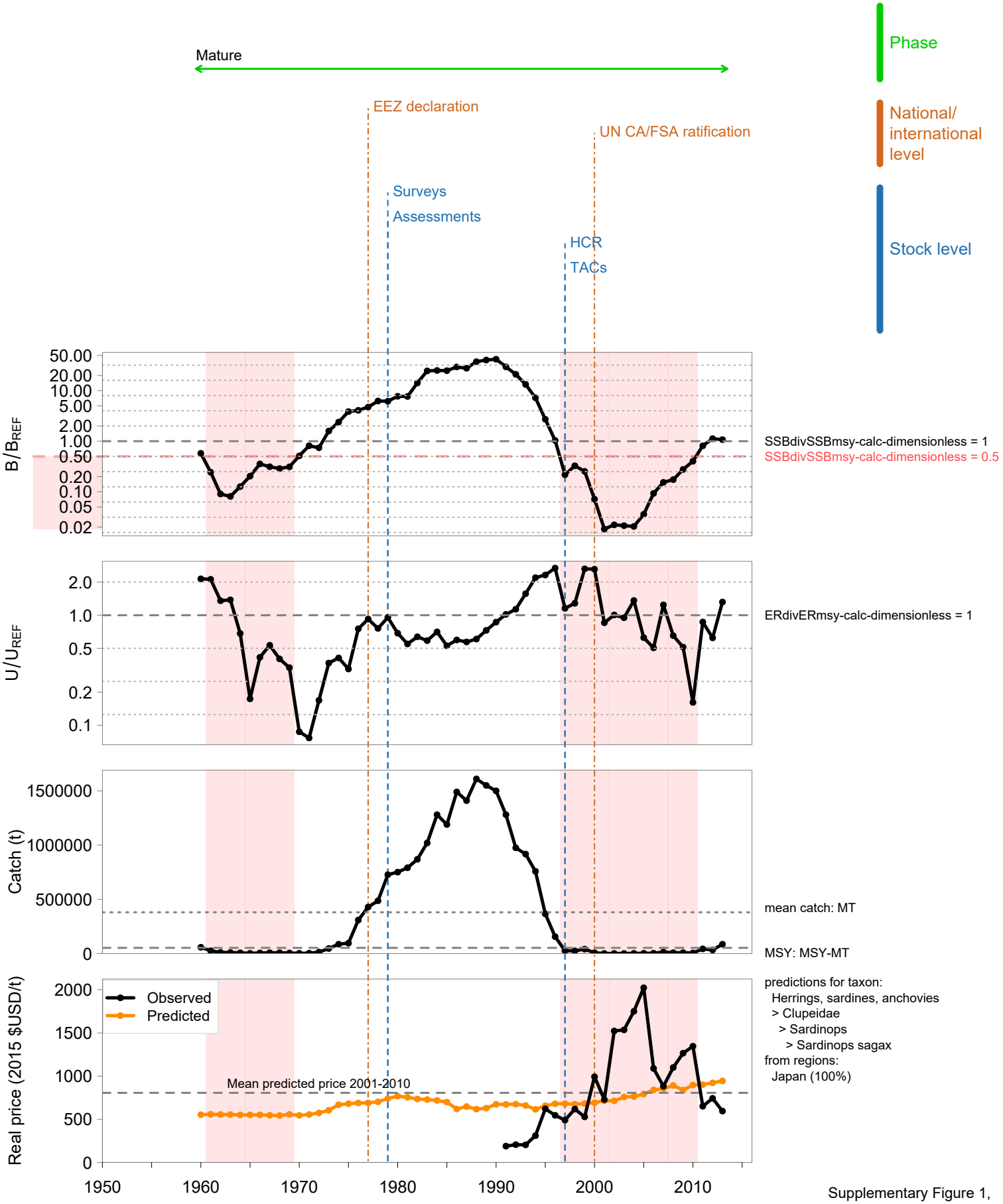
Japan -- PILCHPJPN -- Japanese sardine Pacific Coast of Japan

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Japan



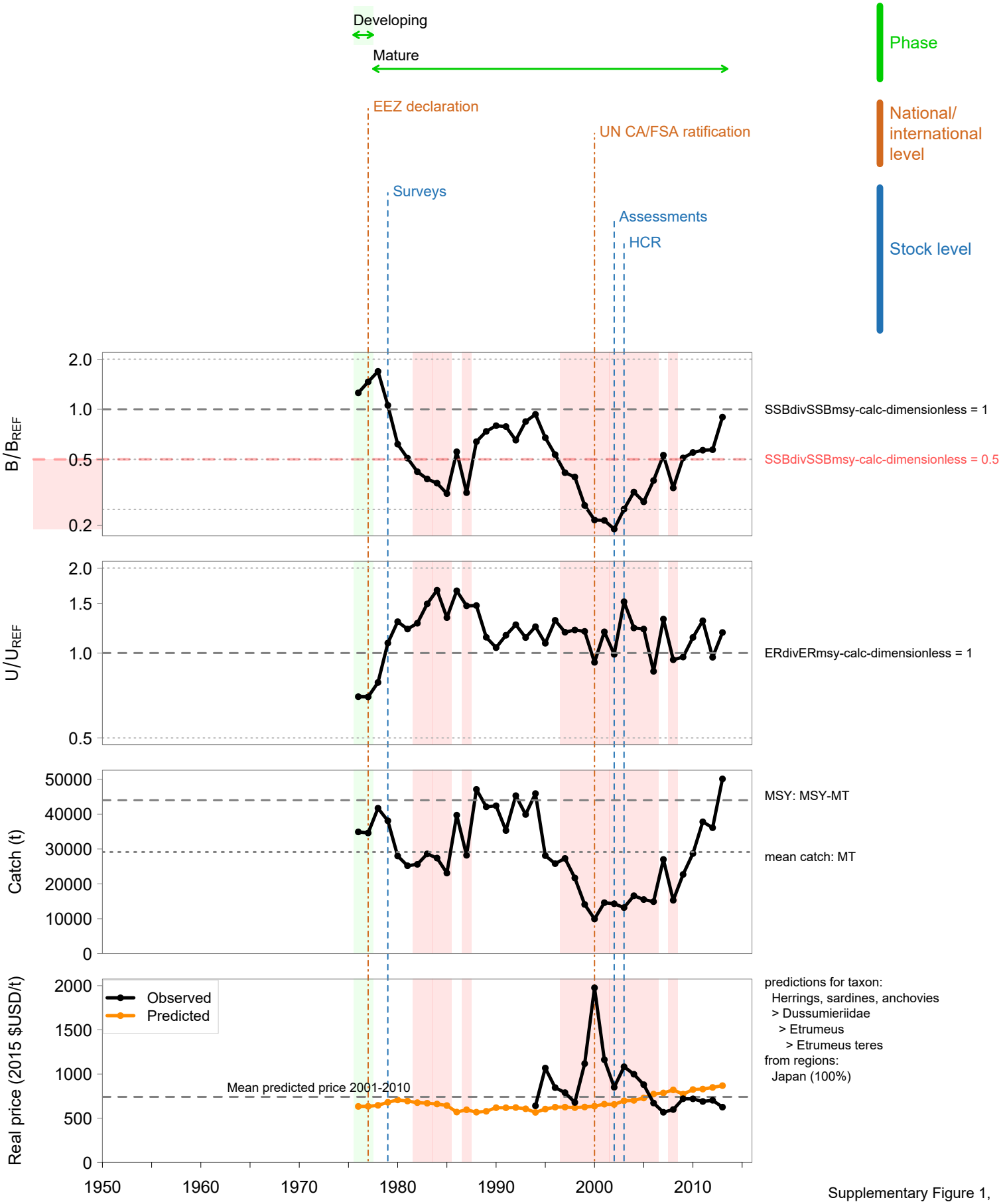
Japan -- PILCHTSST -- Japanese sardine Tsushima Strait

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Japan



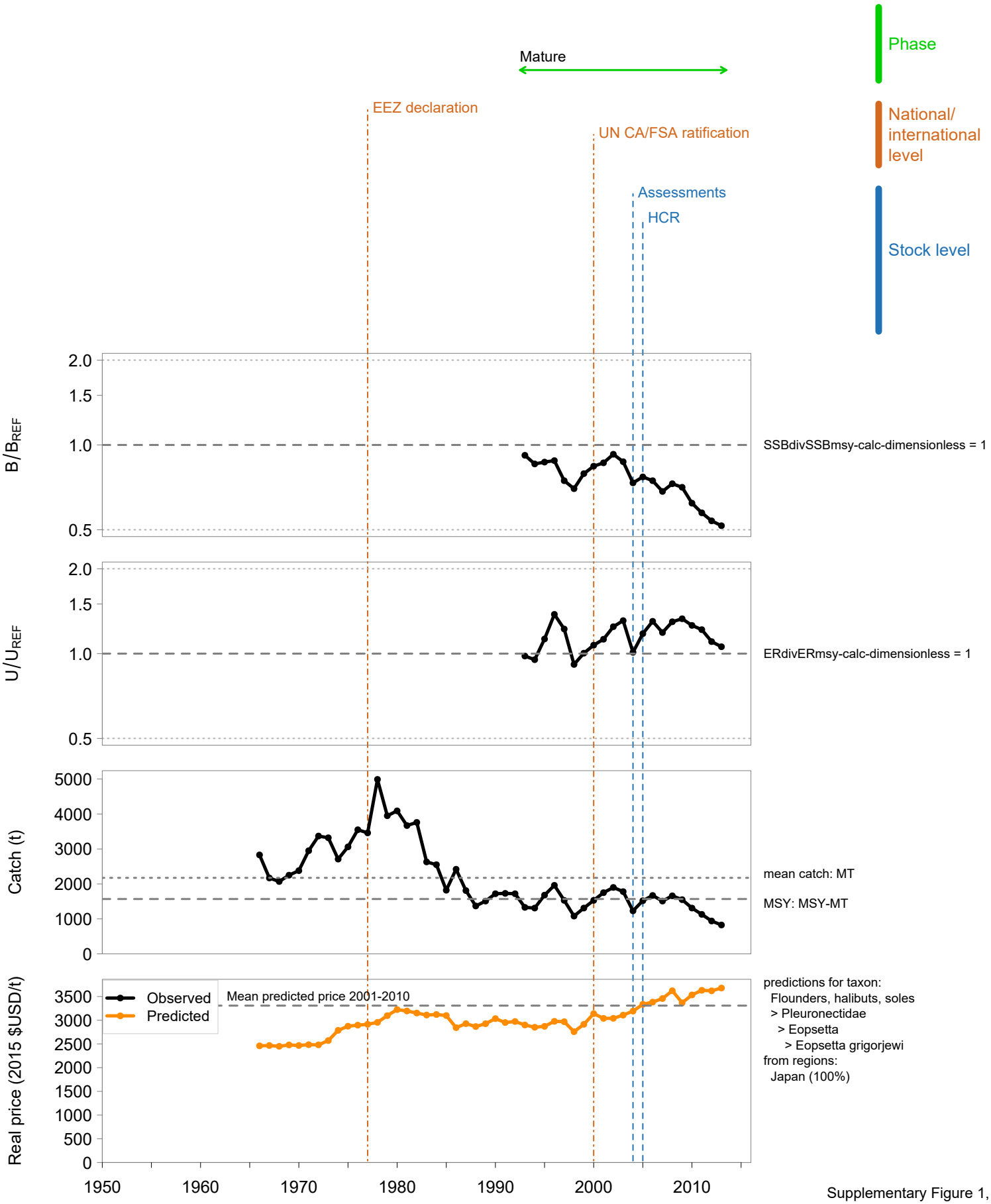
Japan -- RHERRTSST -- Round herring Tsushima Strait

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Japan



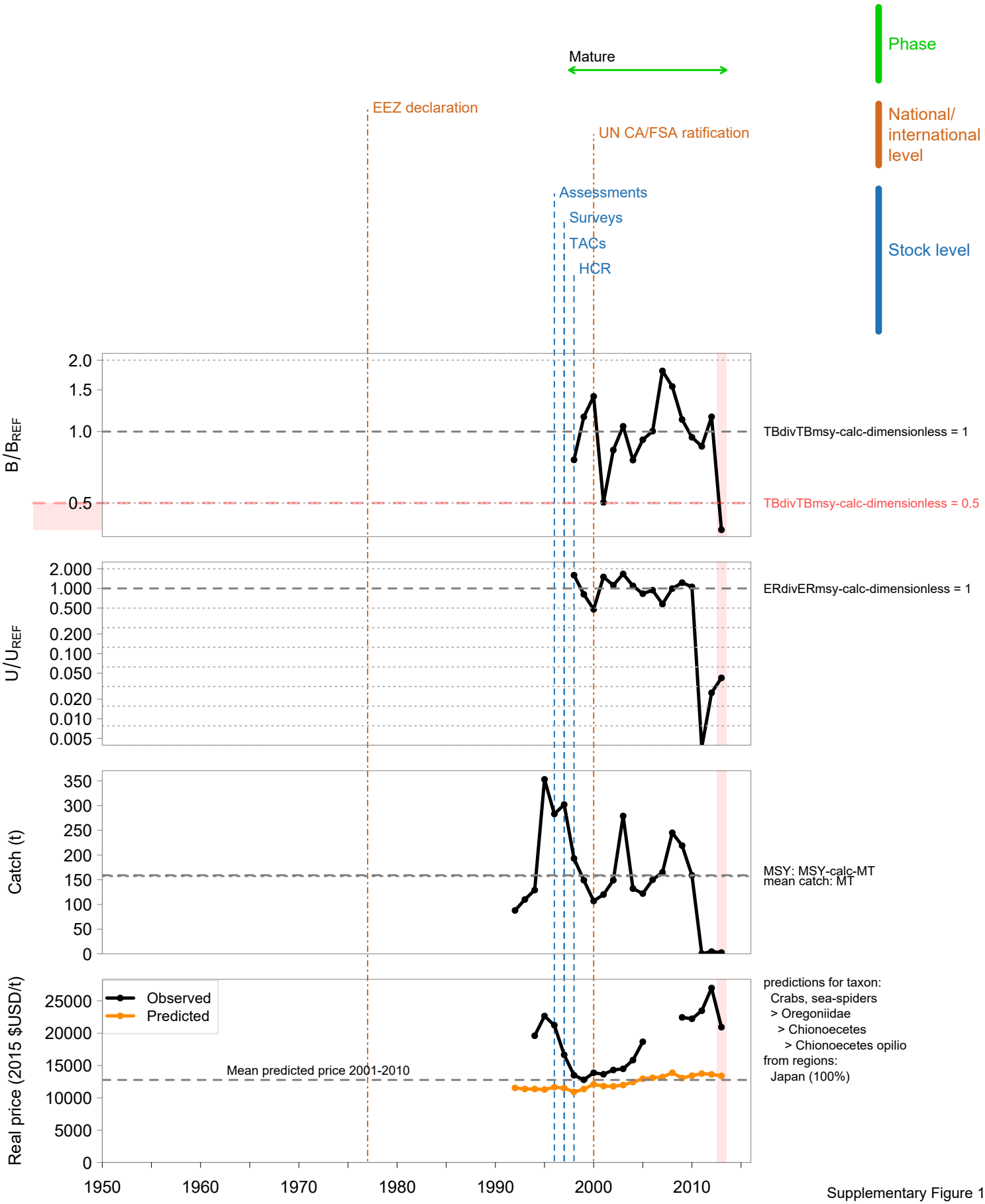
Japan -- RSFLOUNSOJ -- Round nose flounder Sea of Japan

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Japan



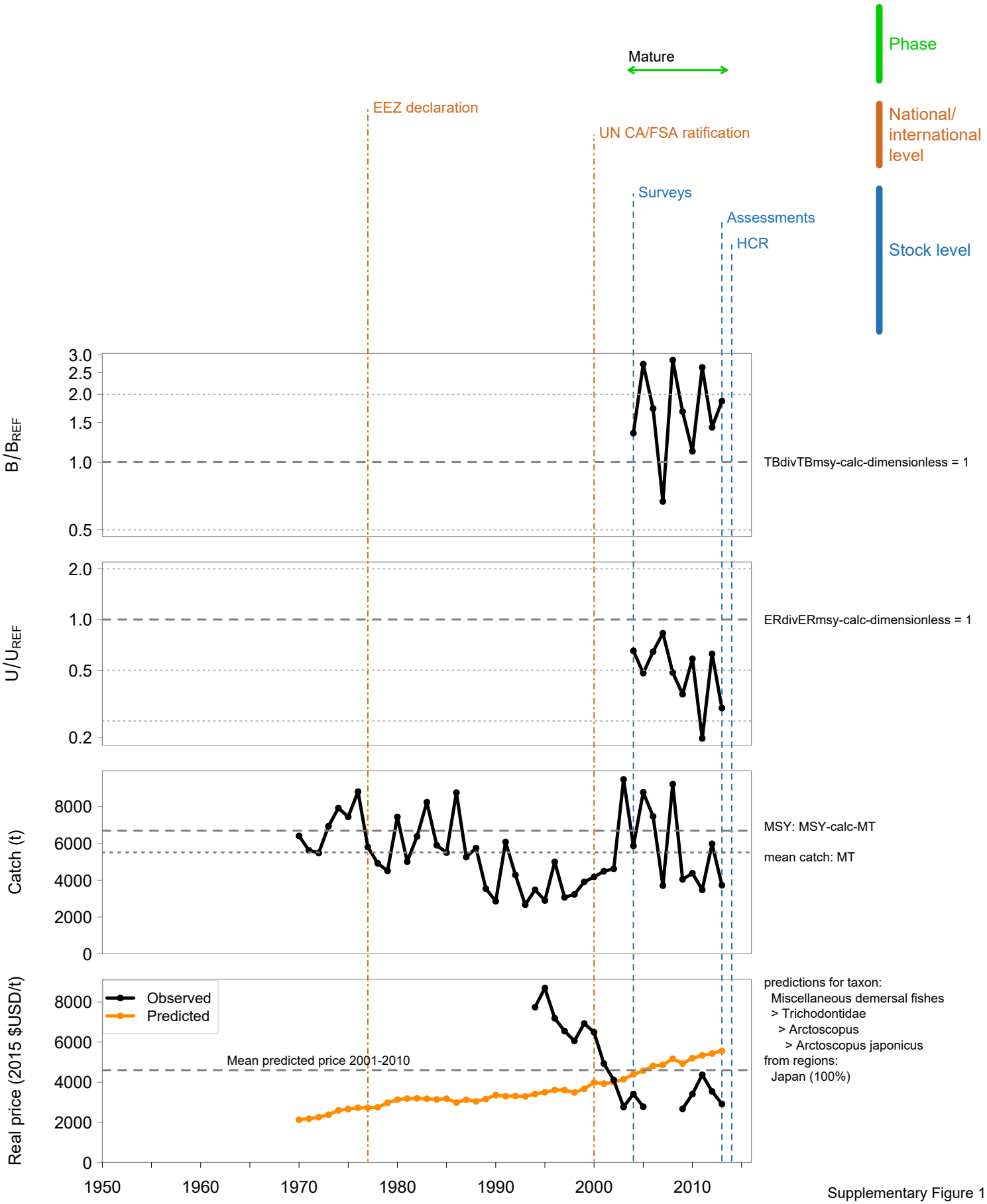
Japan -- SNOWCRABNPAC -- Snow crab North Pacific

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: Japan



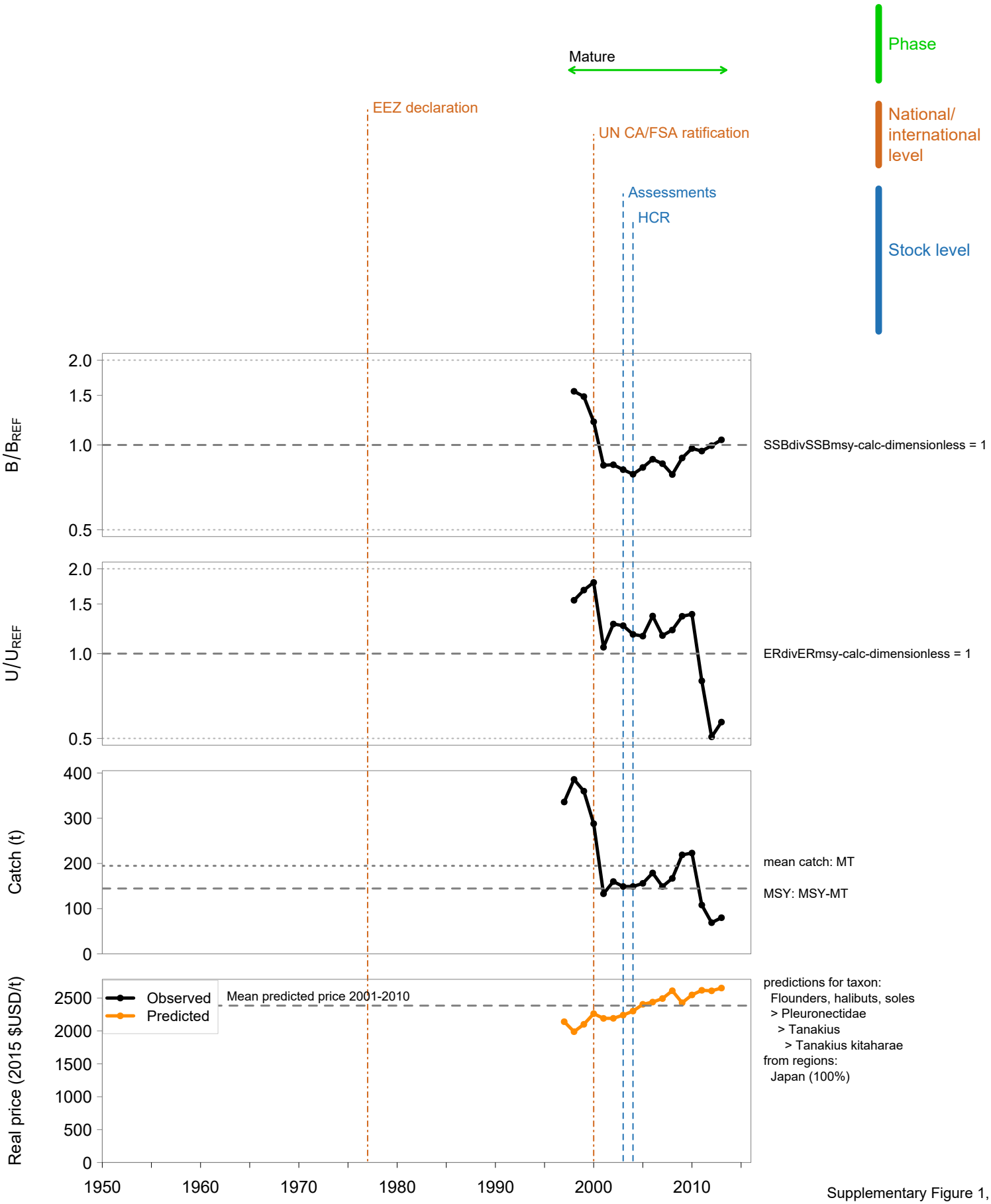
Japan -- SSANDWSJ -- Sailfin sandfish Sea of Japan West

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Japan



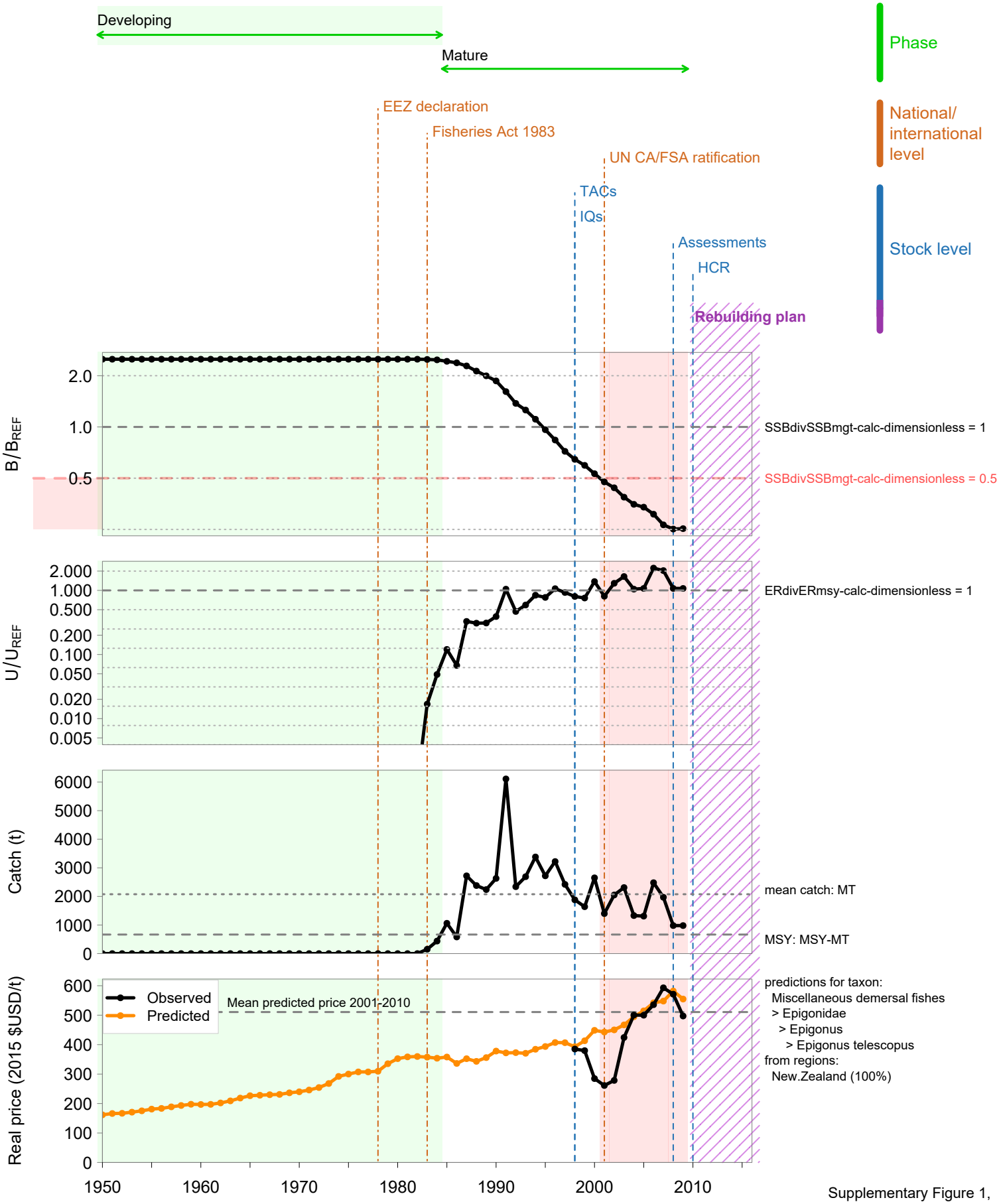
Japan -- WLFLOUNNPAC -- Willowy flounder North Pacific

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: Japan



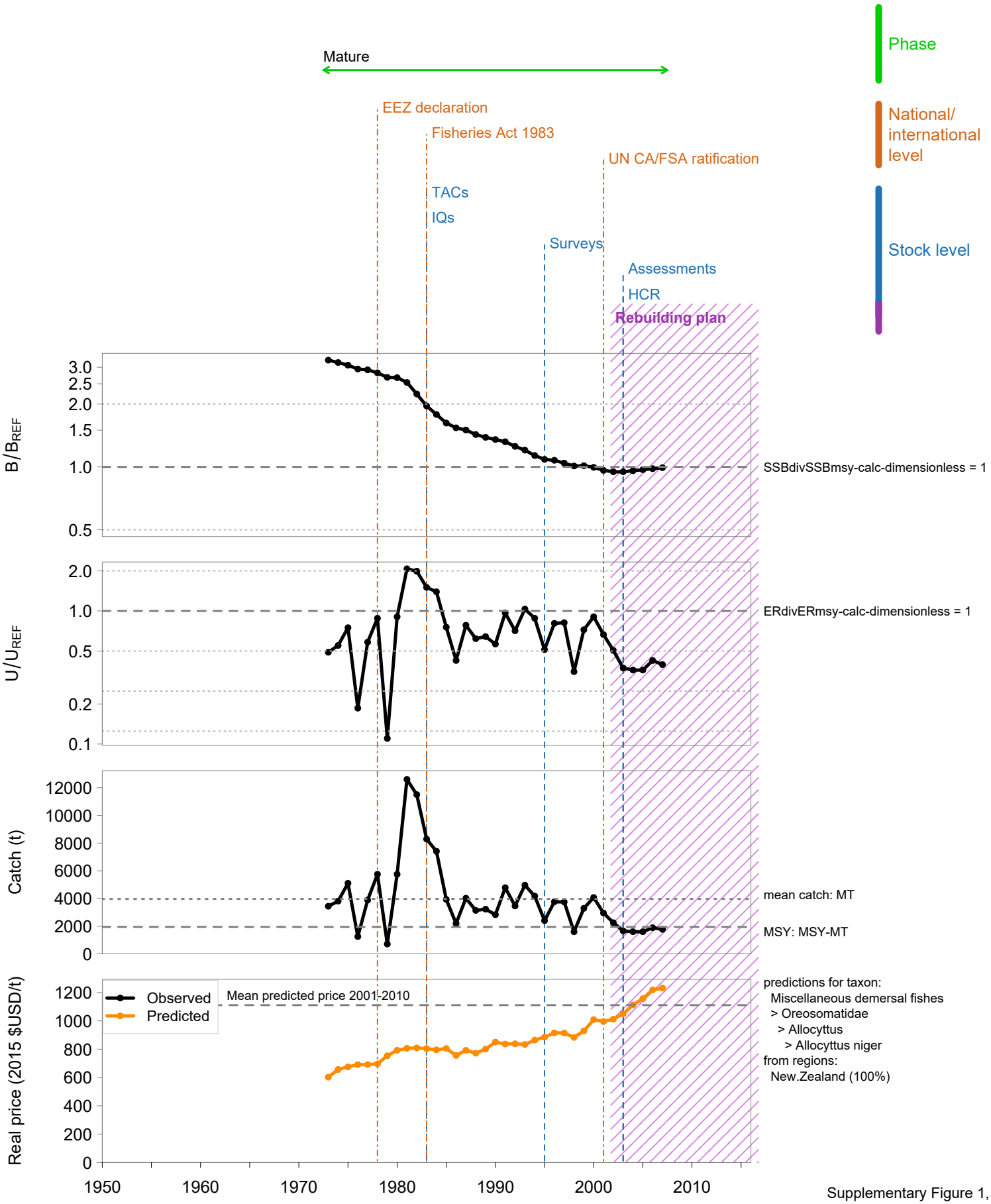
New Zealand -- BKCDLFENI -- Black cardinalfish East coast of North Island

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: single-species, primary country: New Zealand



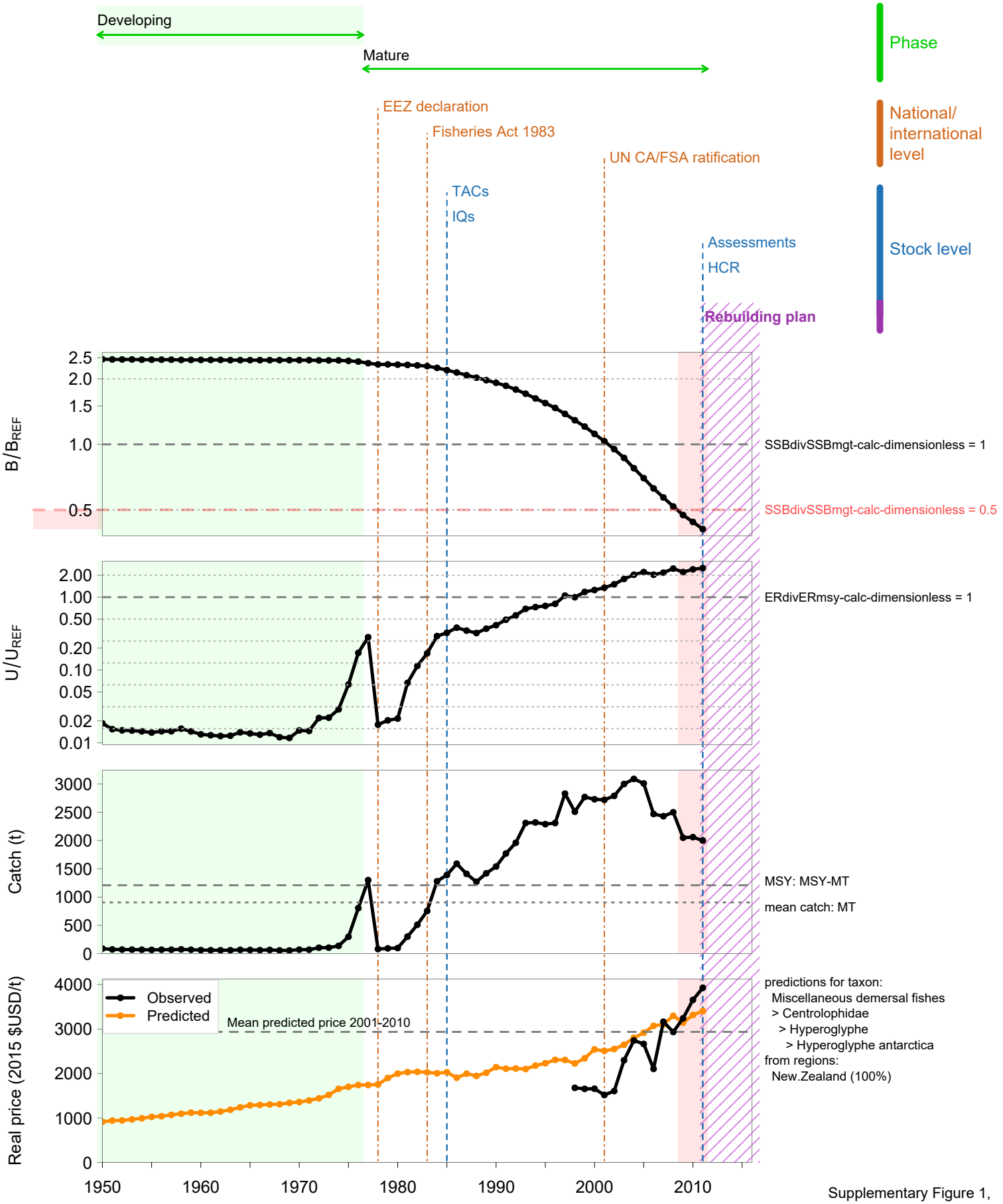
New Zealand -- BLACKOREOWECR -- Black oreo West end of Chatham Rise

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



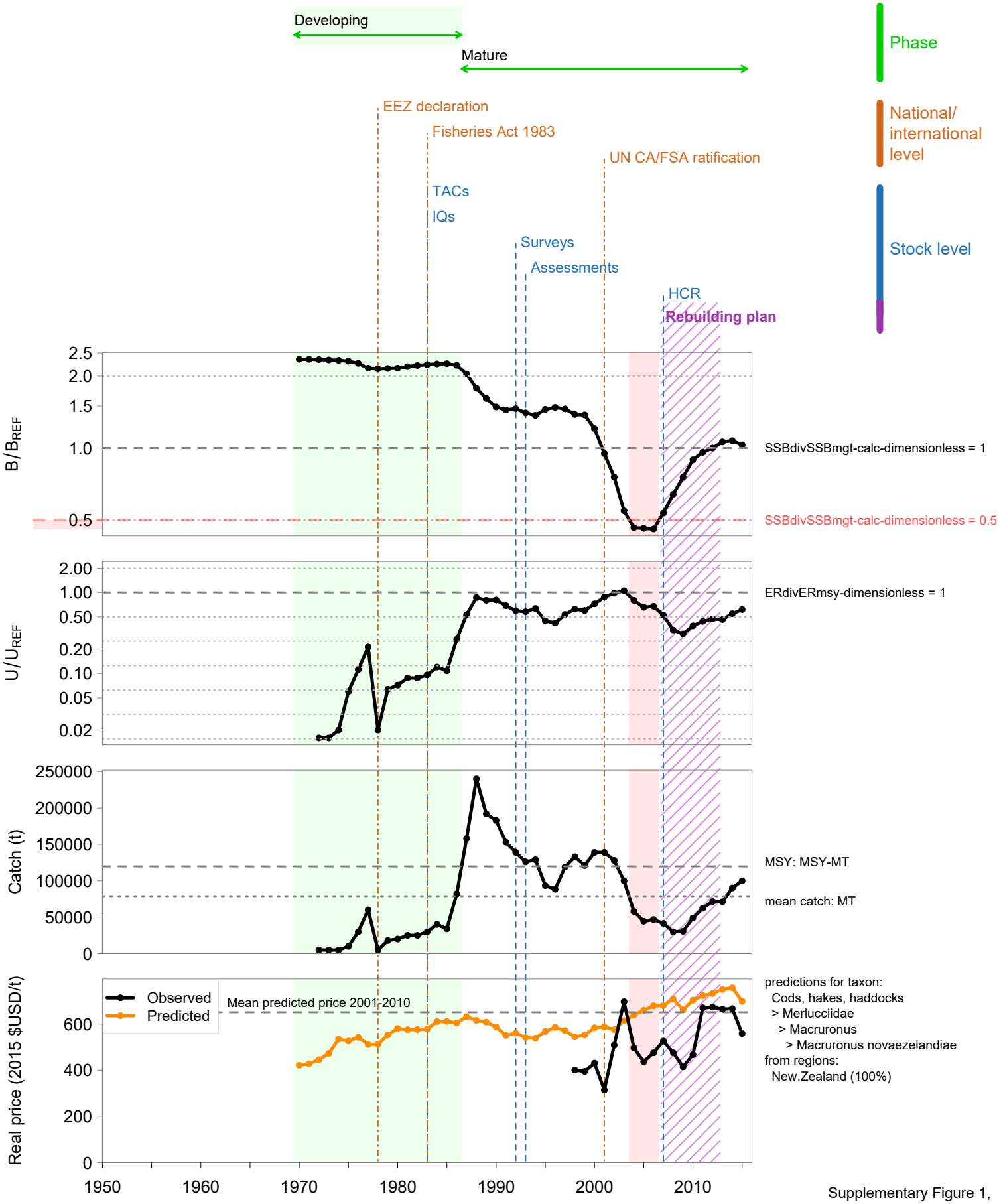
New Zealand -- BNSNZ -- Bluenose New Zealand

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: New Zealand



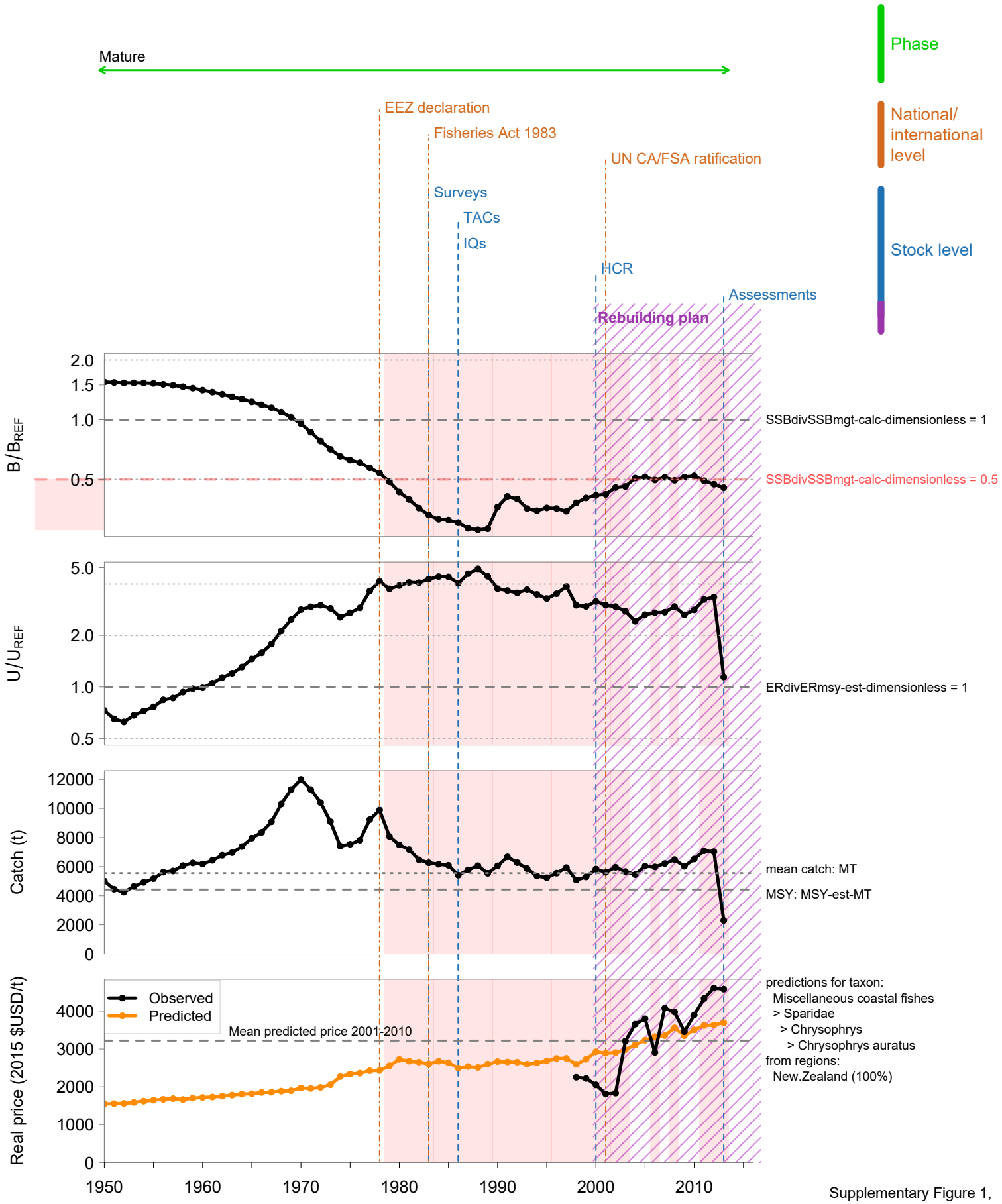
New Zealand -- HOKIWNZ -- Hoki Western New Zealand

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: New Zealand



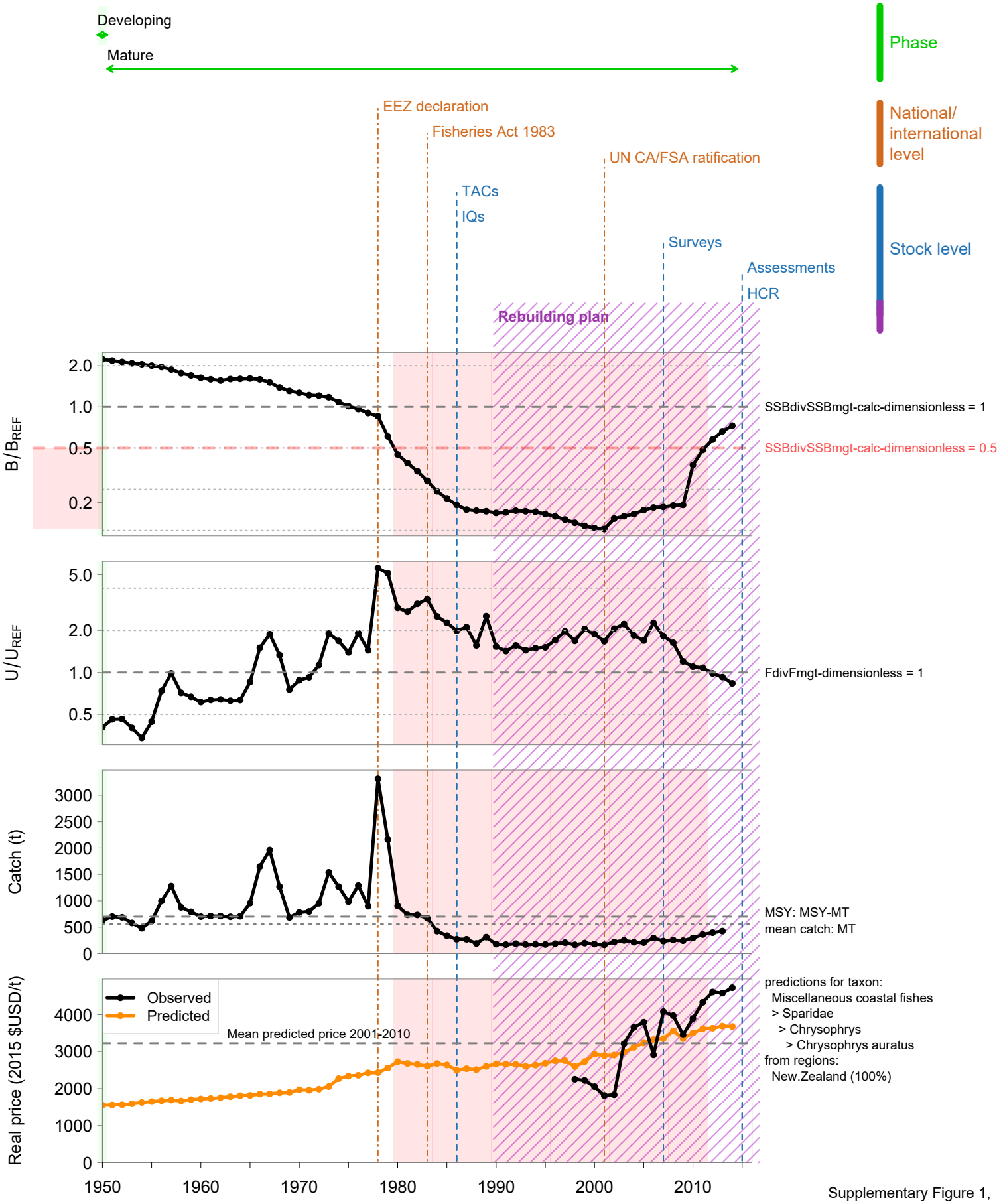
New Zealand -- NZSNAPNZ1BOP-HAGU -- New Zealand snapper New Zealand SNA 1 Bay of Plenty and Hauraki Gulf

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: New Zealand



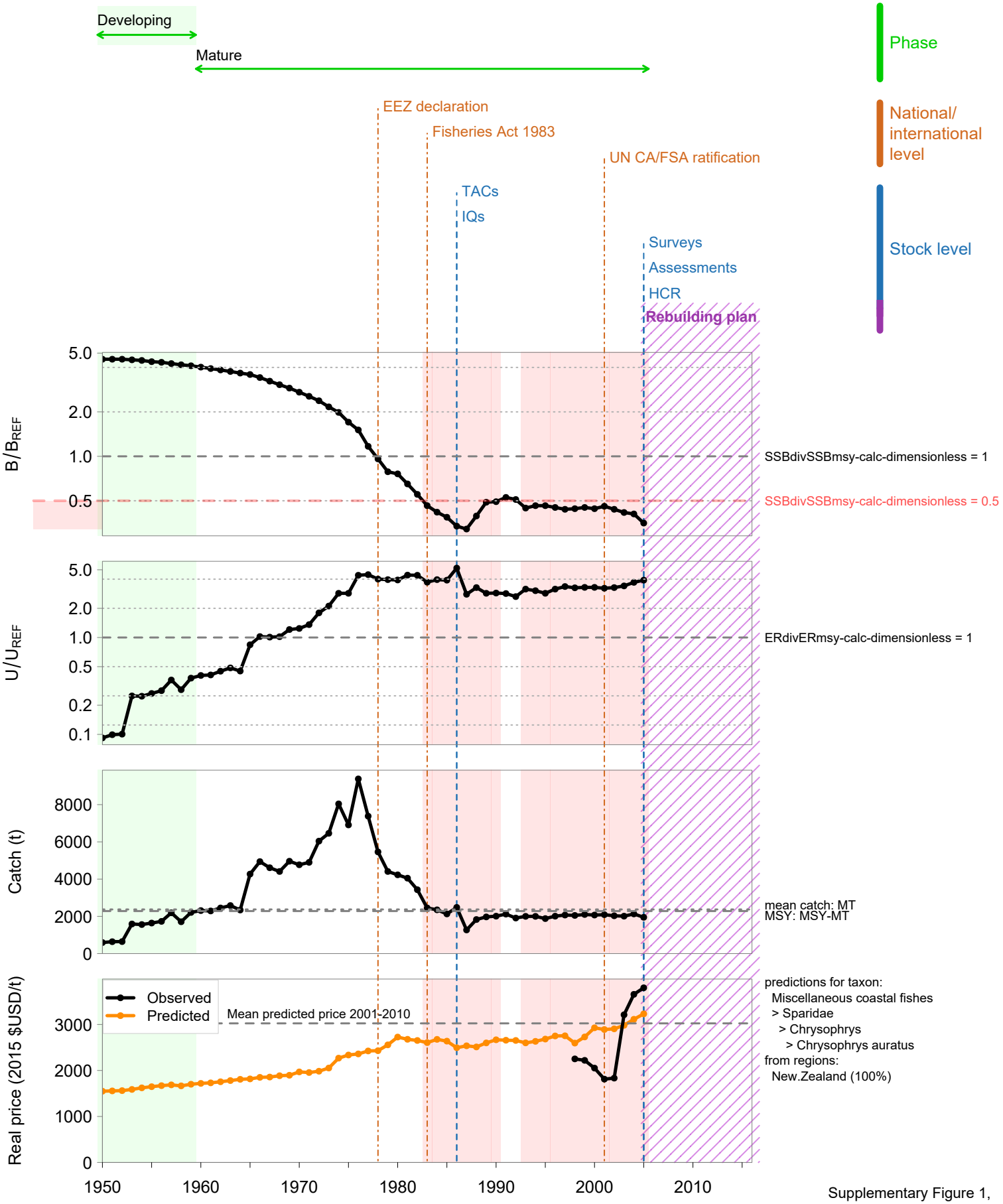
New Zealand -- NZSNAPNZ7 -- New Zealand snapper New Zealand SNA 7

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: New Zealand



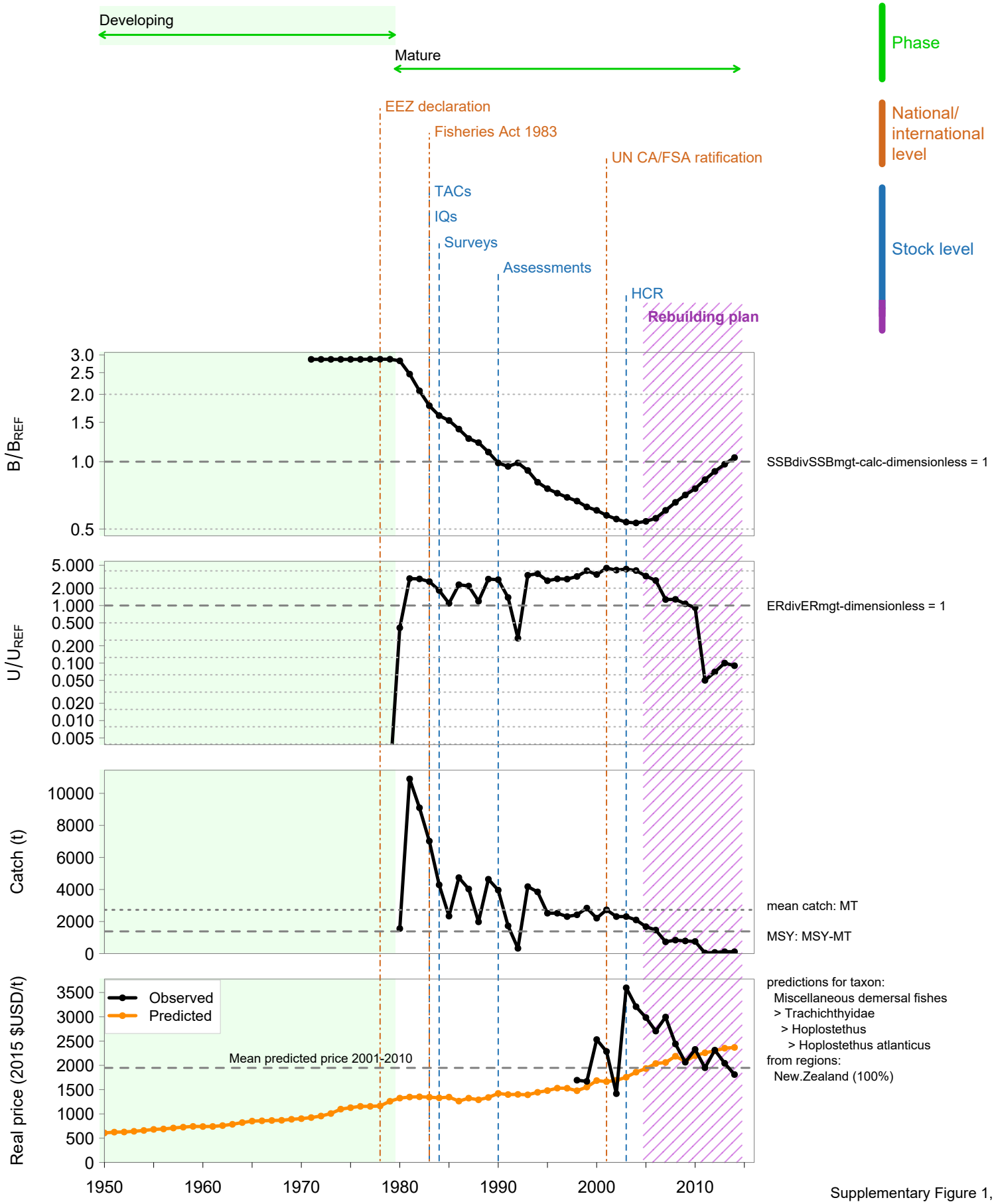
New Zealand -- NZSNAPNZ8 -- New Zealand snapper New Zealand Area 8 (Auckland and Central West)

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: New Zealand



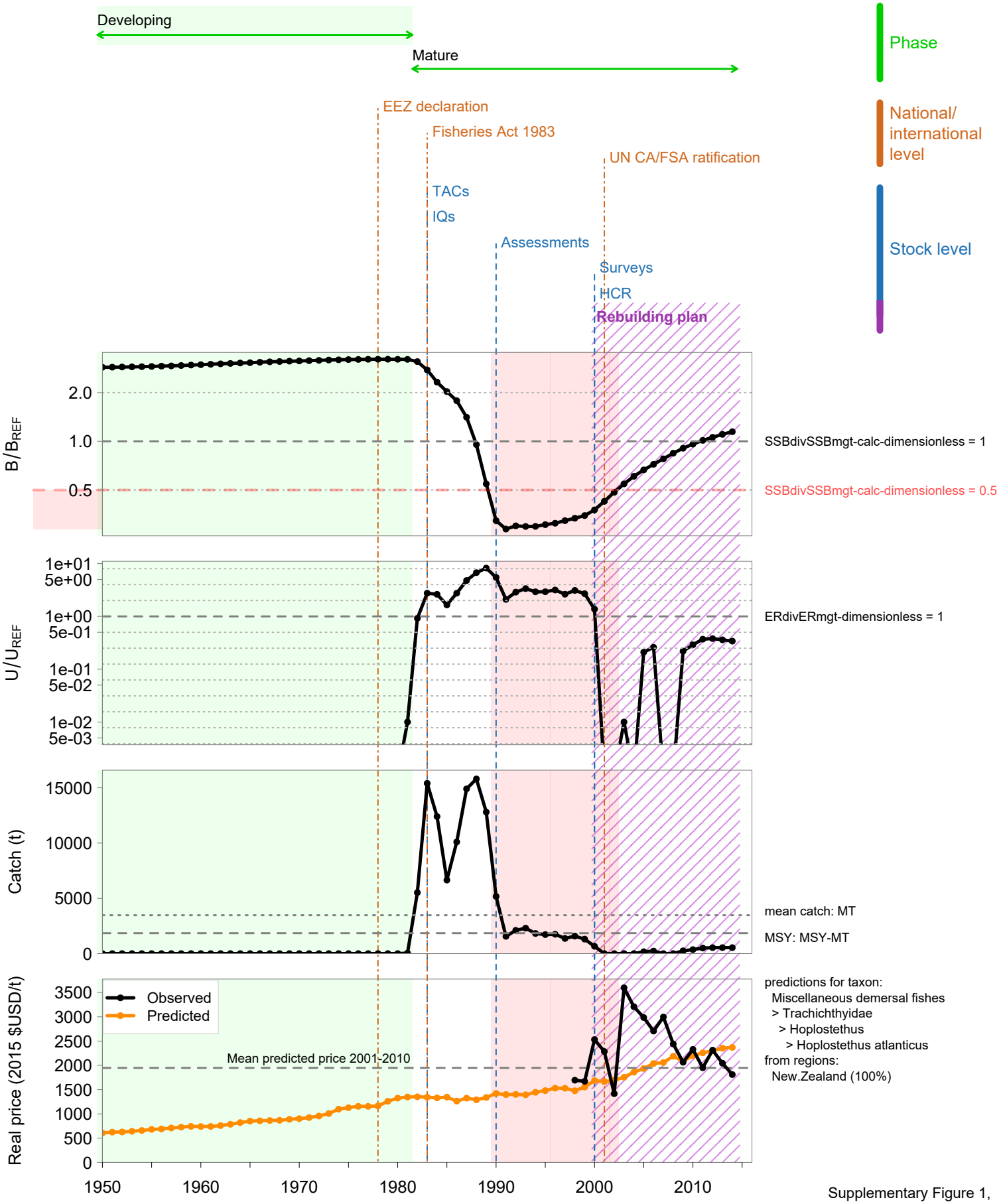
New Zealand -- OROUGHYNWCR -- Orange roughy Northwest Chatham Rise

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



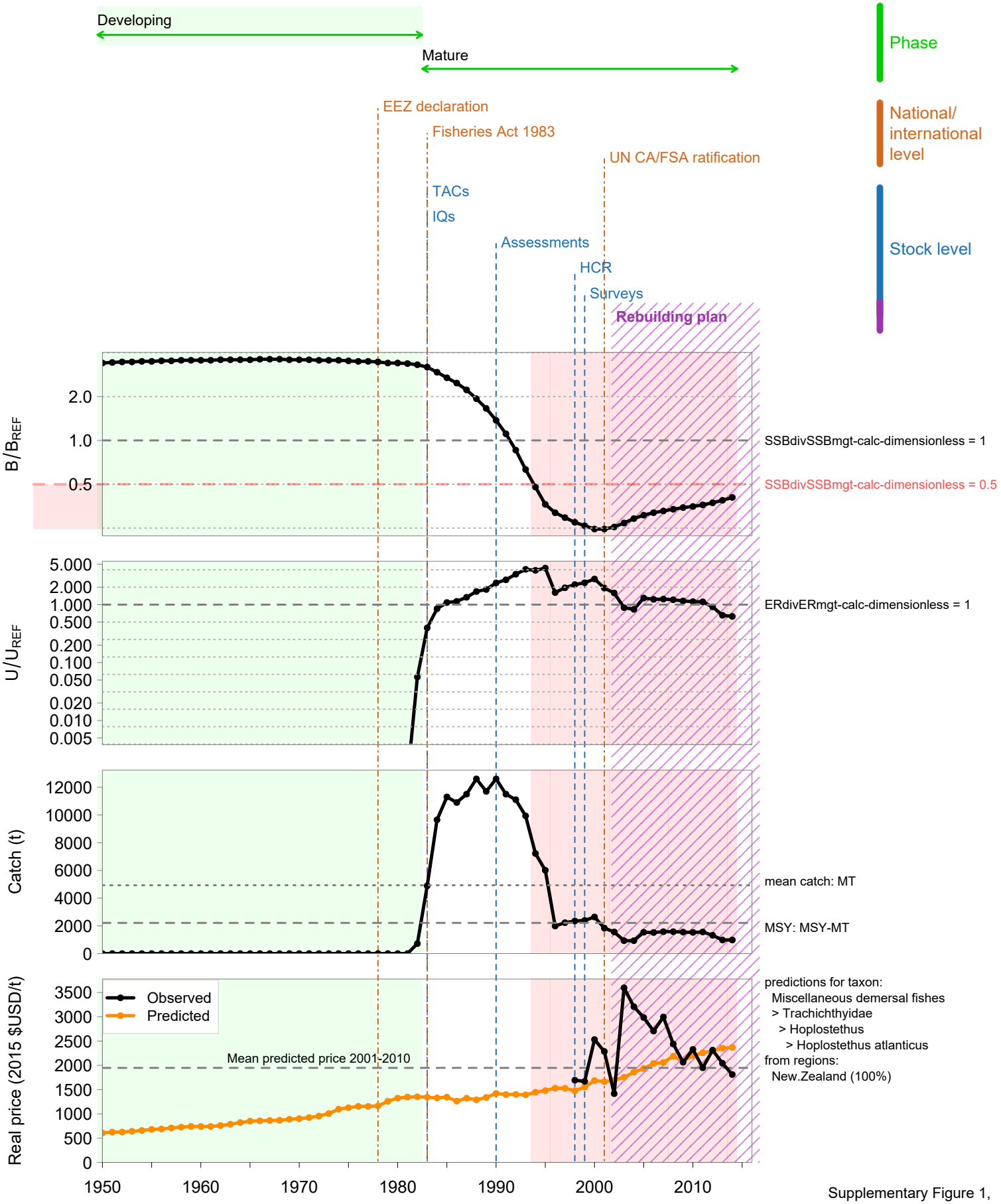
New Zealand -- OROUGHYNZ7A -- Orange roughy New Zealand Challenger Plateau

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



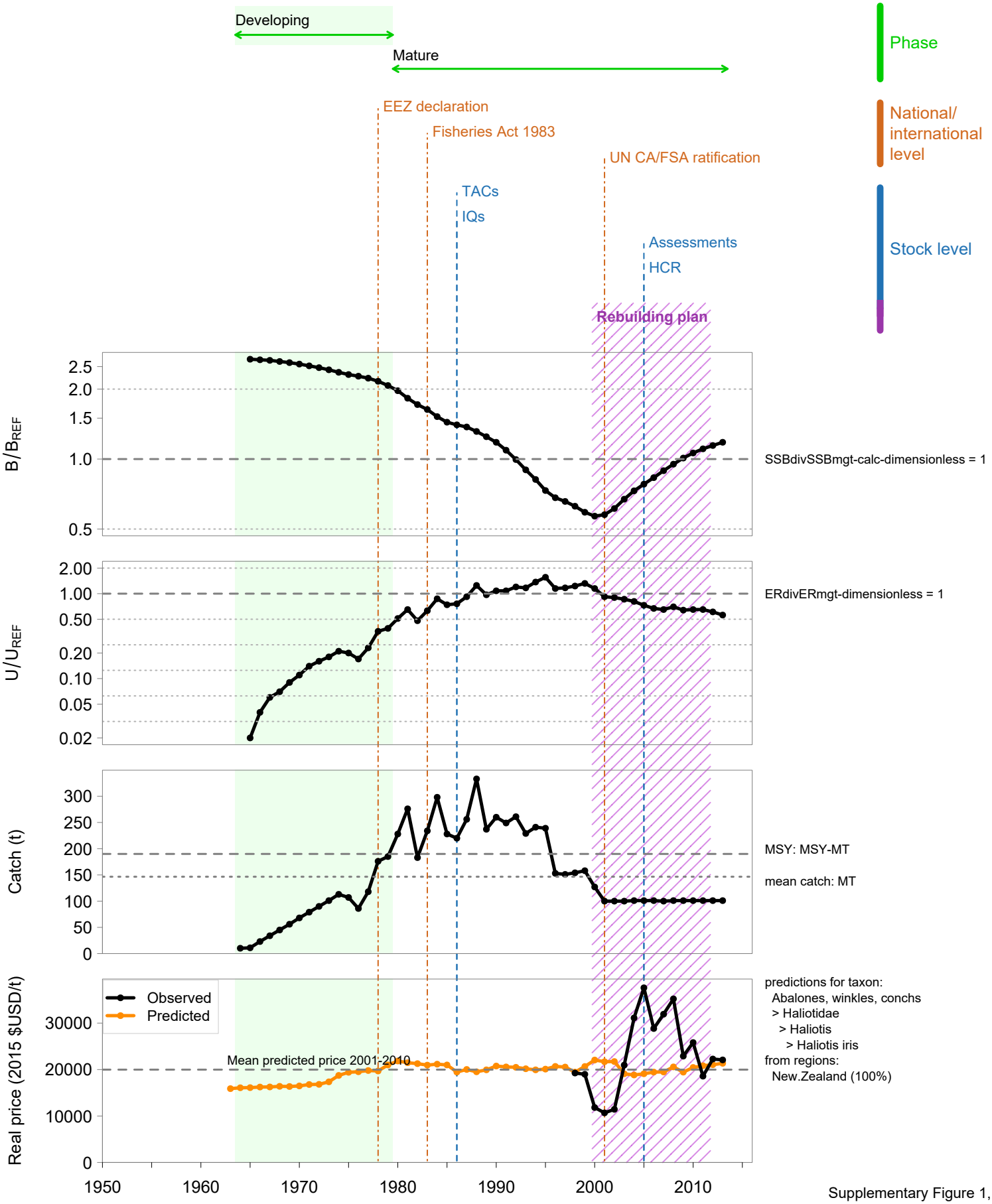
New Zealand -- OROUGHYNZMEC -- Orange roughy New Zealand Mid East Coast

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



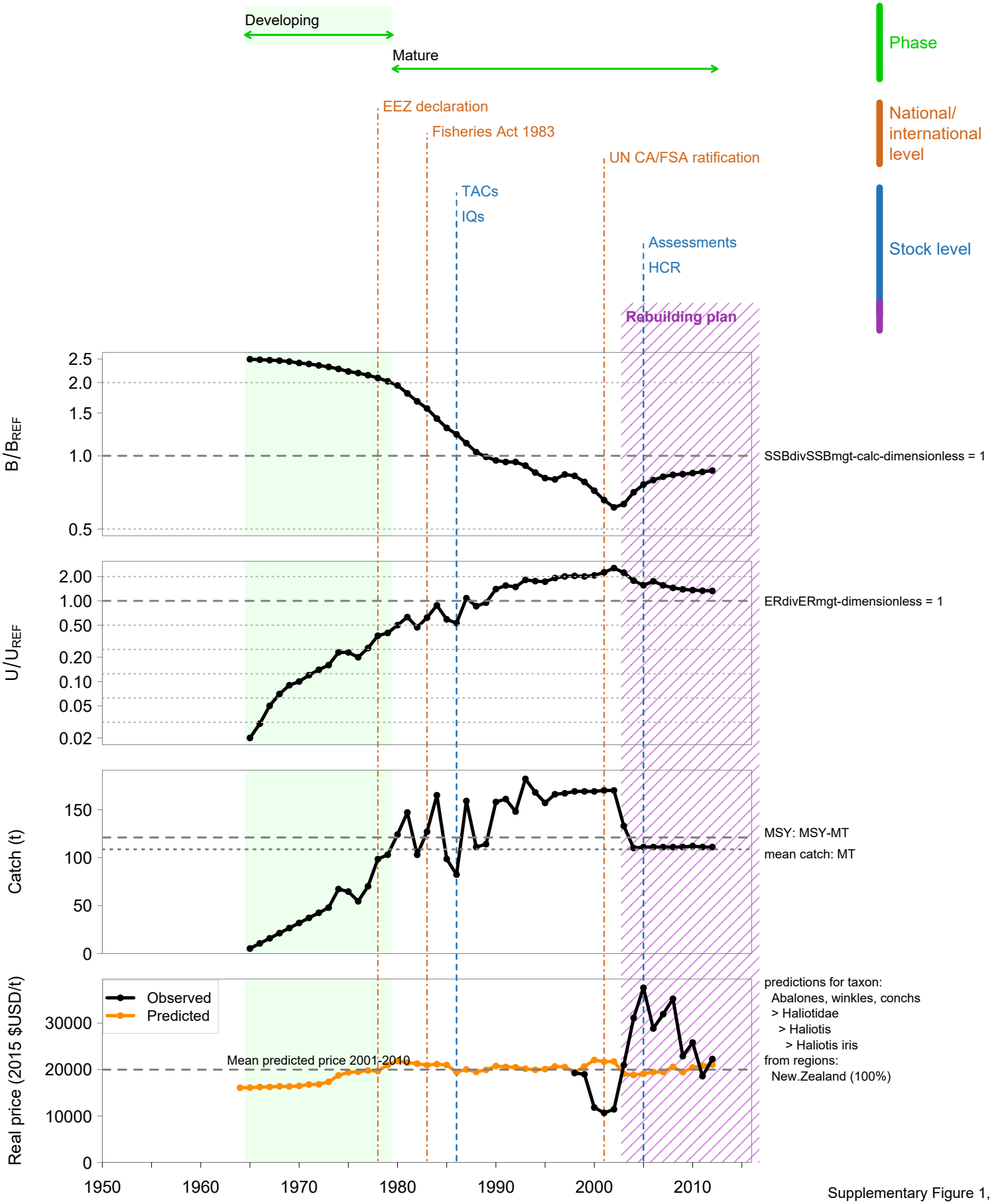
New Zealand -- PAUAPAU5B -- Paua New Zealand Area PAU 5B (Stewart Island)

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: New Zealand



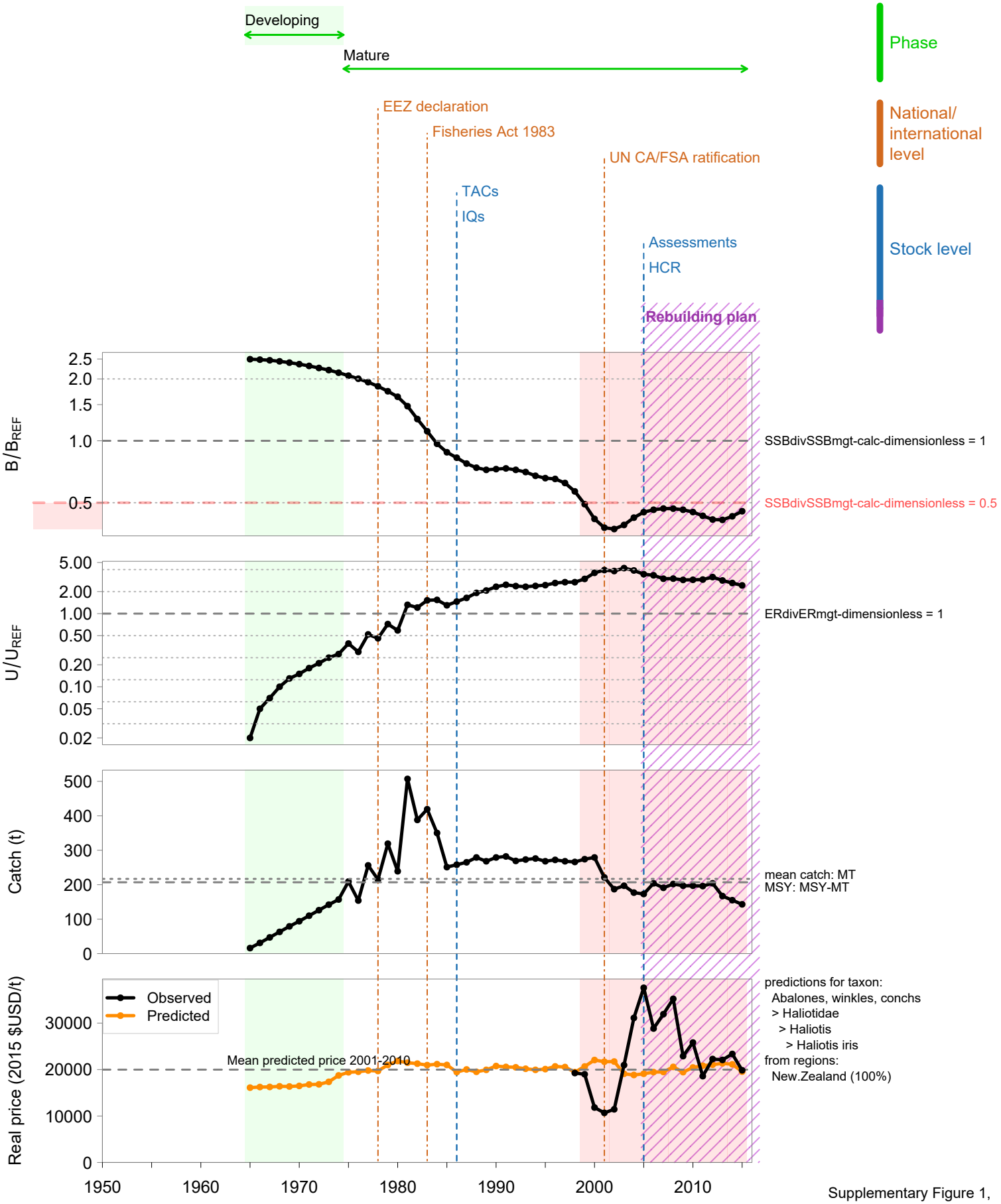
New Zealand -- PAUAPAU5D -- Paua New Zealand Area PAU 5D (Otago)

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: New Zealand



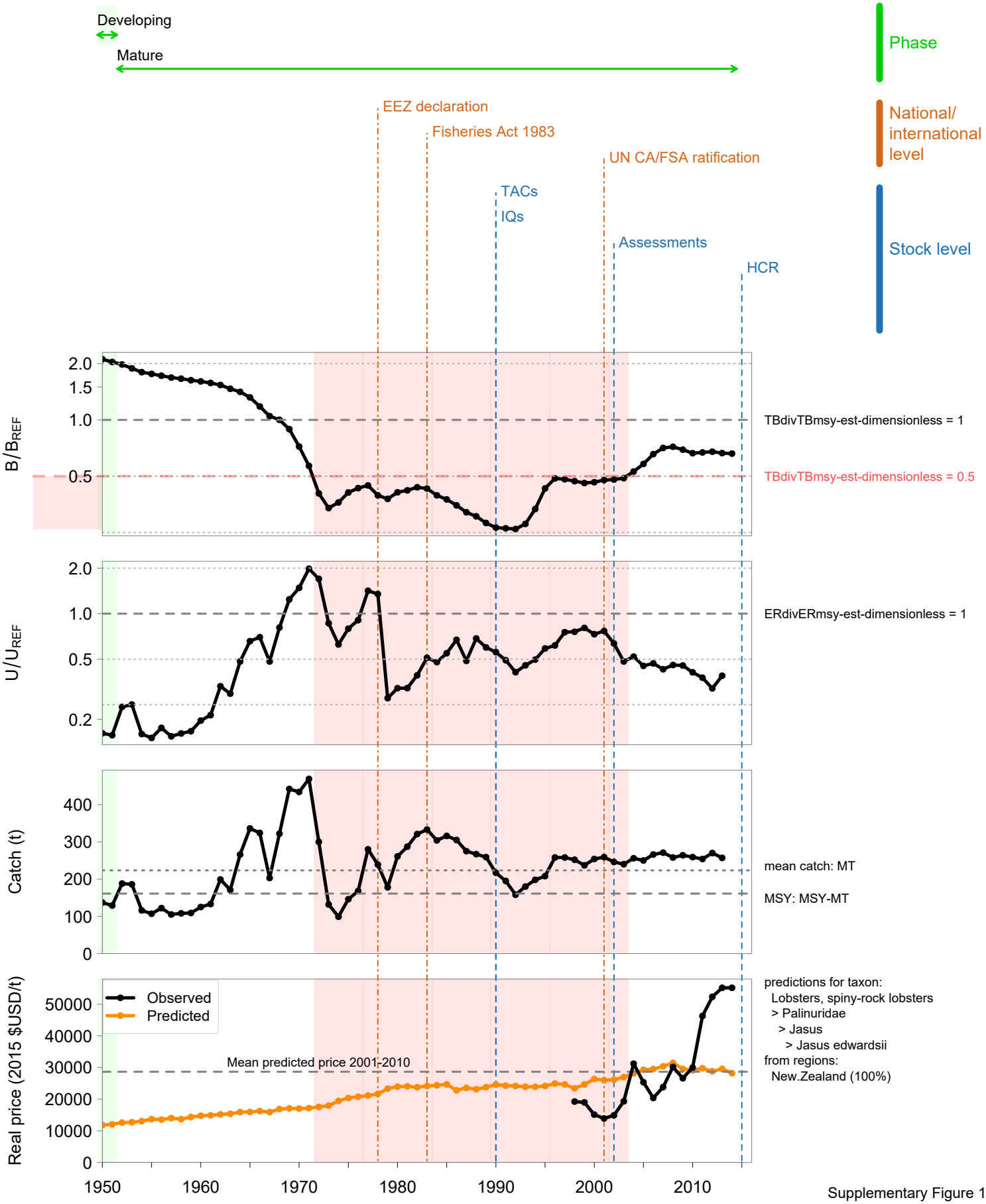
New Zealand -- PAUAPAU7 -- Paua New Zealand Area PAU 7 (Marlborough)

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: New Zealand



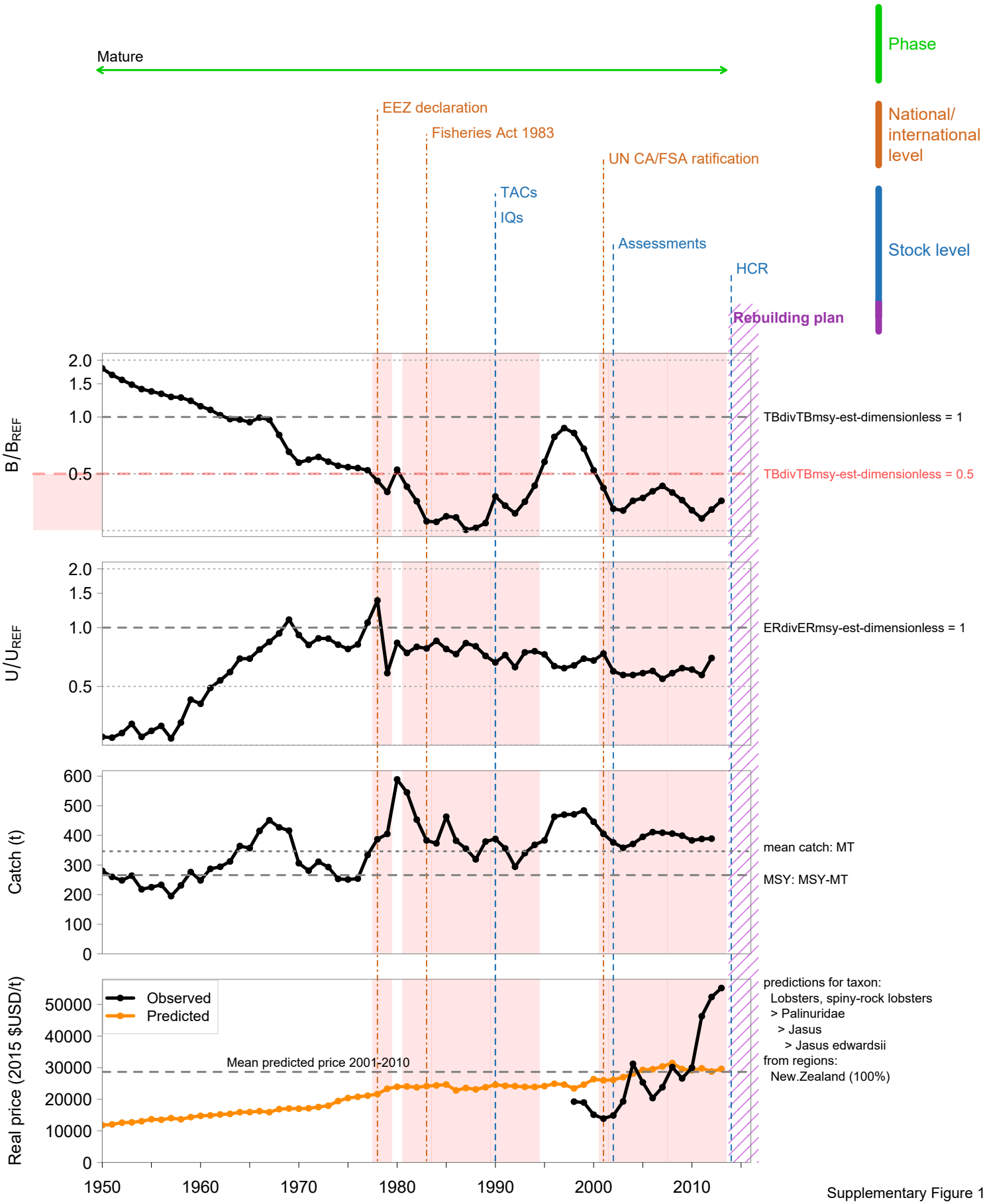
New Zealand -- RROCKLOBSTERCRA1 -- Red rock lobster New Zealand Area CRA1

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



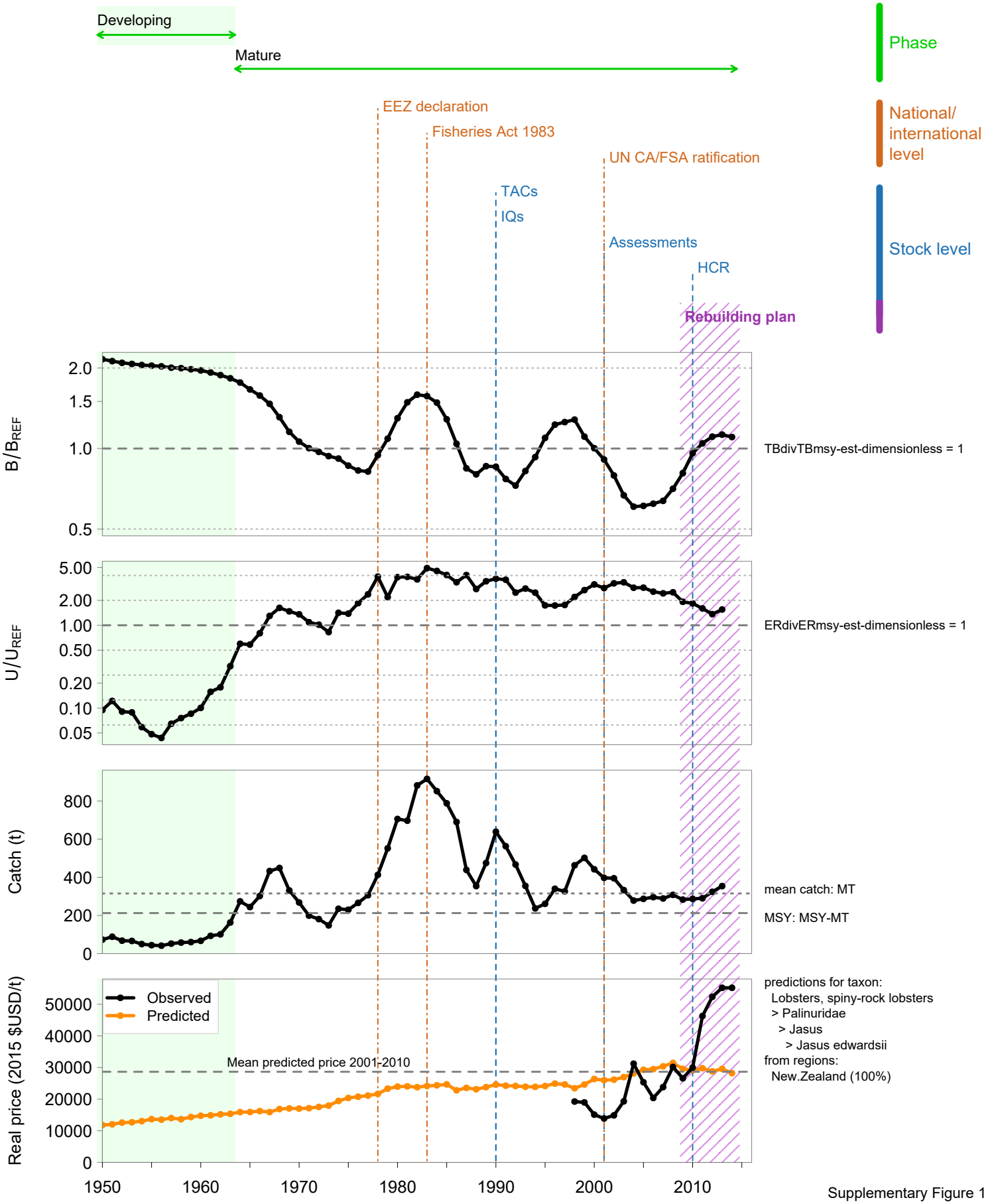
New Zealand -- RROCKLOBSTERCRA2 -- Red rock lobster New Zealand Area CRA2

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



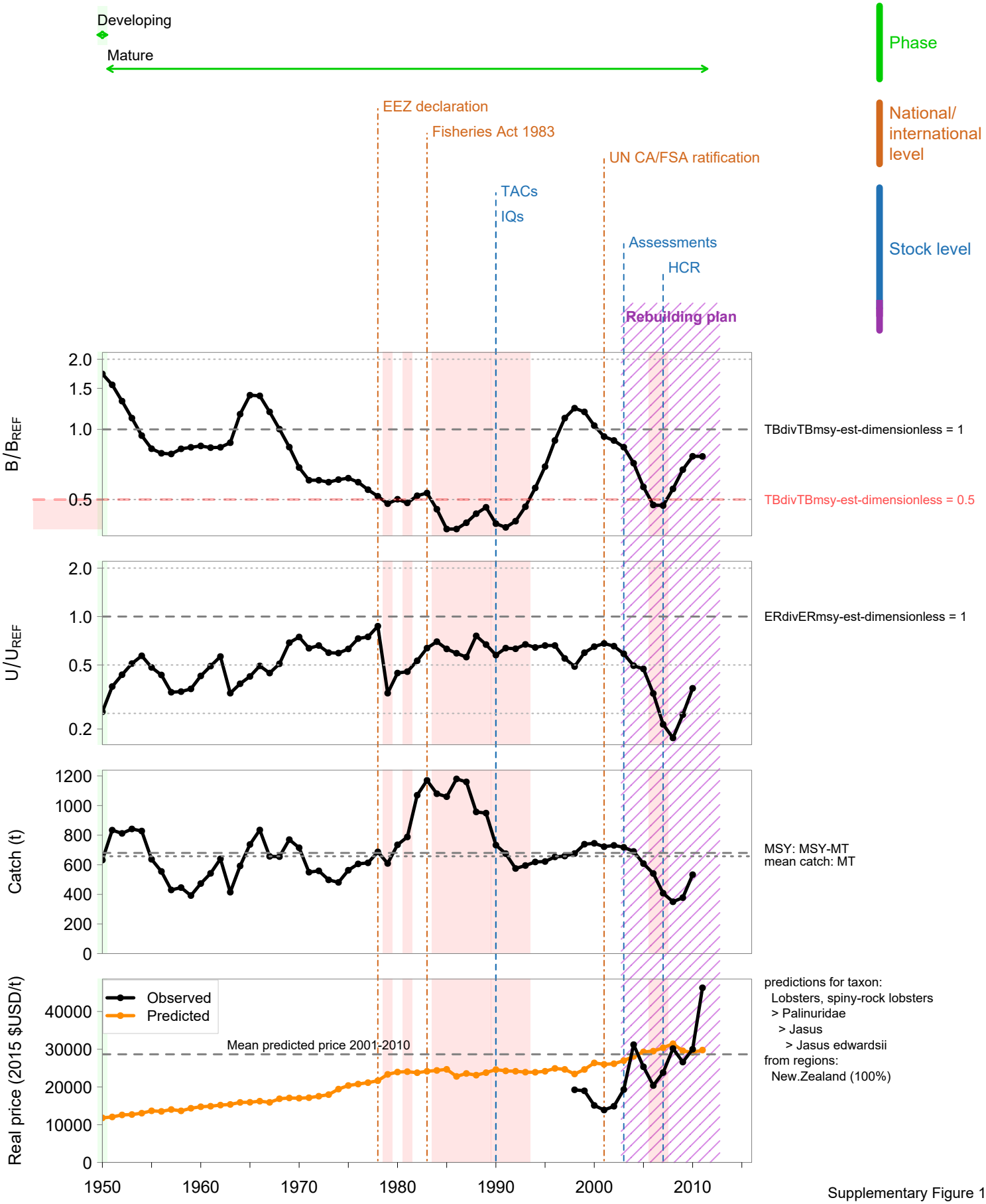
New Zealand -- RROCKLOBSTERCRA3 -- Red rock lobster New Zealand Area CRA3

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



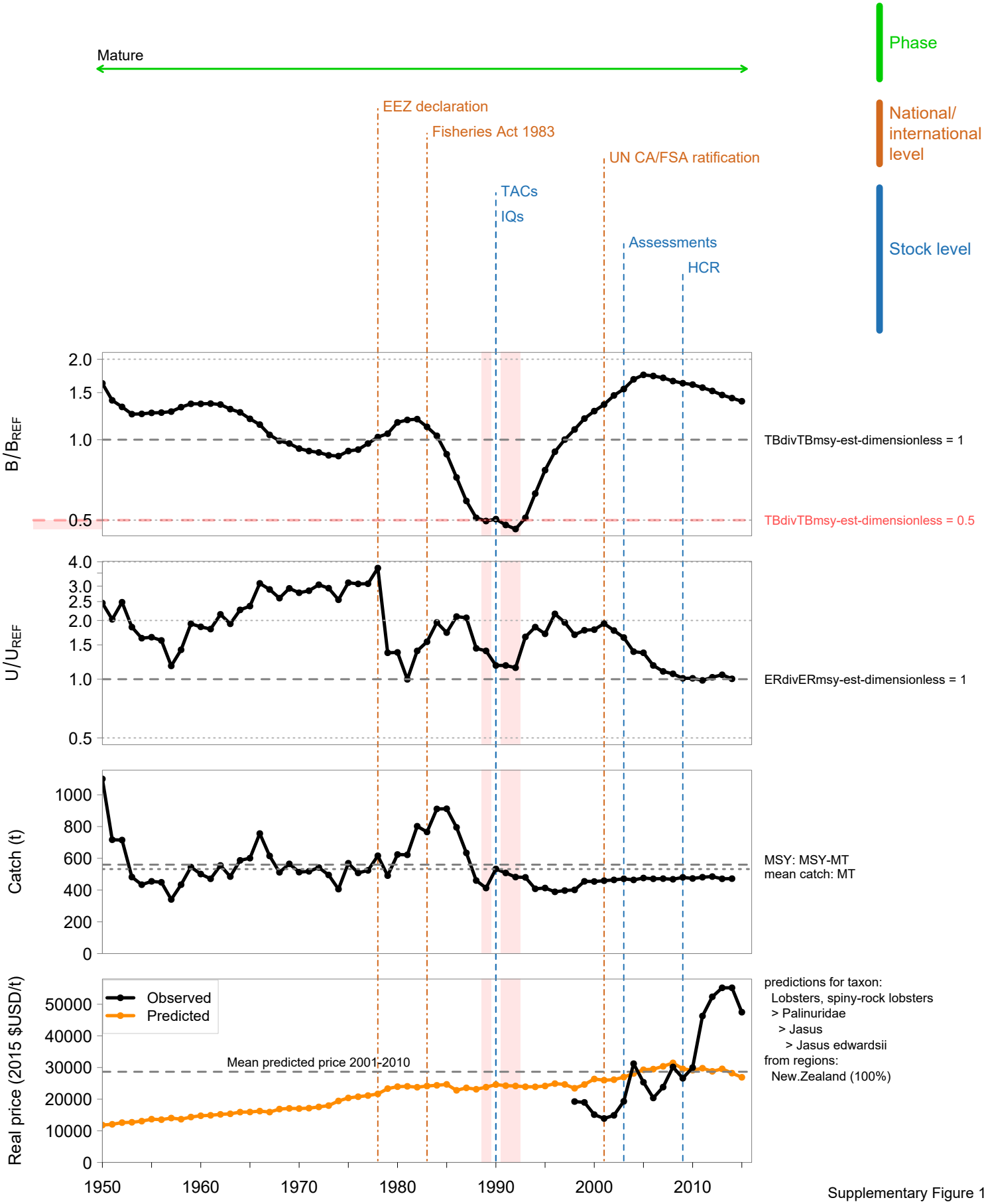
New Zealand -- RROCKLOBSTERCRA4 -- Red rock lobster New Zealand Area CRA4

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



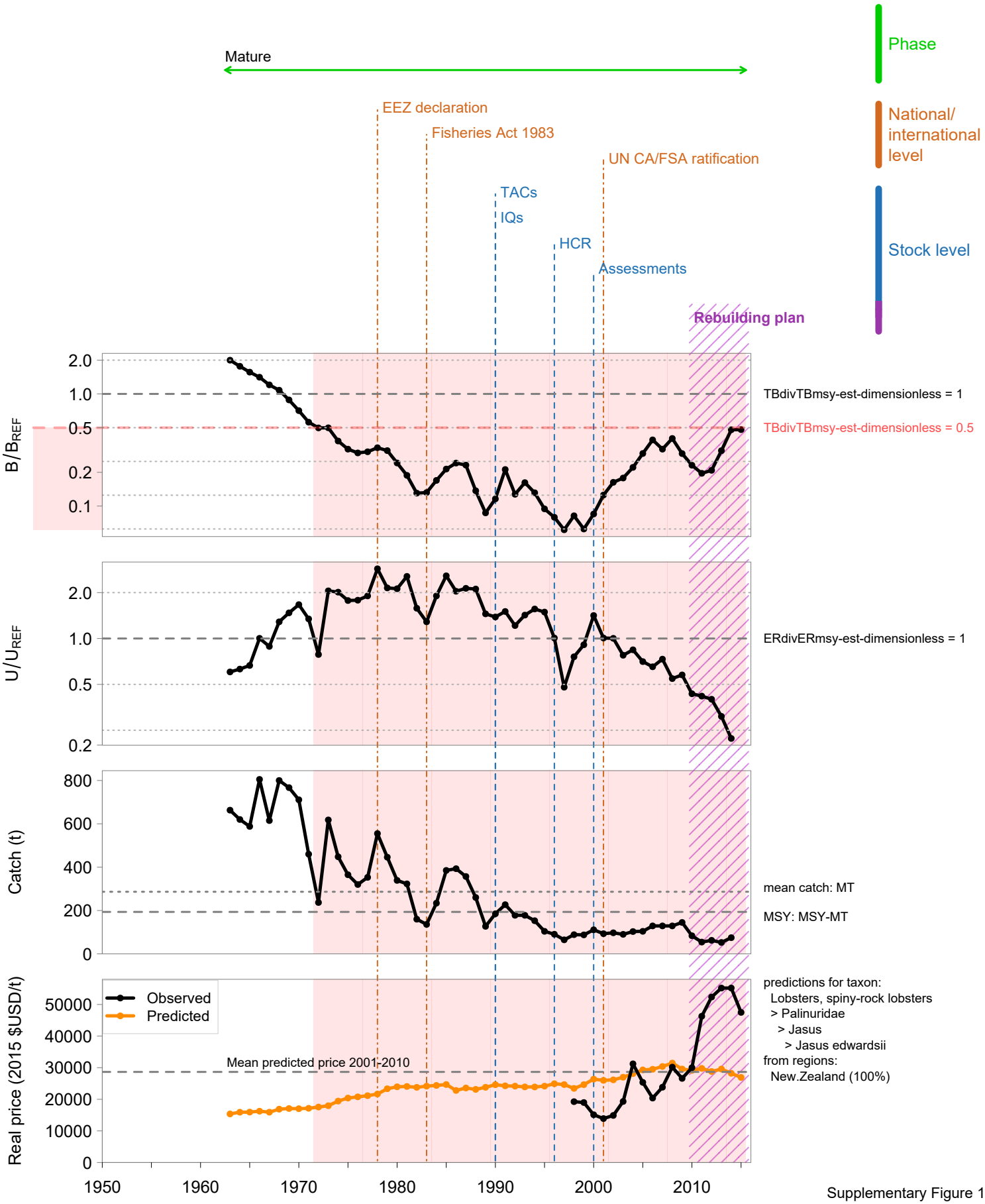
New Zealand -- RROCKLOBSTERCRA5 -- Red rock lobster New Zealand Area CRA5

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



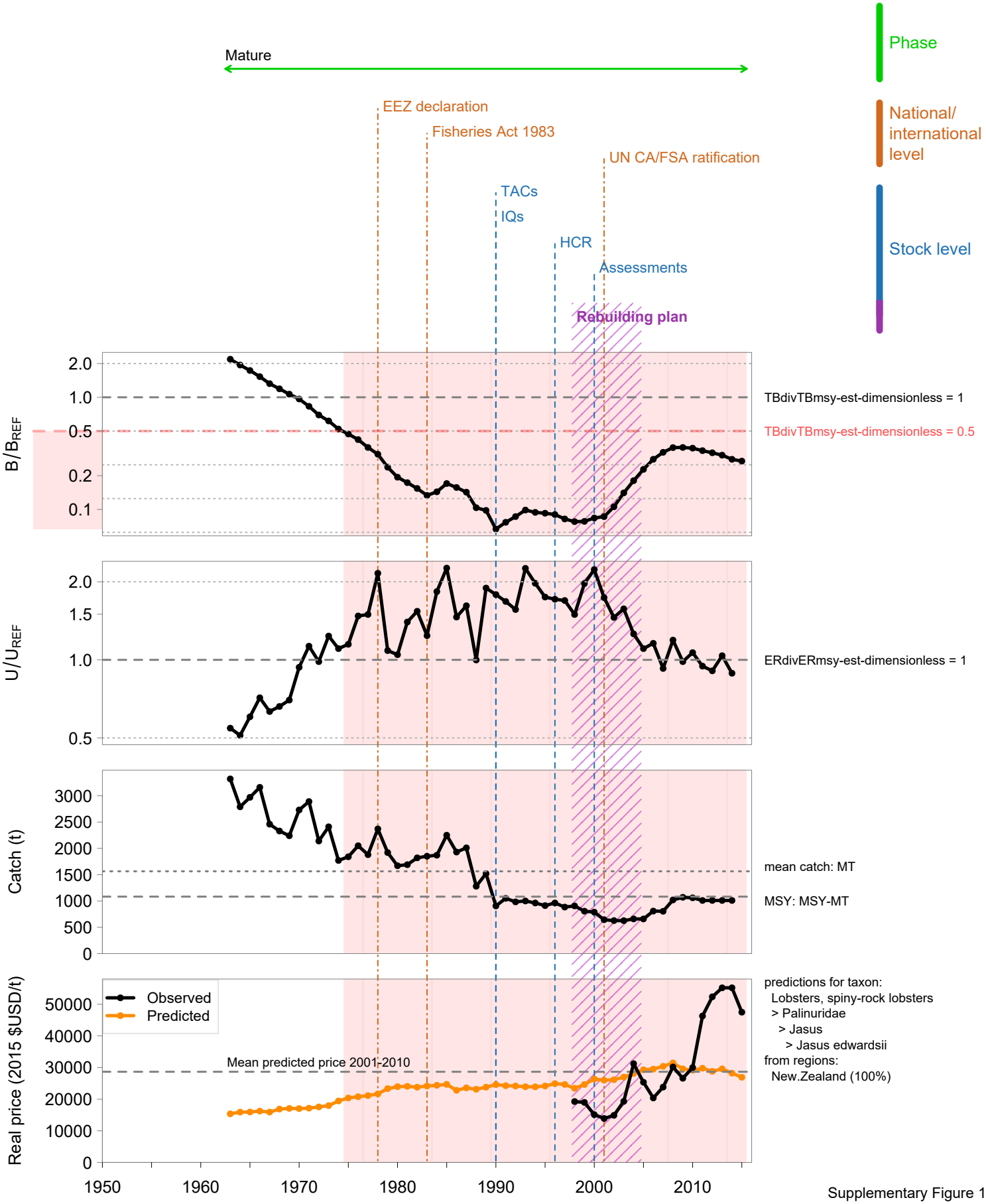
New Zealand -- RROCKLOBSTERCRA7 -- Red rock lobster New Zealand Area CRA7

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



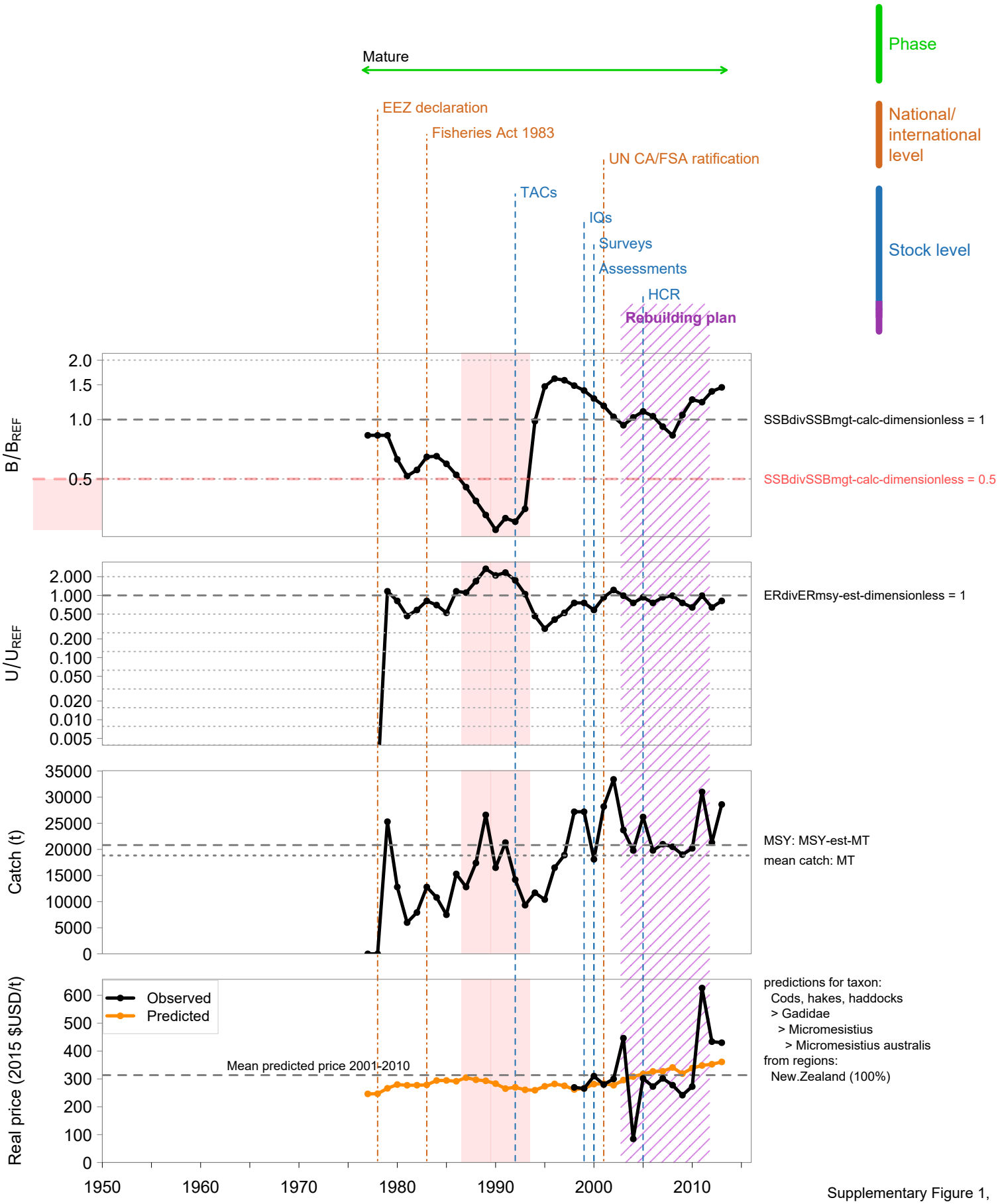
New Zealand -- RROCKLOBSTERCRA8 -- Red rock lobster New Zealand Area CRA8

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: New Zealand



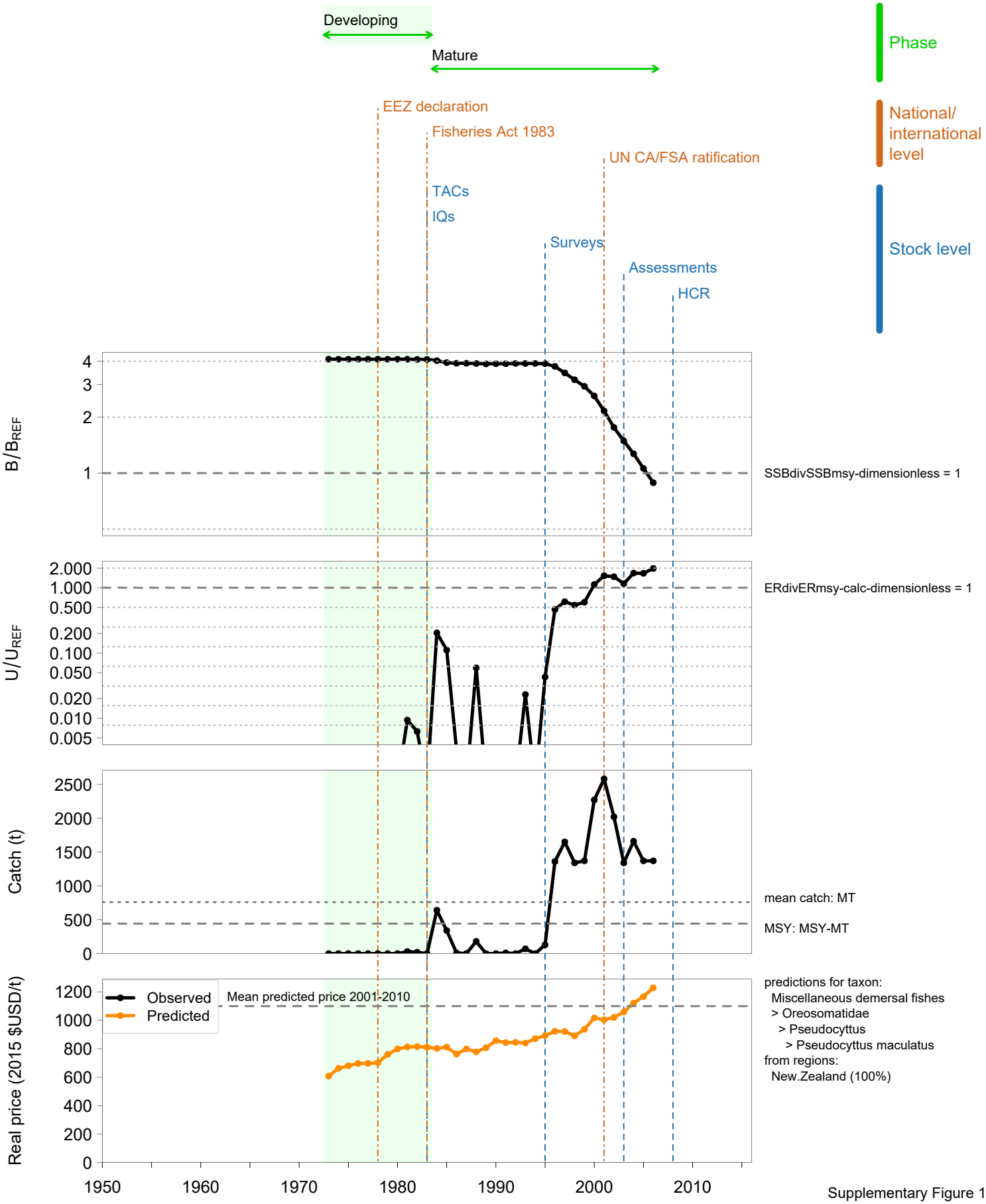
New Zealand -- SBWHITACIR -- Southern blue whiting Campbell Island Rise

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: New Zealand



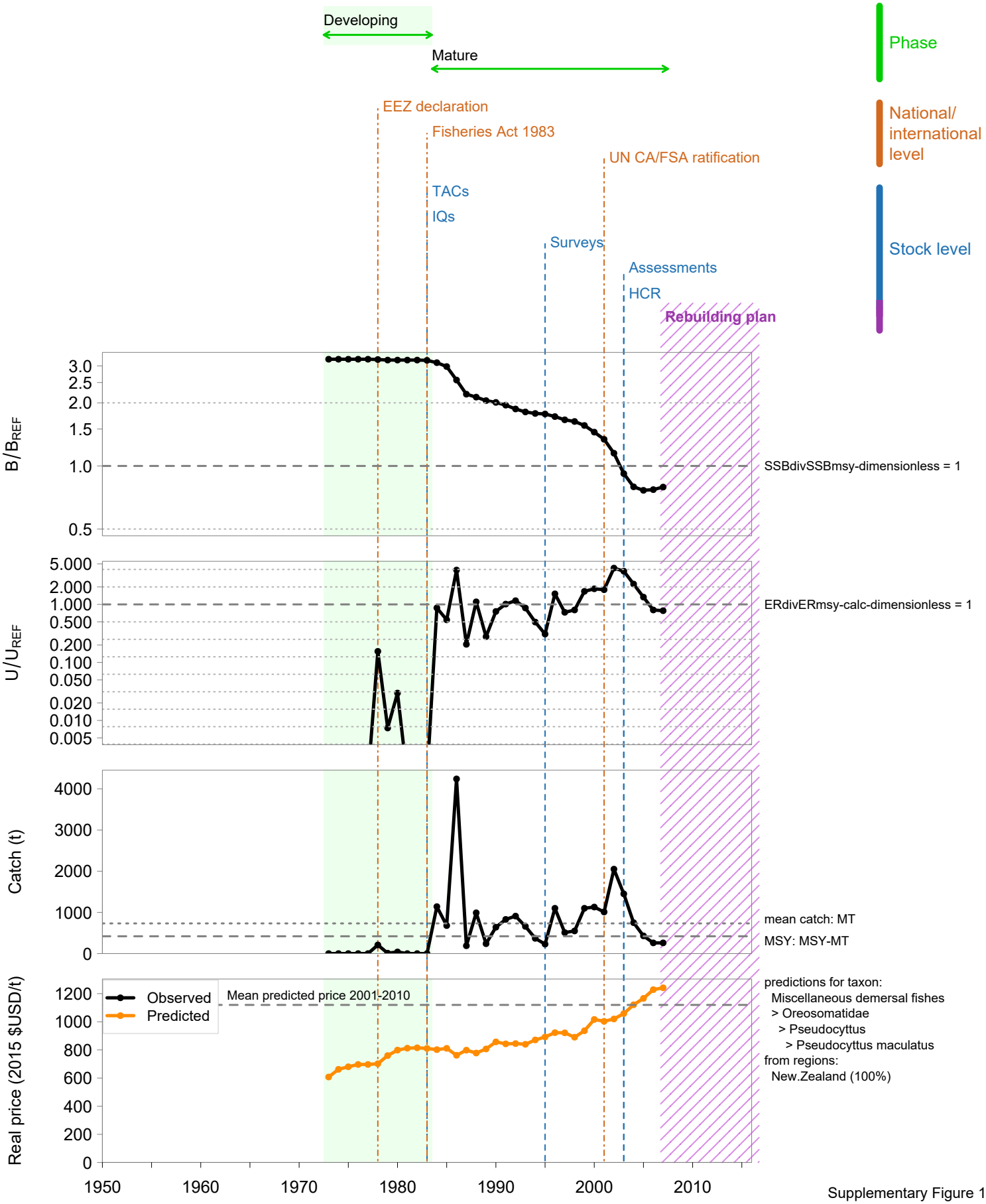
New Zealand -- SMOOTHOREOEPR -- Smooth oreo East Pukaki Rise

taxonomic group: demersal fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



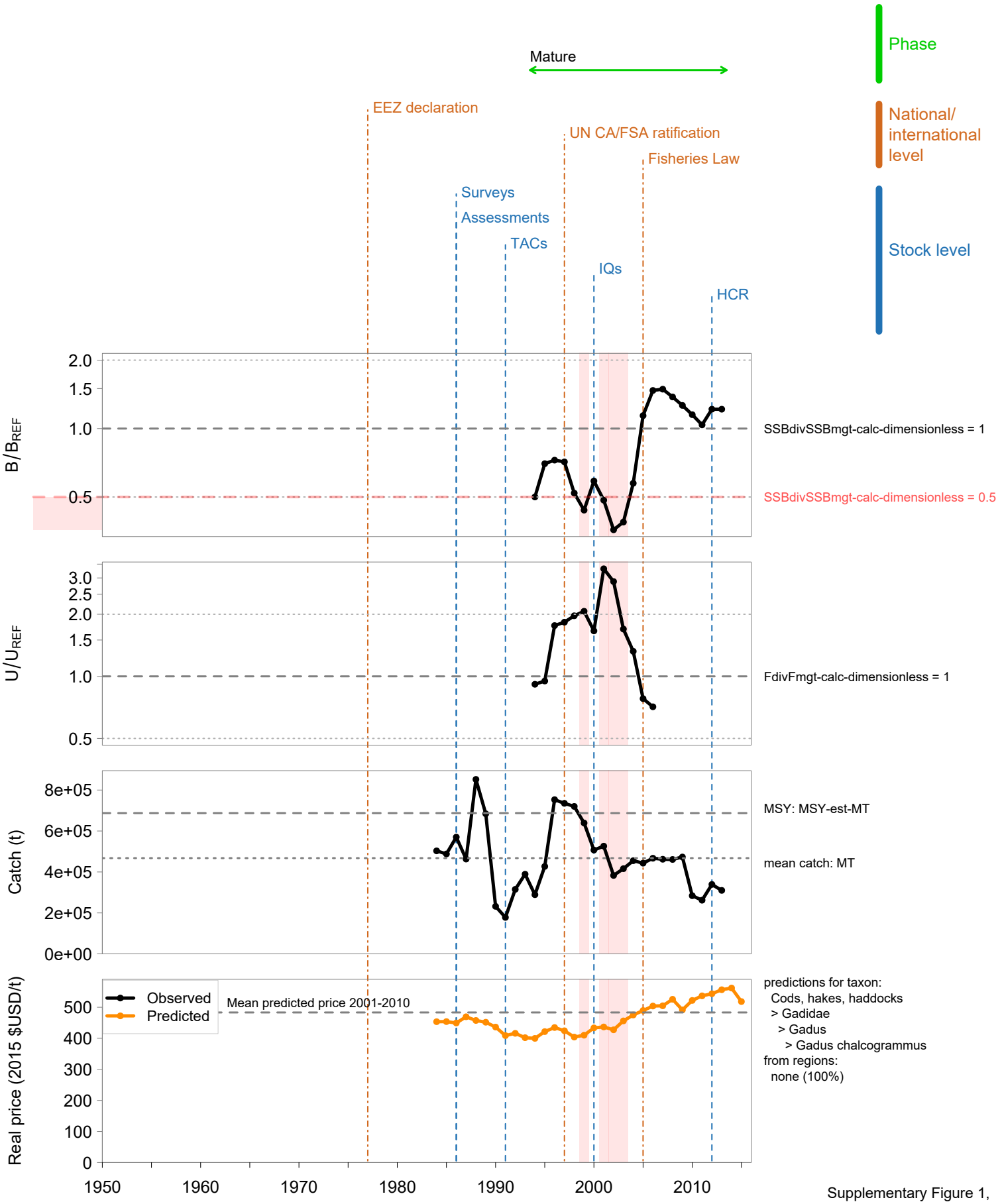
New Zealand -- SMOOTHOREOSLD -- Smooth oreo Southland

taxonomic group: demersal fish (Other marine fish), predominant fishery type: single-species, primary country: New Zealand



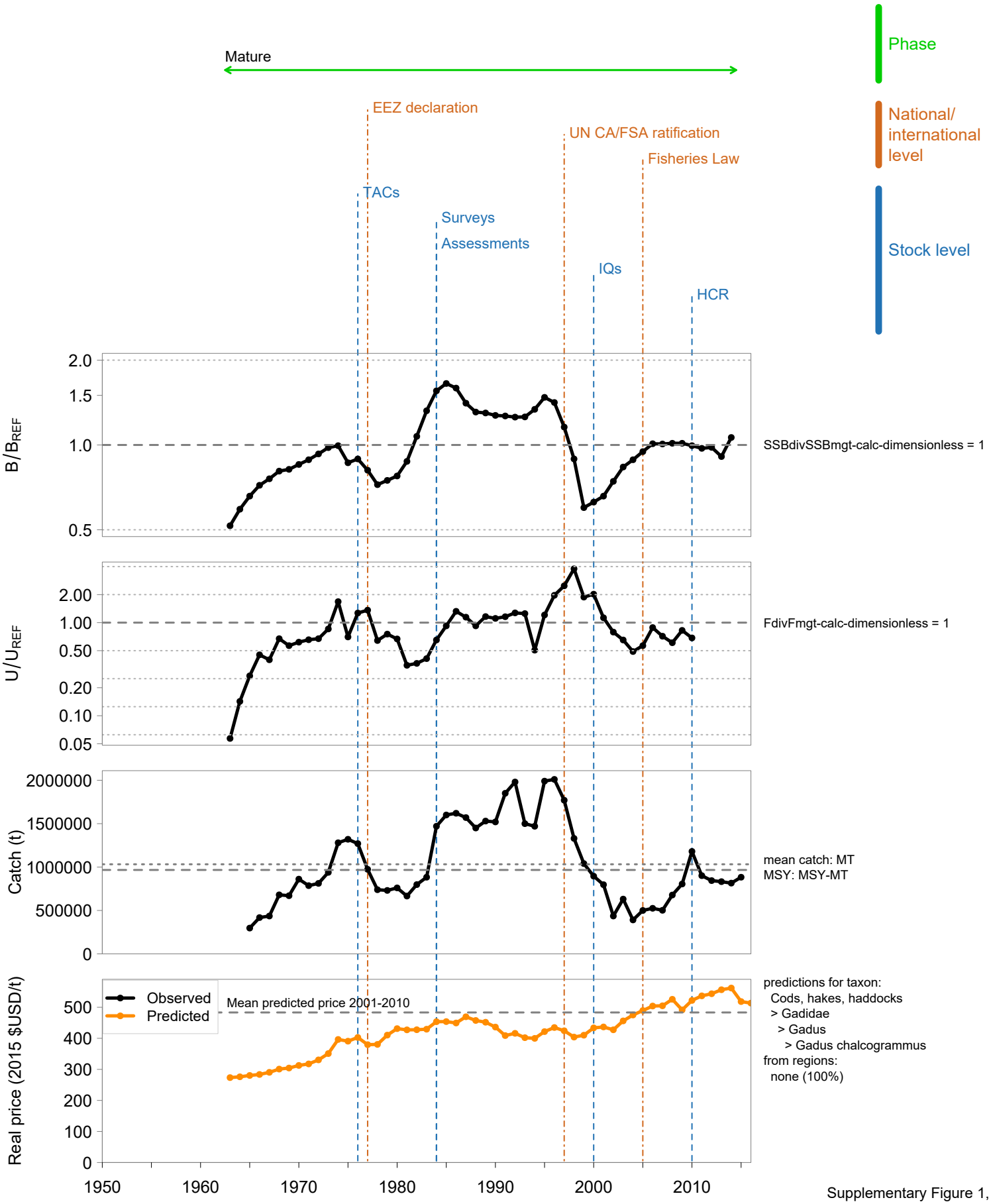
Russia-East Coast -- WPOLLNAVAR -- Walleye pollock Navarinsky

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Russia



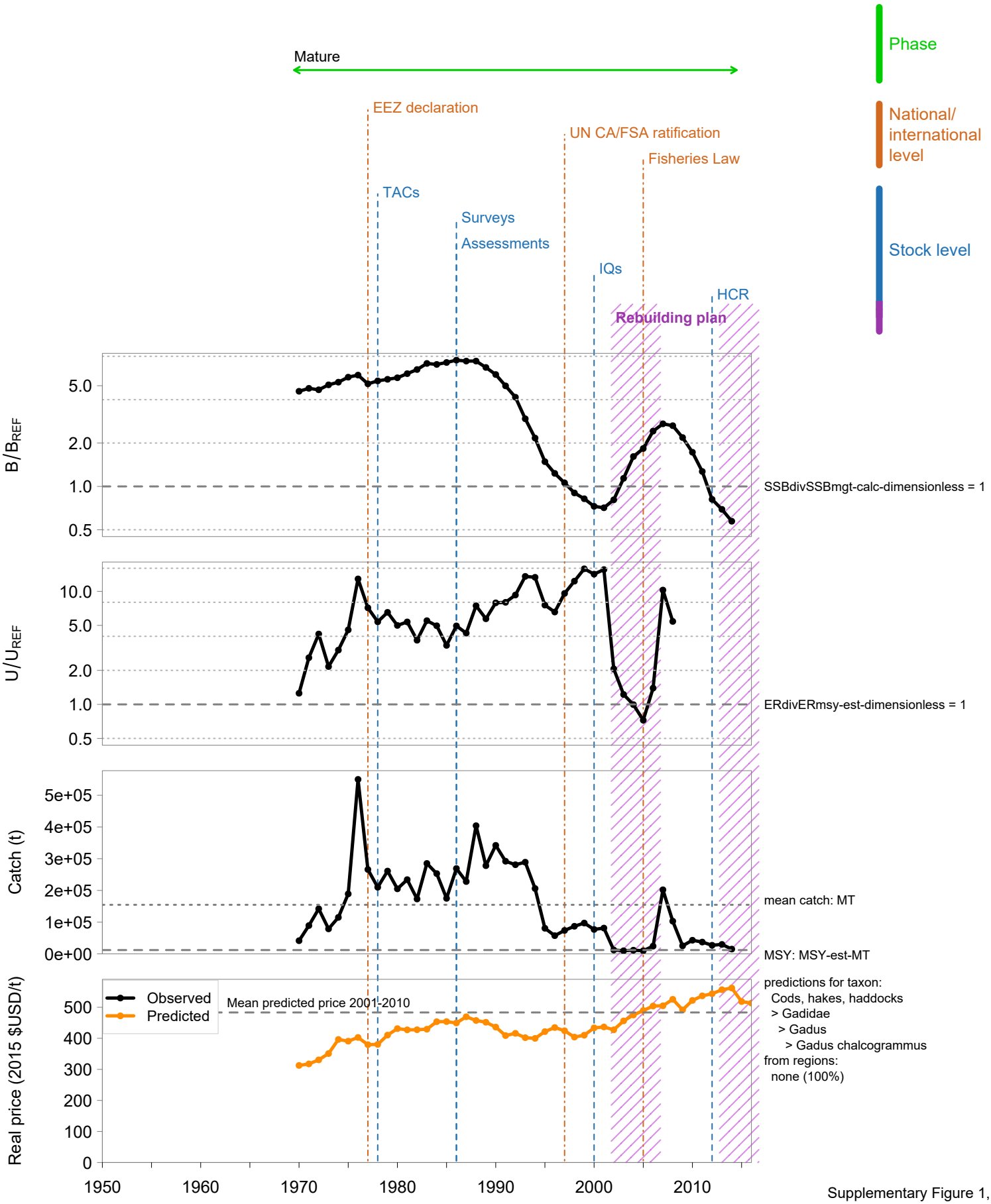
Russia-East Coast -- WPOLLNSO -- Walleye pollock Northern Sea of Okhotsk

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Russia



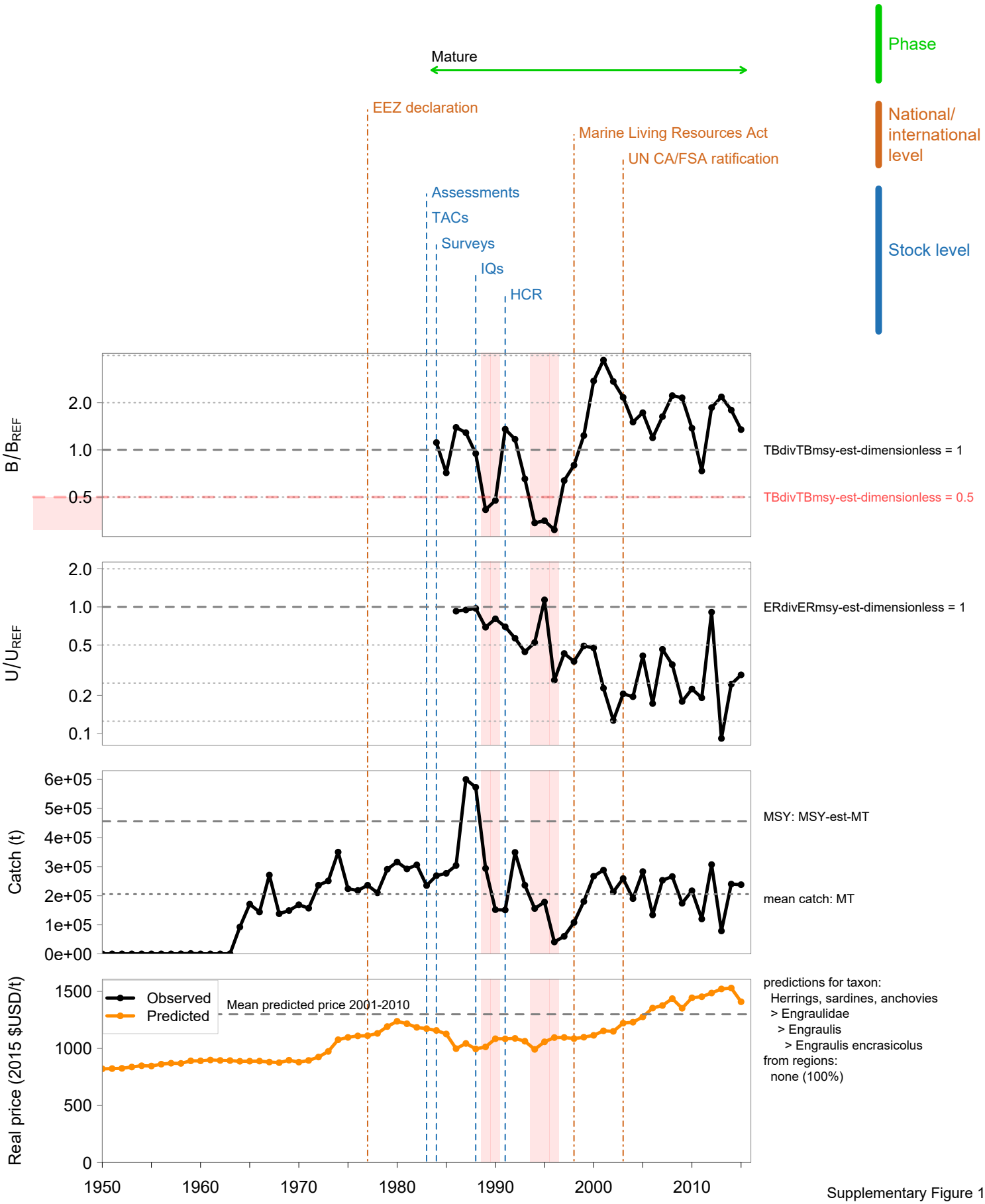
Russia-East Coast -- WPOLLWBS -- Walleye pollock Western Bering Sea

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Russia



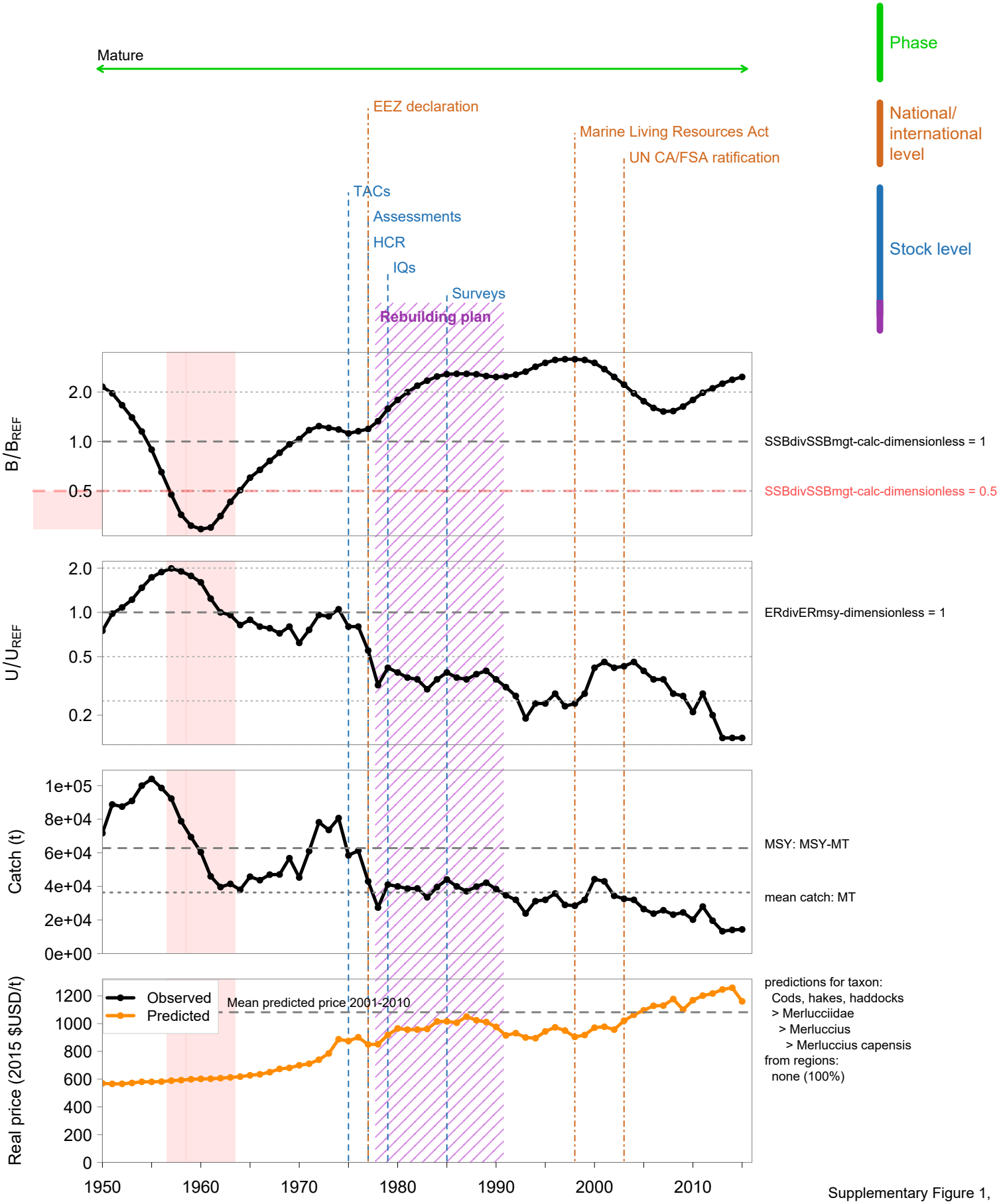
South Africa -- ANCHOSA -- Anchovy South Africa

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: South Africa



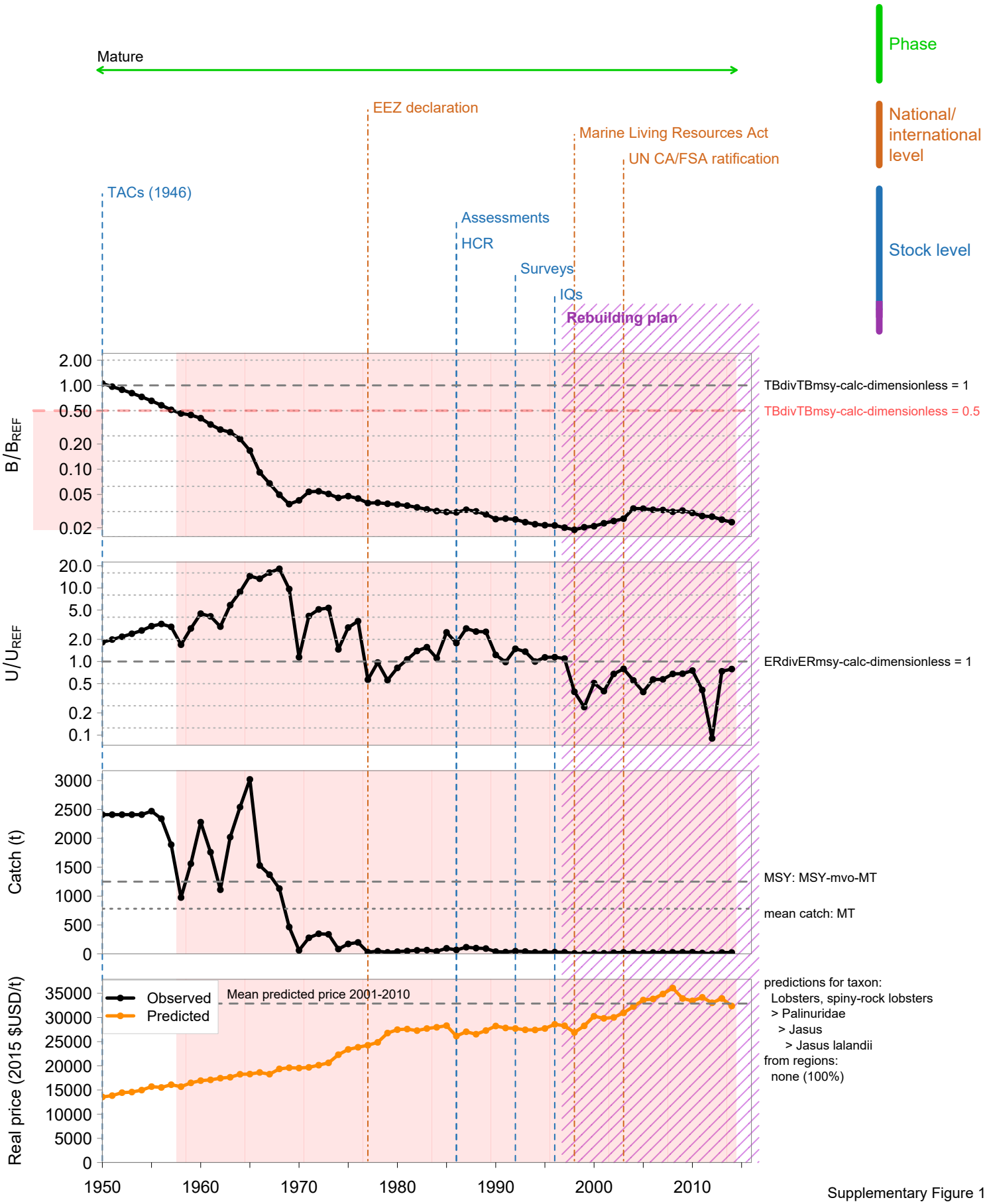
South Africa -- CHAKESA -- Shallow water cape hake South Africa

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: South Africa



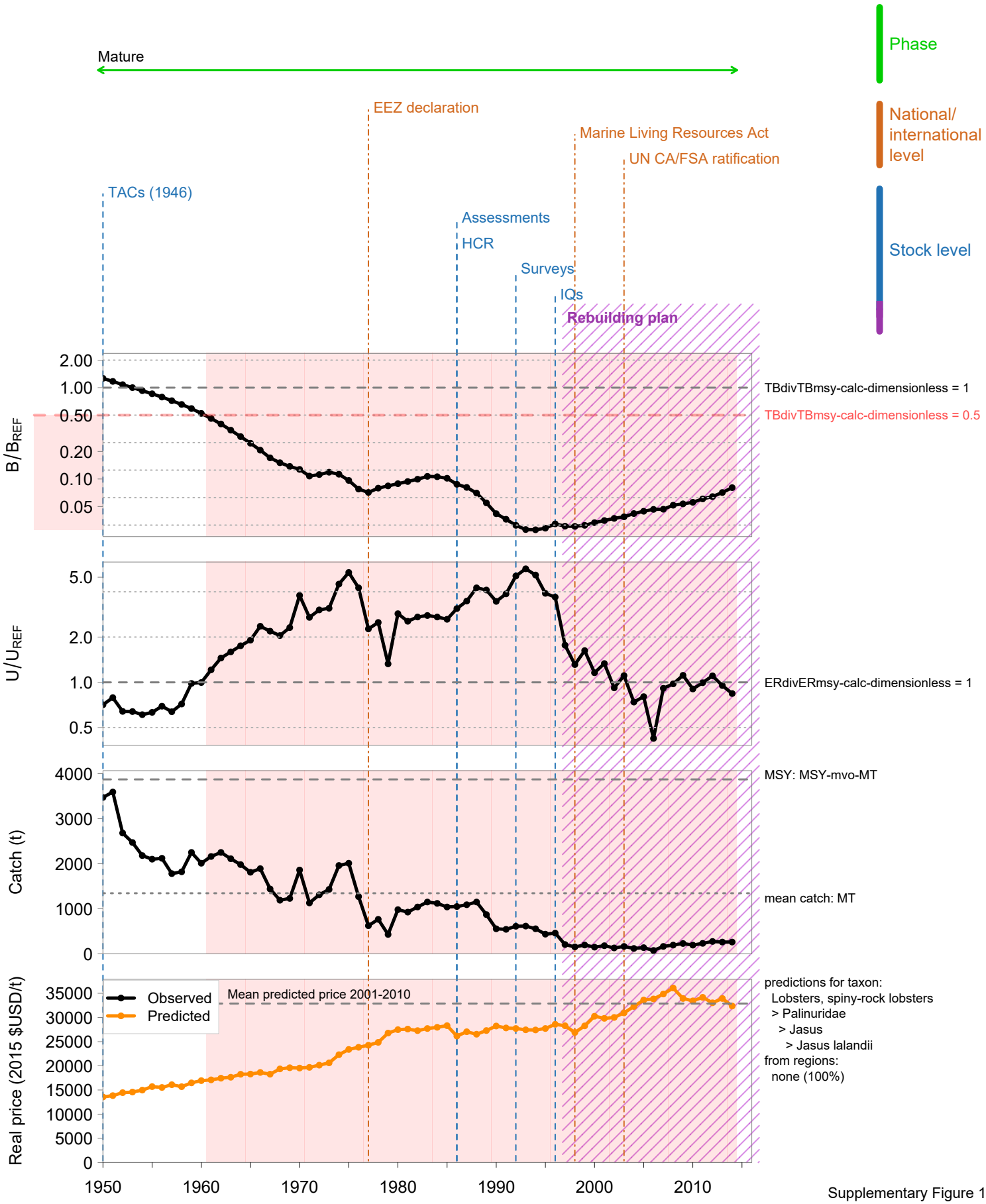
South Africa -- CRLOBSTERSA12 -- West coast rock lobster South Africa Areas 1-2

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



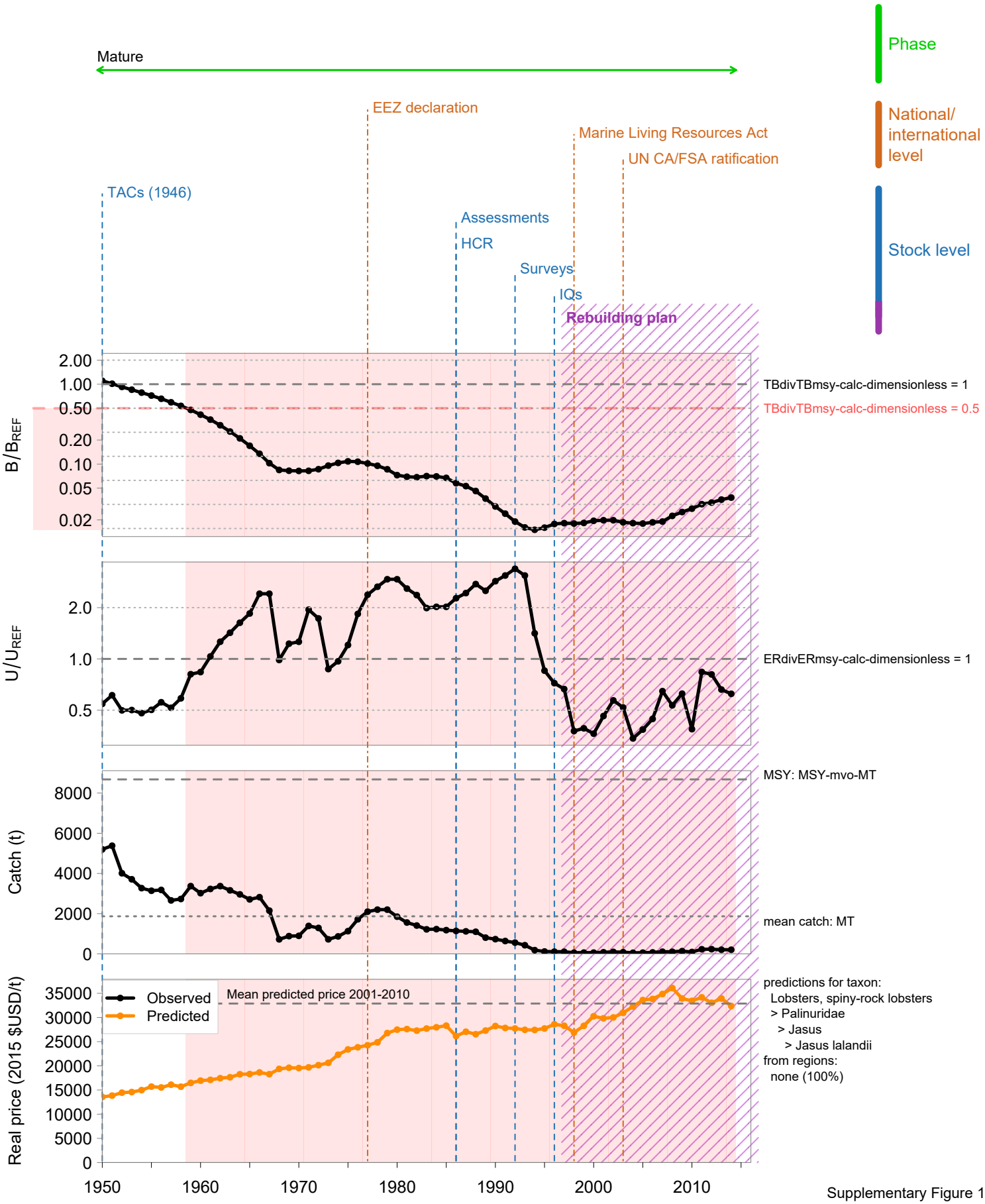
South Africa -- CRLOBSTERSA34 -- West coast rock lobster South Africa Areas 3-4

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



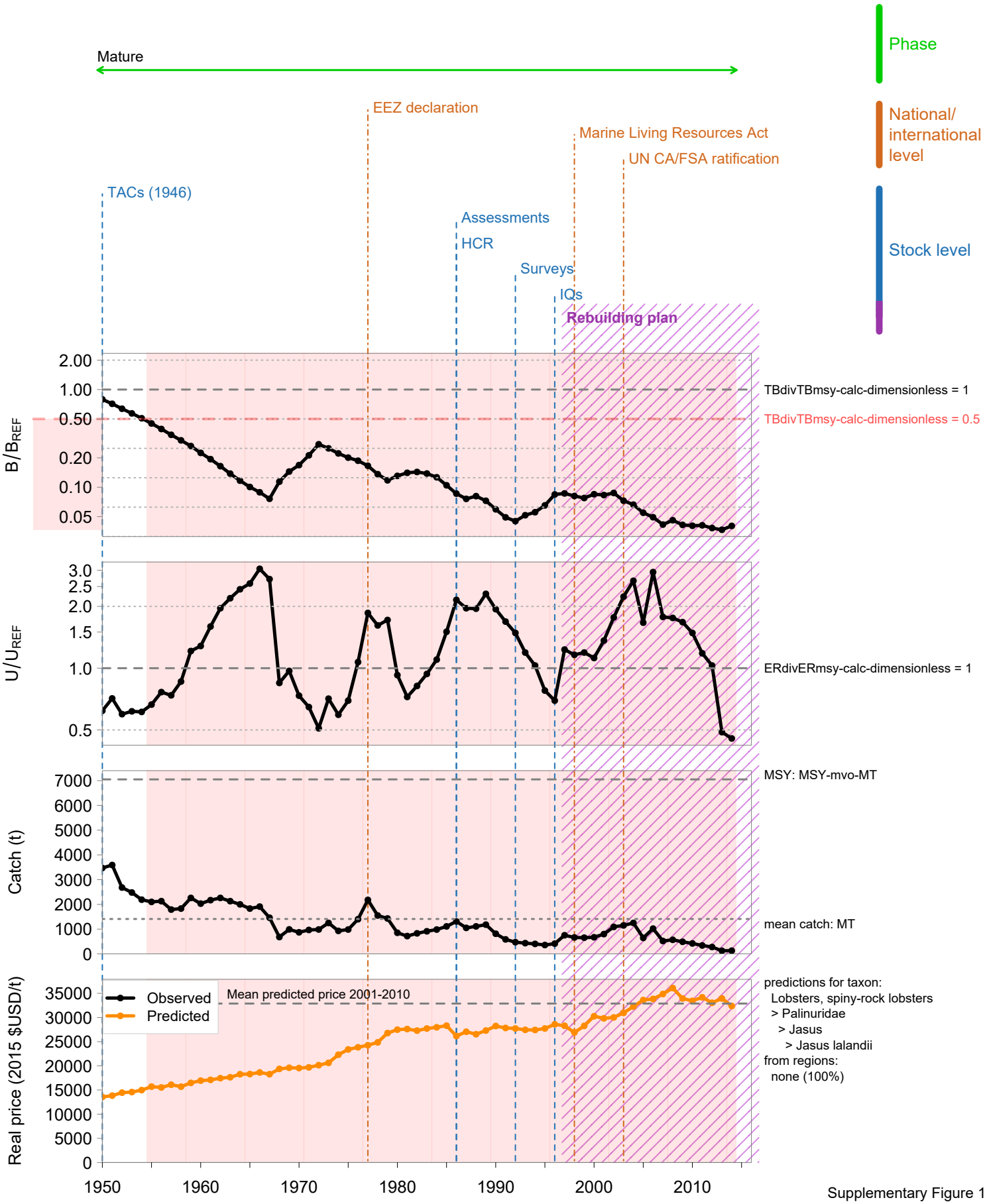
South Africa -- CRLOBSTERSA56 -- West coast rock lobster South Africa Areas 5-6

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



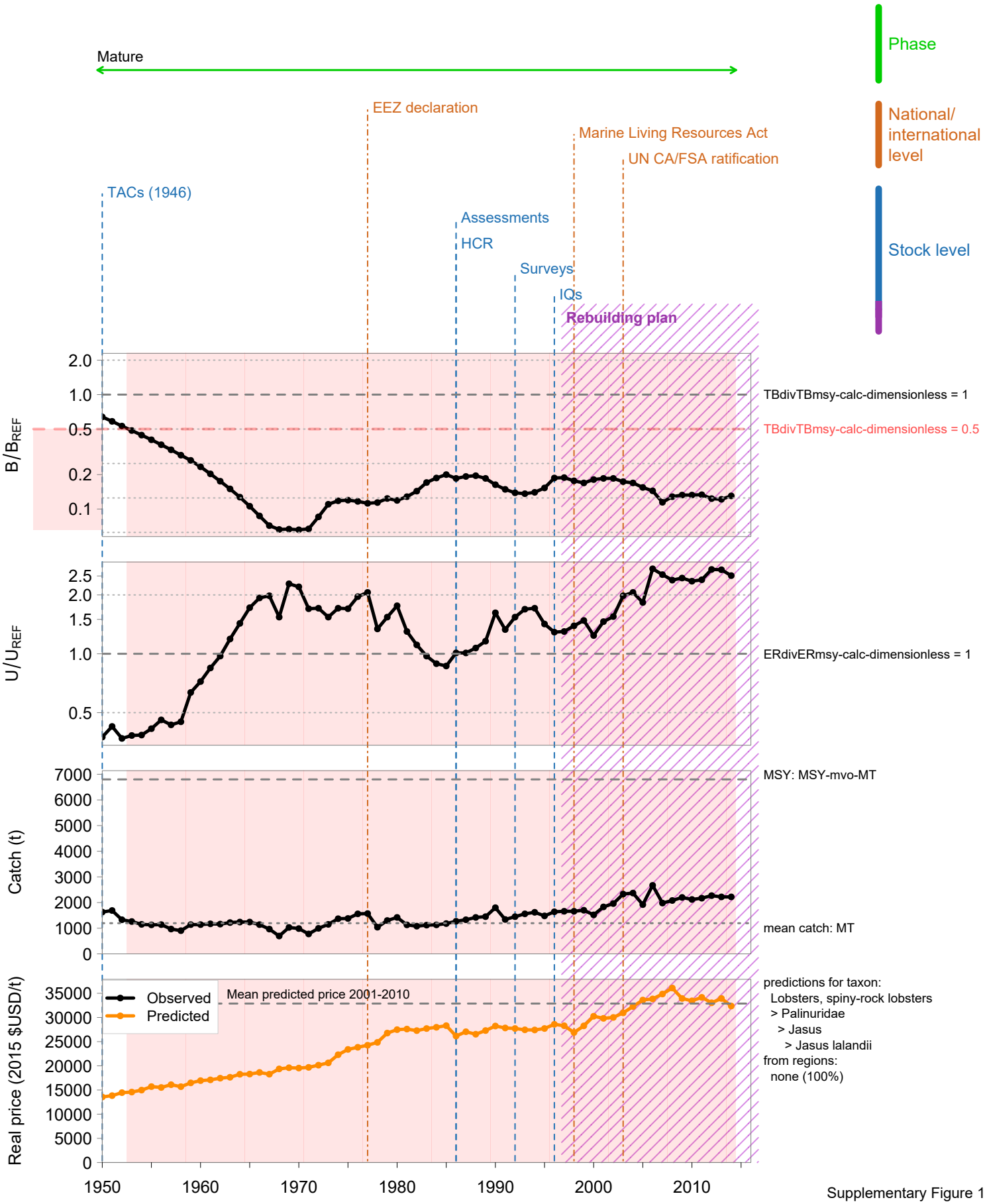
South Africa -- CRLOBSTERSA7 -- West coast rock lobster South Africa Area 7

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



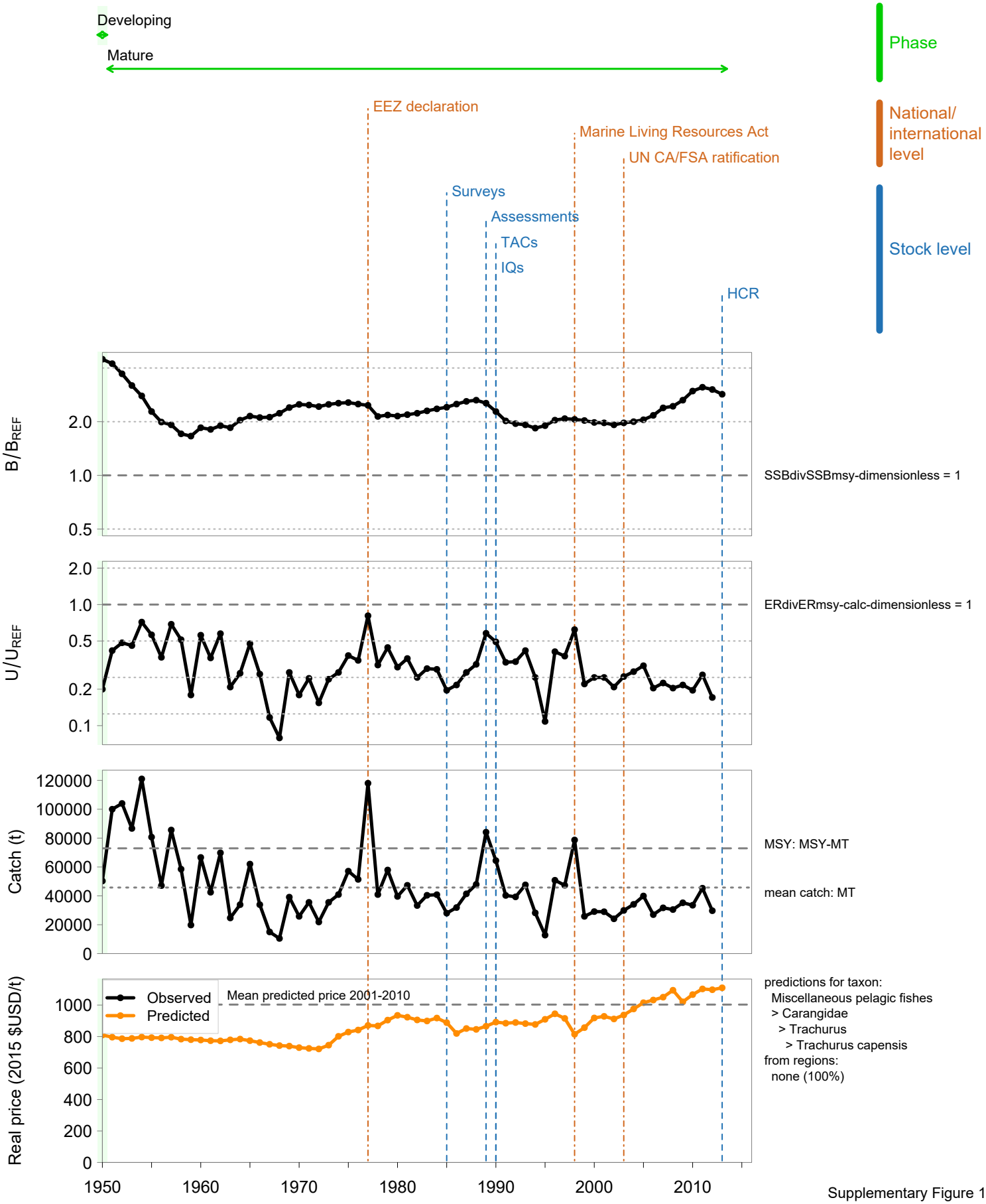
South Africa -- CRLOBSTERSA8 -- West coast rock lobster South Africa Area 8

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



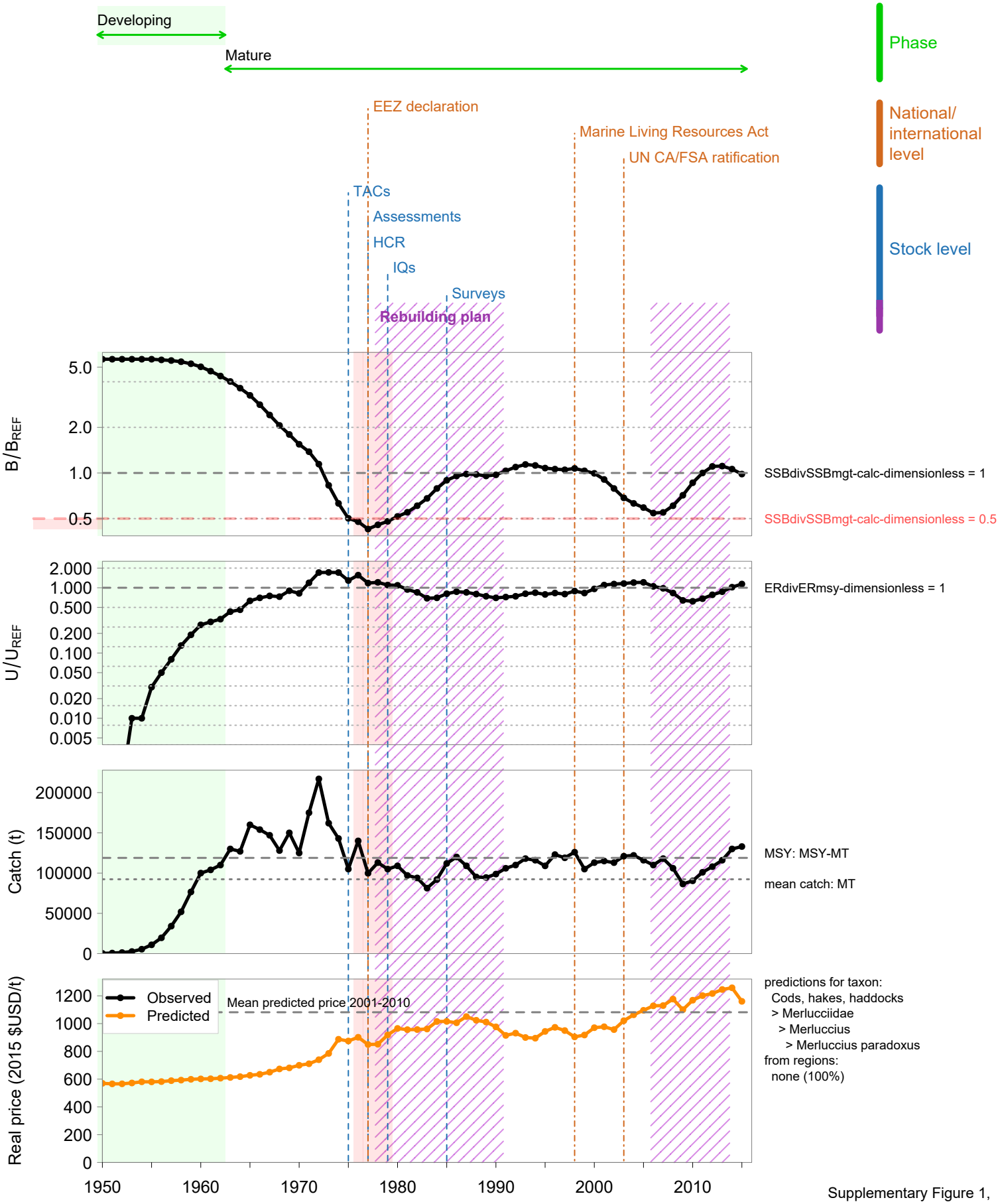
South Africa -- CTRACSA -- Cape horse mackerel South Africa South coast

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: South Africa



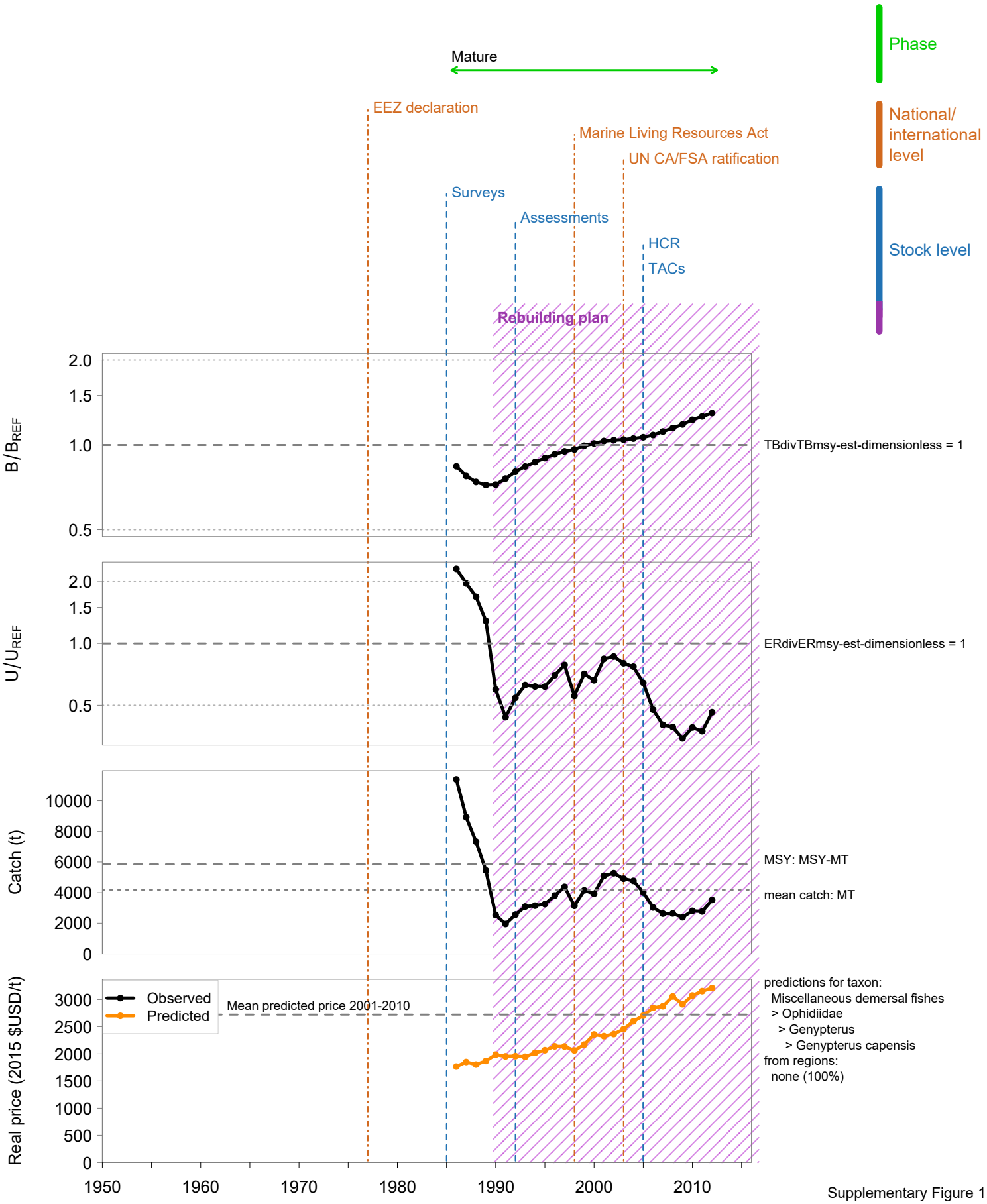
South Africa -- DEEPCHAKESA -- Deep water cape hake South Africa

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: South Africa



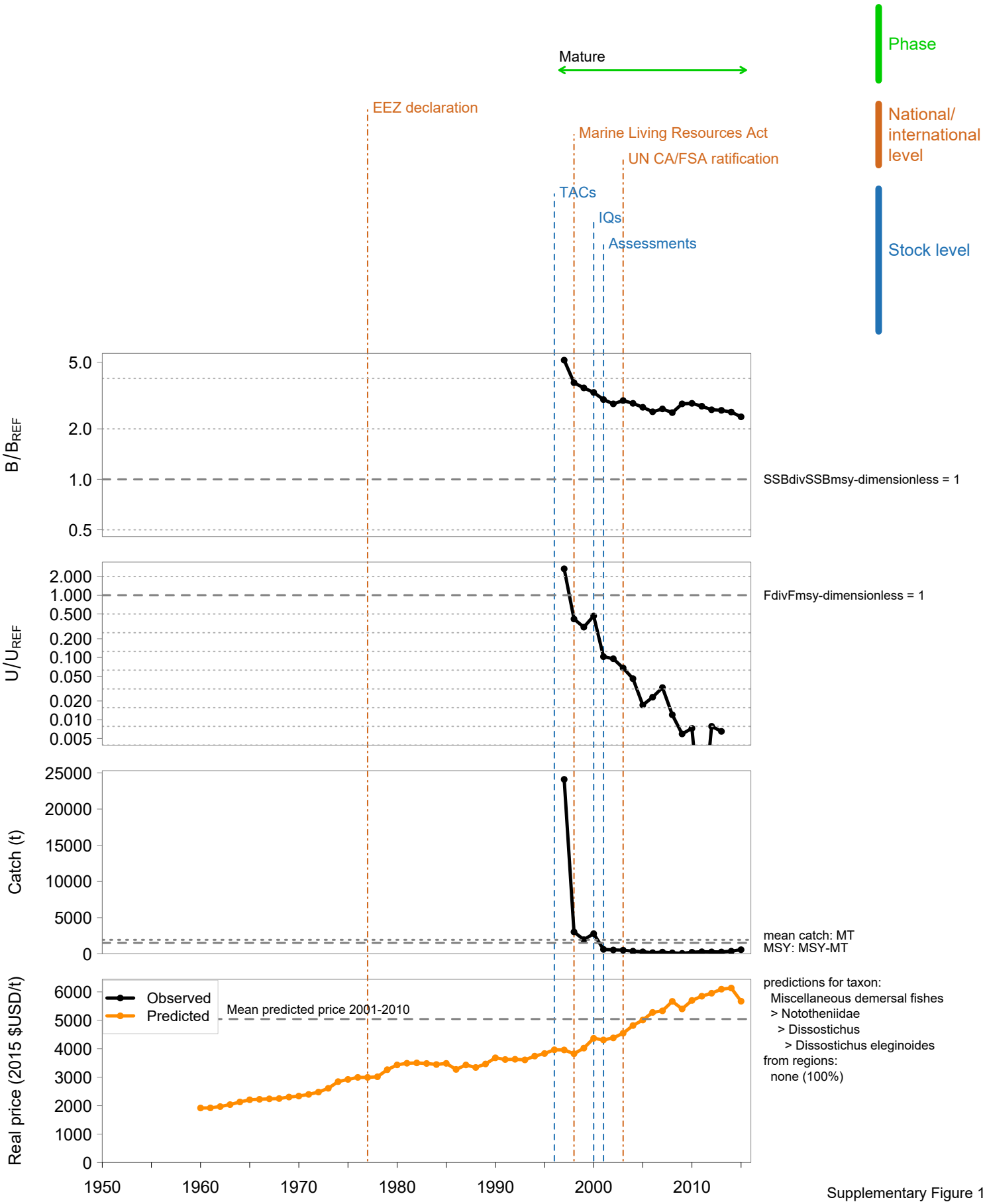
South Africa -- KINGKLIPSA -- Kingklip South Africa

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: South Africa



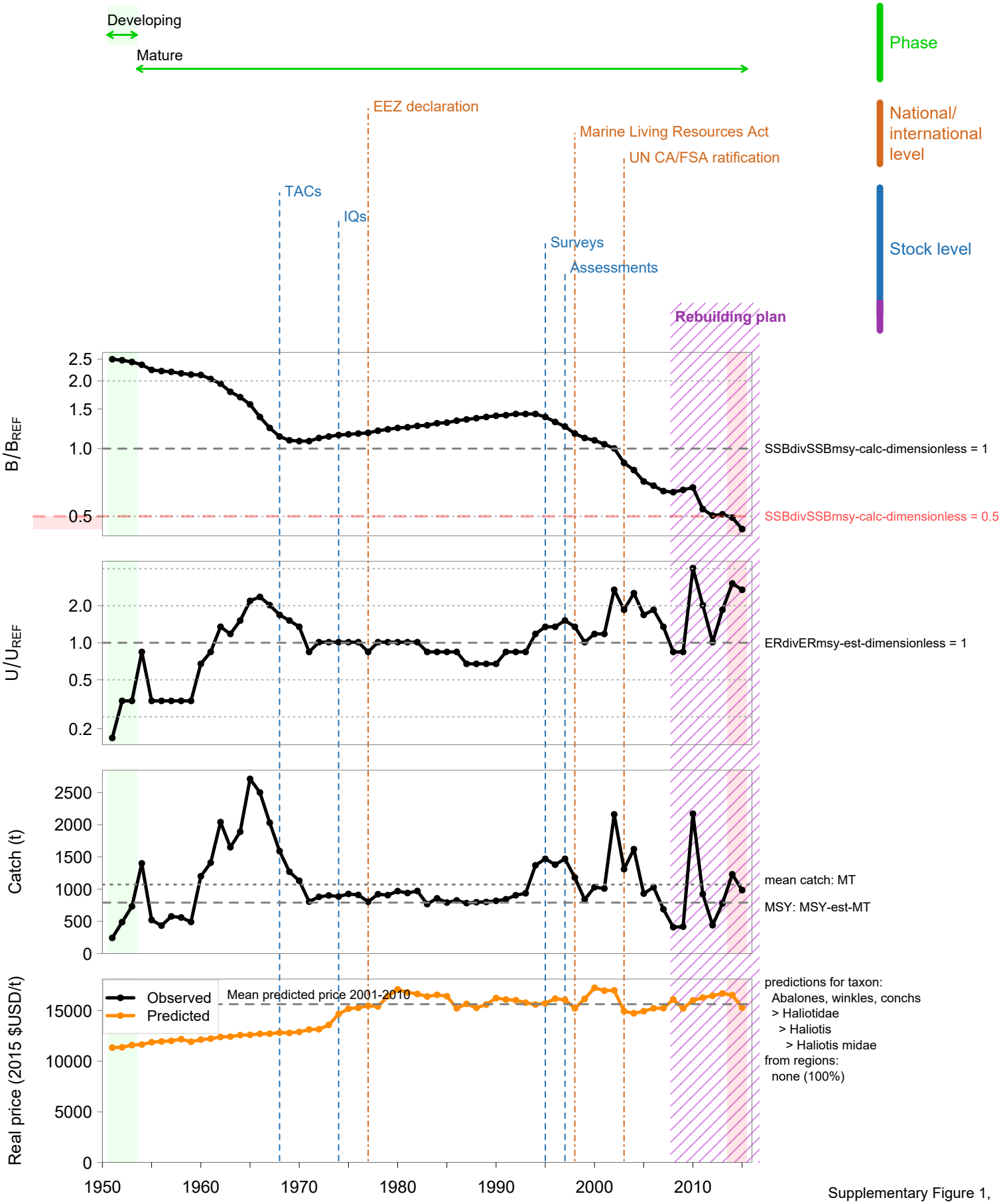
South Africa -- PTOOTHFISHPEI -- Patagonian toothfish South Africa Subantarctic Prince Edward Islands

taxonomic group: pelagic fish (Other marine fish), predominant fishery type: single-species, primary country: South Africa



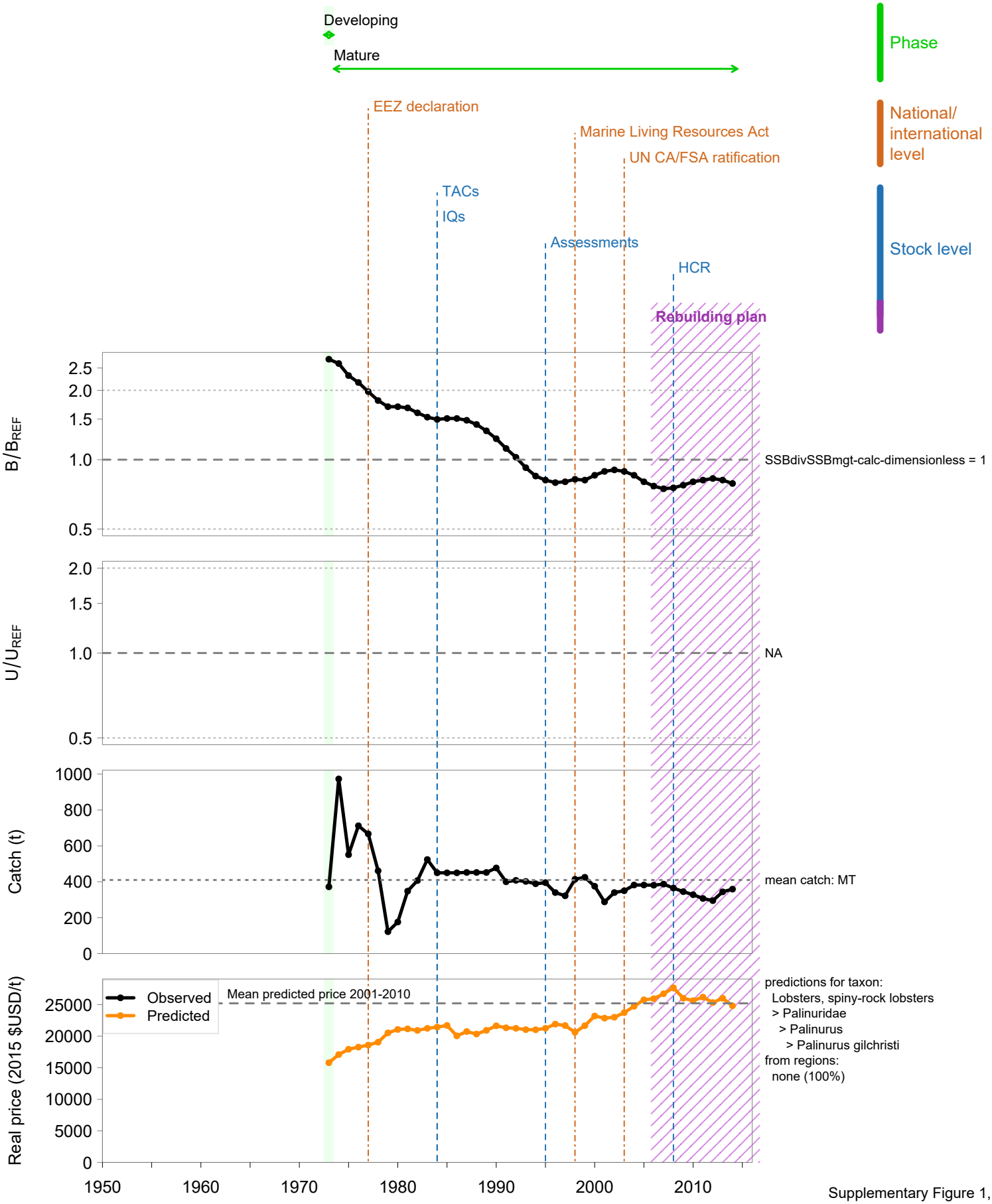
South Africa -- SAABALONESA -- South African abalone South Africa

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: South Africa



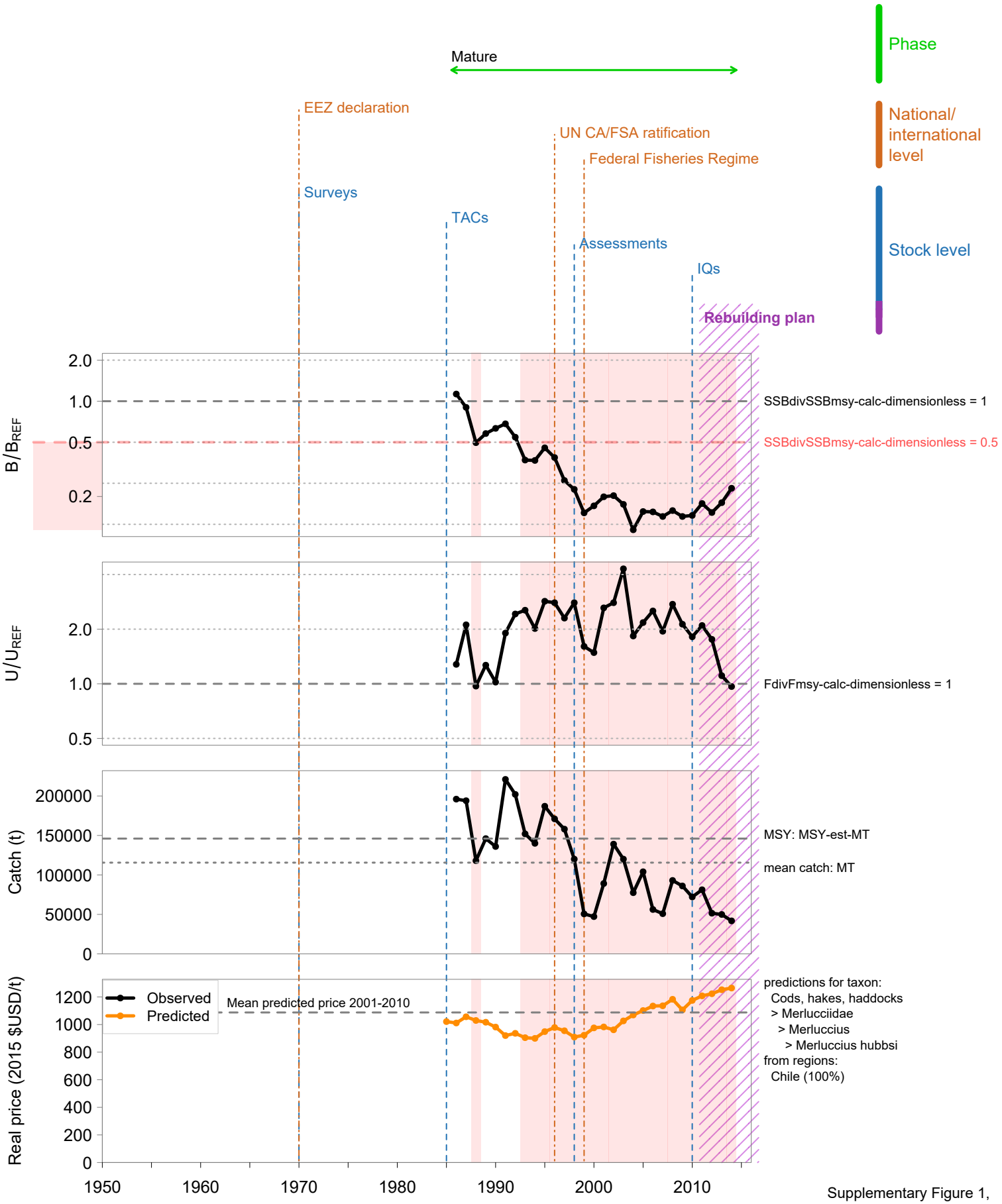
South Africa -- SSLOBSTERSASC -- Southern spiny lobster South Africa South coast

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: South Africa



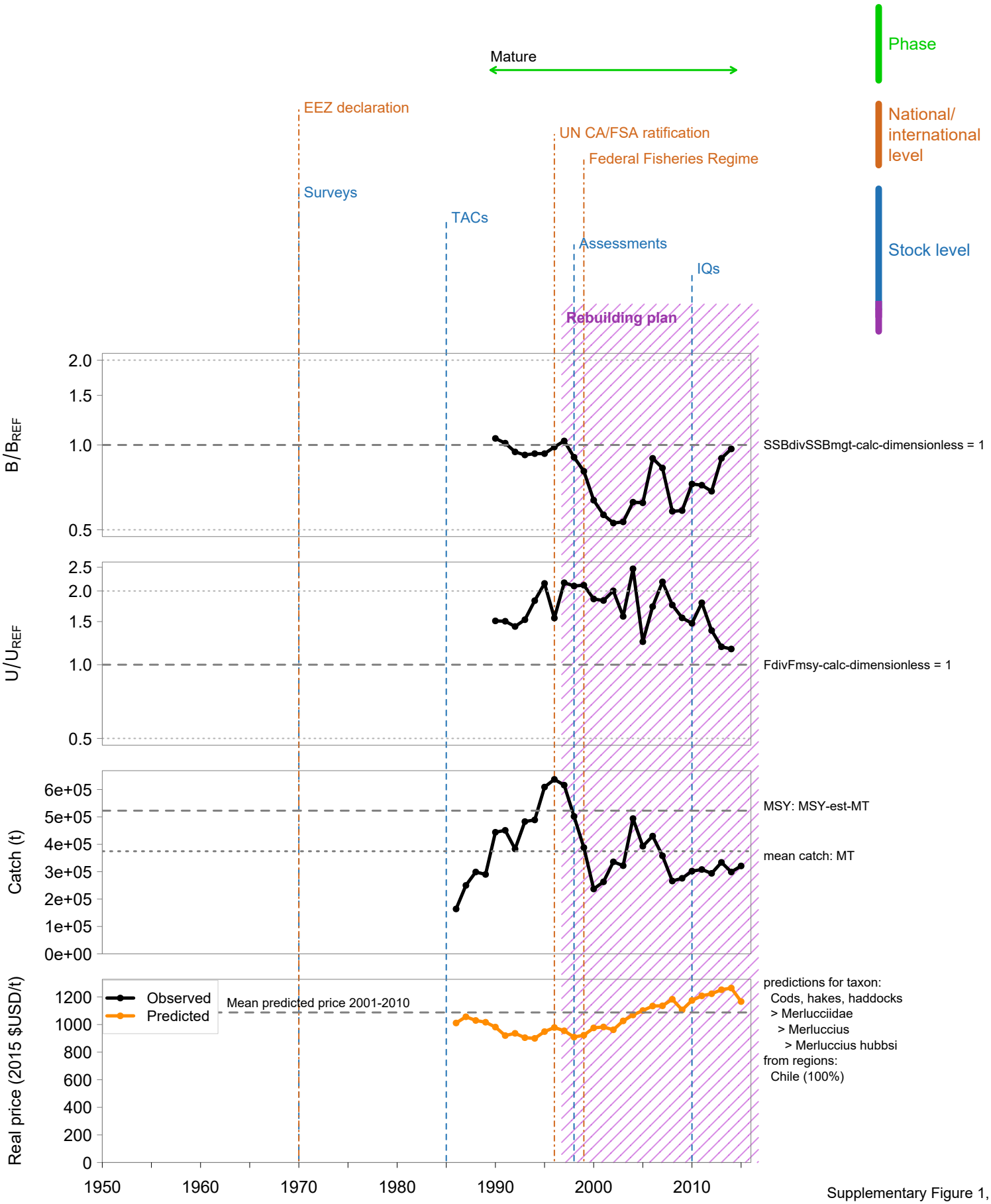
South America -- ARGHAKENARG -- Argentine hake Northern Argentina

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Argentina



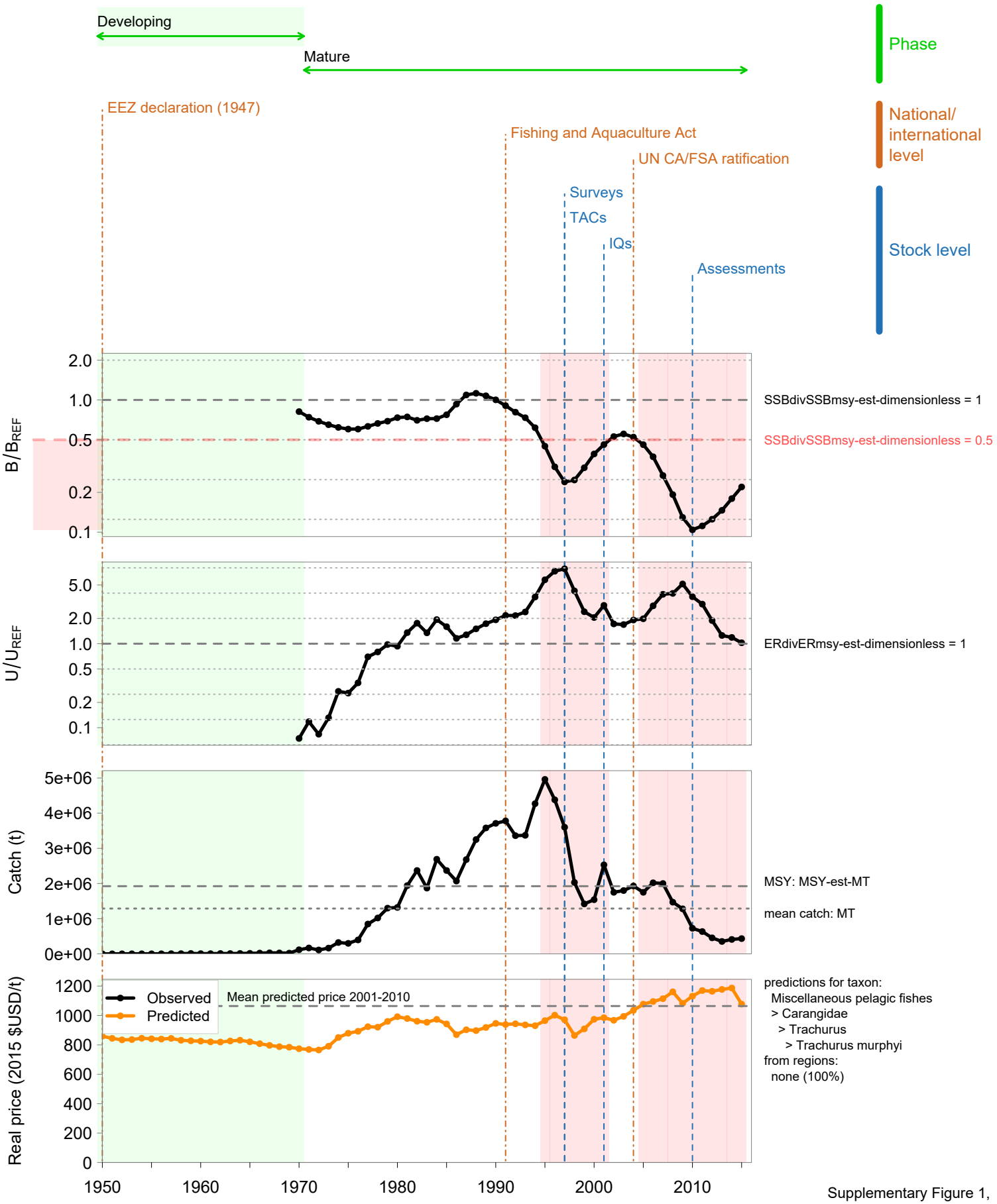
South America -- ARGHAKESARG -- Argentine hake Southern Argentina

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Argentina



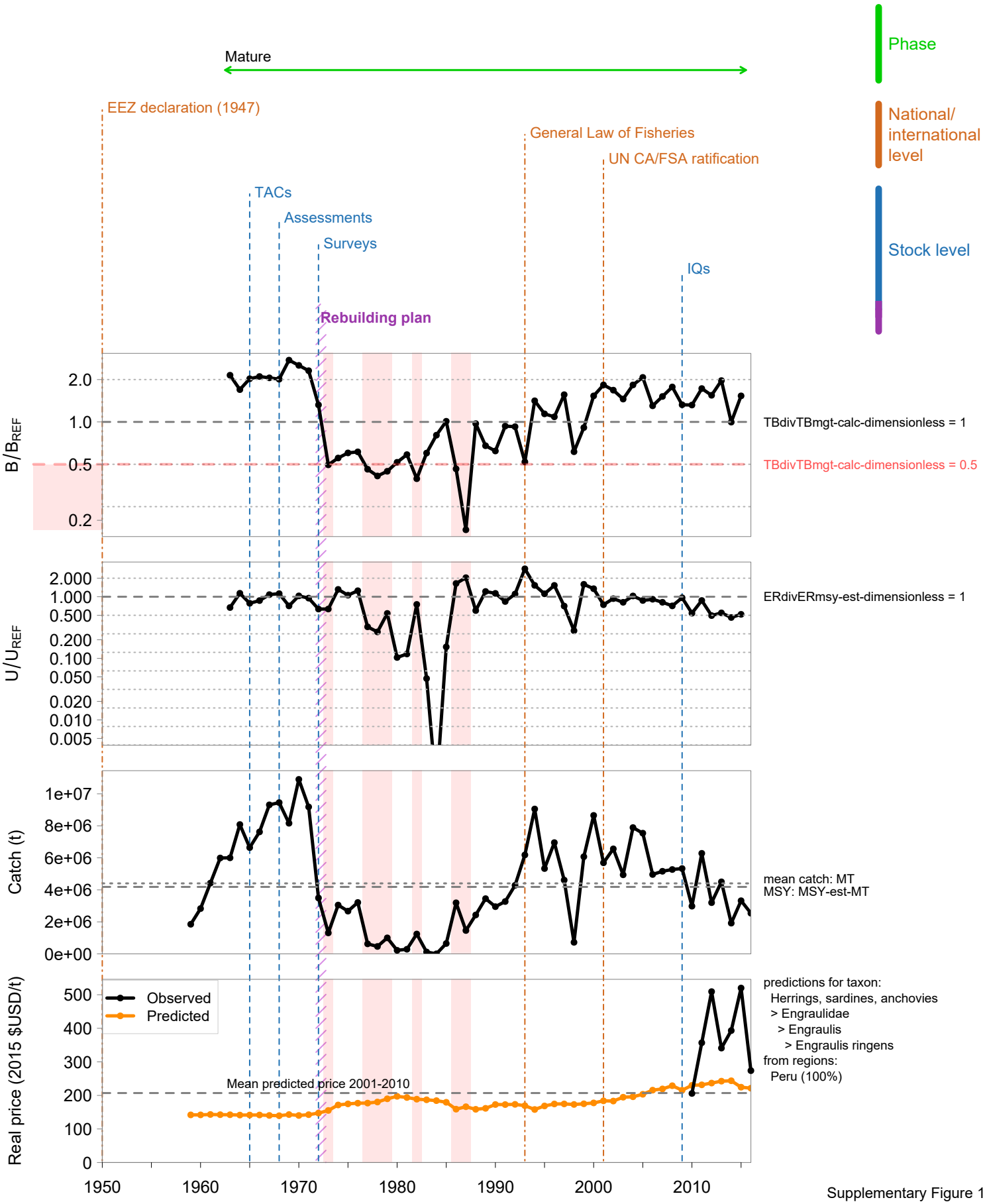
South America -- CHTRACCH -- Chilean jack mackerel Chilean EEZ and offshore

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: single-species, primary country: Chile



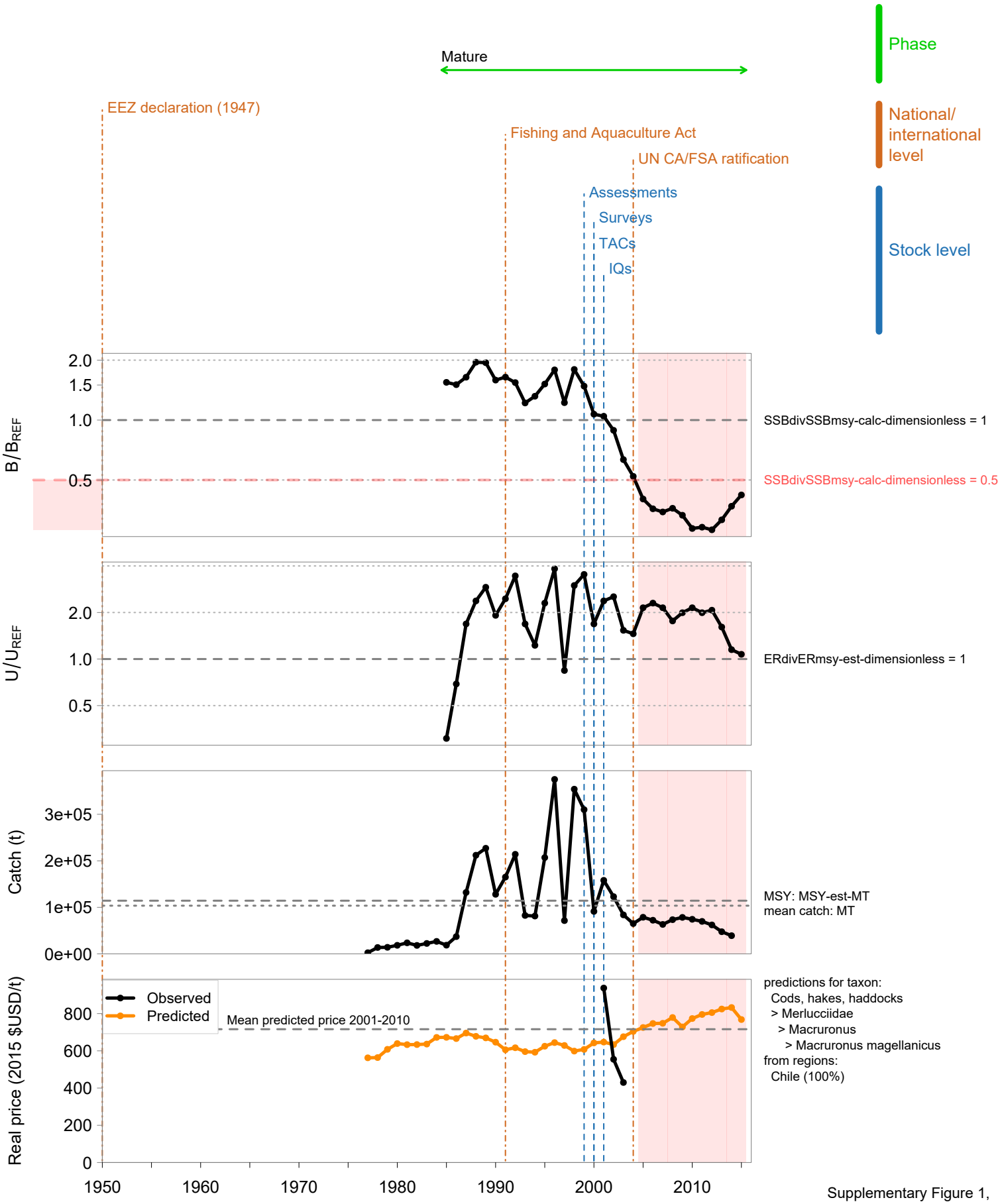
South America -- PANCHPERUNC -- Peruvian anchoveta North-Central Peruvian coast

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: Peru



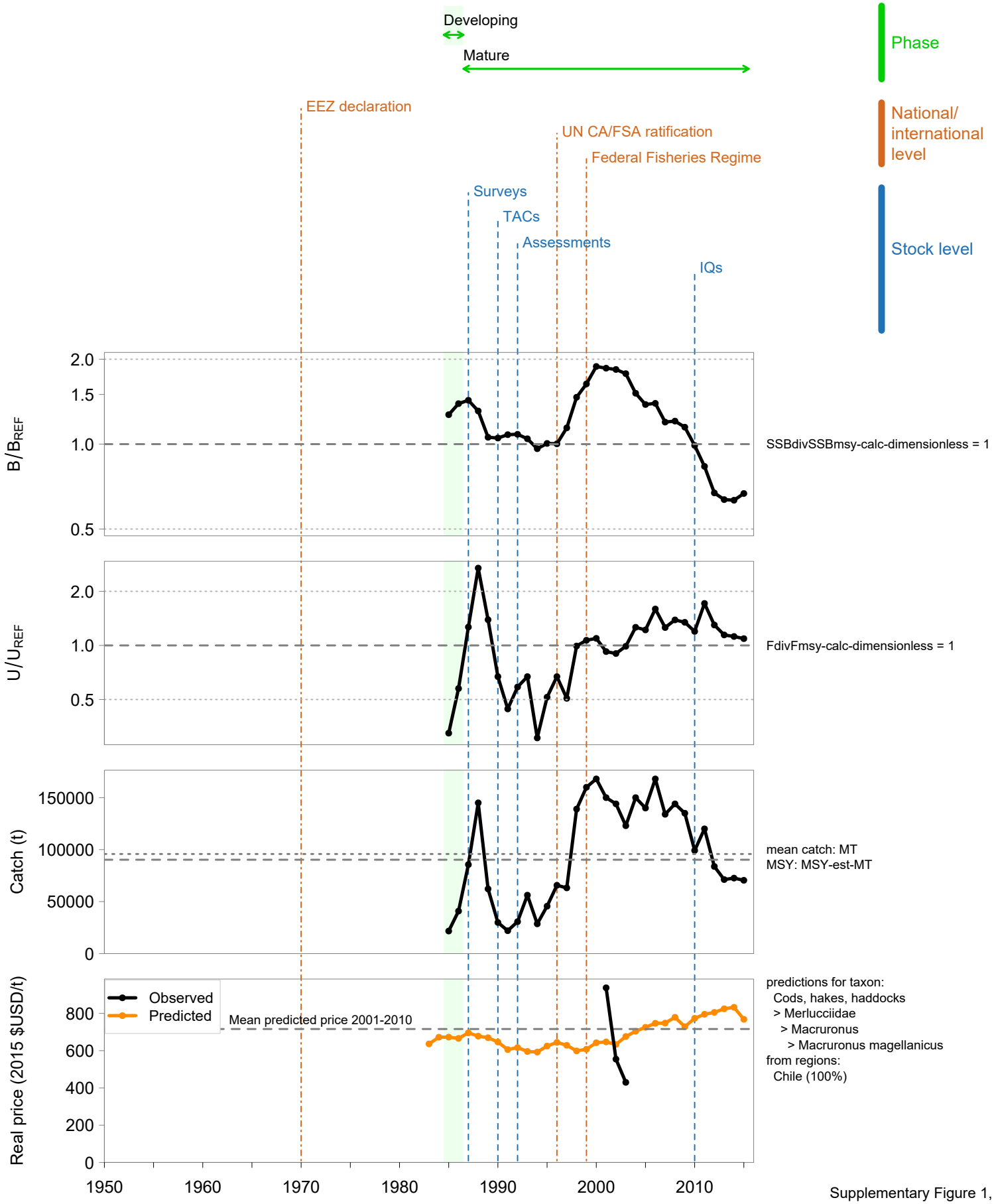
South America -- PATGRENADIERCH -- Patagonian grenadier Central-Southern Chile

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Chile



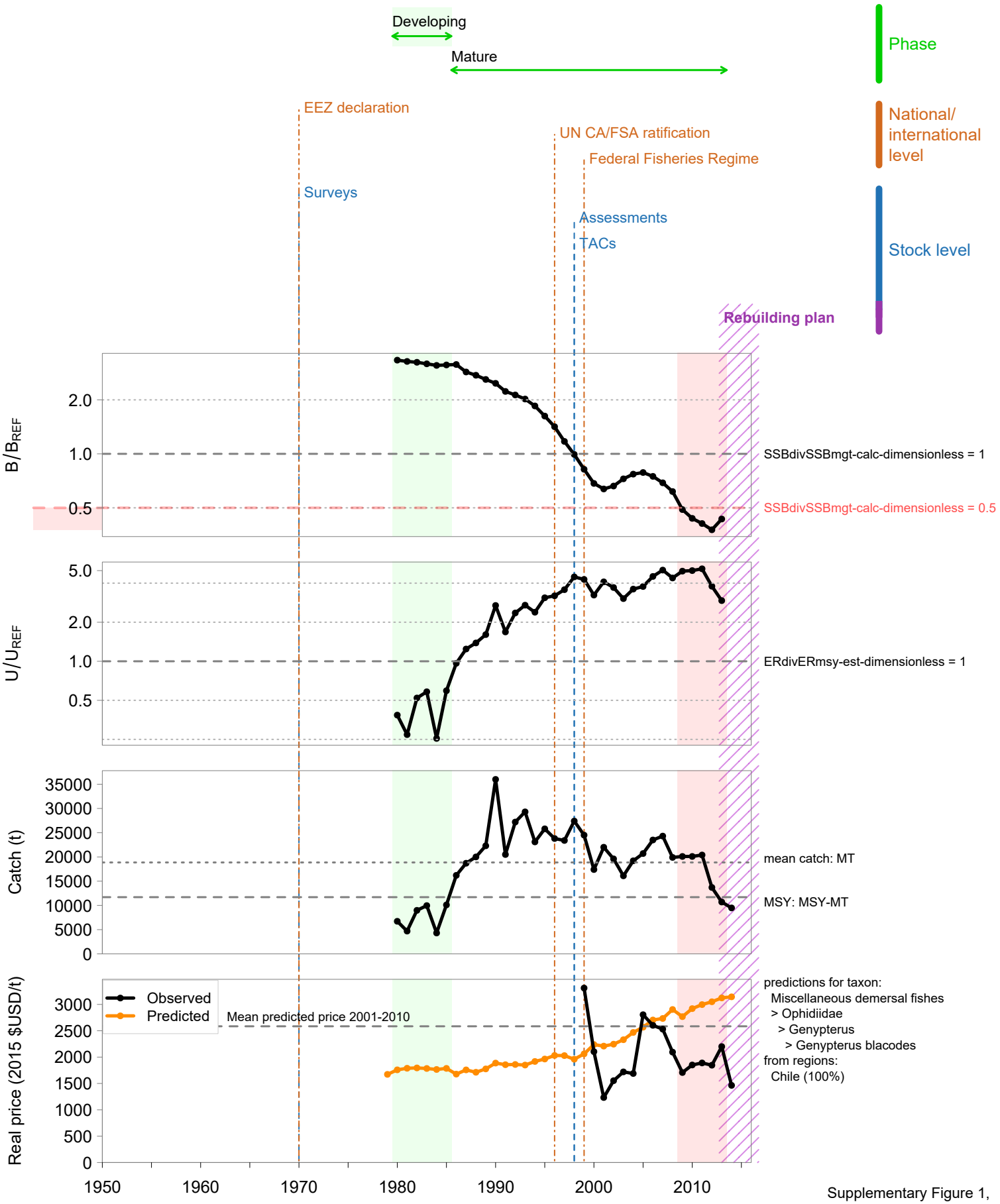
South America -- PATGRENADIERSARG -- Patagonian grenadier Southern Argentina

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Argentina



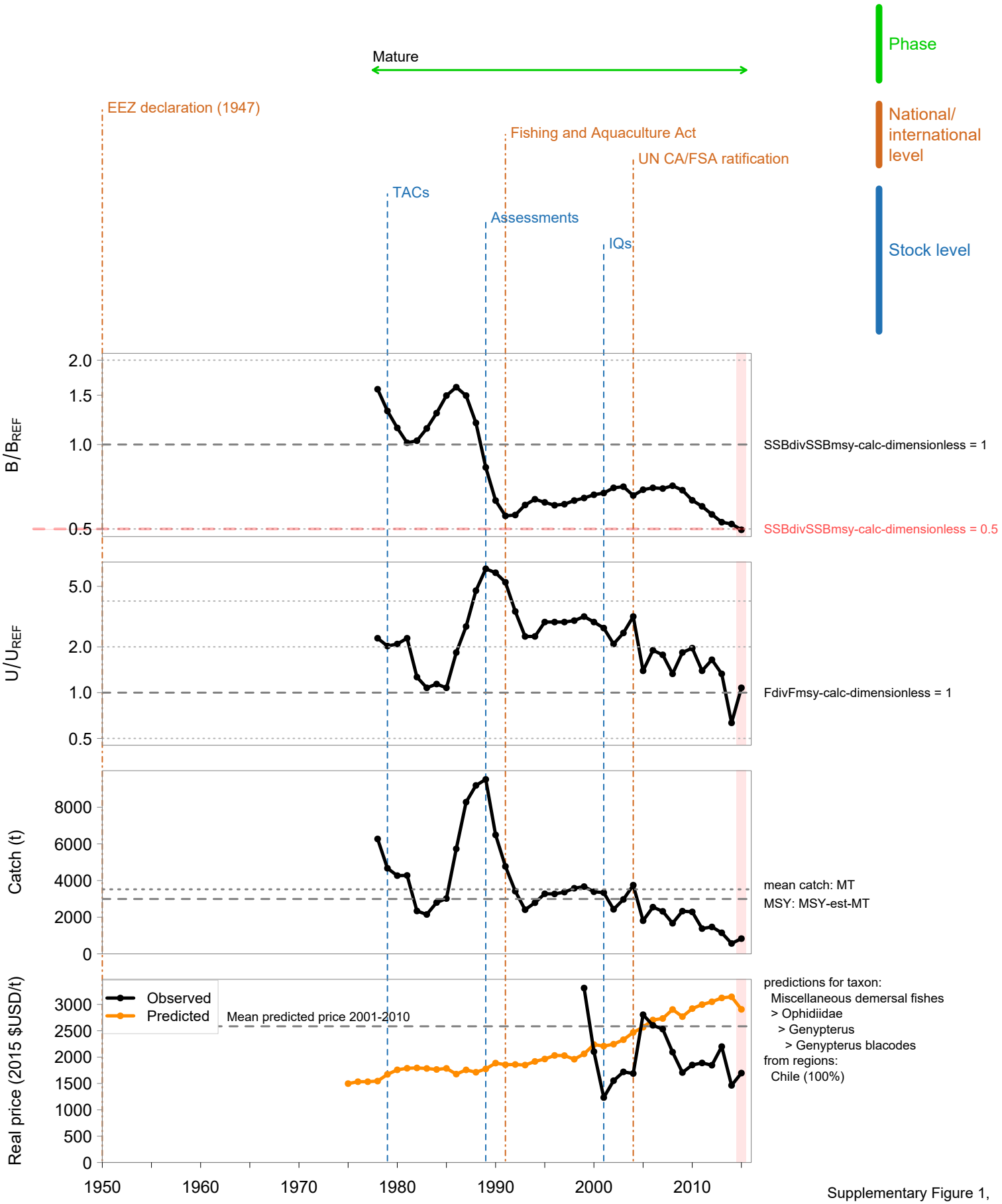
South America -- PCEELARGS -- Pink cusk eel Southern Argentina

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Argentina



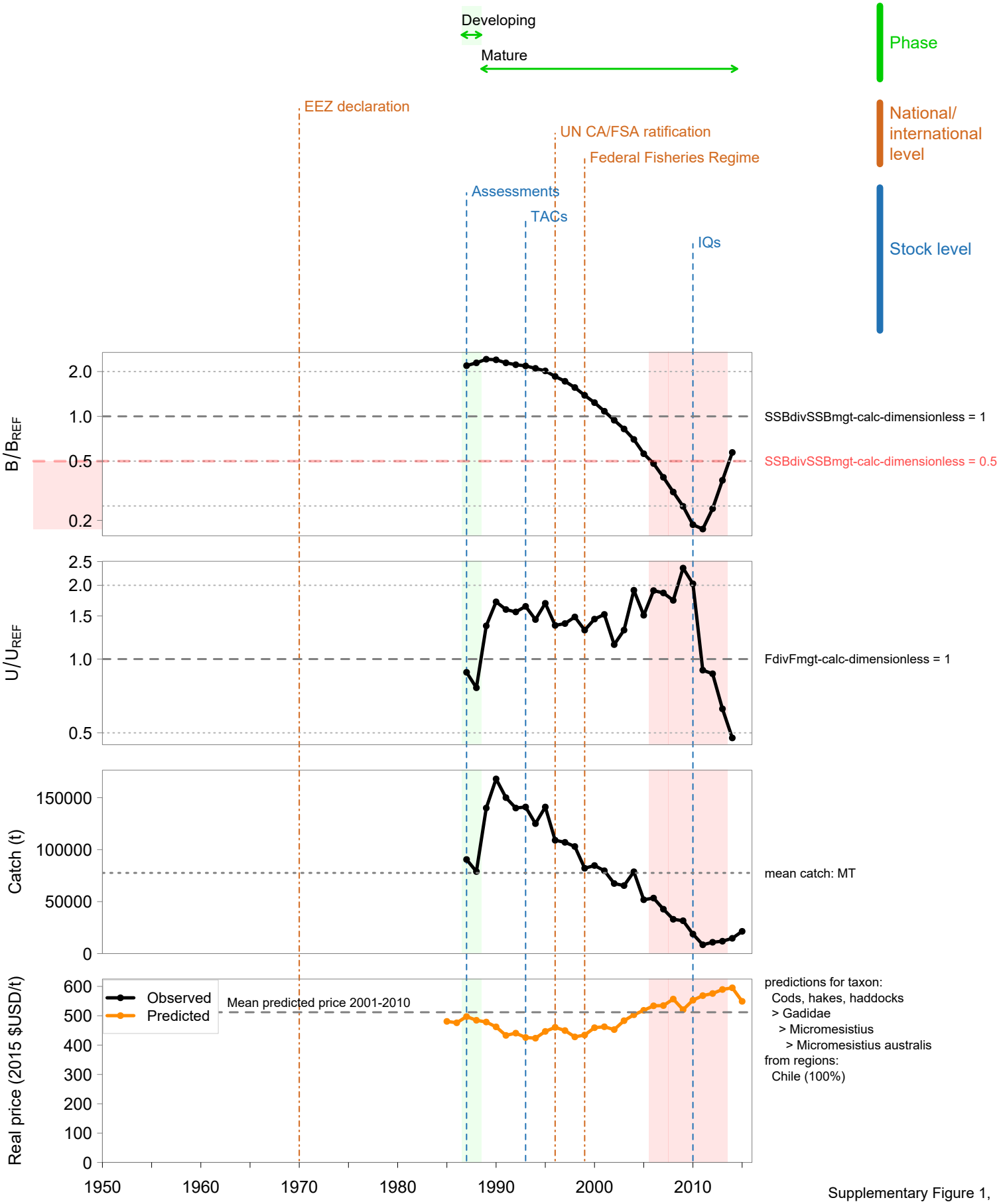
South America -- PCEELCSCH -- Pink cusk eel Central-Southern Chile

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: Chile



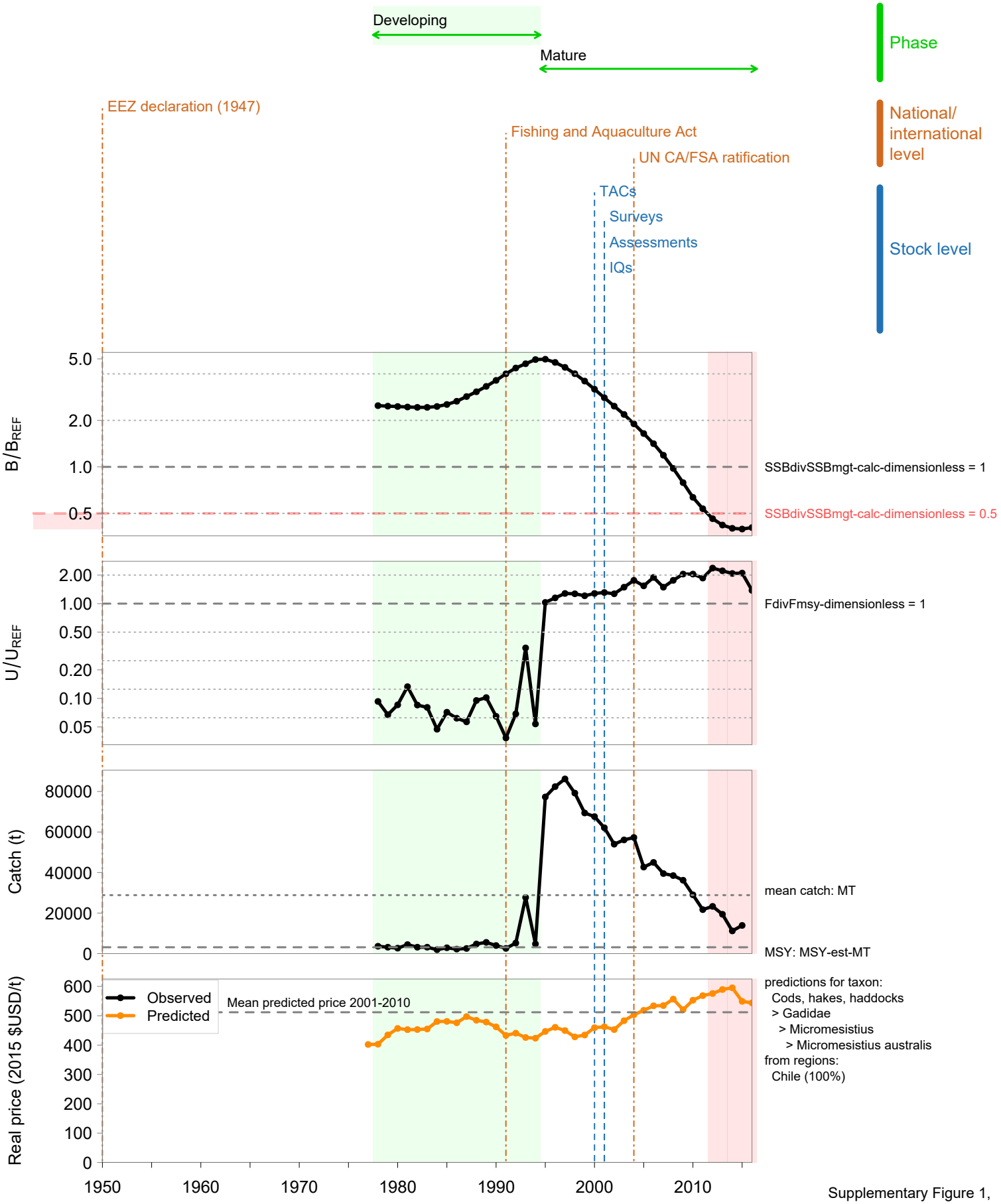
South America -- SBWHITARGS -- Southern blue whiting Southern Argentina

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Argentina



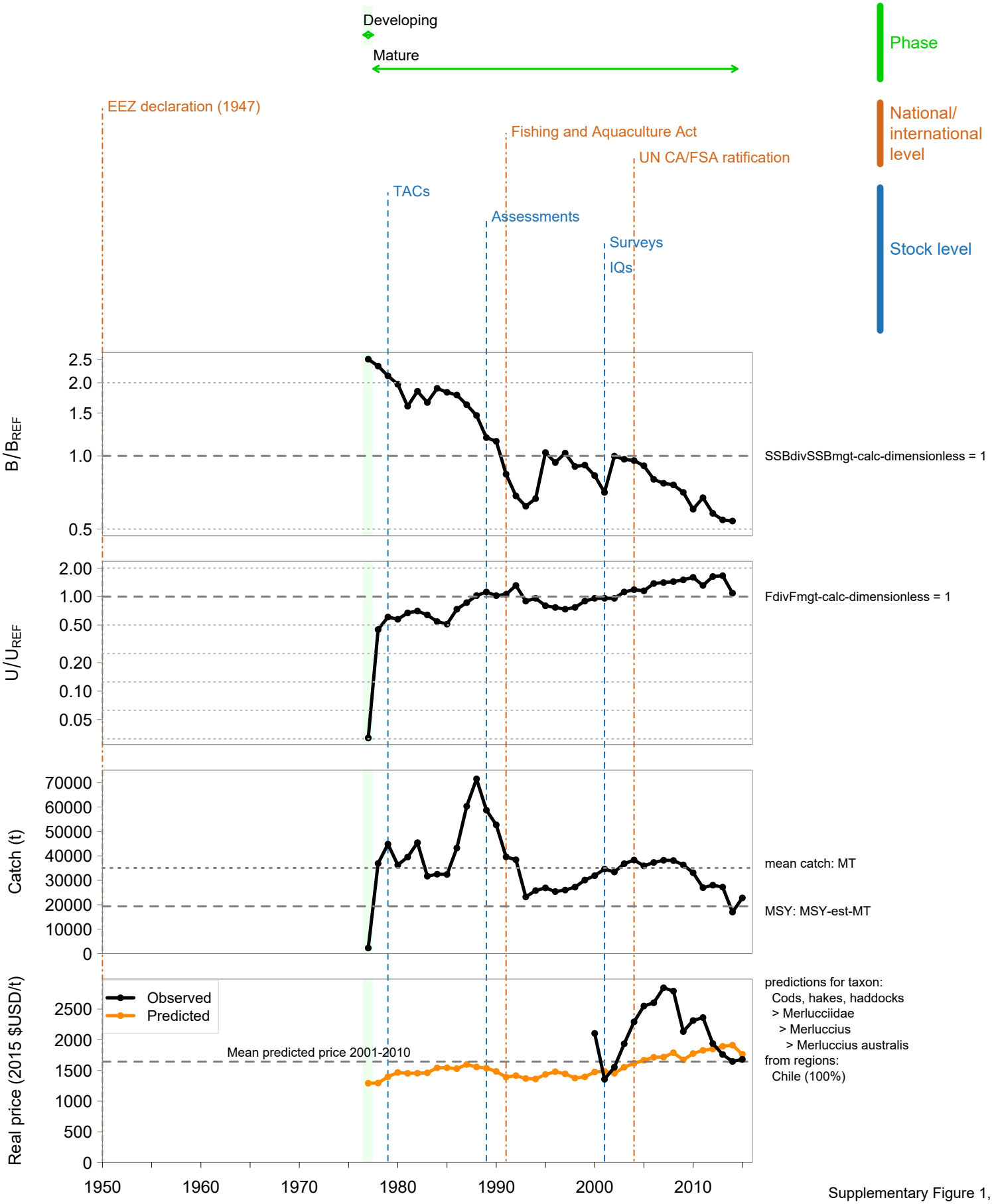
South America -- SBWHITCH -- Southern blue whiting Central-Southern Chile

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: Chile



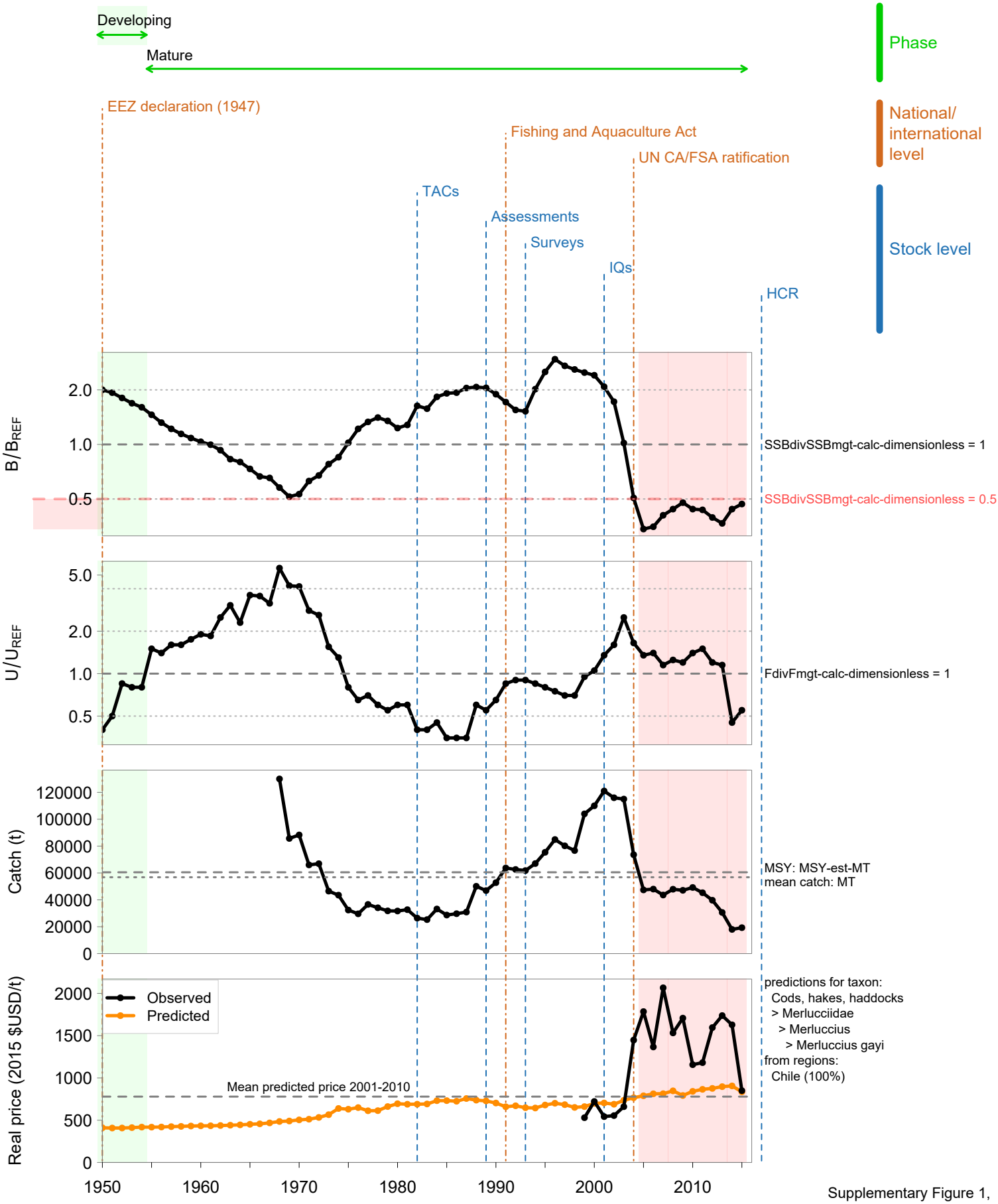
South America -- SOUTHHAKECH -- Southern hake Central-Southern Chile

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Chile



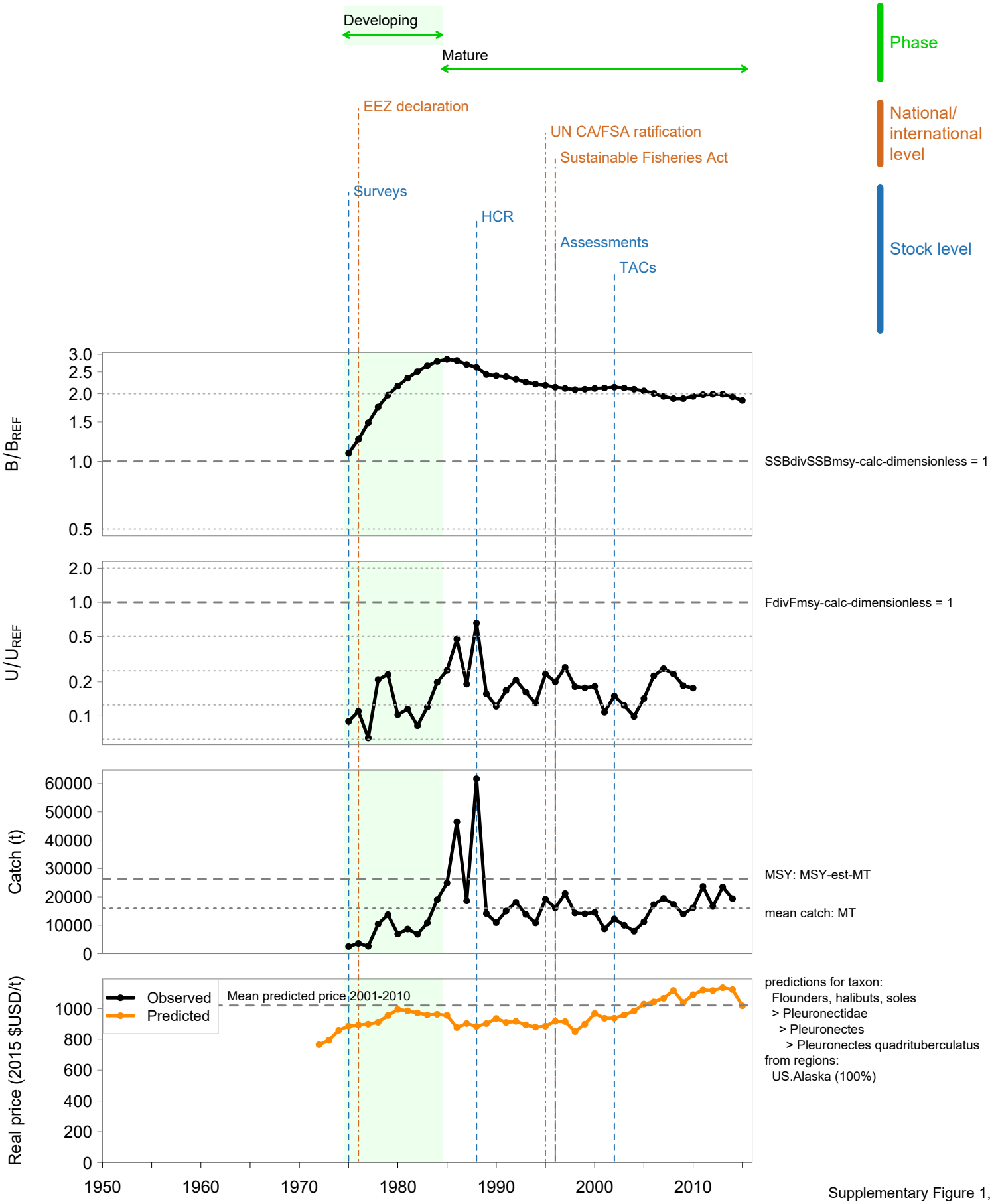
South America -- SPHAKECH -- South Pacific hake Central-Southern Chile

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: Chile



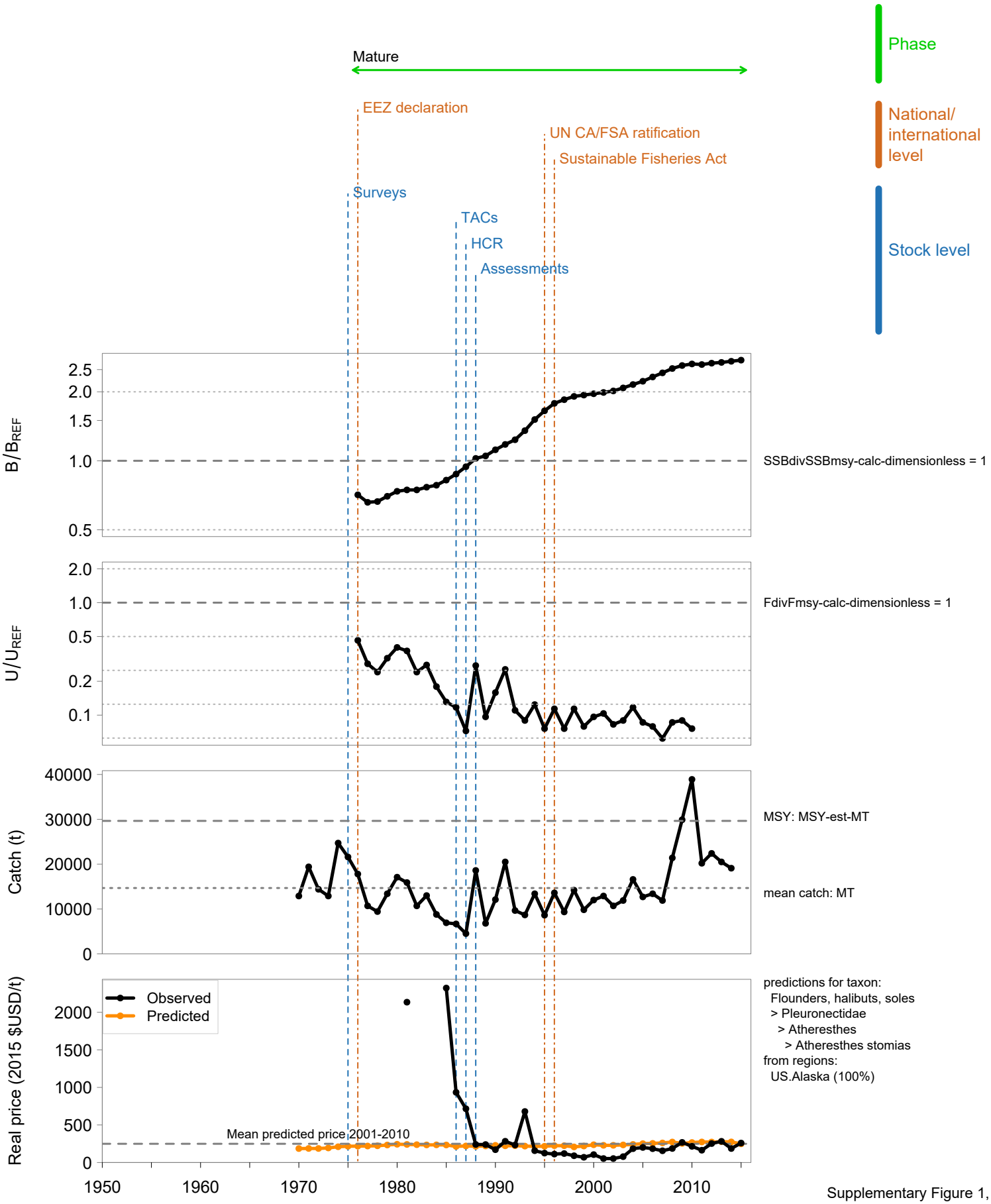
US-Alaska -- ALPLAICBSAI -- Alaska plaice Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



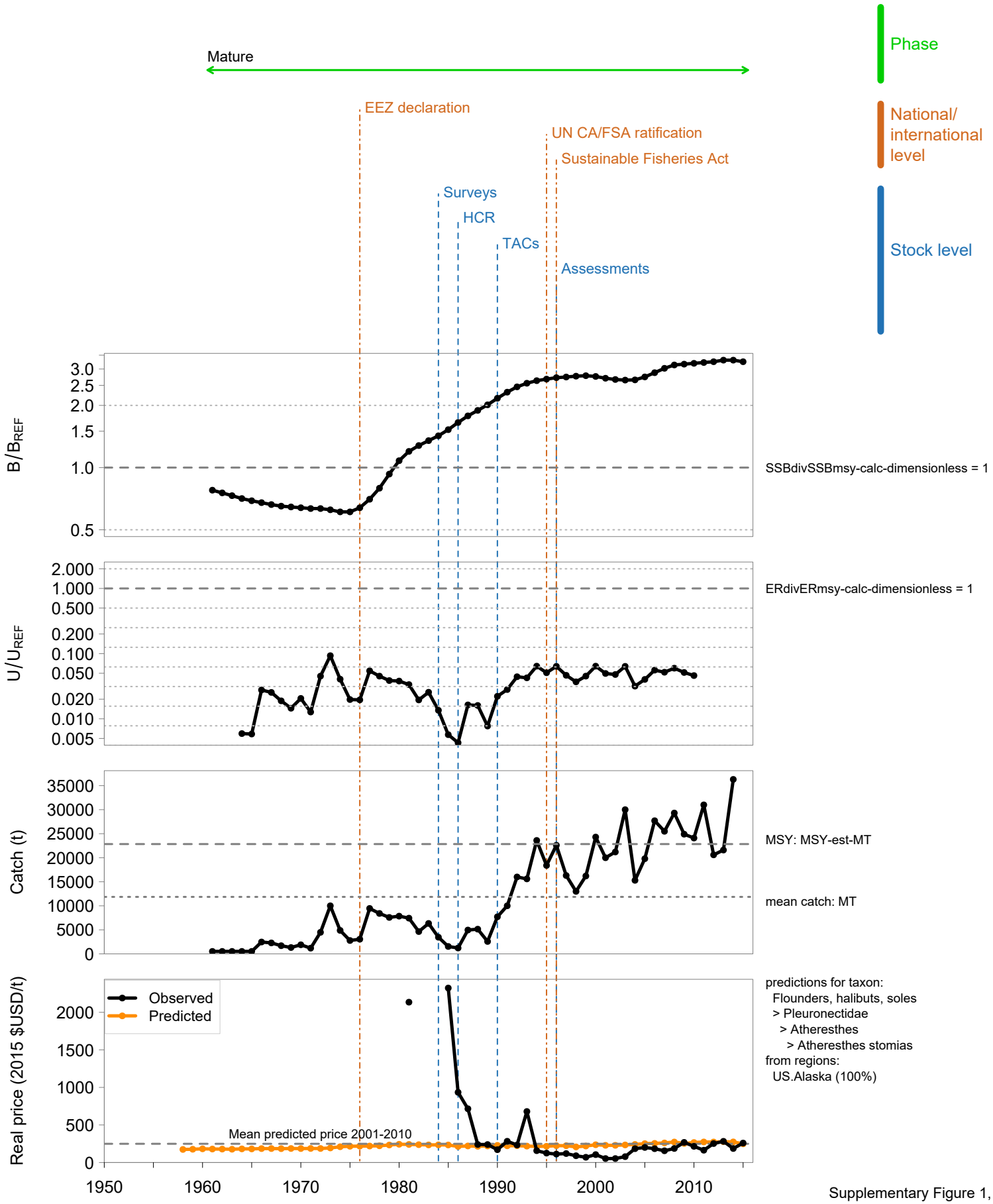
US-Alaska -- ARFLOUNDBSAI -- Arrowtooth flounder Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



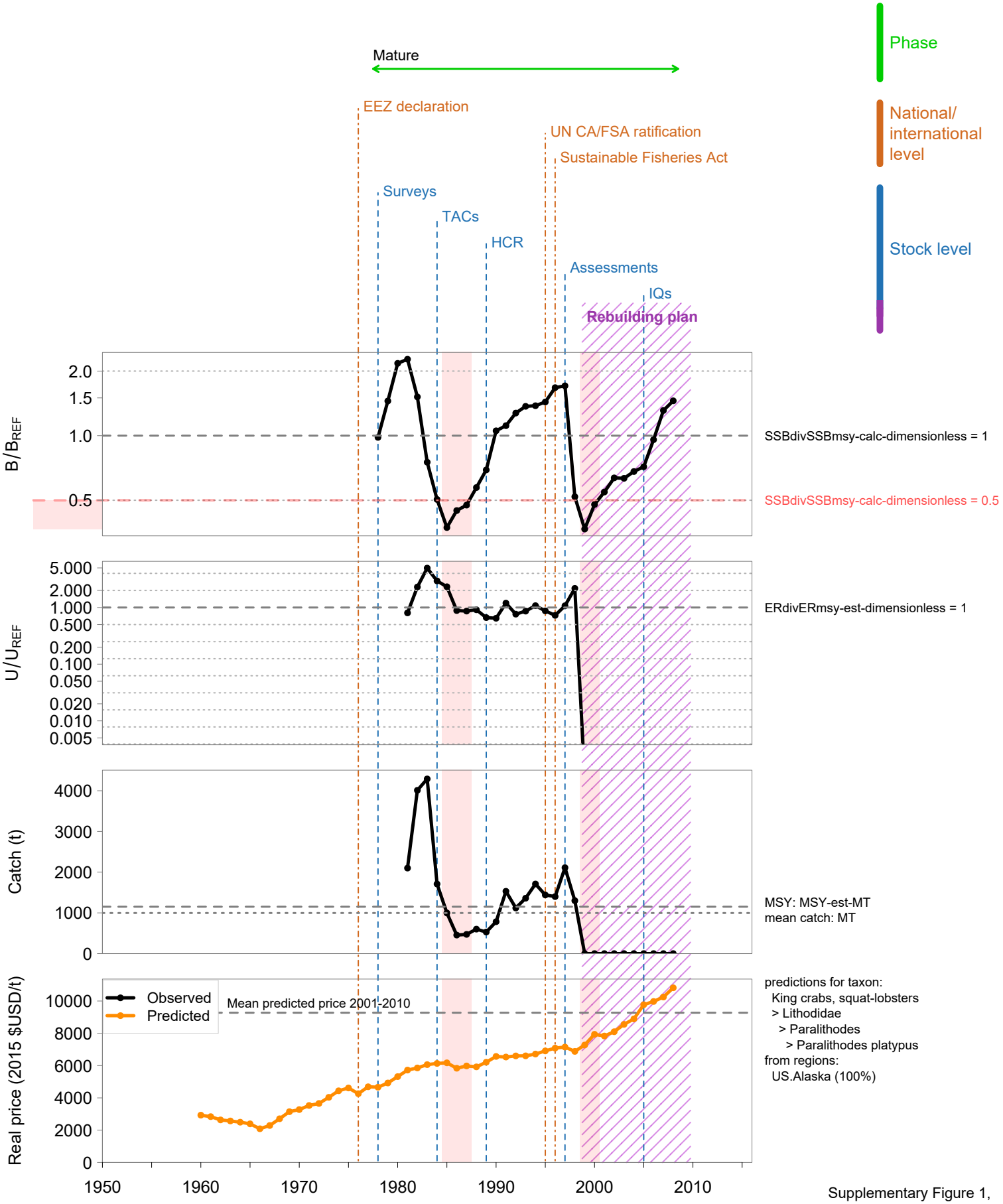
US-Alaska -- ARFLOUNDGA -- Arrowtooth flounder Gulf of Alaska

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



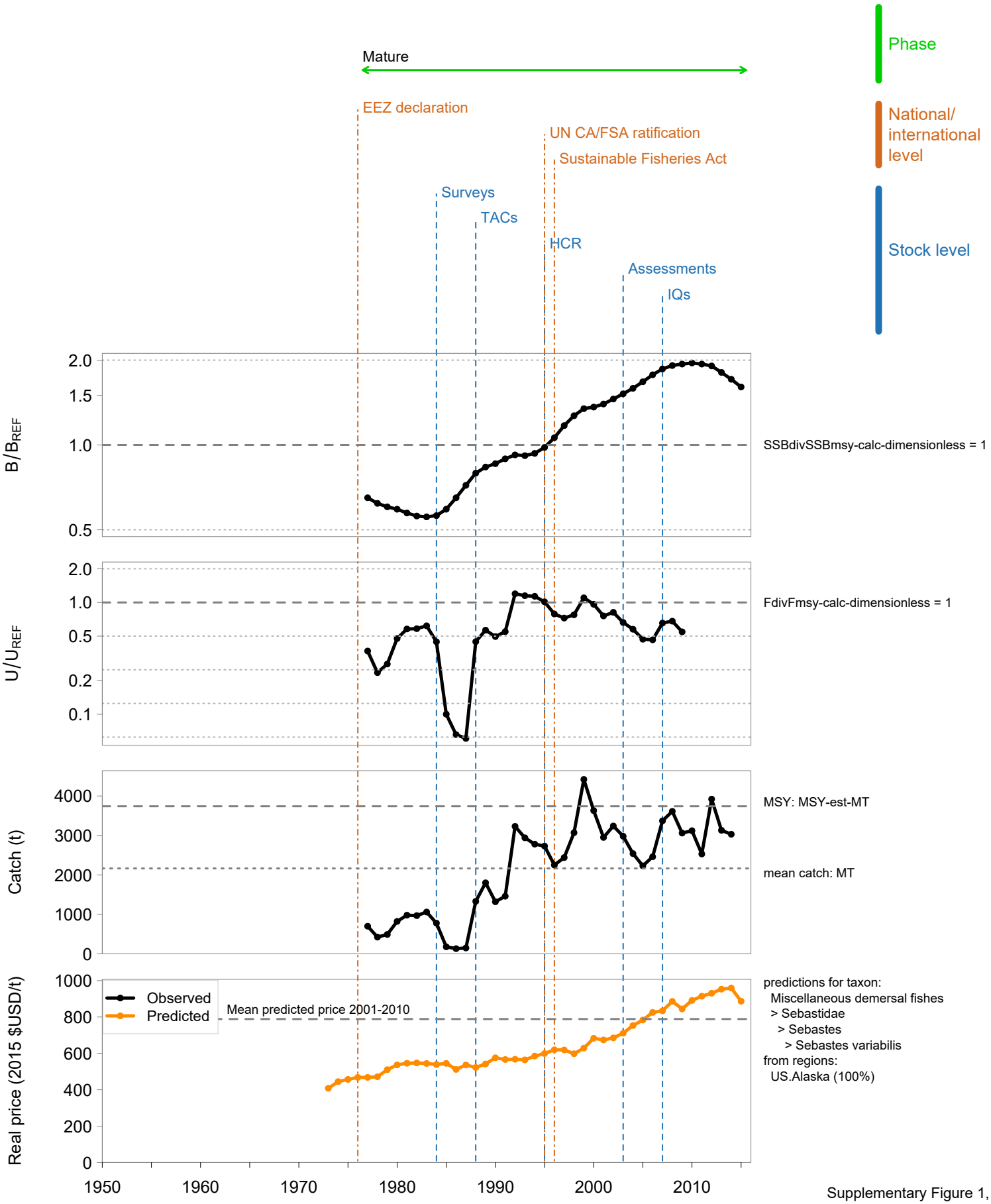
US-Alaska -- BKINGCRABSMI -- Blue king crab Saint Matthews Island

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



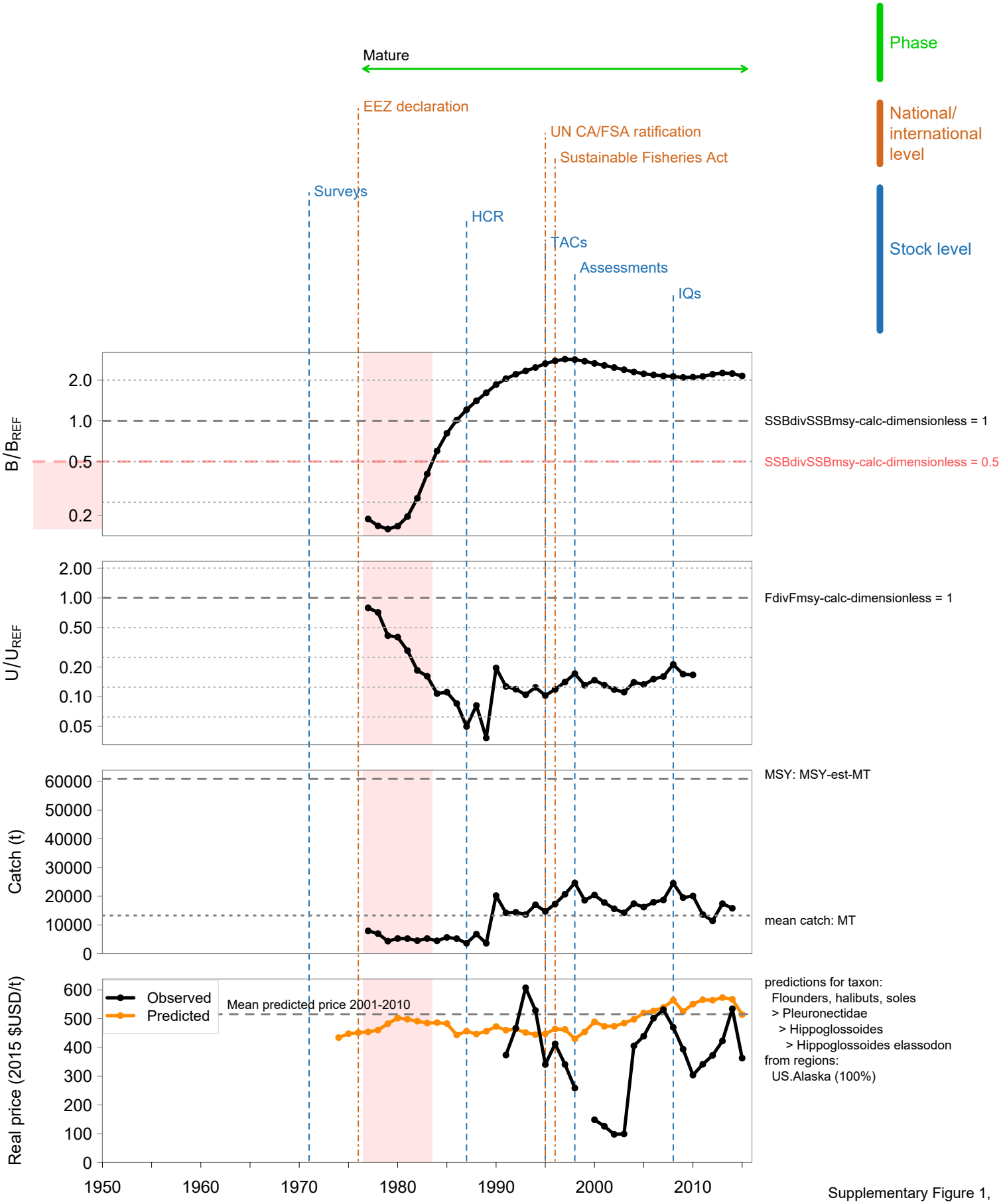
US-Alaska -- DUSROCKGA -- Dusky rockfish Gulf of Alaska

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



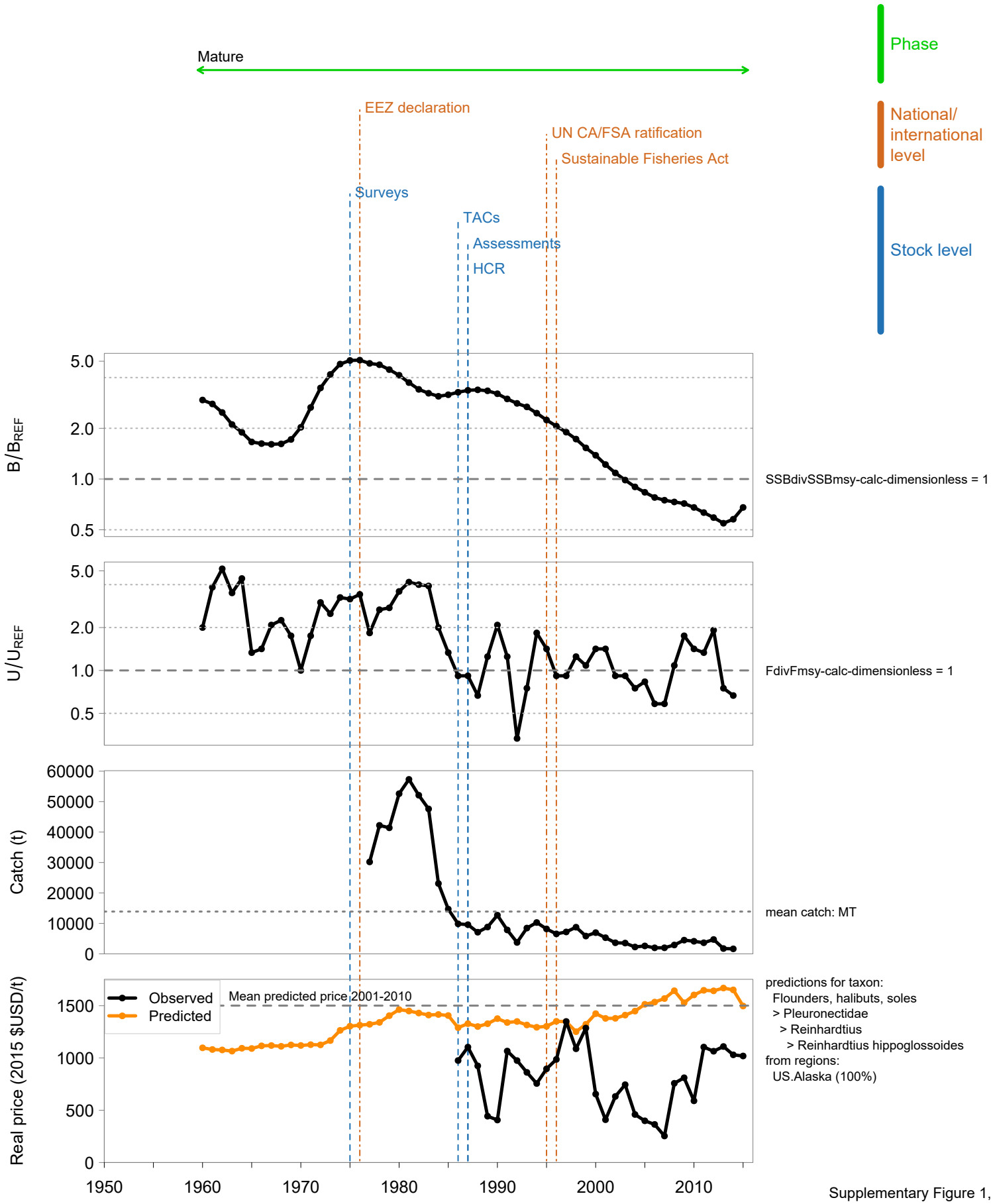
US-Alaska -- FLSOLEBSAI -- Flathead sole Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



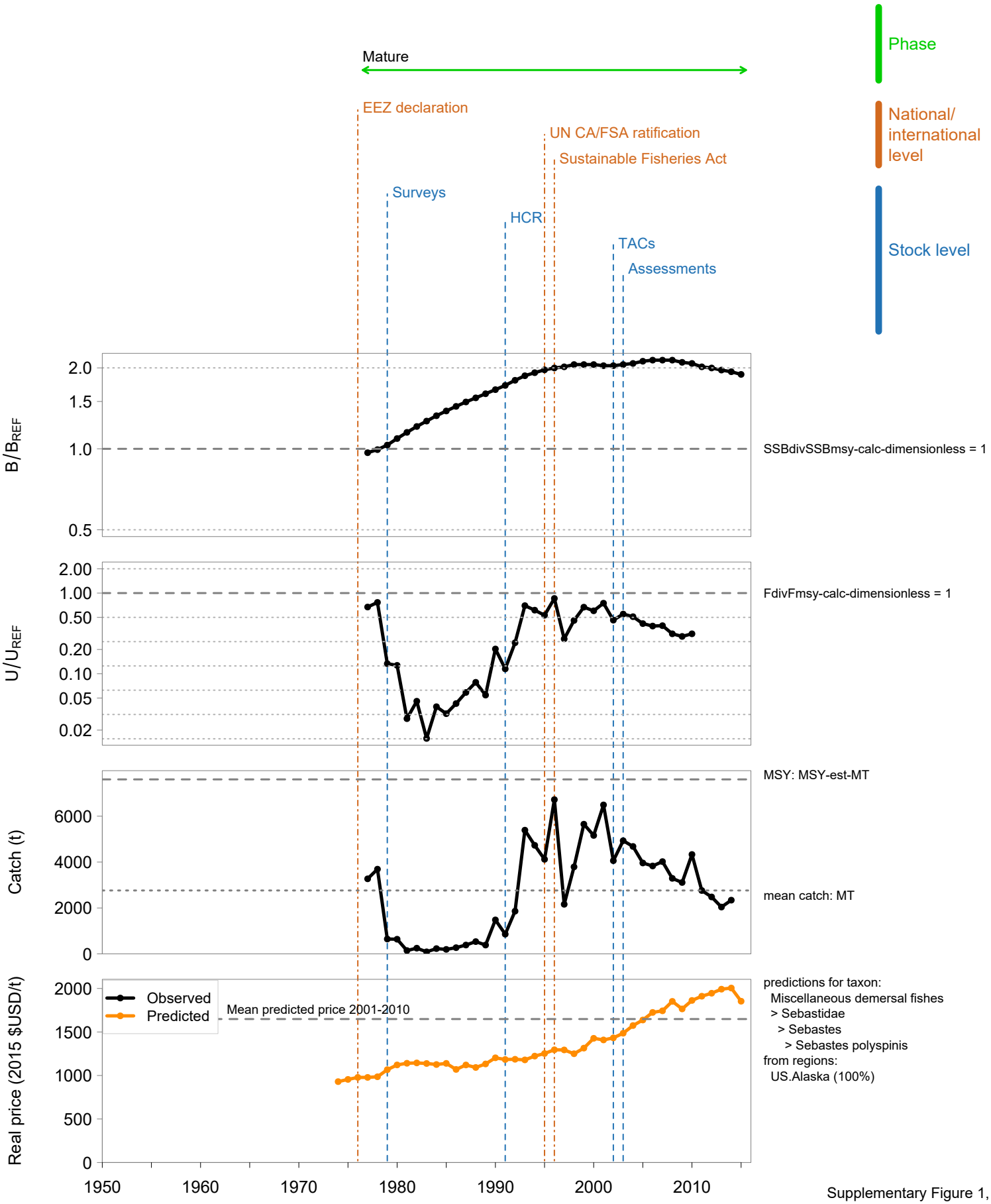
US-Alaska -- GHALBSAI -- Greenland halibut Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



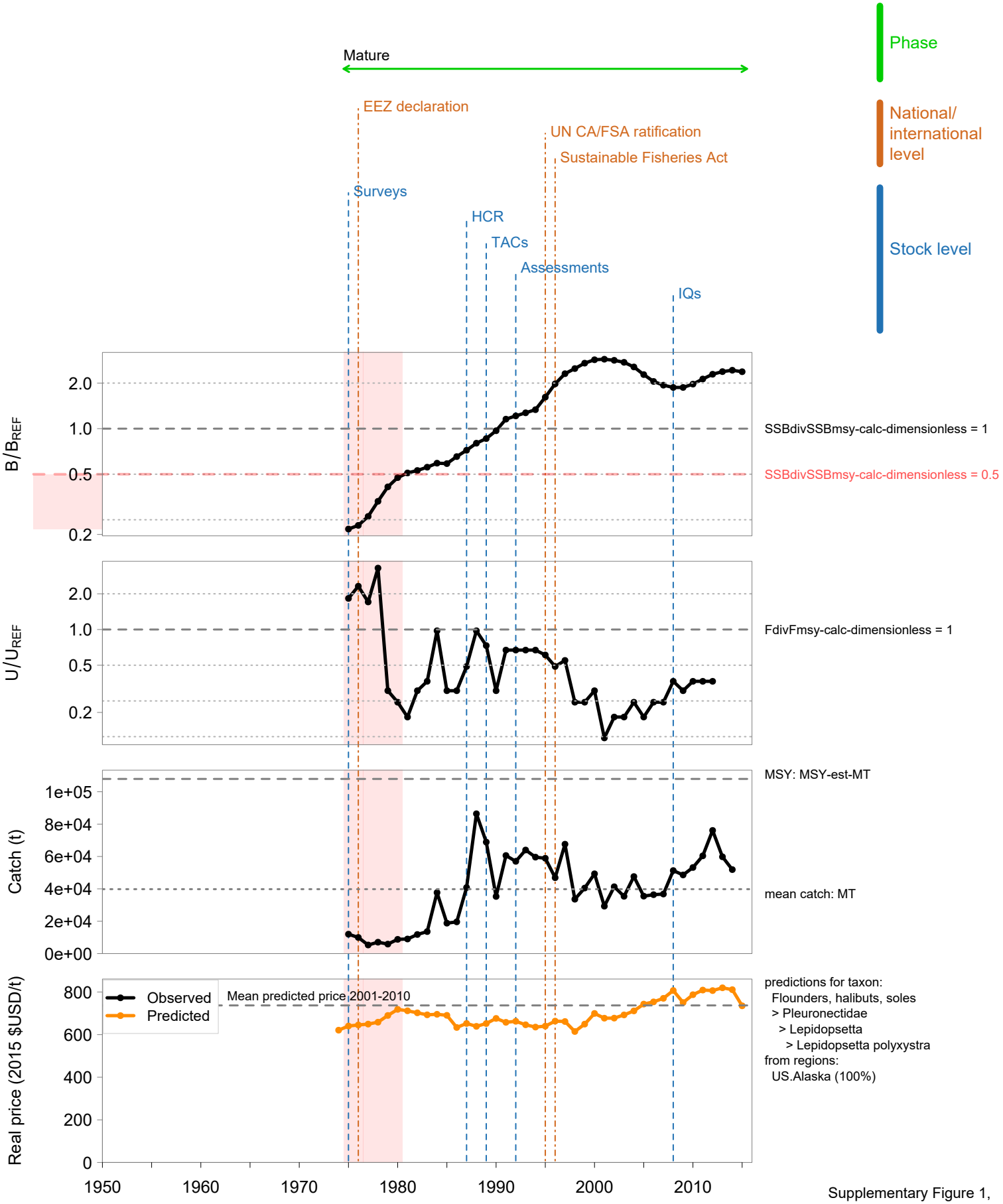
US-Alaska -- NROCKBSAI -- Northern rockfish Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



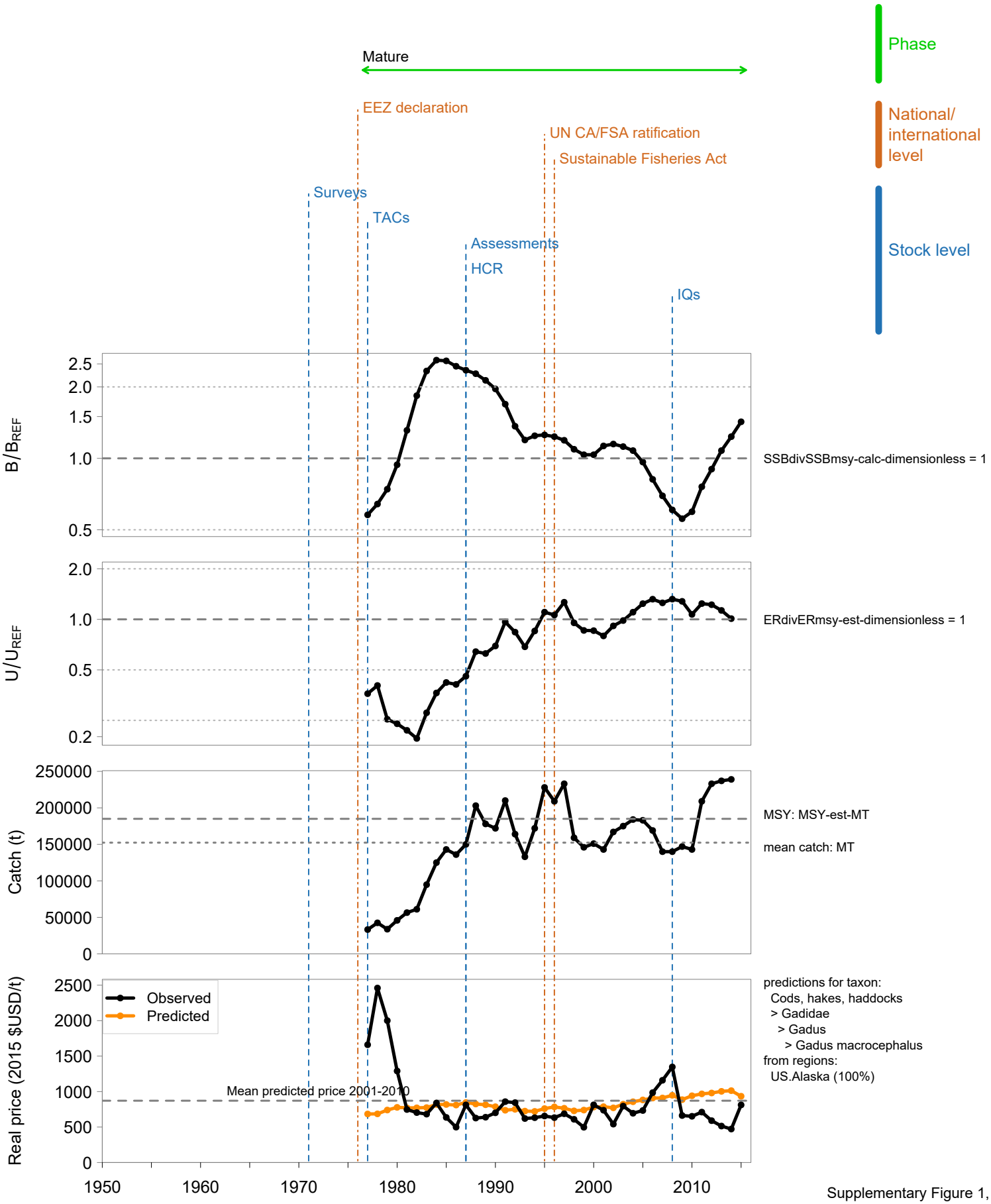
US-Alaska -- NRSOLEEBSAI -- Northern rock sole Eastern Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



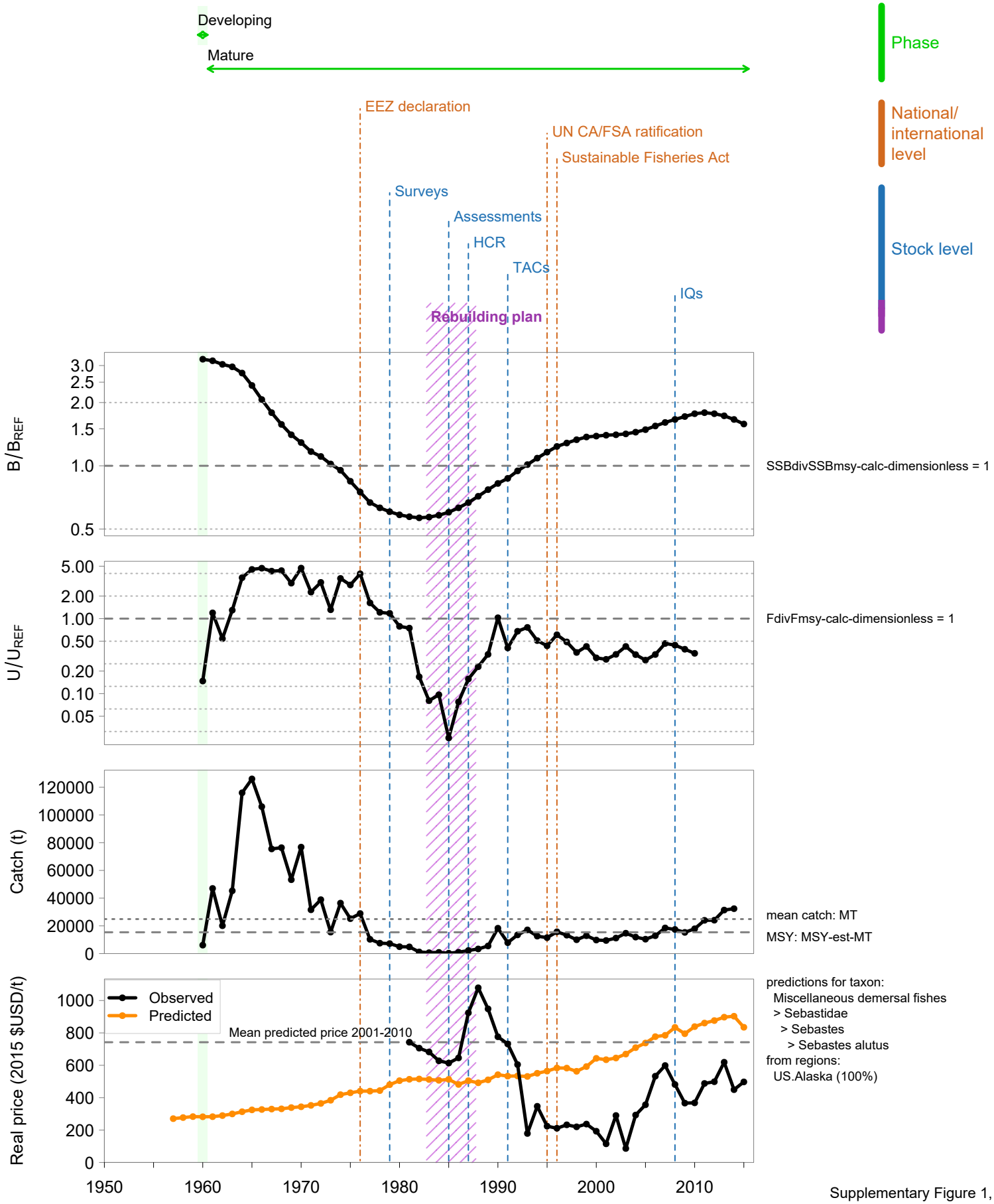
US-Alaska -- PCODBS -- Pacific cod Bering Sea

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: USA



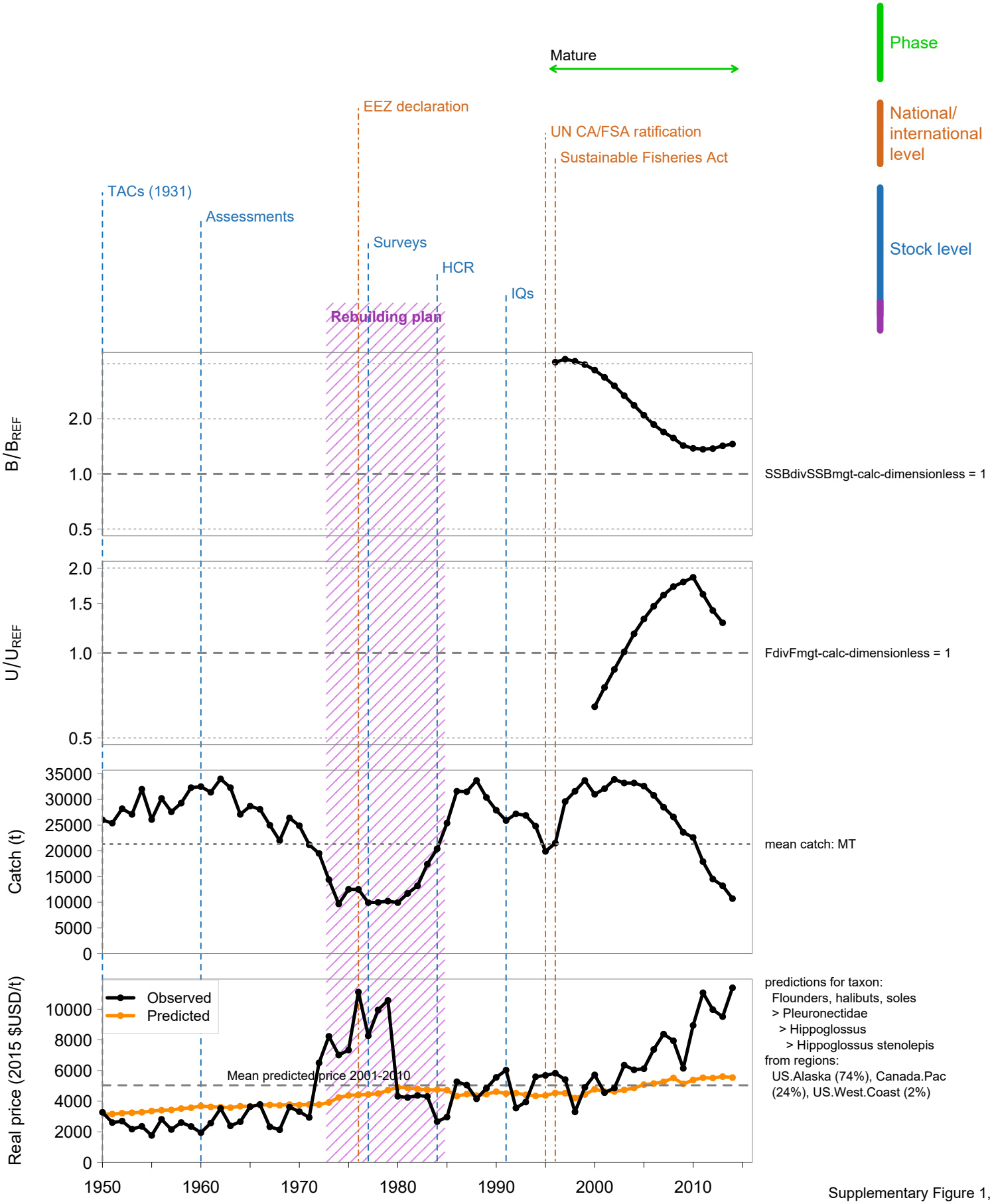
US-Alaska -- PERCHEBSAI -- Pacific ocean perch Eastern Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



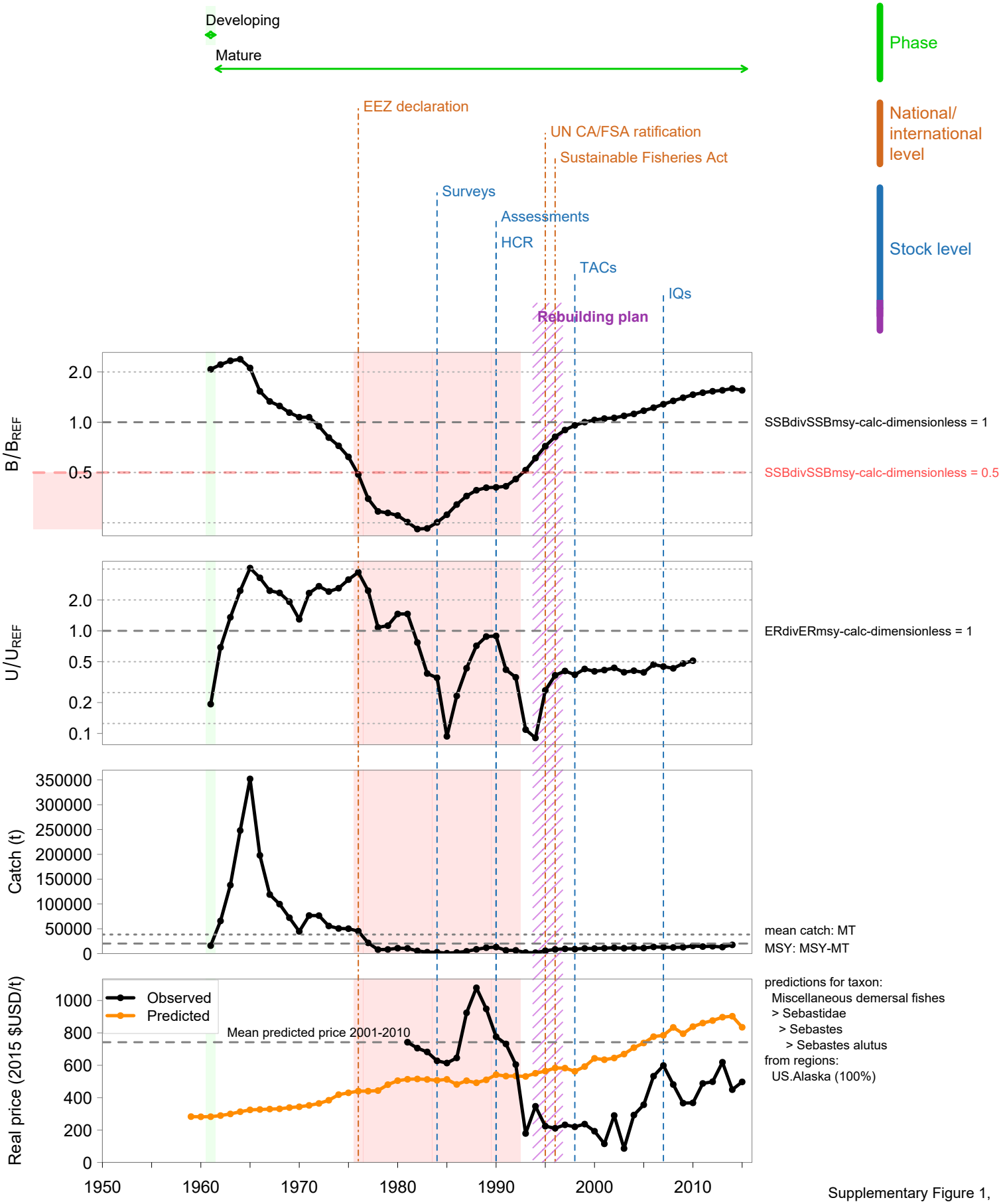
US-Alaska -- PHALNPAC -- Pacific halibut North Pacific

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: single-species, primary country: USA



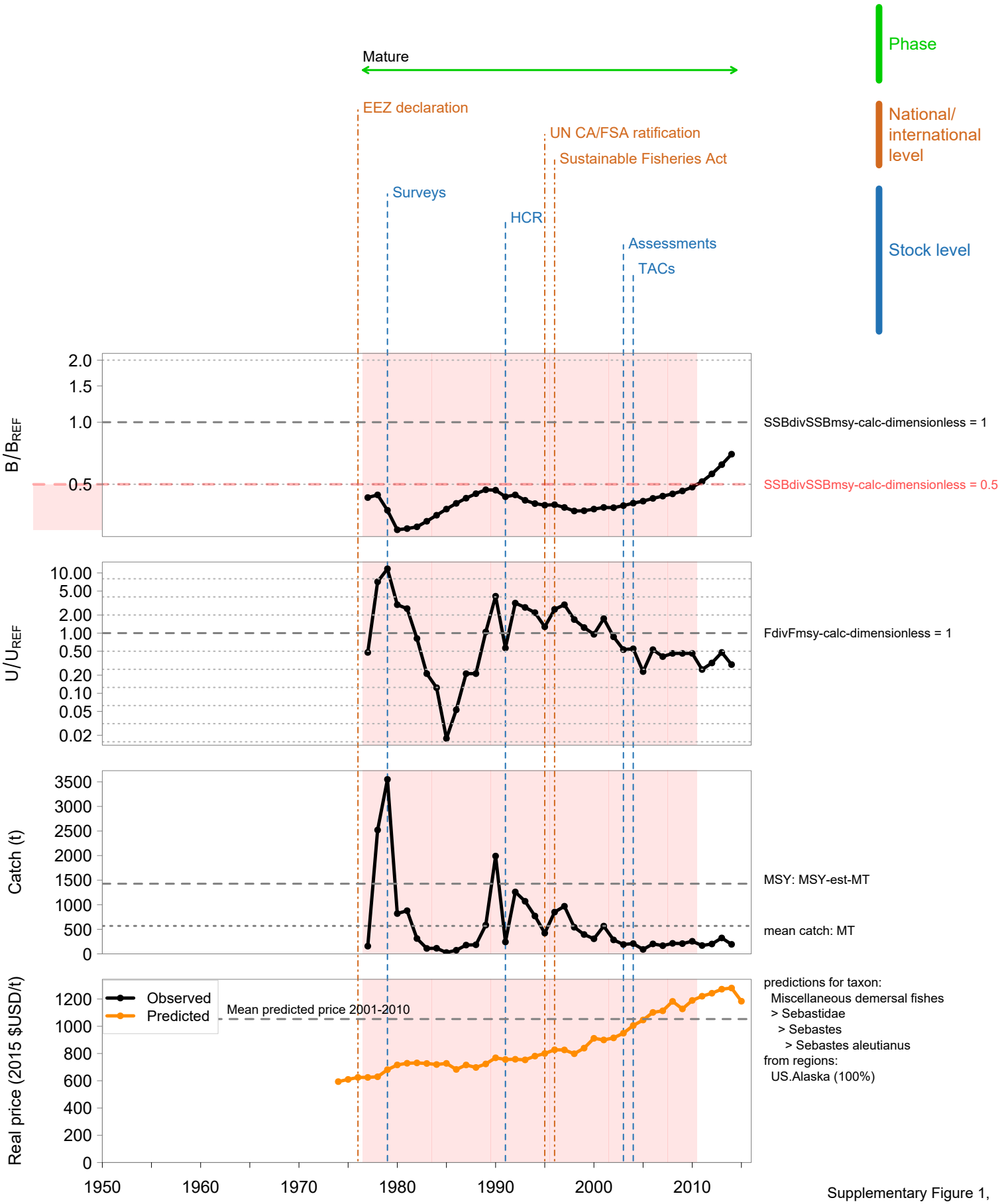
US-Alaska -- POPERCHGA -- Pacific ocean perch Gulf of Alaska

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



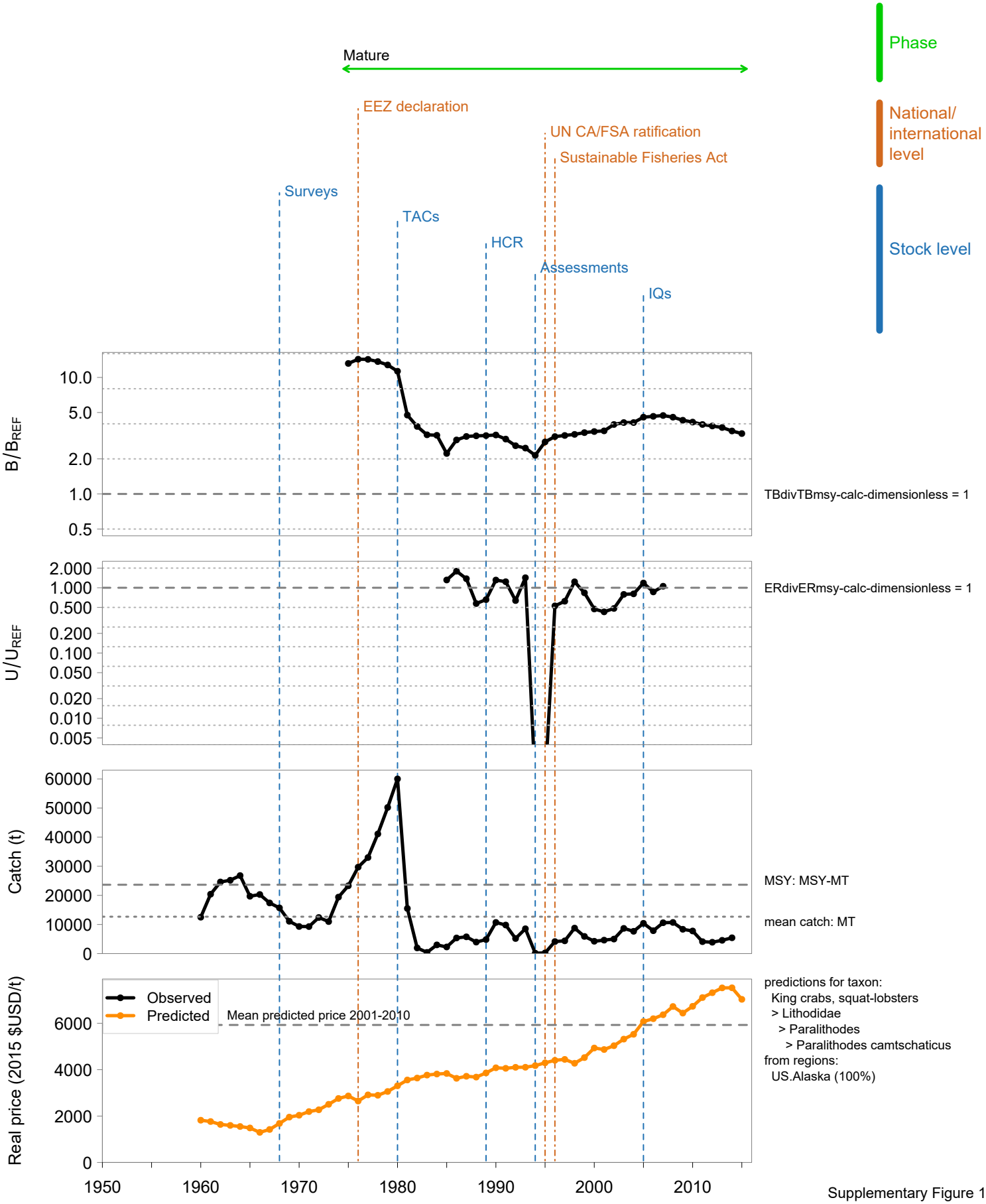
US-Alaska -- REYEROCKBSAI -- Rougheye rockfish Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



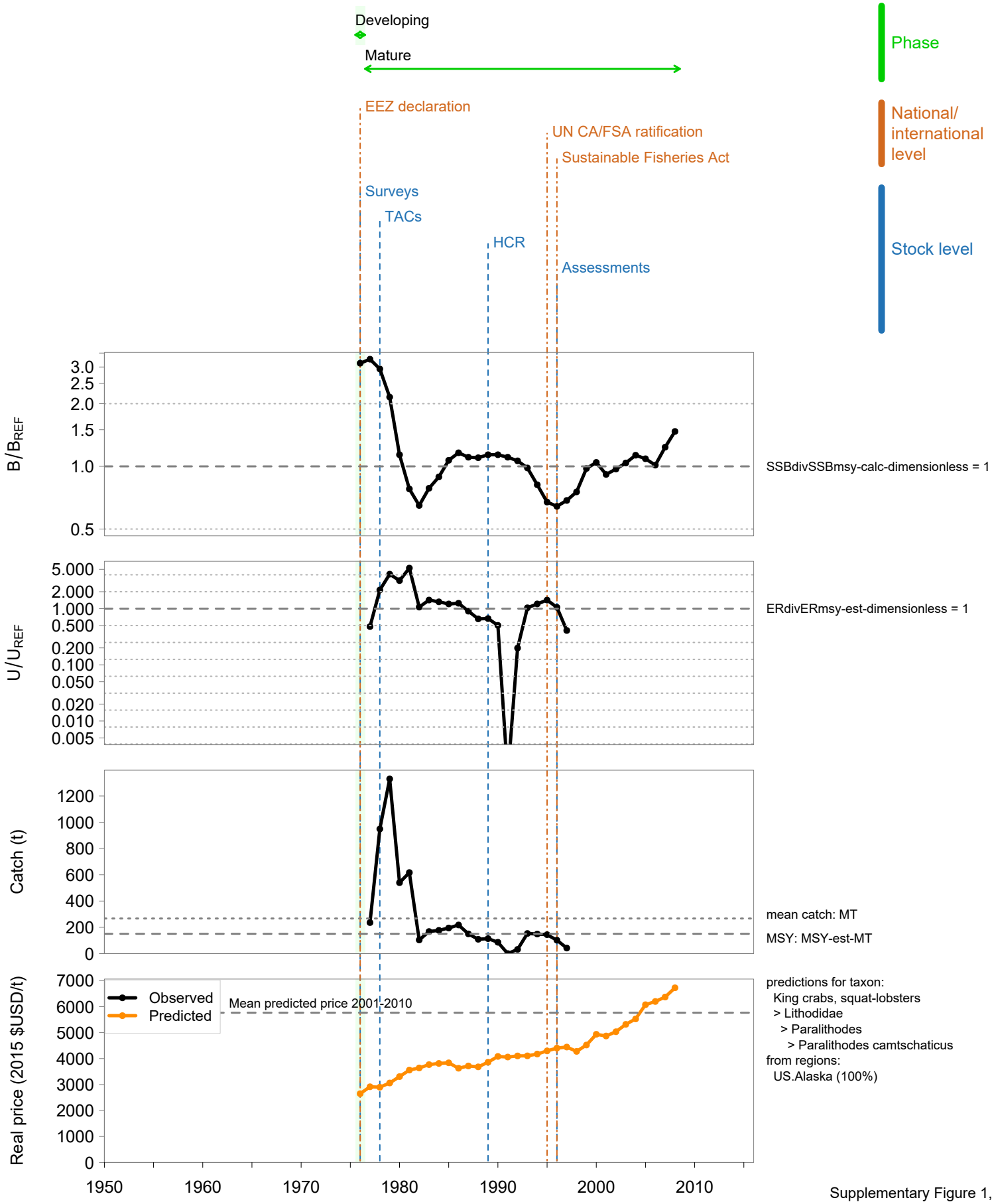
US-Alaska -- RKCRABBB -- Red king crab Bristol Bay

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



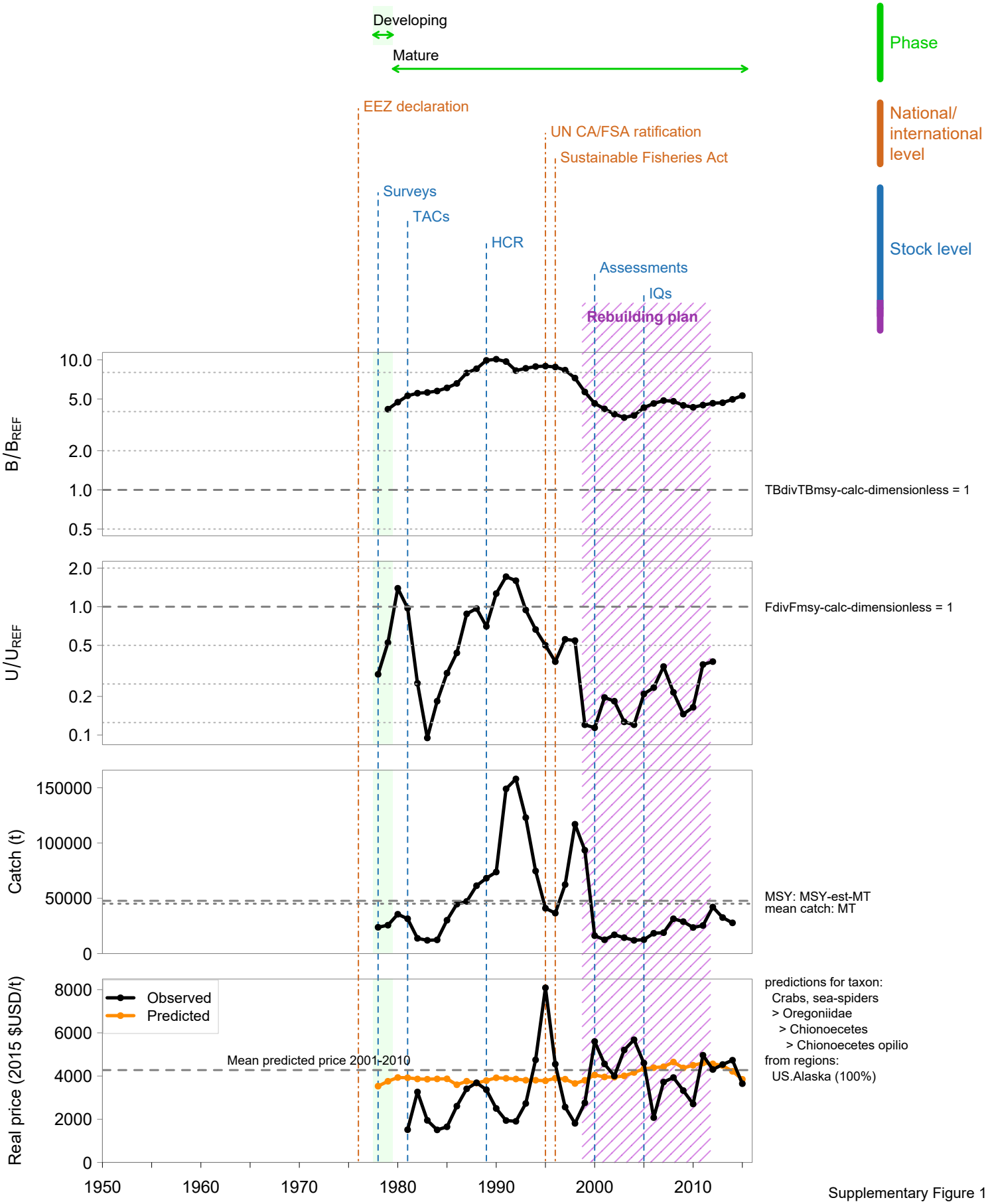
US-Alaska -- RKCRABNS -- Red king crab Norton Sound

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



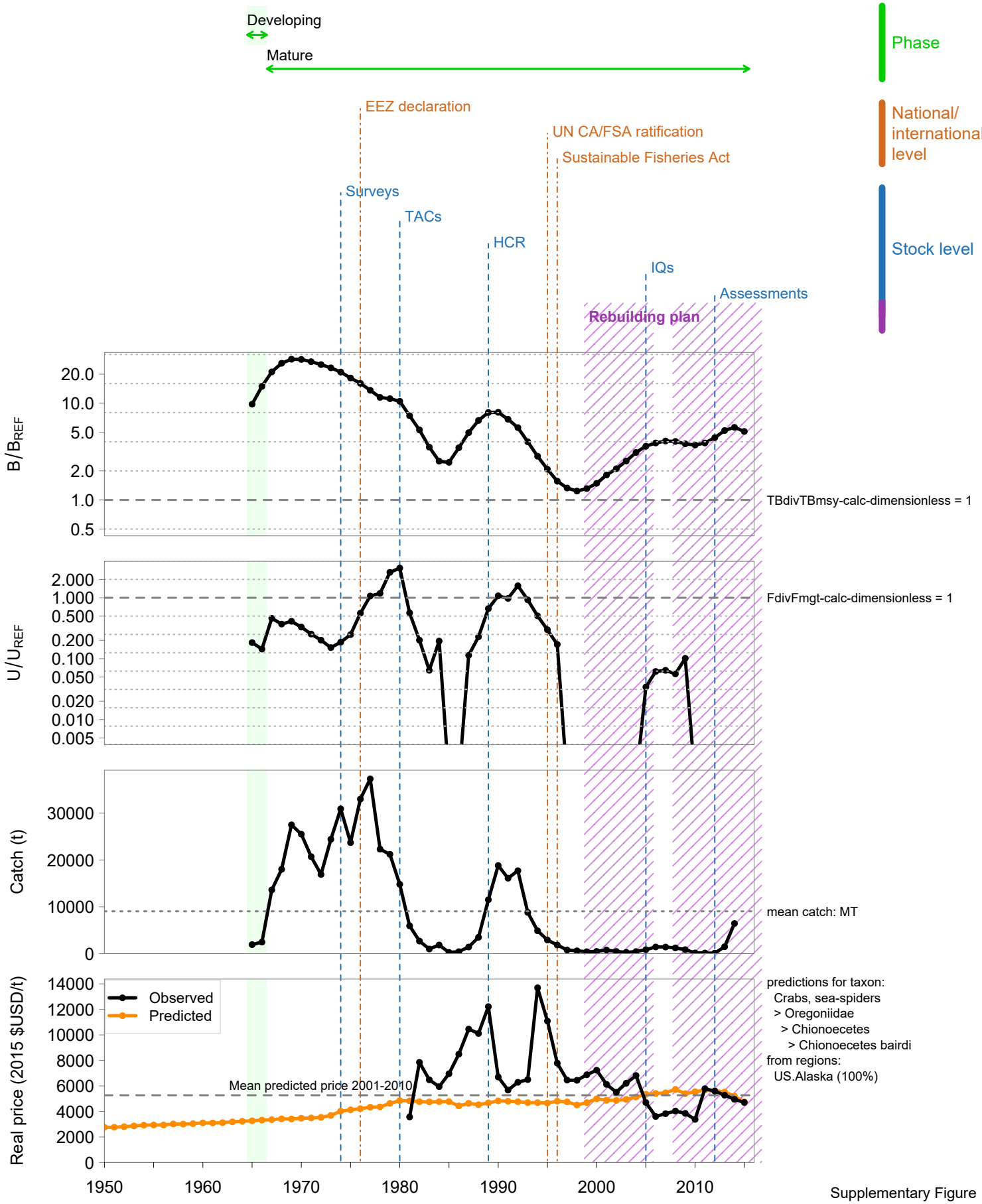
US-Alaska -- SNOWCRABBS -- Snow crab Bering Sea

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: USA



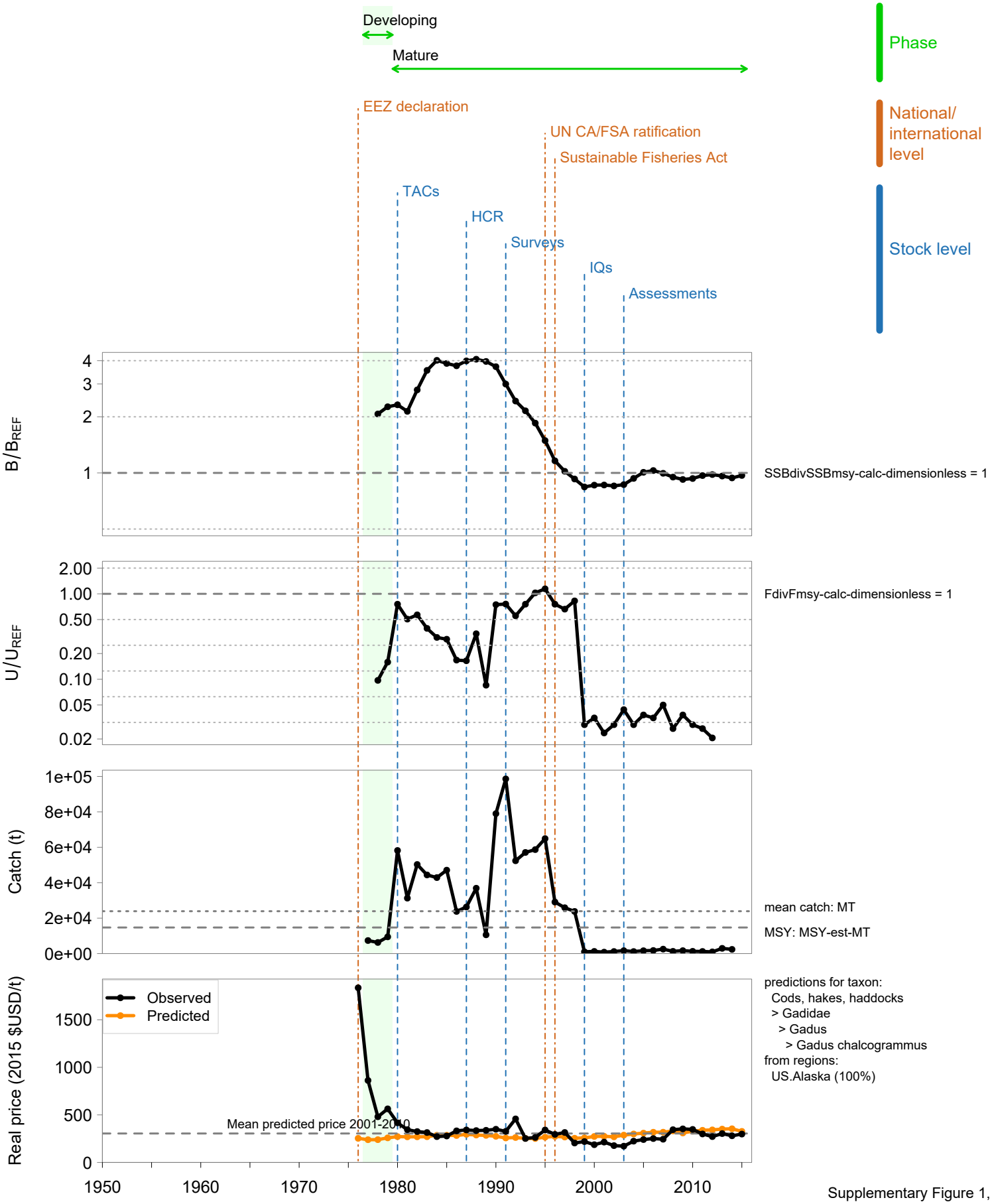
US-Alaska -- TANNERCRABBSAI -- Tanner crab Bering Sea and Aleutian Islands

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: USA



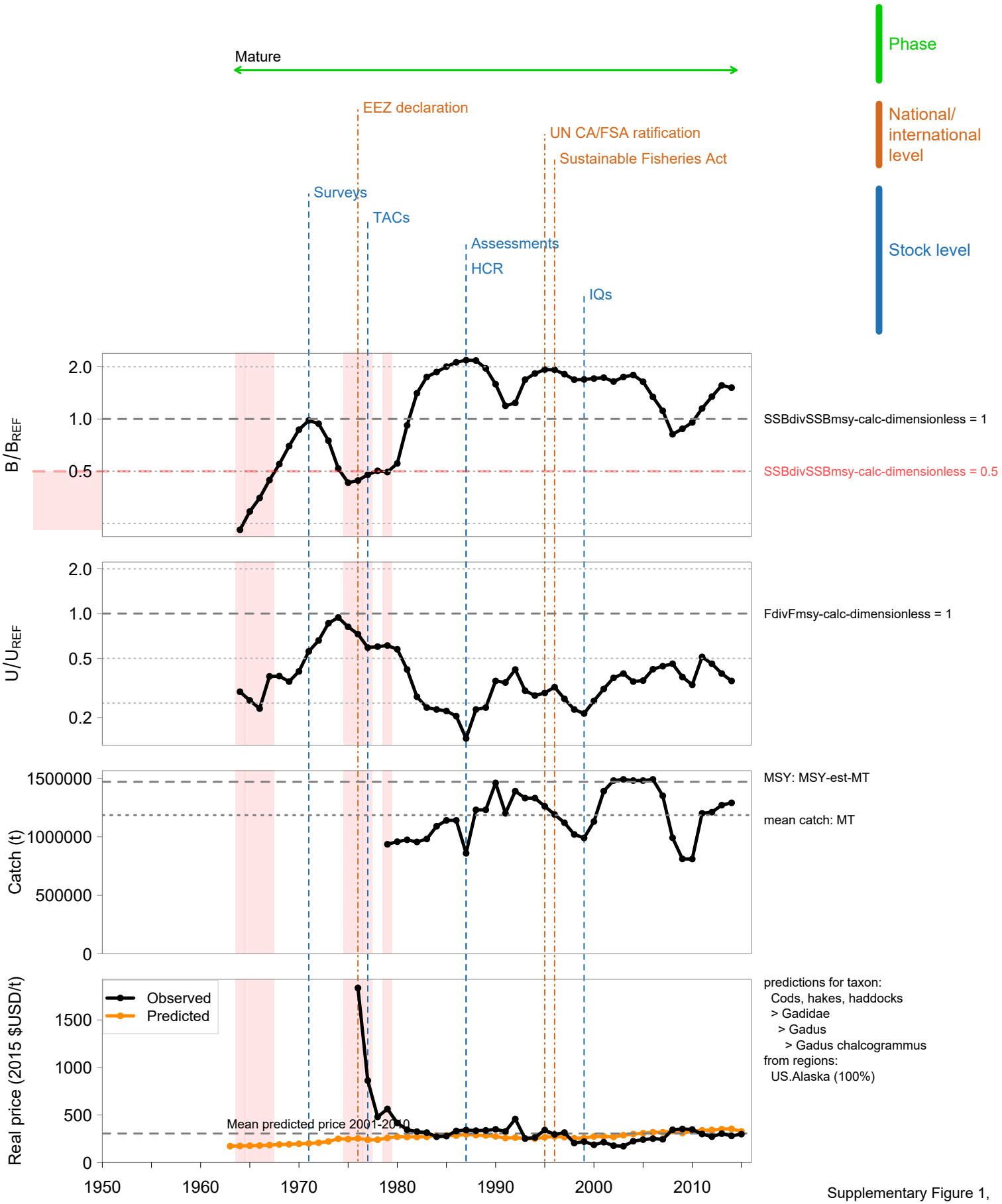
US-Alaska -- WPOLLAI -- Walleye pollock Aleutian Islands

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: USA



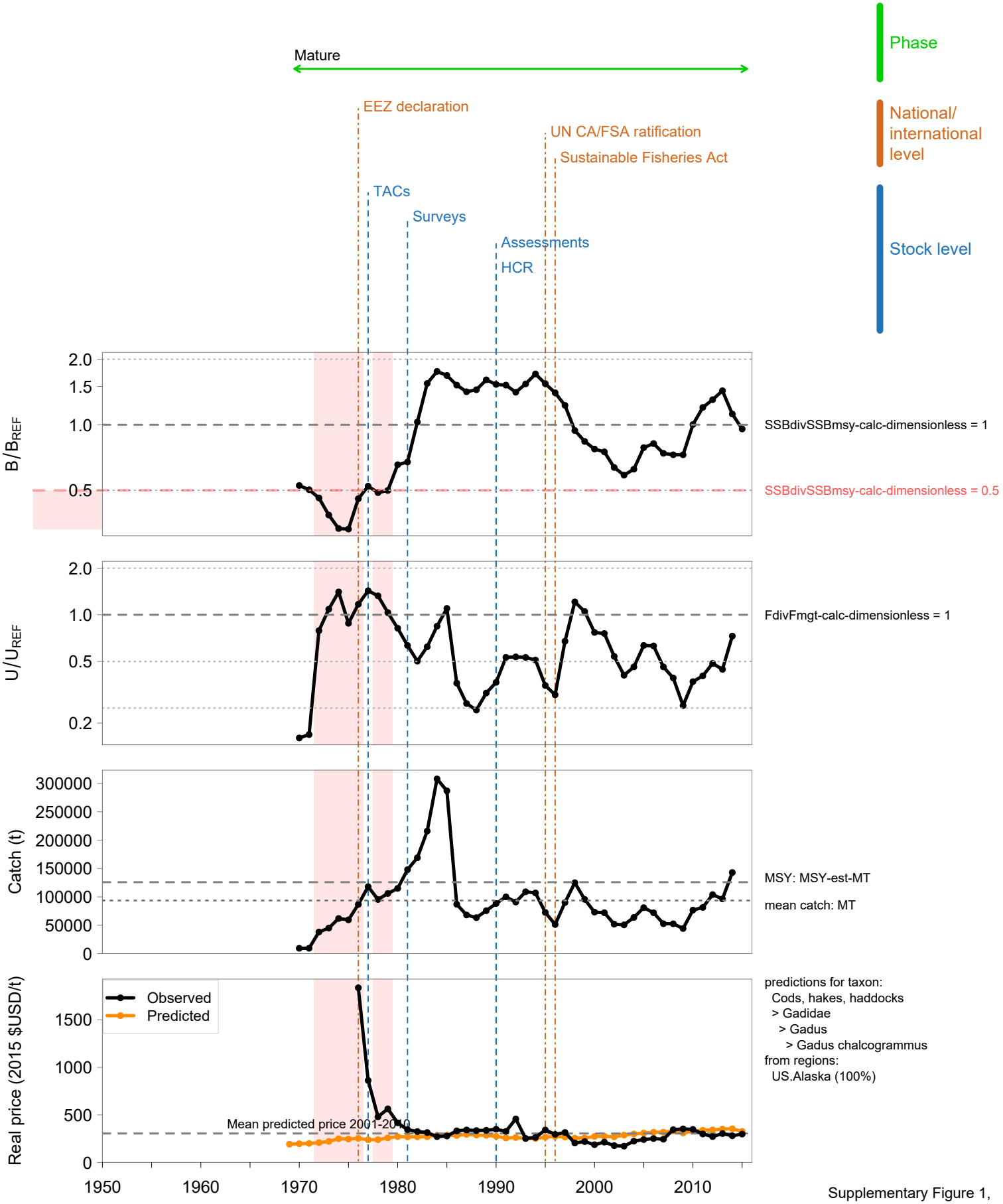
US-Alaska -- WPOLLEBS -- Walleye pollock Eastern Bering Sea

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: USA



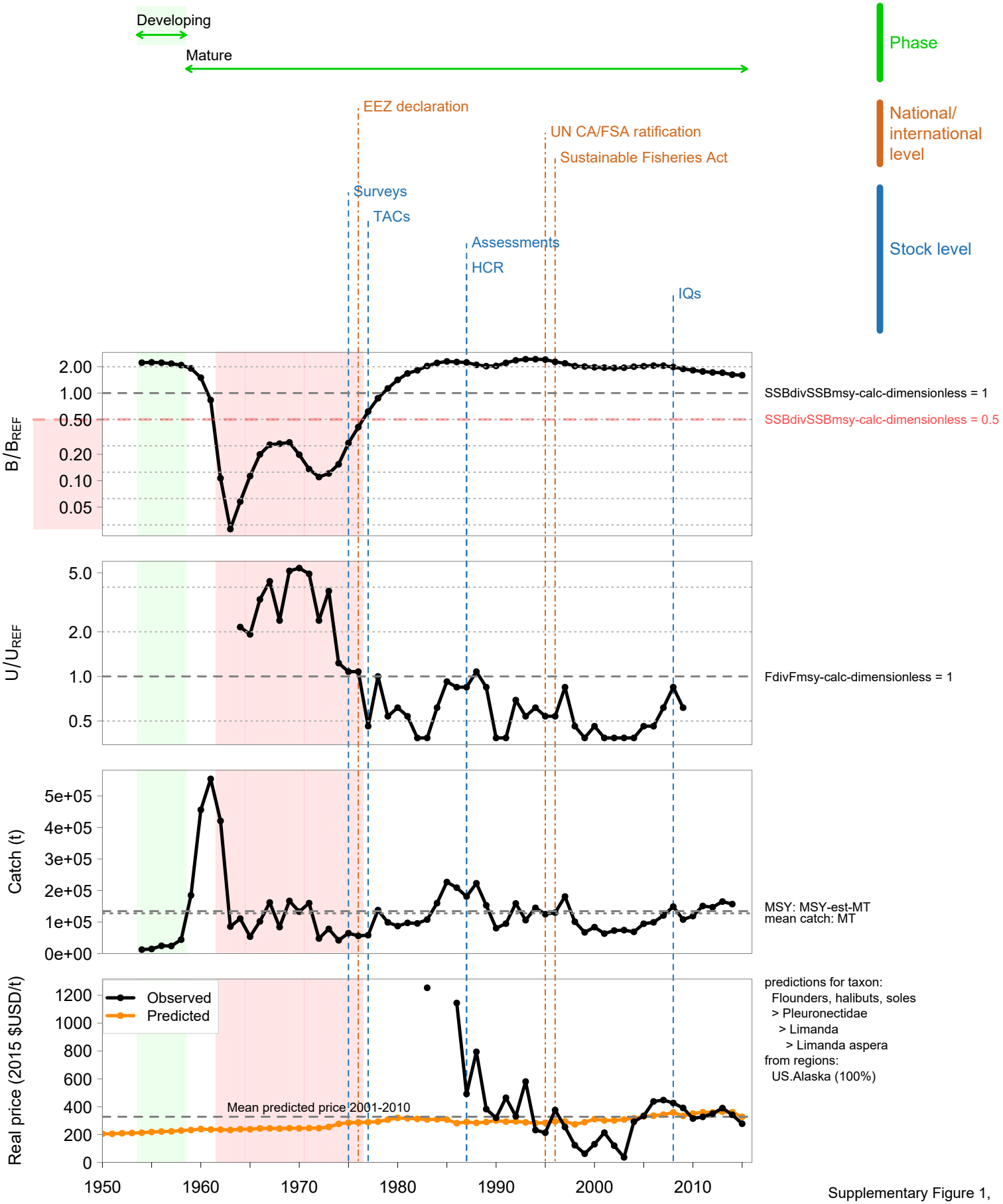
US-Alaska -- WPOLLGA -- Walleye pollock Gulf of Alaska

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: USA



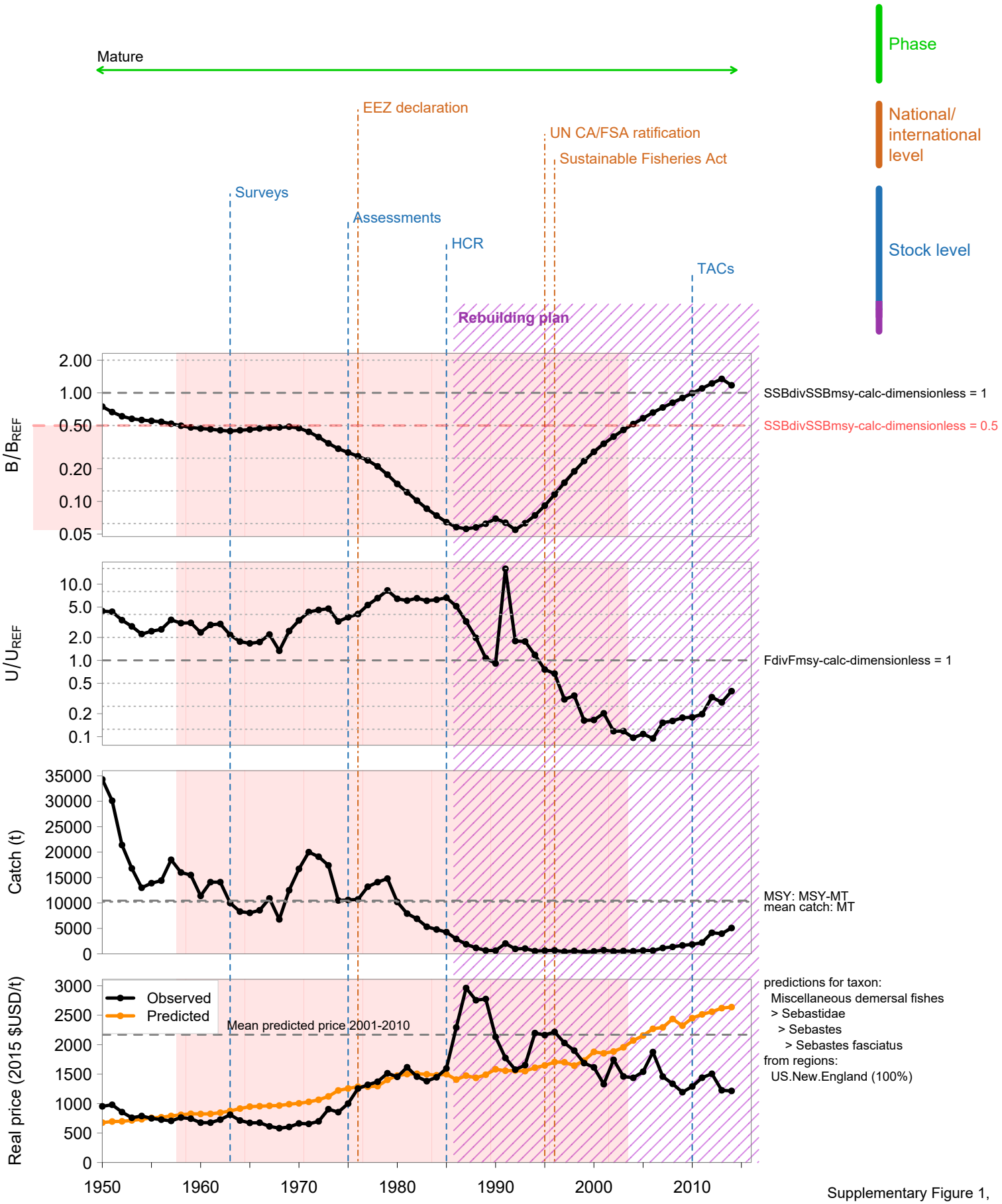
US-Alaska -- YSOLEBSAI -- Yellowfin sole Bering Sea and Aleutian Islands

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



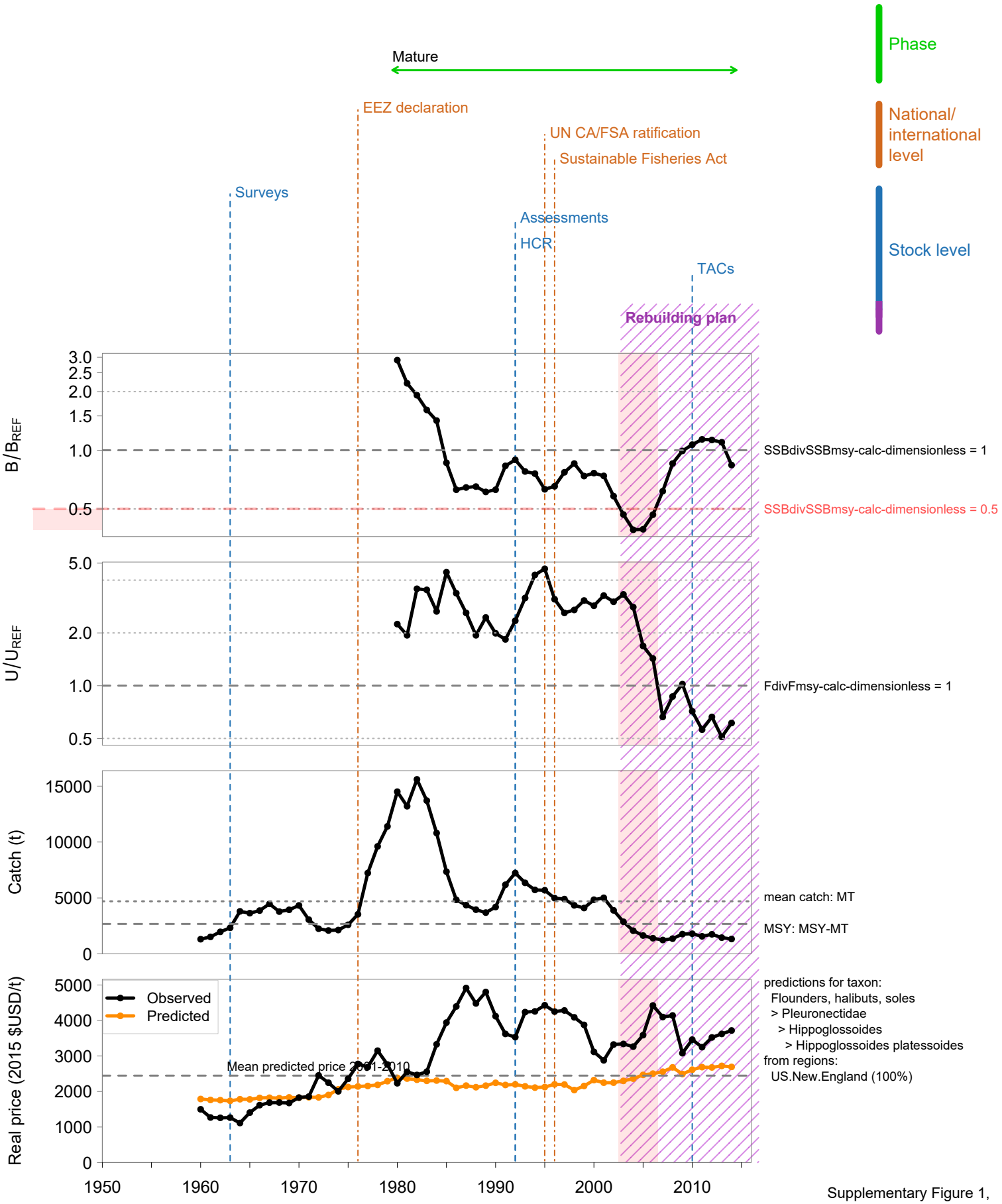
US-Northeast -- ACADREDGOMGB -- Acadian redfish Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



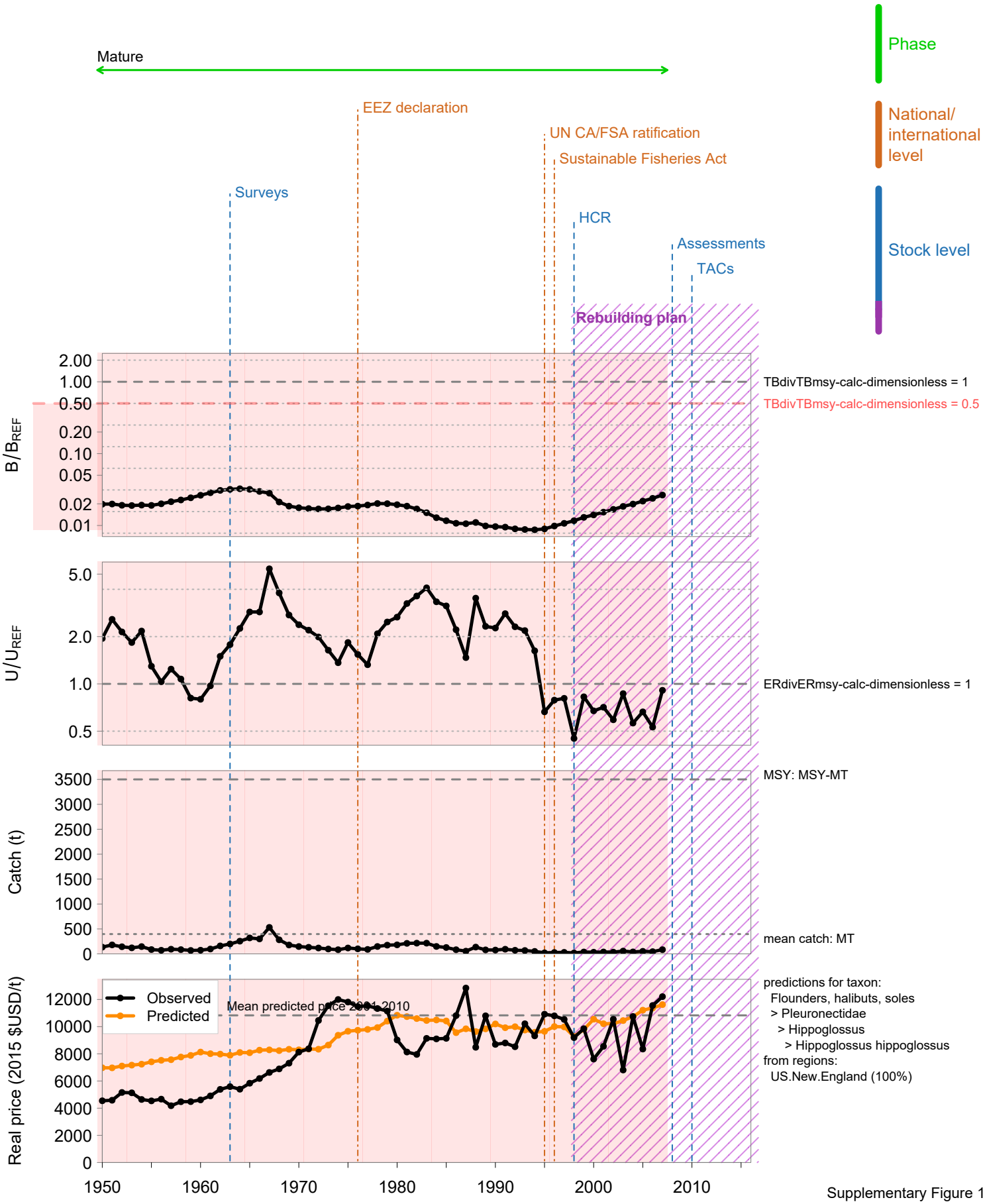
US-Northeast -- AMPL5YZ -- American plaice Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



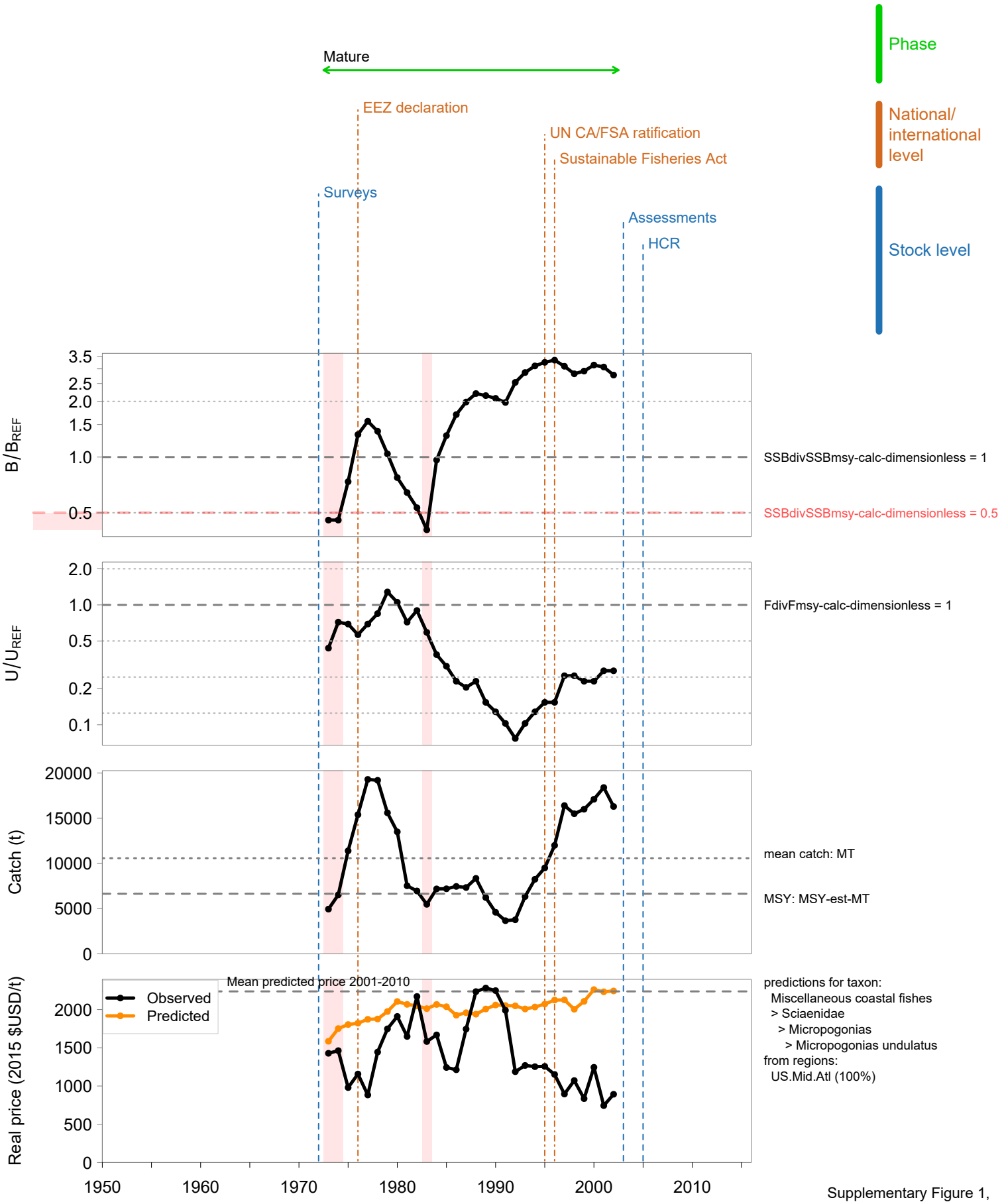
US-Northeast -- ATHAL5YZ -- Atlantic halibut Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



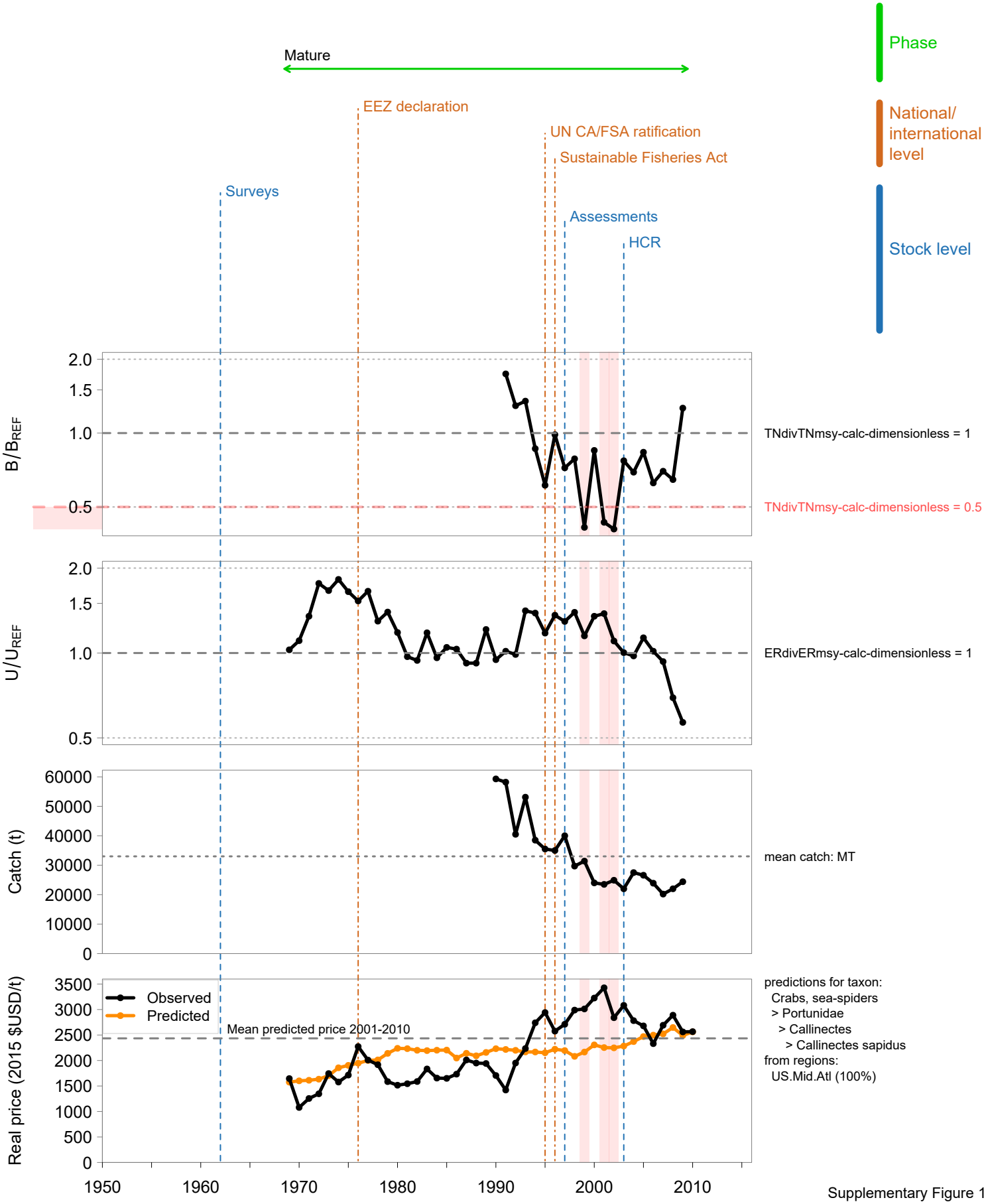
US-Northeast -- ATLCROAKMATLC -- Atlantic croaker Mid-Atlantic Coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



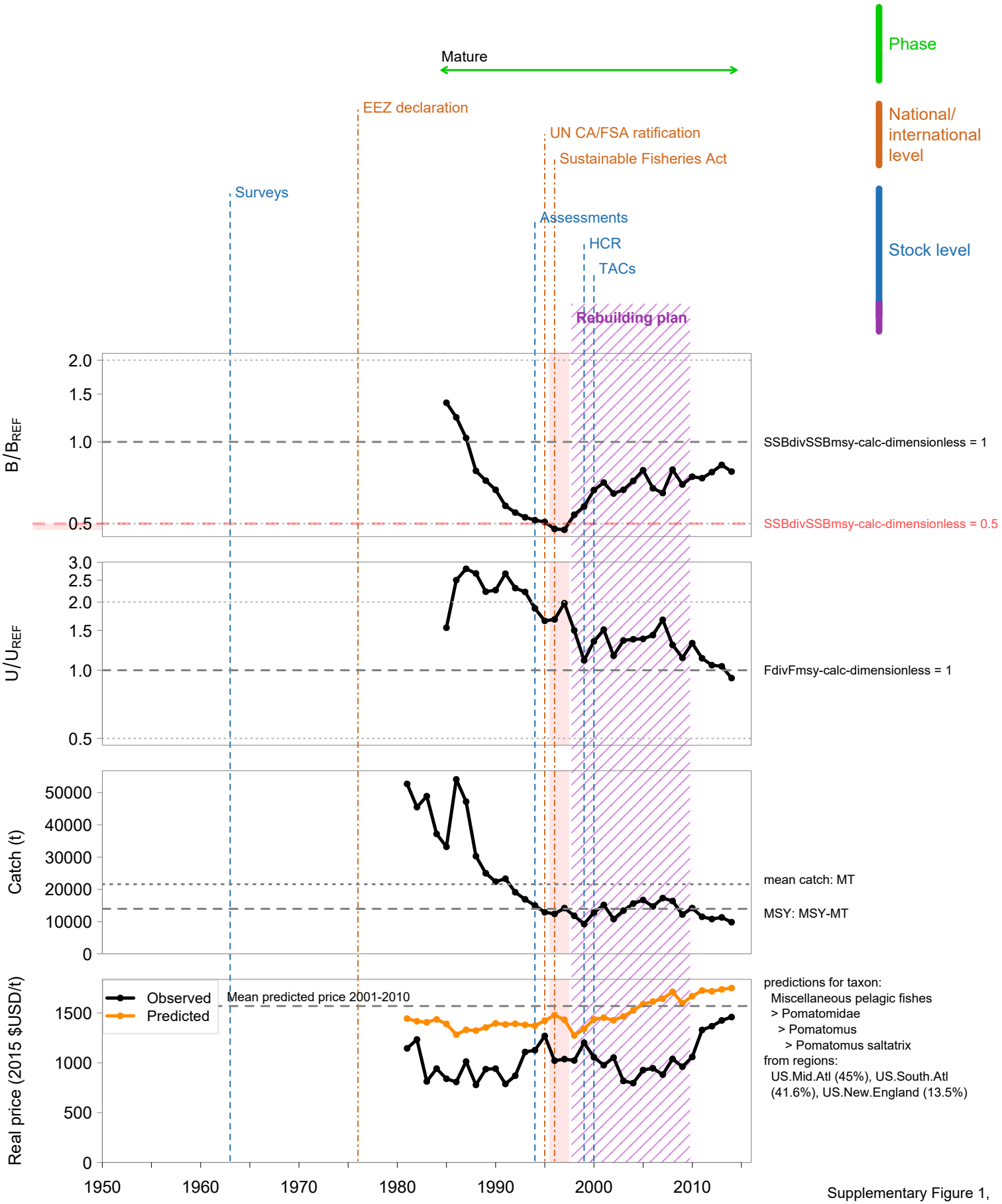
US-Northeast -- BCRABCHESB -- Blue crab Chesapeake Bay

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



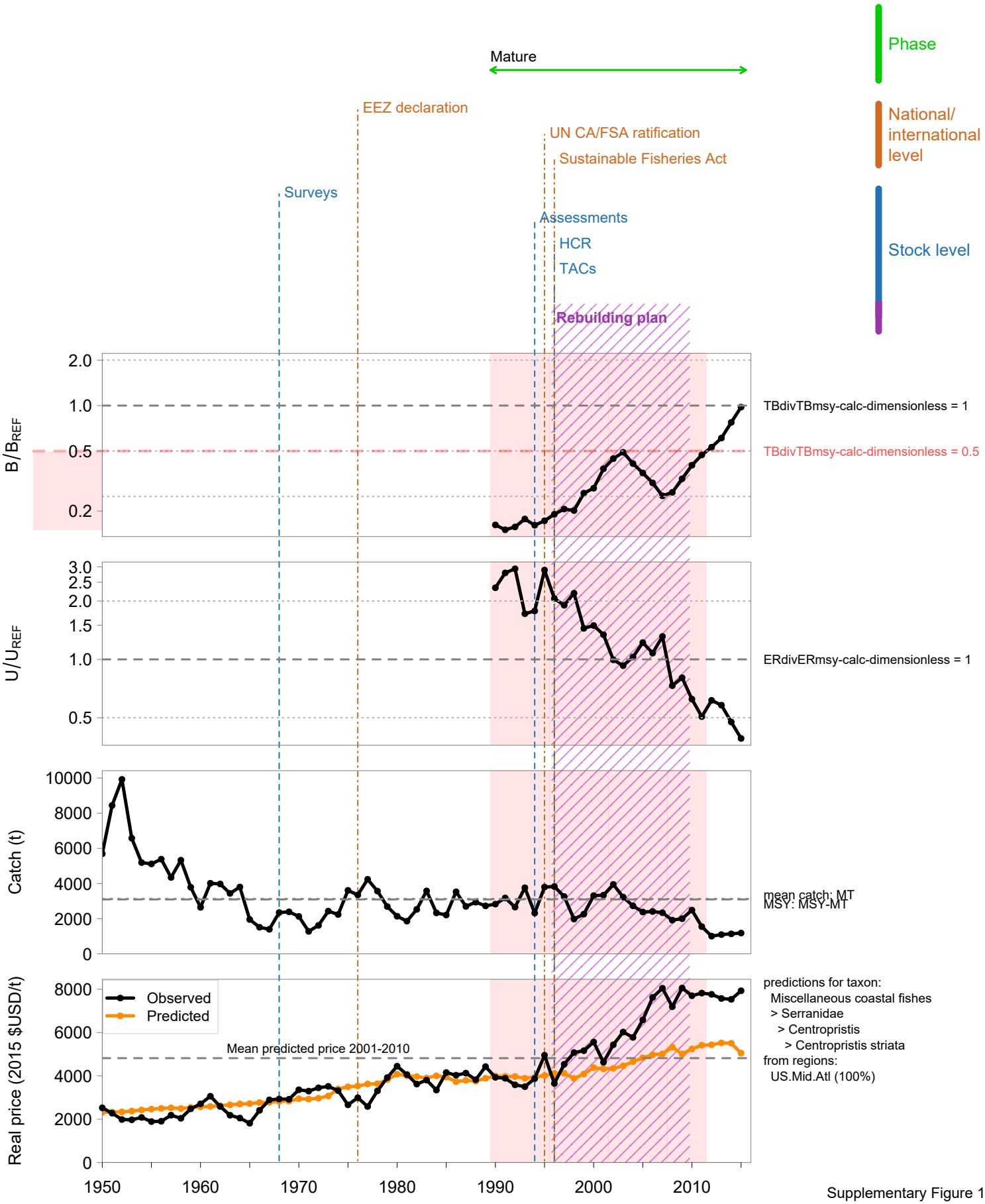
US-Northeast -- BLUEFISHATLC -- Bluefish Atlantic Coast

taxonomic group: pelagic fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



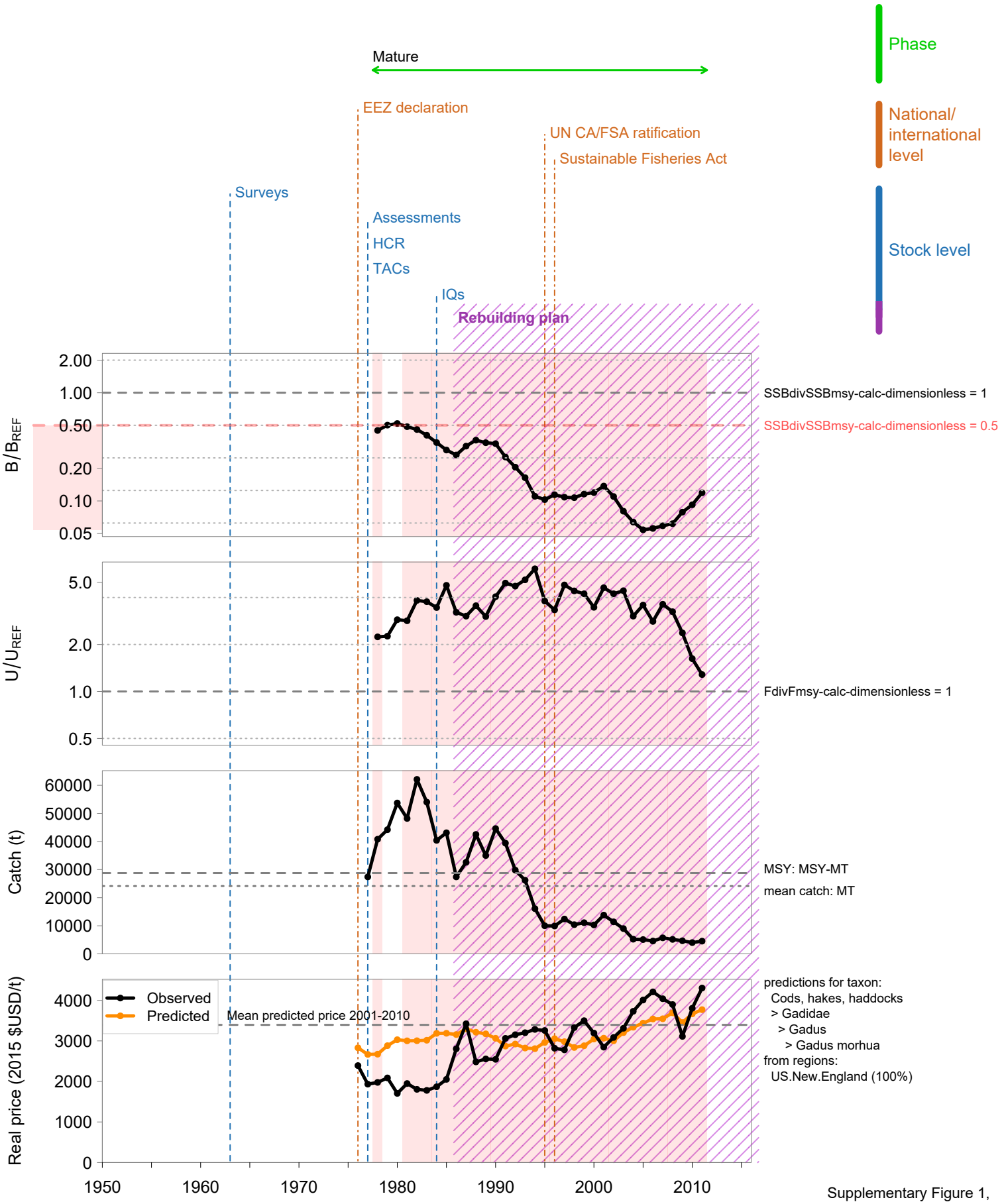
US-Northeast -- BSBASSMATLC -- Black sea bass Mid-Atlantic Coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



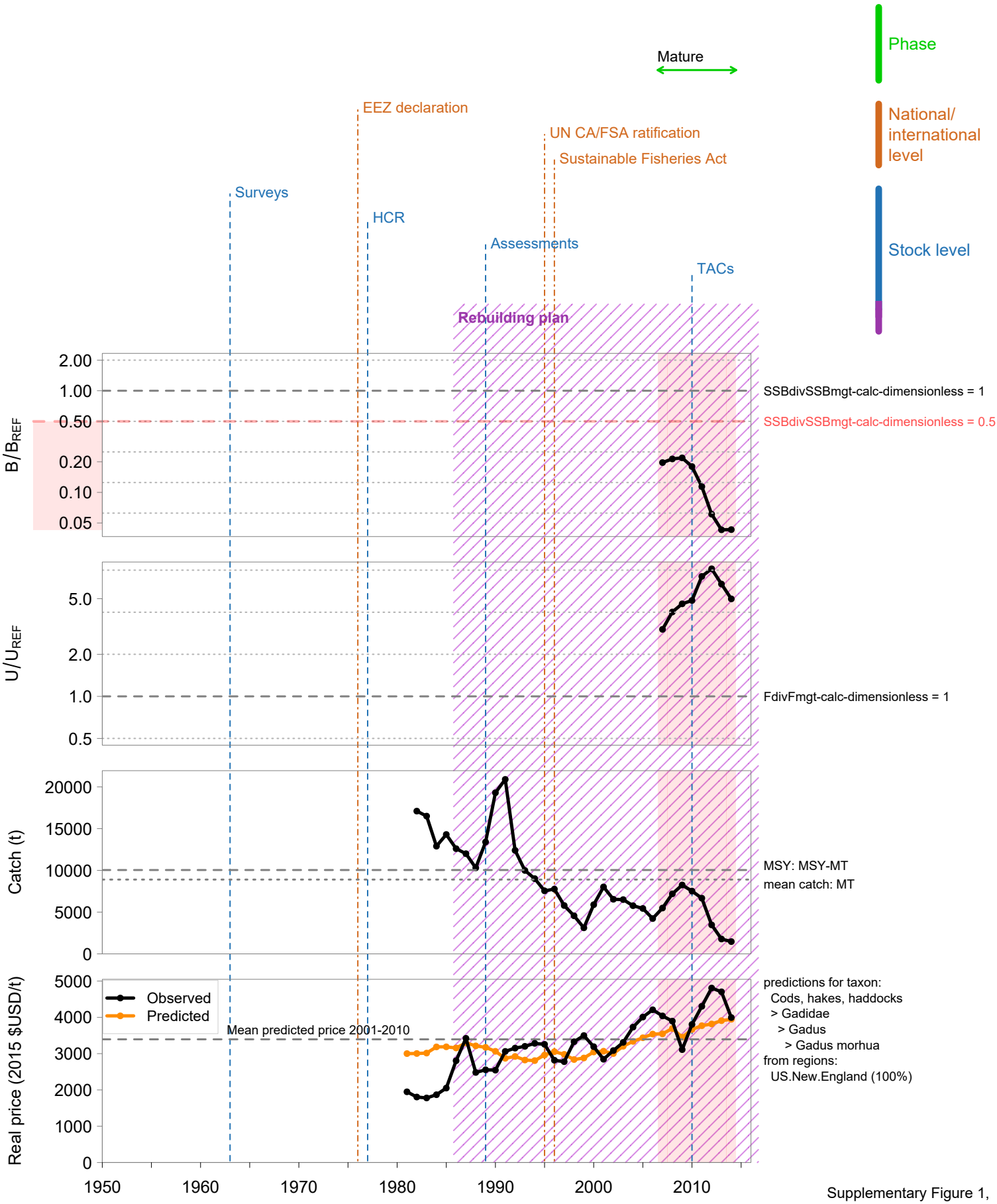
US-Northeast -- CODGB -- Atlantic cod Georges Bank

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



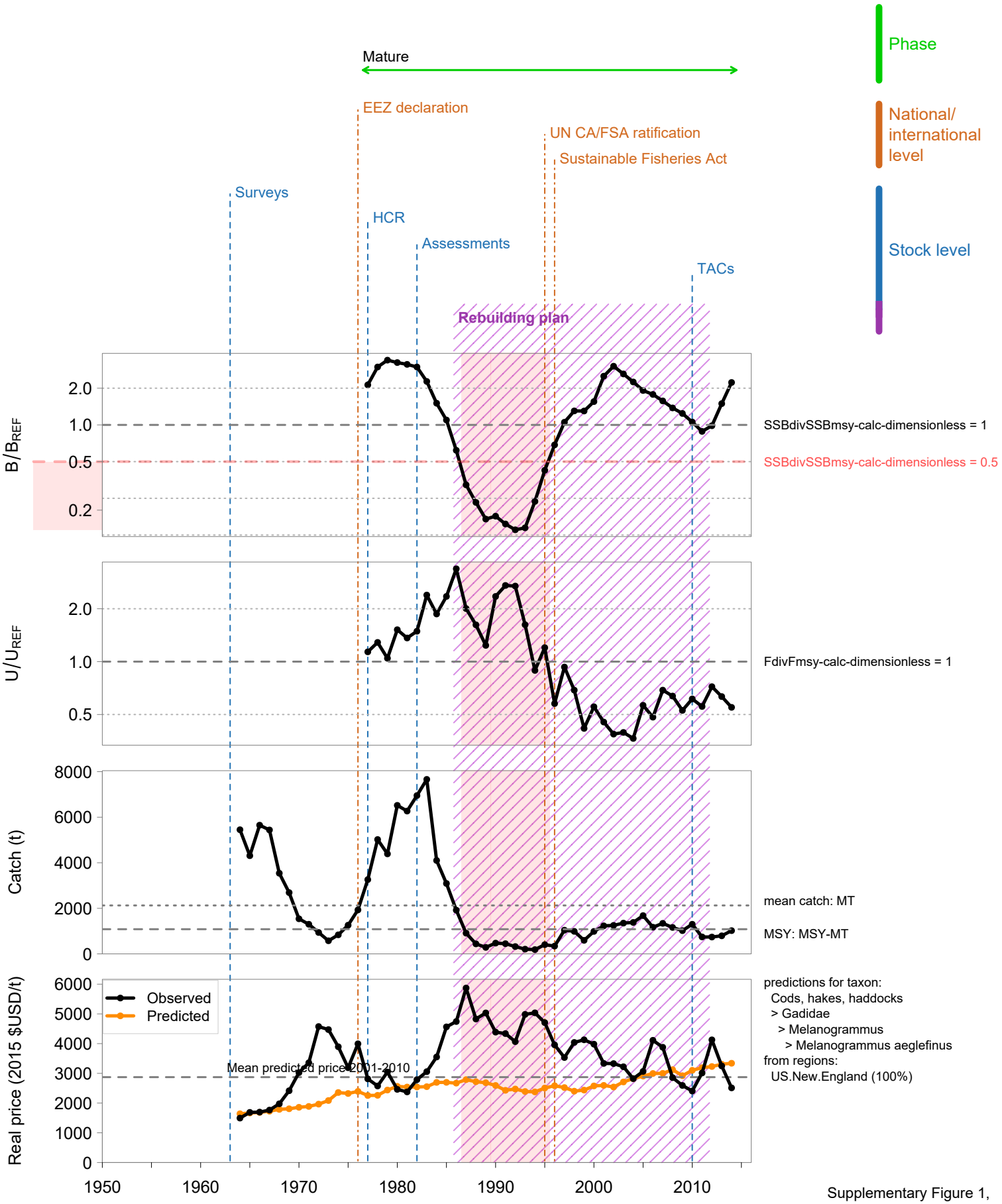
US-Northeast -- CODGOM -- Atlantic cod Gulf of Maine

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



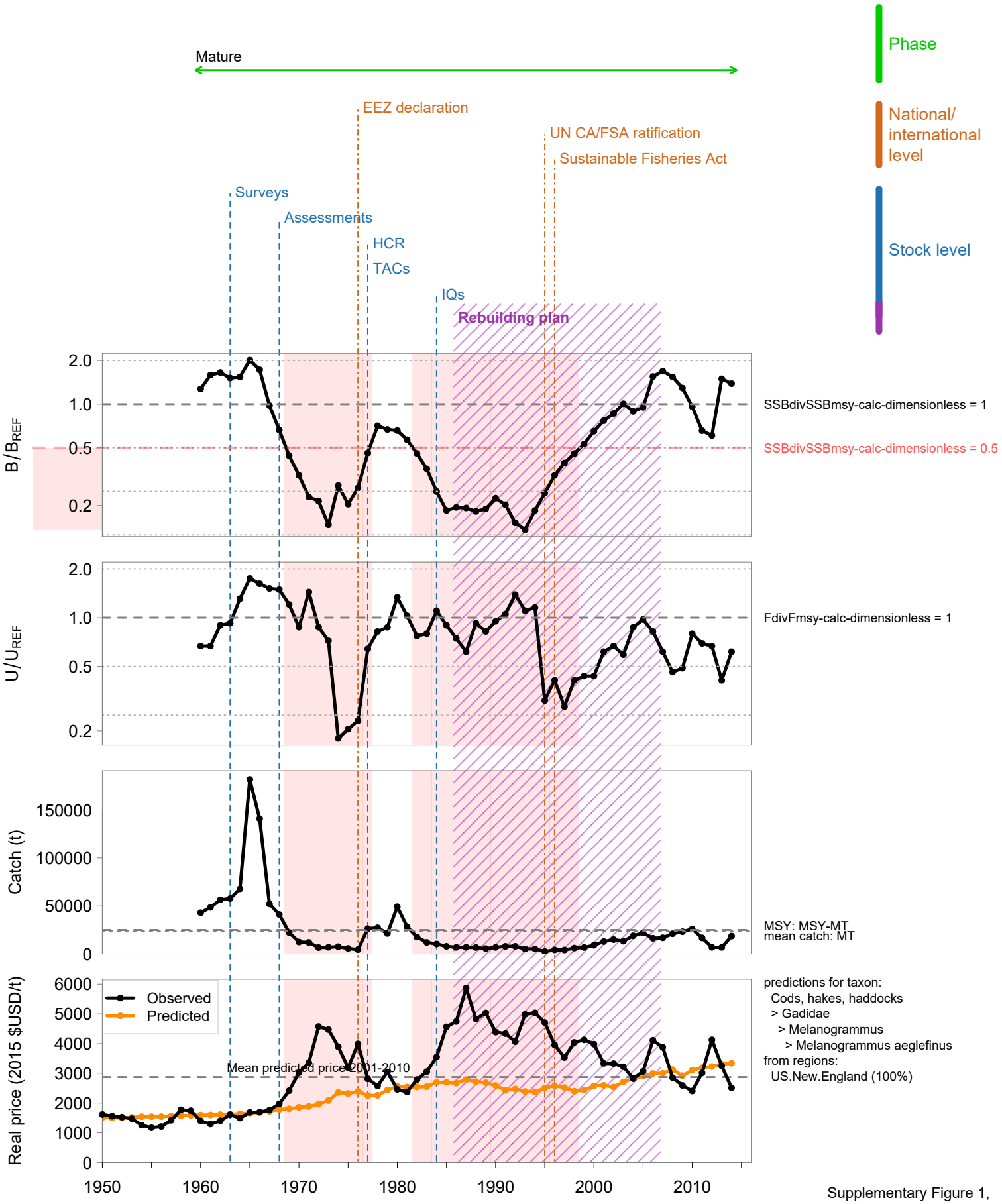
US-Northeast -- HAD5Y -- Haddock Gulf of Maine

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



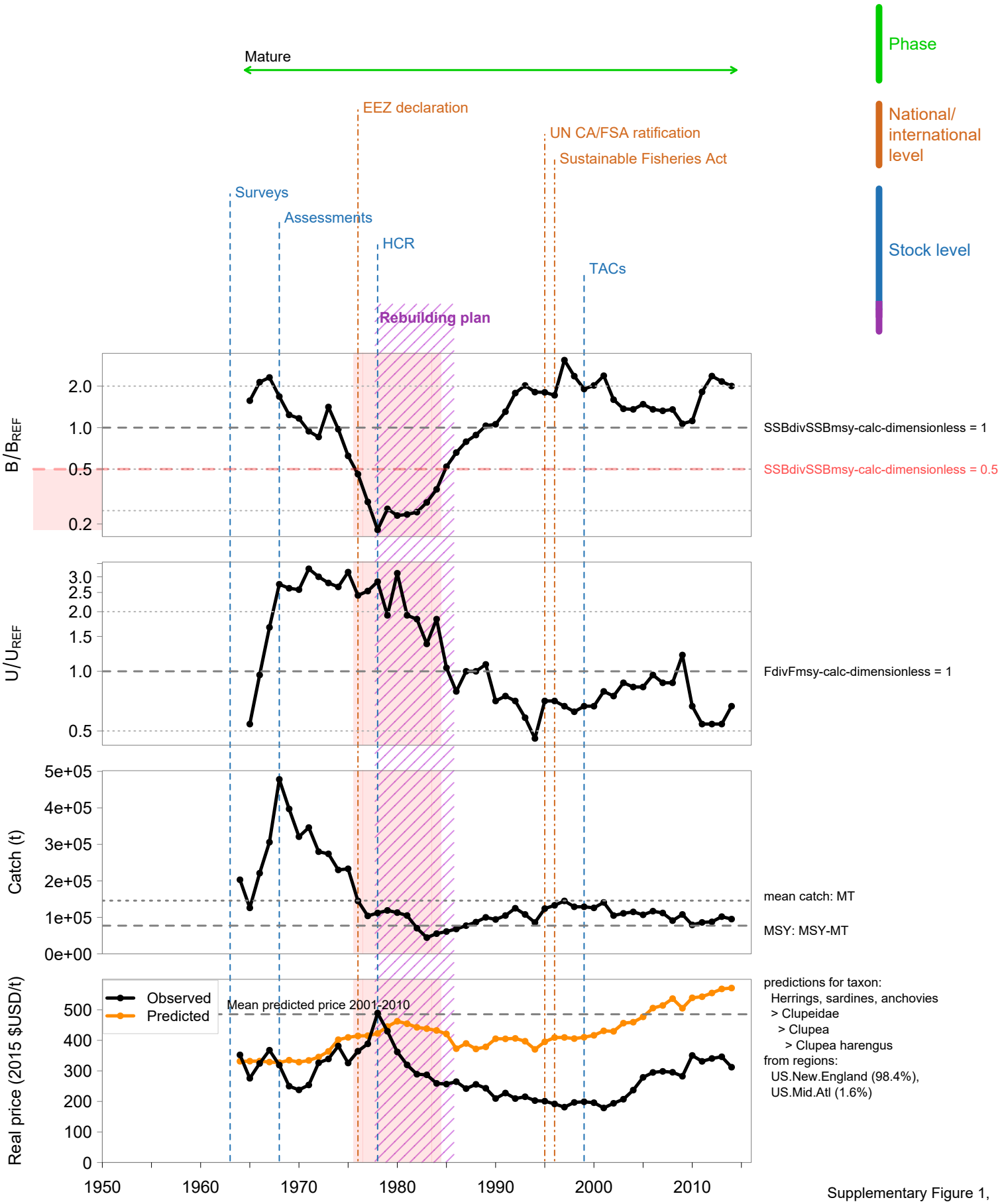
US-Northeast -- HADGB -- Haddock Georges Bank

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



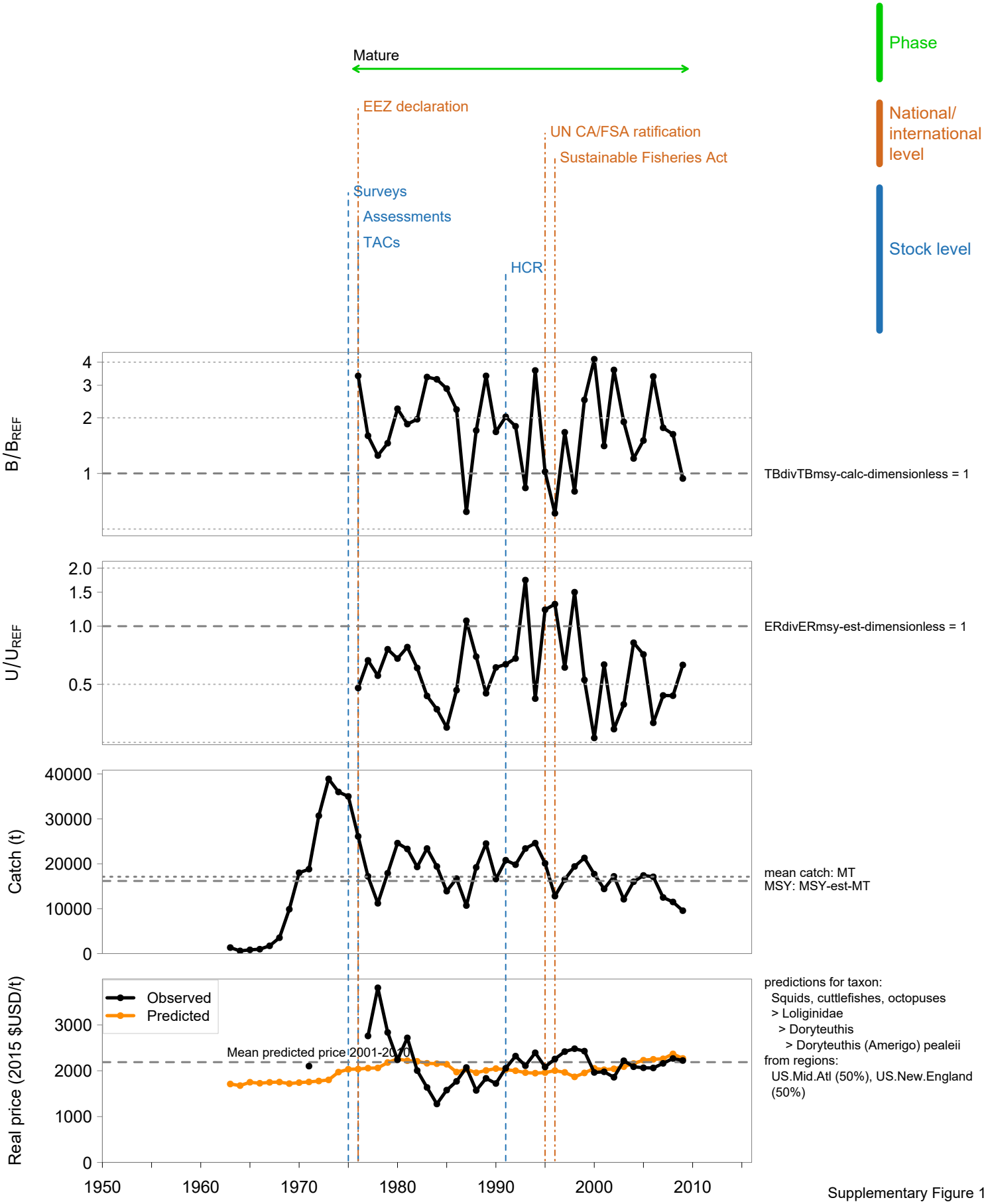
US-Northeast -- HERRNWATLC -- Herring Northwestern Atlantic Coast

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: USA



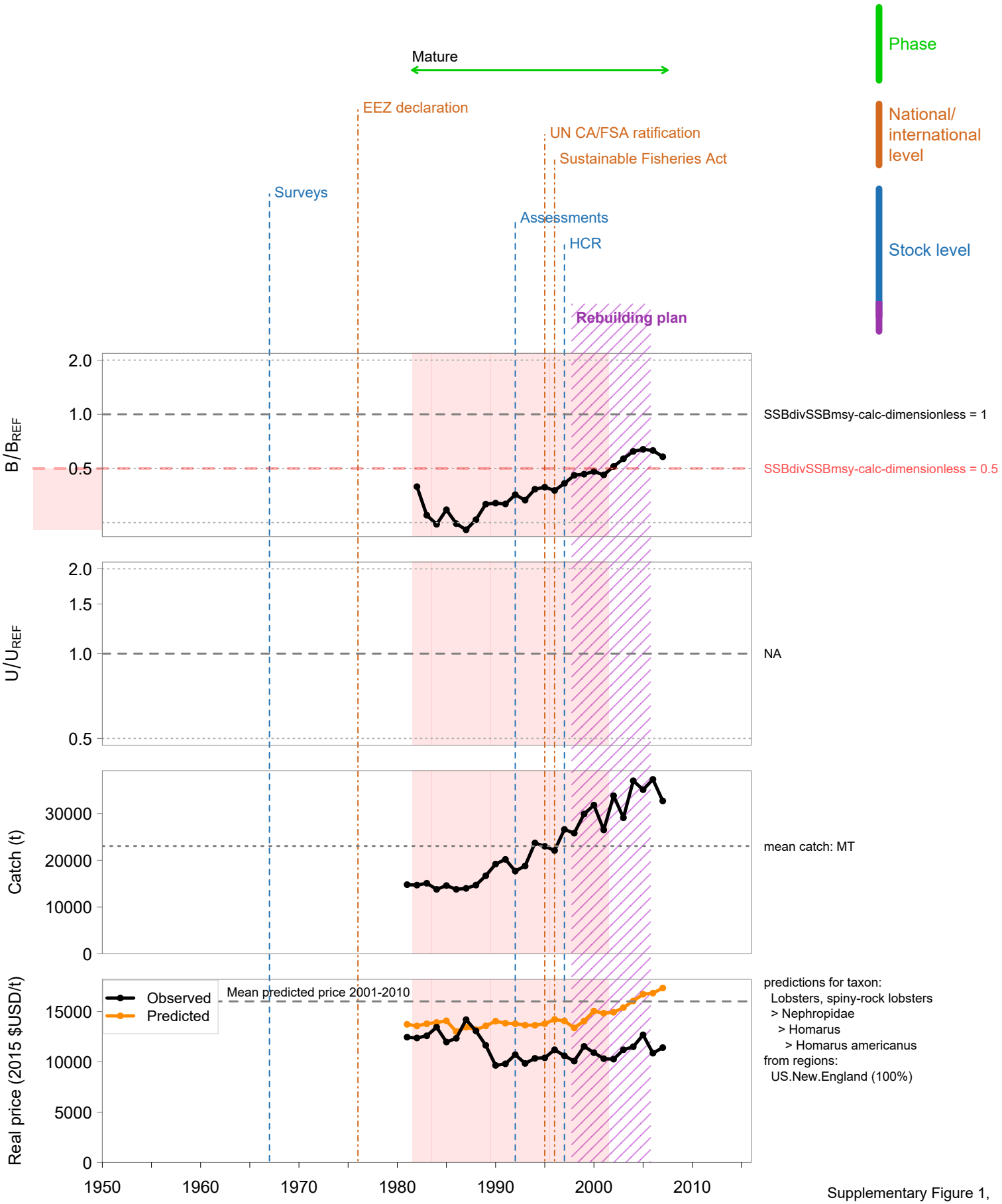
US-Northeast -- LISQUIDATLC -- Longfin inshore squid Atlantic Coast

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: USA



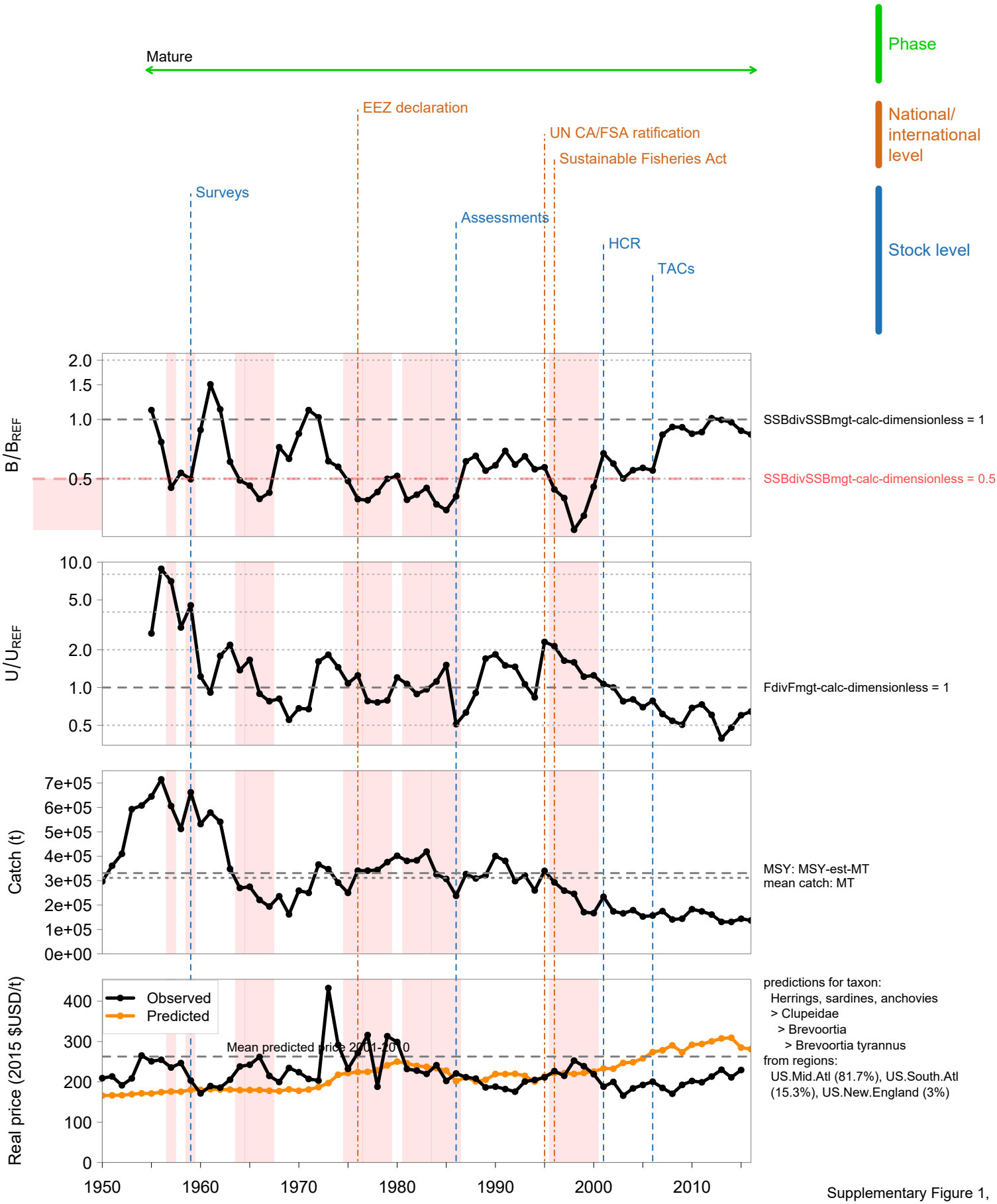
US-Northeast -- LOBSTERGOM -- American lobster Gulf of Maine

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



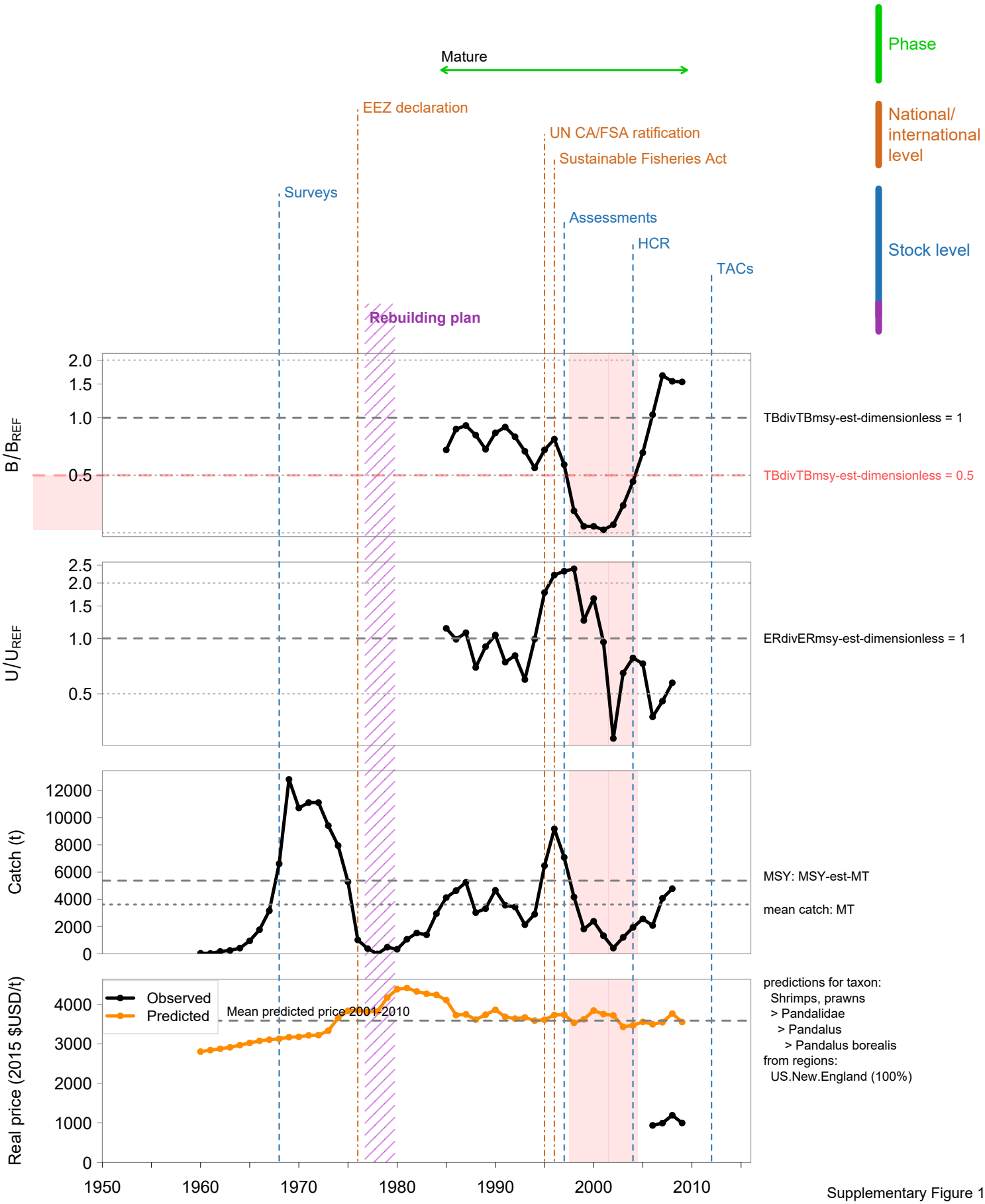
US-Northeast -- MENATLAN -- Atlantic menhaden Atlantic

taxonomic group: pelagic fish (Forage fish), predominant fishery type: single-species, primary country: USA



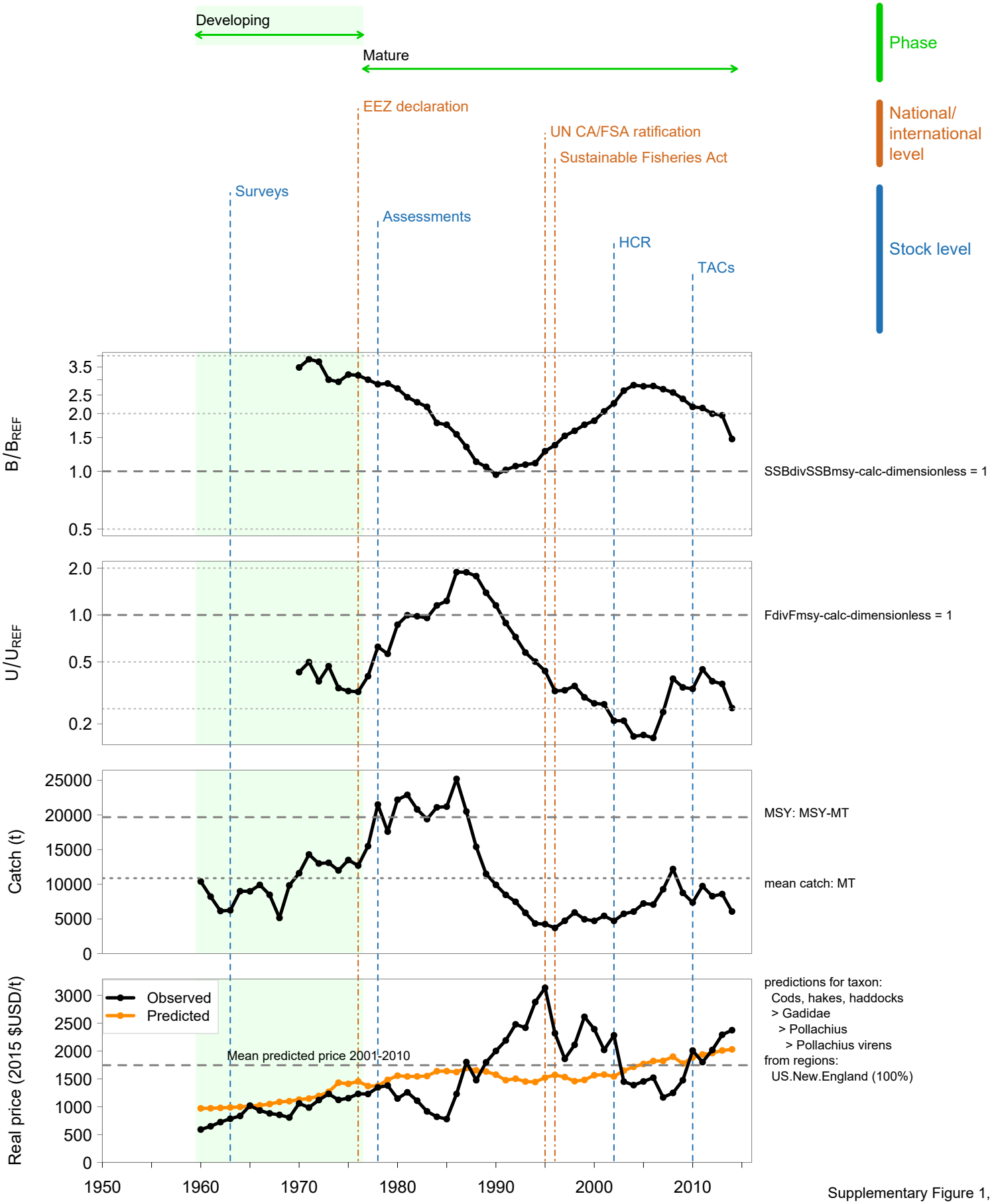
US-Northeast -- PANDALGOM -- Northern shrimp Gulf of Maine

taxonomic group: invertebrate (Crustaceans), predominant fishery type: single-species, primary country: USA



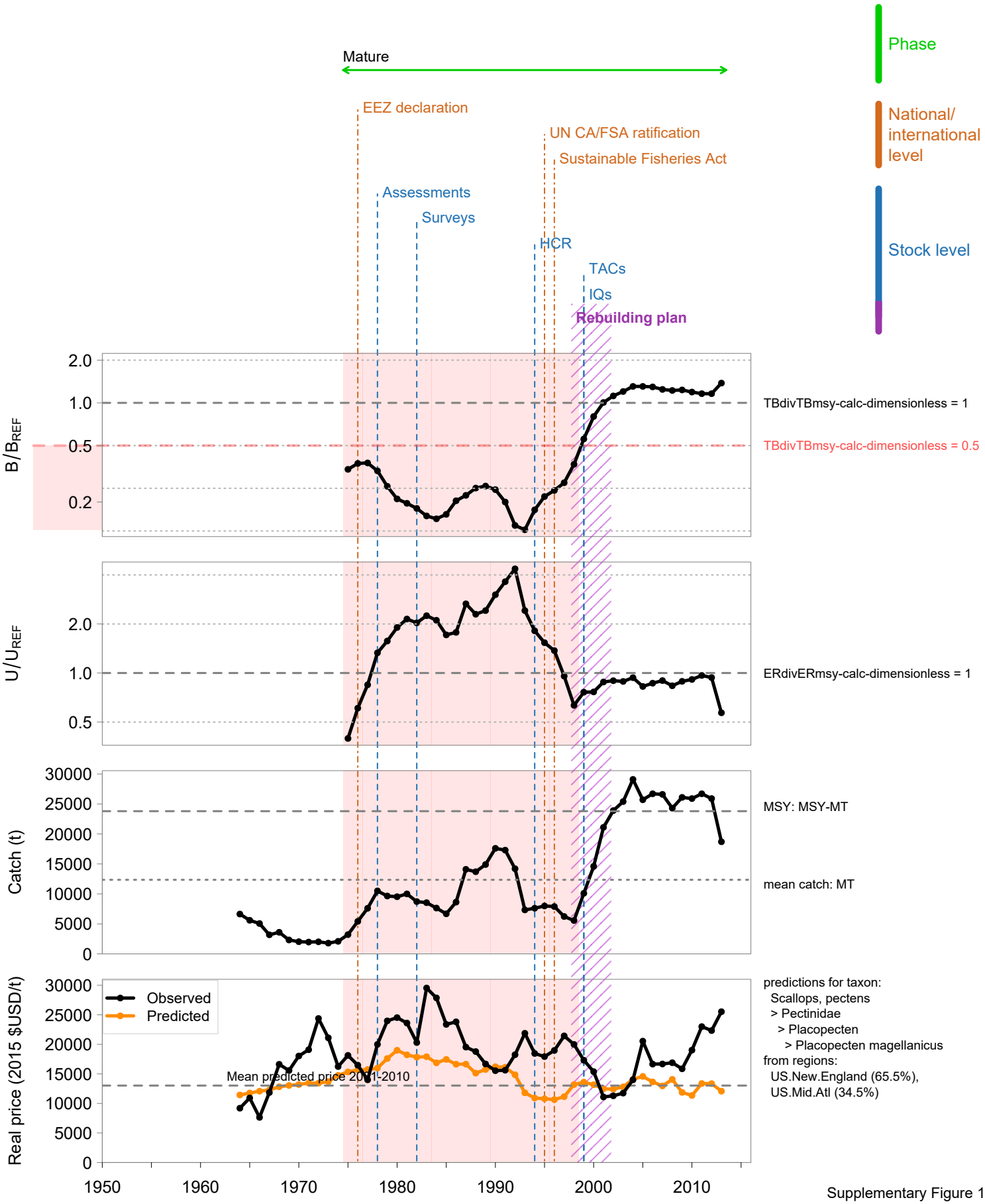
US-Northeast -- POLL5YZ -- Pollock Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



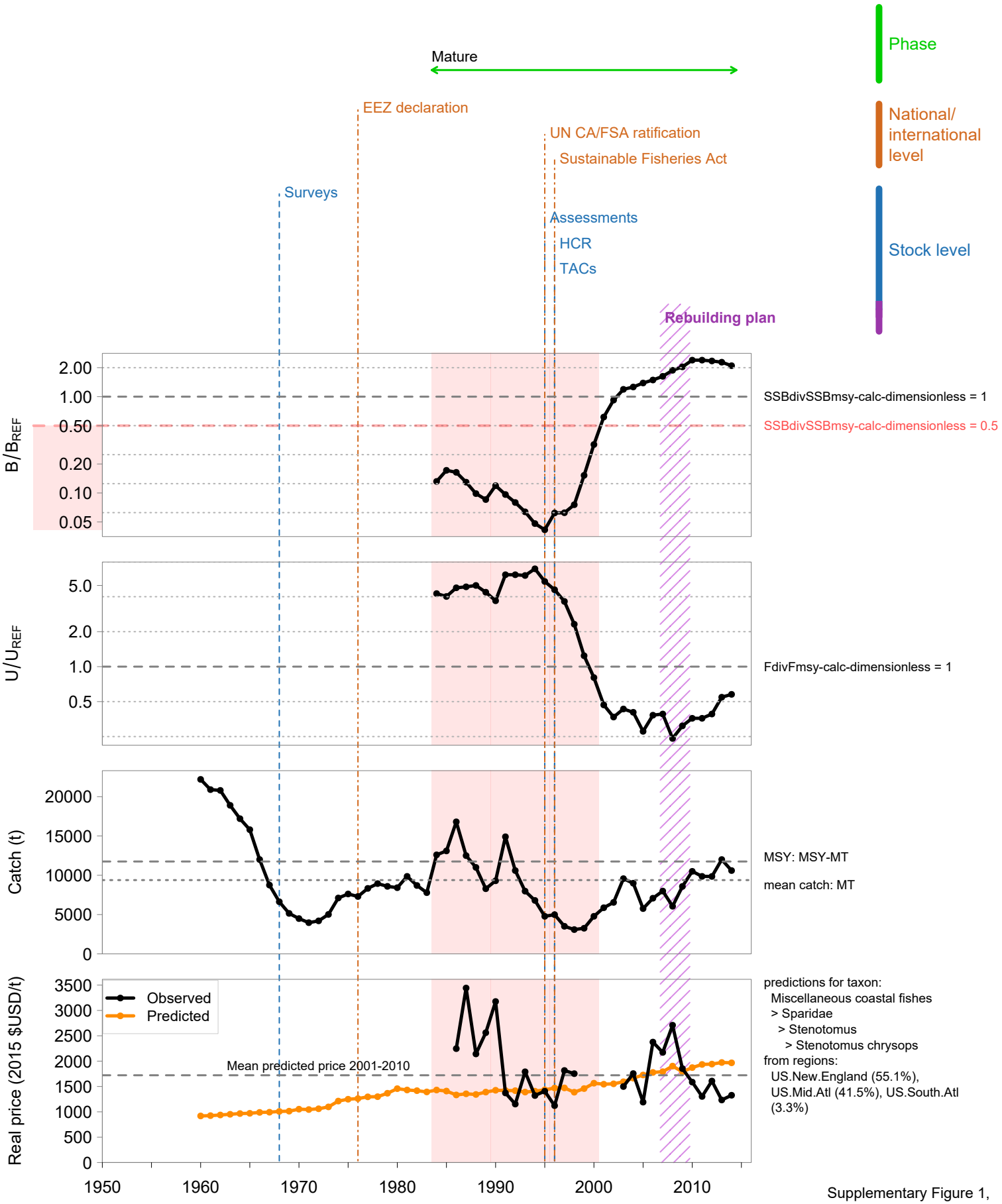
US-Northeast -- SCALL5ZMAB -- Sea scallop Georges Bank and Mid-Atlantic Bight

taxonomic group: invertebrate (Molluscs), predominant fishery type: single-species, primary country: USA



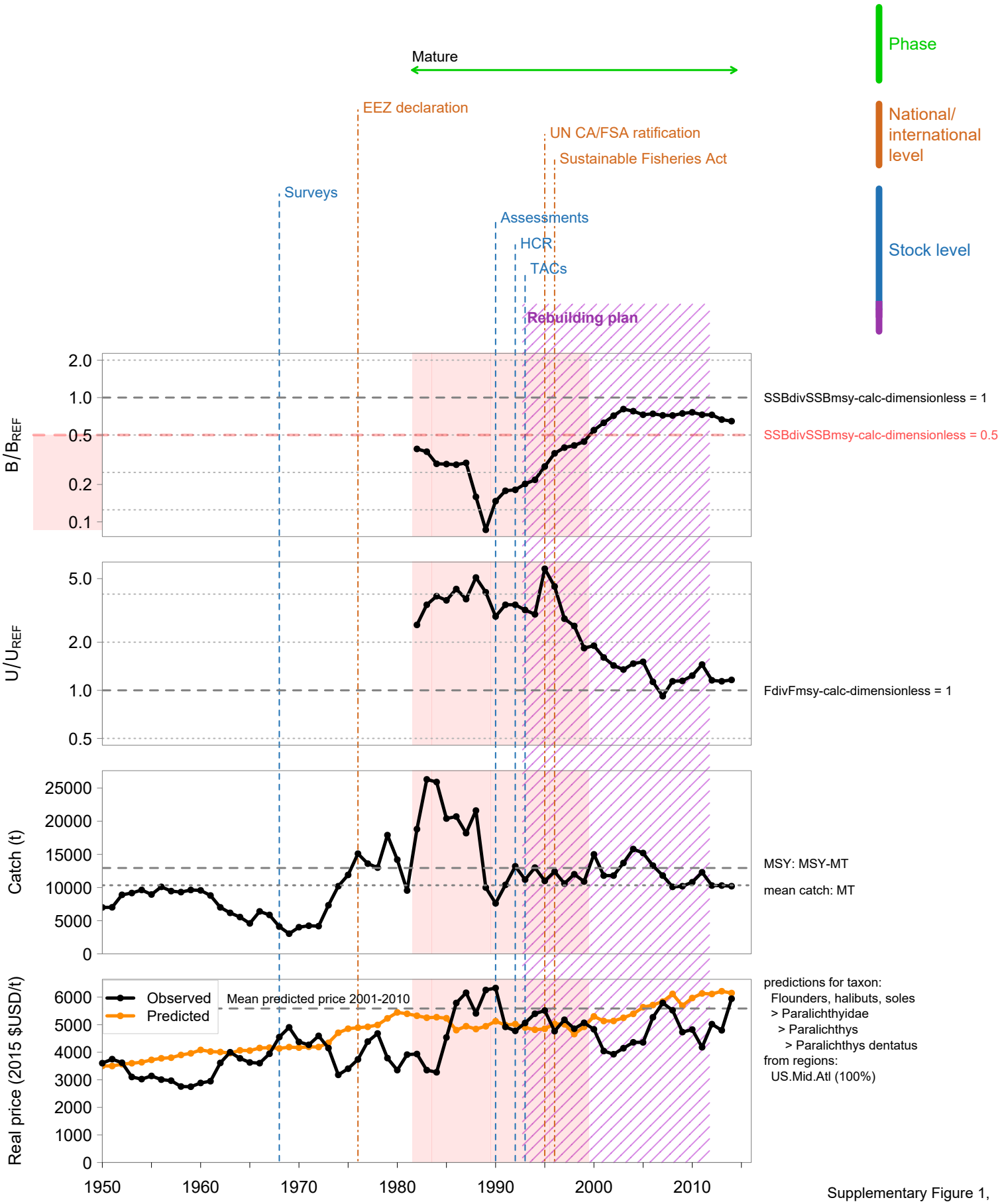
US-Northeast -- SCUPNWATLC -- Scup Northwestern Atlantic Coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



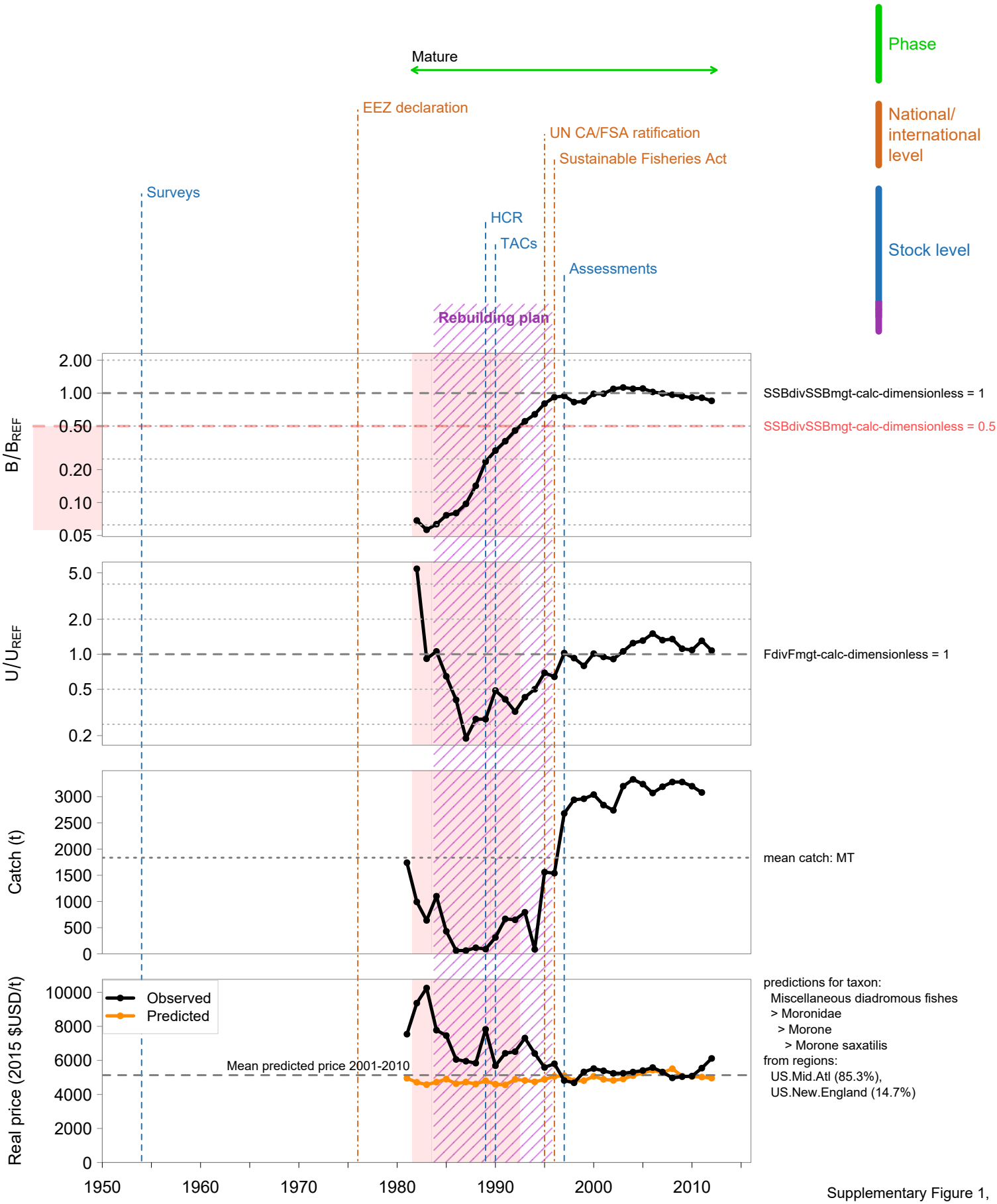
US-Northeast -- SFLOUNMATLC -- Summer flounder Mid-Atlantic Coast

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



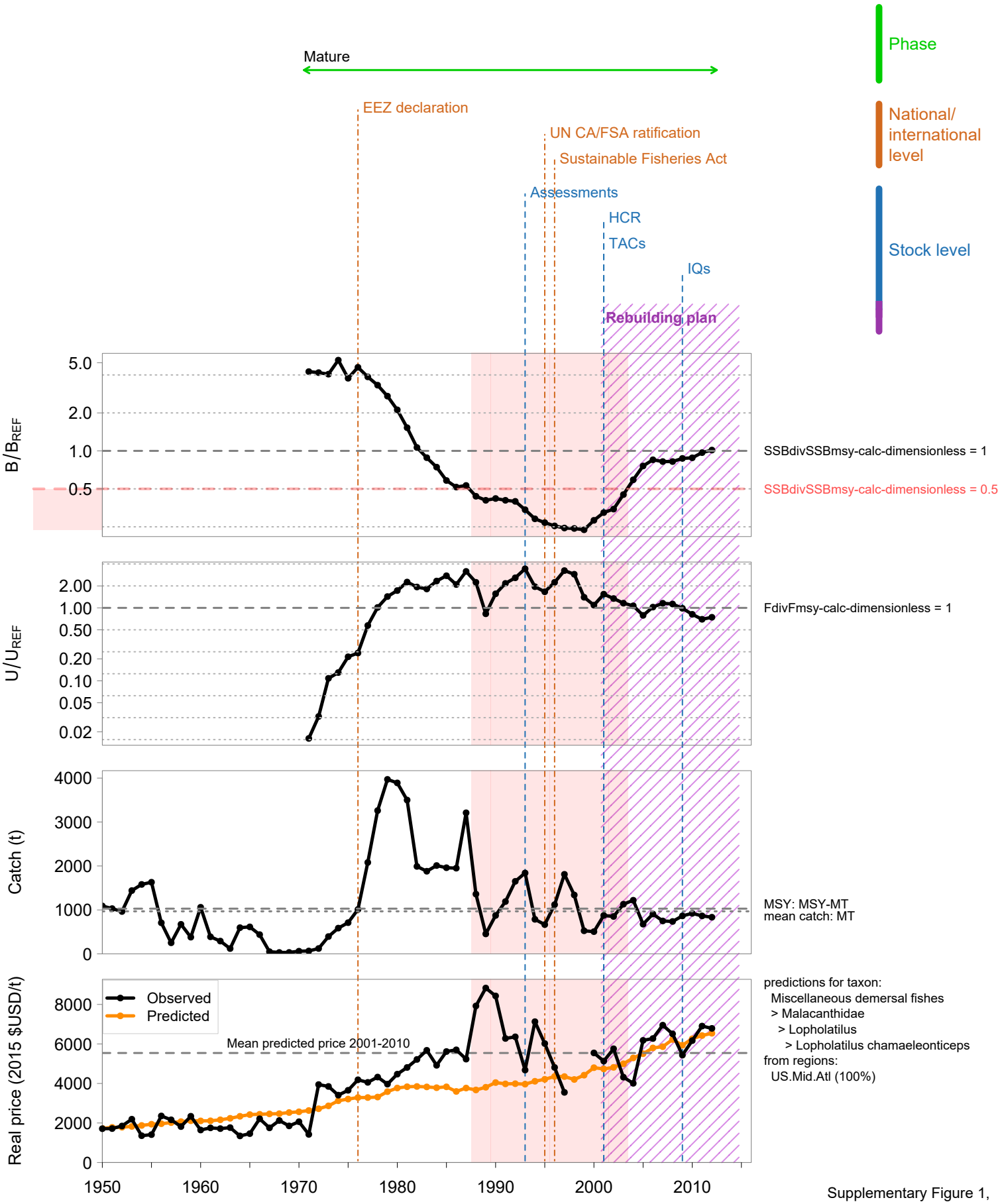
US-Northeast -- STRIPEDBASSGOMCHATT -- Striped bass Gulf of Maine / Cape Hatteras

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: single-species, primary country: USA



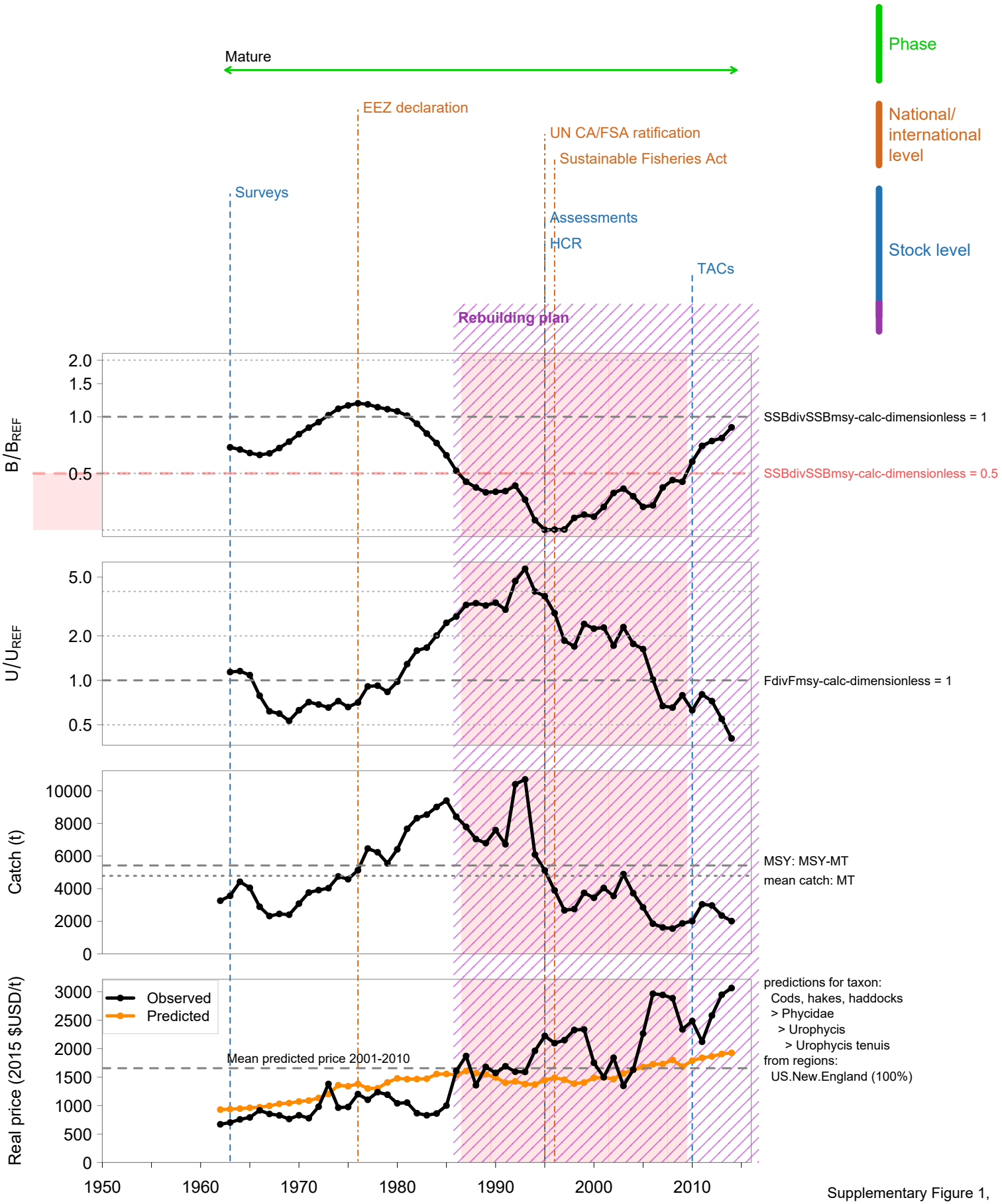
US-Northeast -- TILEMATLC -- Tilefish Mid-Atlantic Coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: single-species, primary country: USA



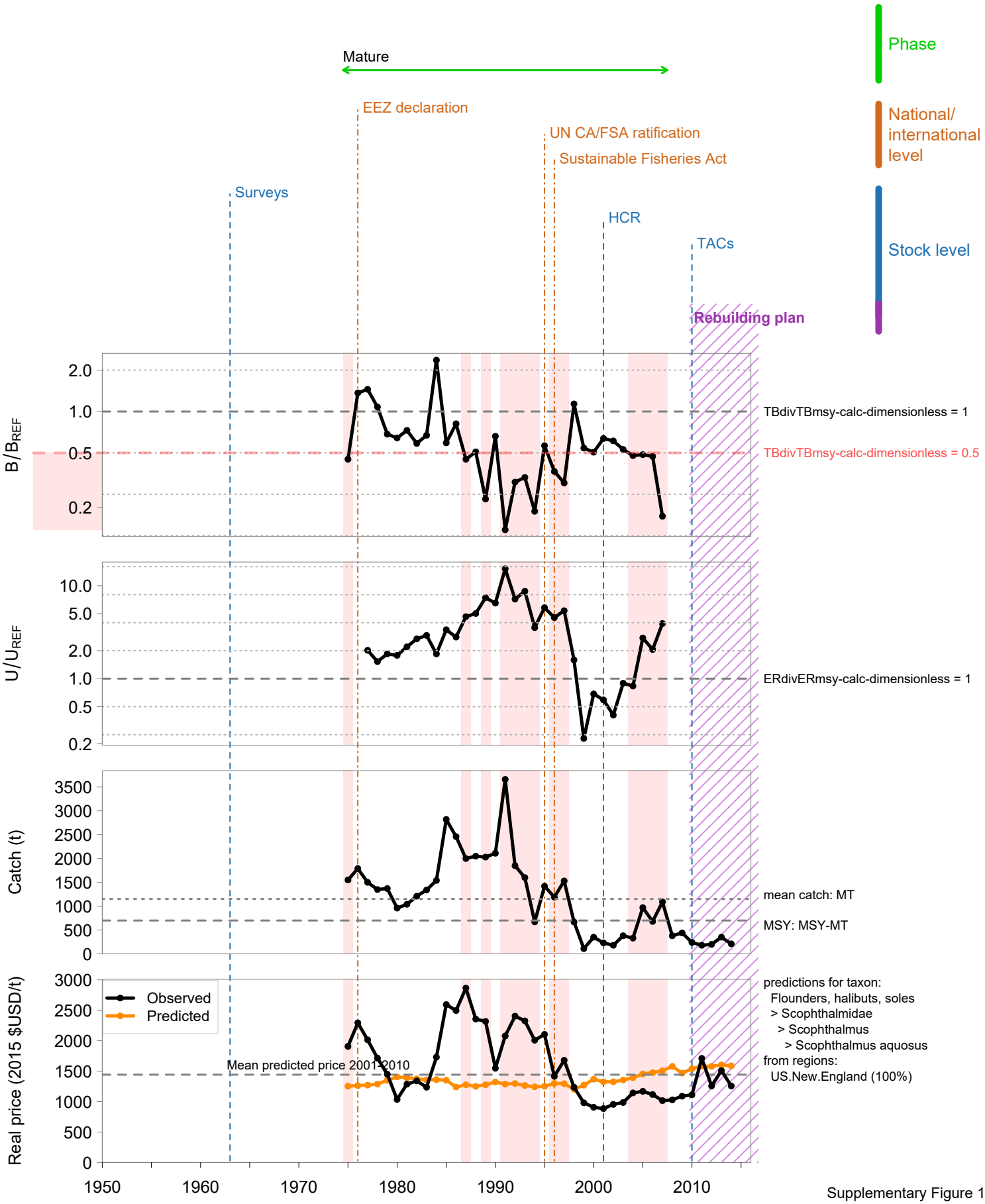
US-Northeast -- WHAKEGBGOM -- White hake Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Gadids), predominant fishery type: mixed-species, primary country: USA



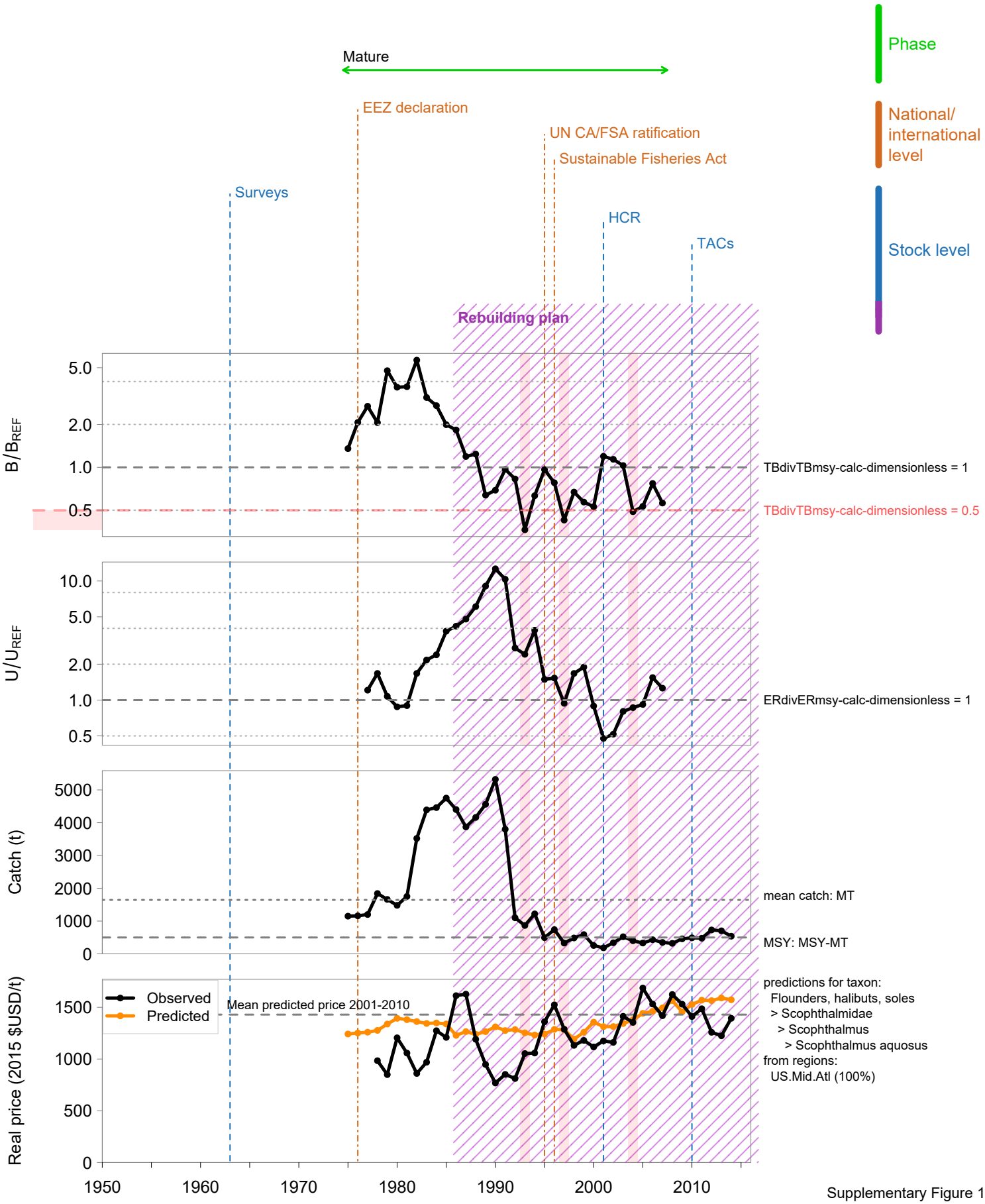
US-Northeast -- WINDOWGOMGB -- Windowpane flounder Gulf of Maine / Georges Bank

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



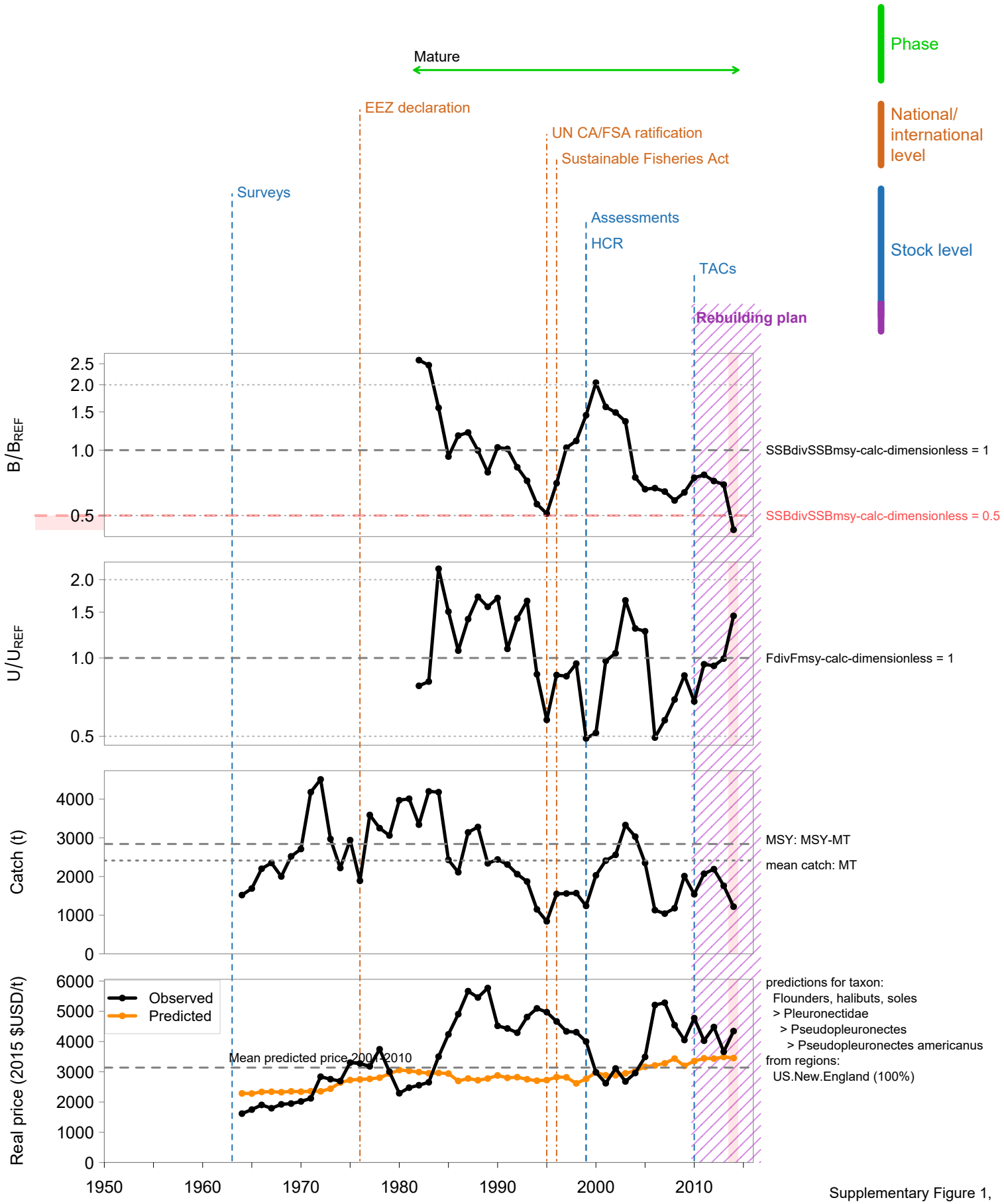
US-Northeast -- WINDOWSNEMATL -- Windowpane flounder Southern New England /Mid Atlantic

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



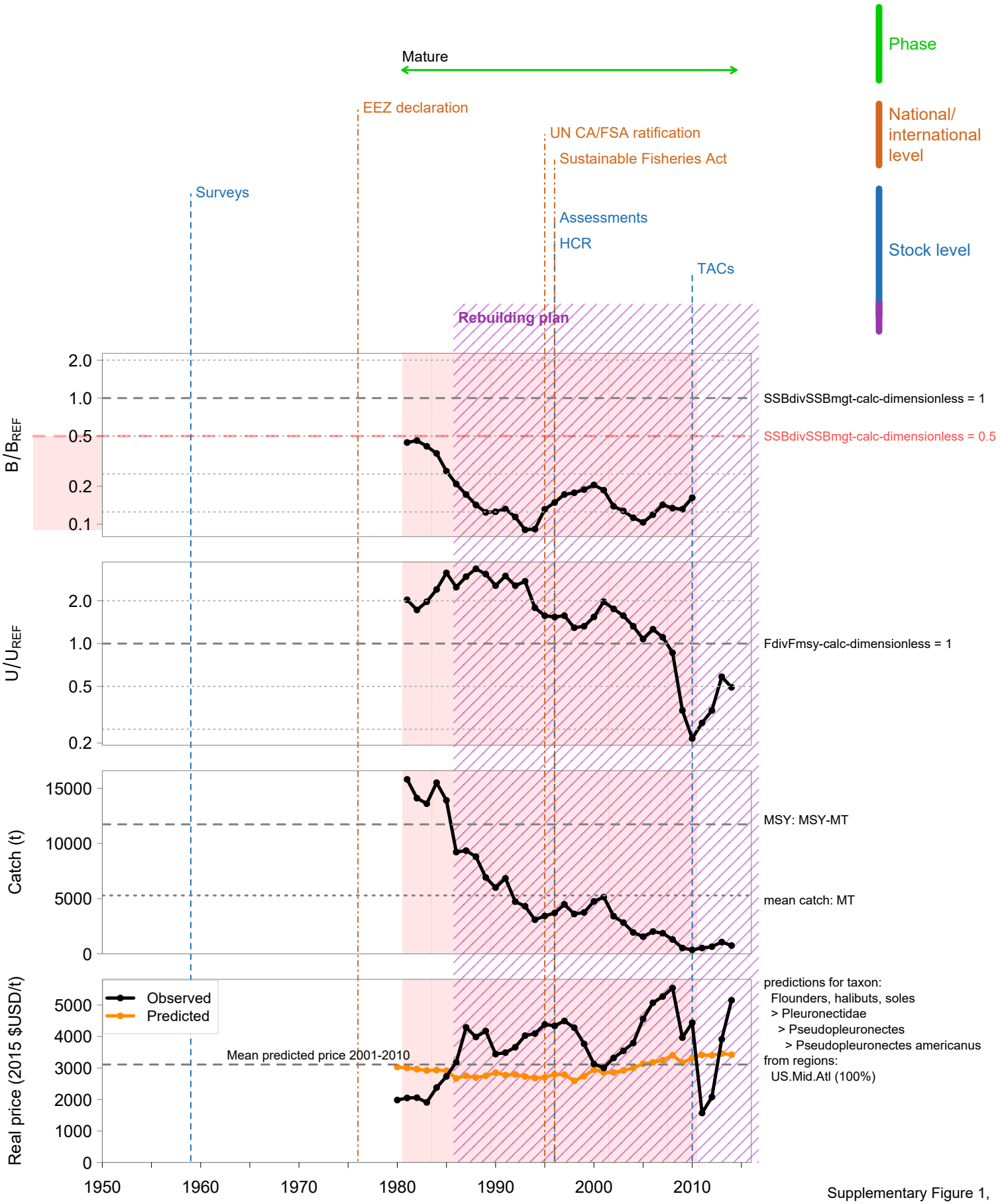
US-Northeast -- WINFLOUN5Z -- Winter flounder Georges Bank

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



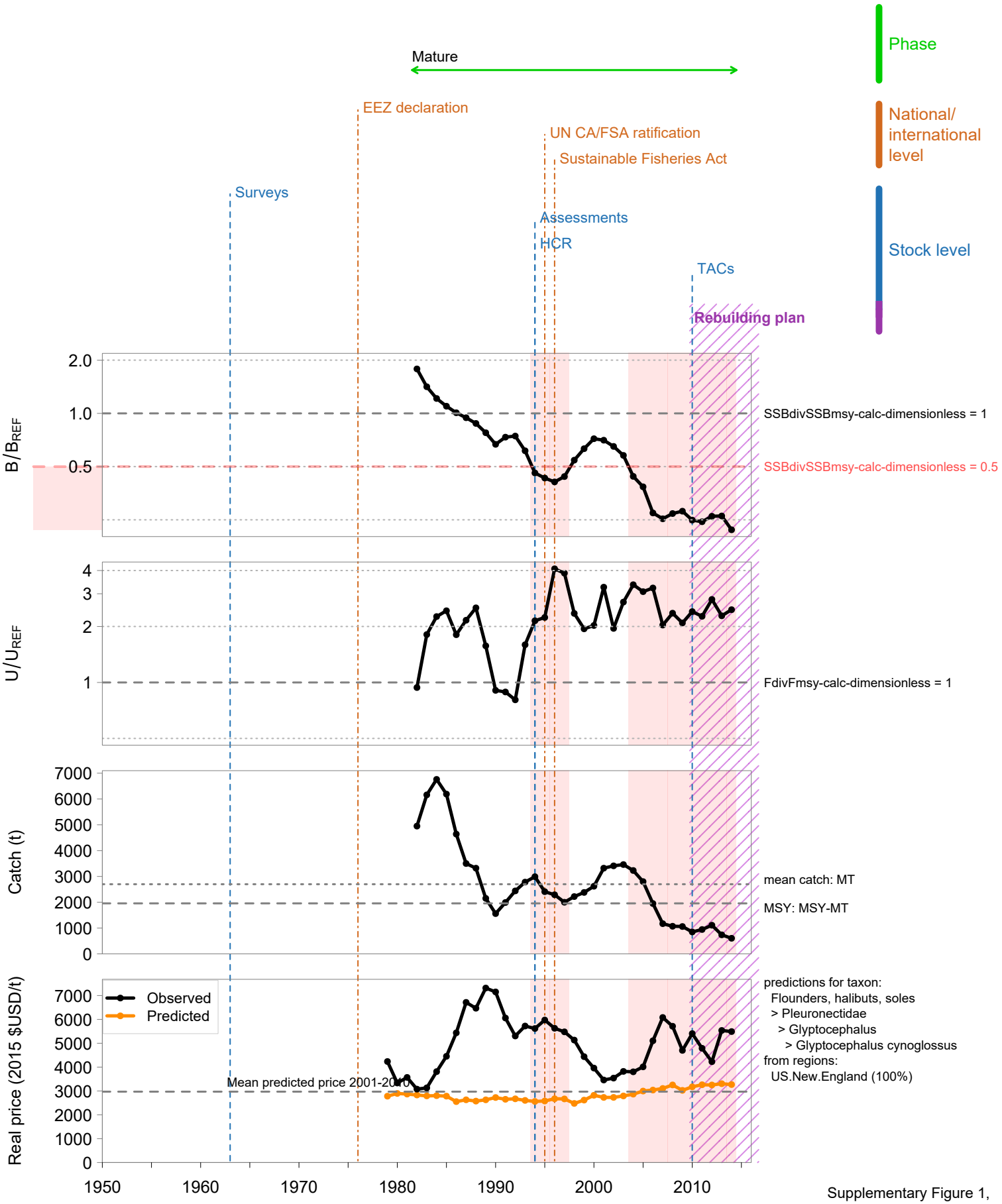
US-Northeast -- WINFLOUNSNEMATL -- Winter flounder Southern New England /Mid Atlantic

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



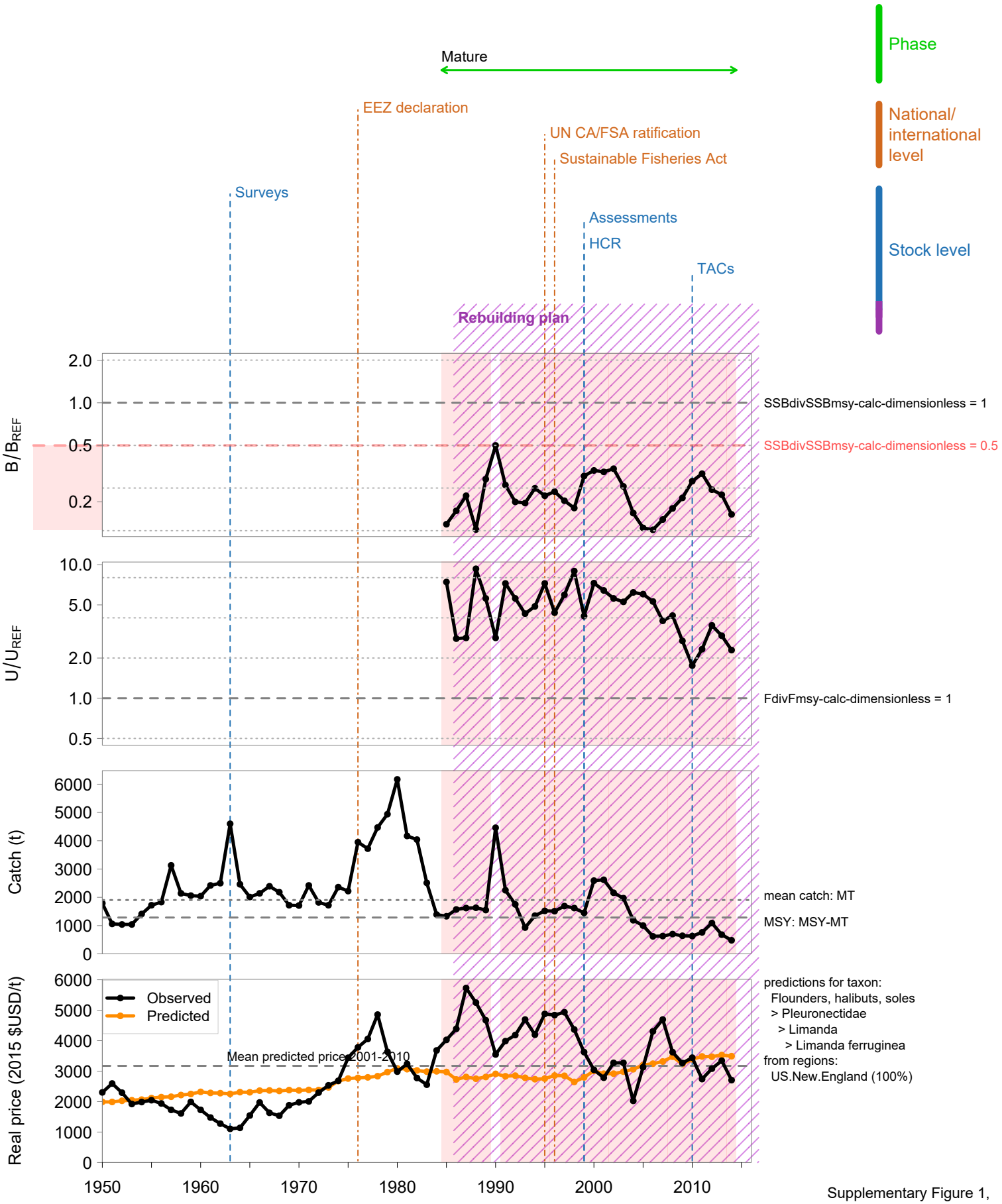
US-Northeast -- WITFLOUN5Y -- Witch flounder Gulf of Maine

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



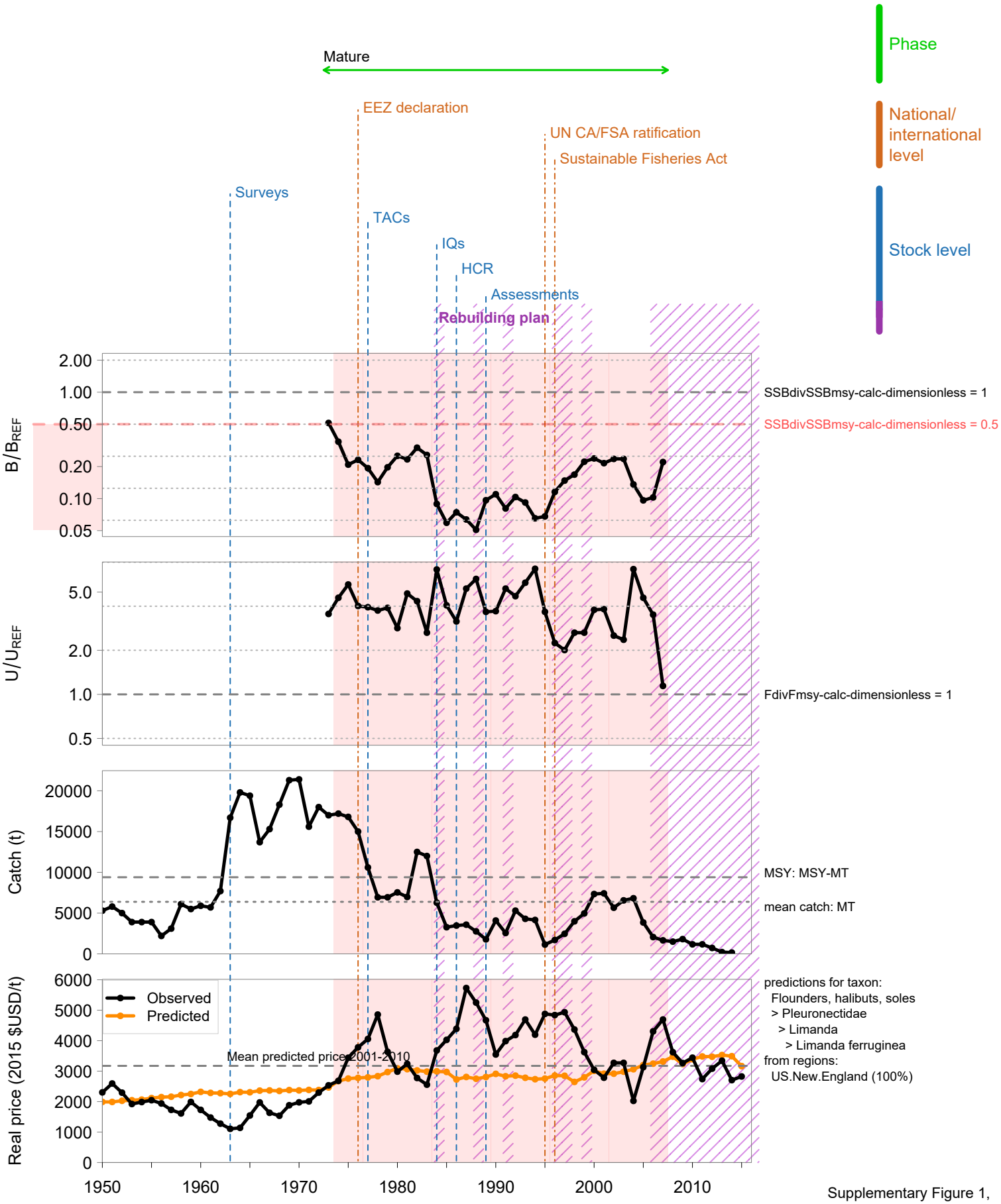
US-Northeast -- YELLCCODGOM -- Yellowtail flounder Cape Cod / Gulf of Maine

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



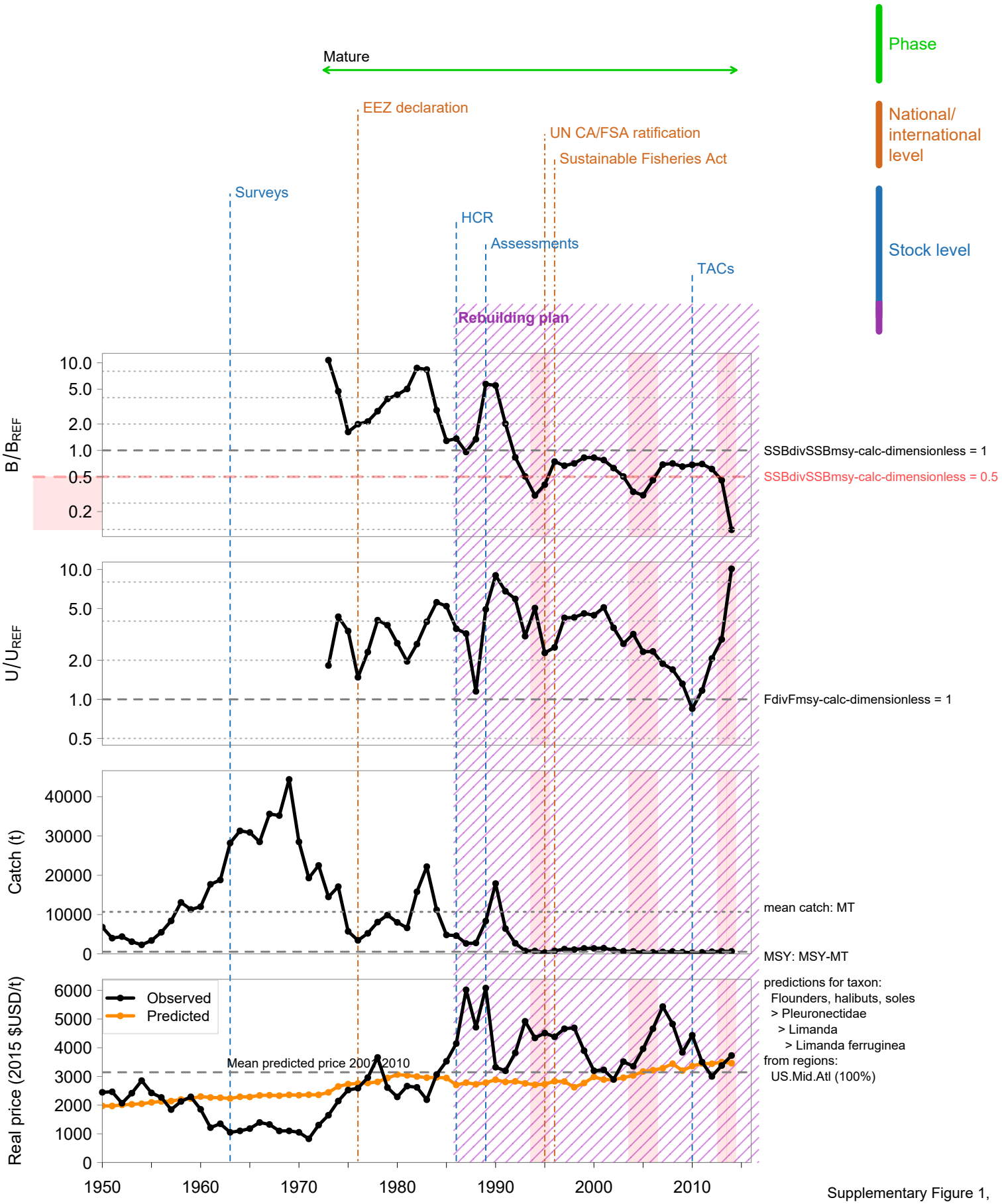
US-Northeast -- YELLGB -- Yellowtail flounder Georges Bank

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



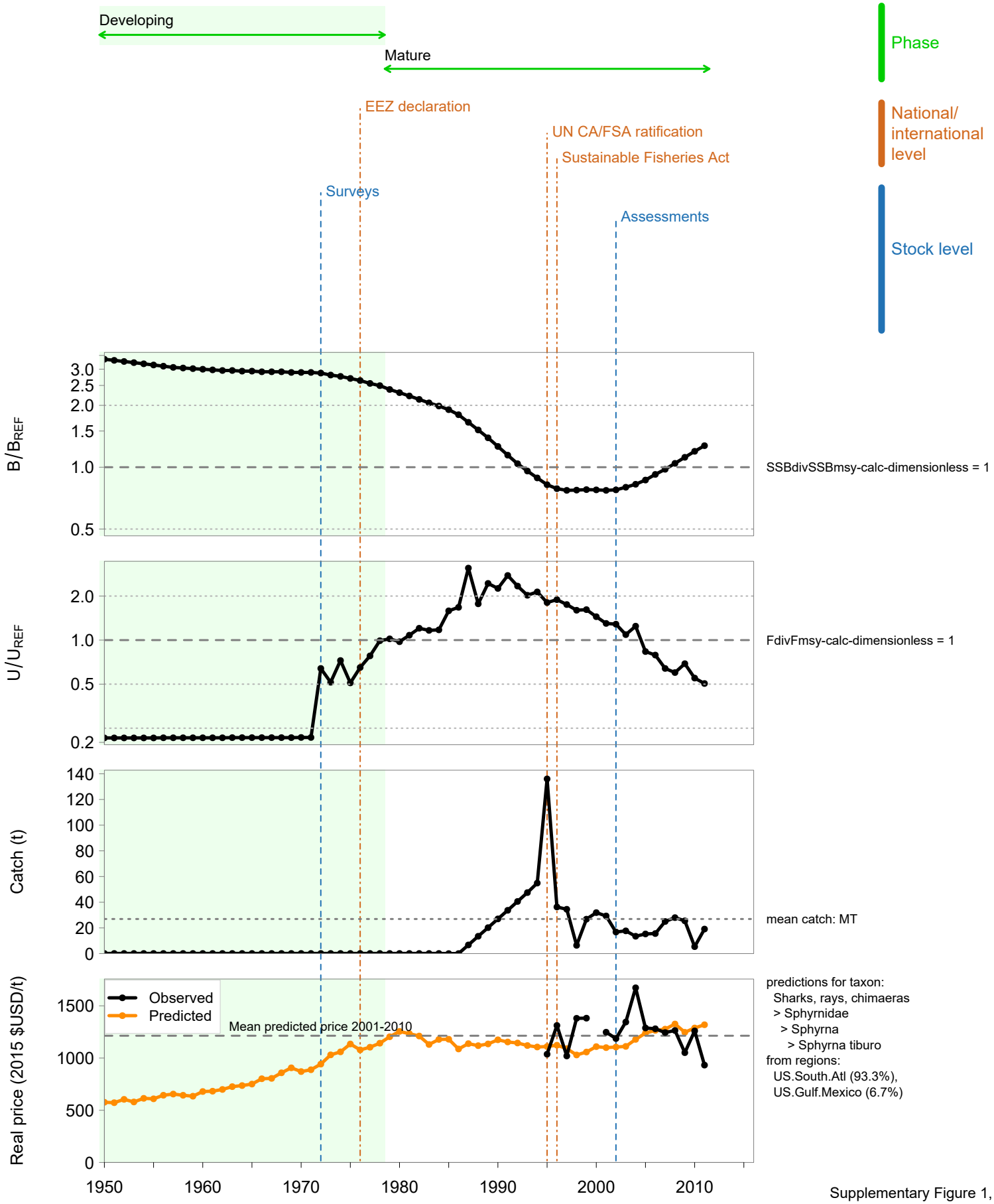
US-Northeast -- YELLSNEMATL -- Yellowtail flounder Southern New England /Mid Atlantic

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



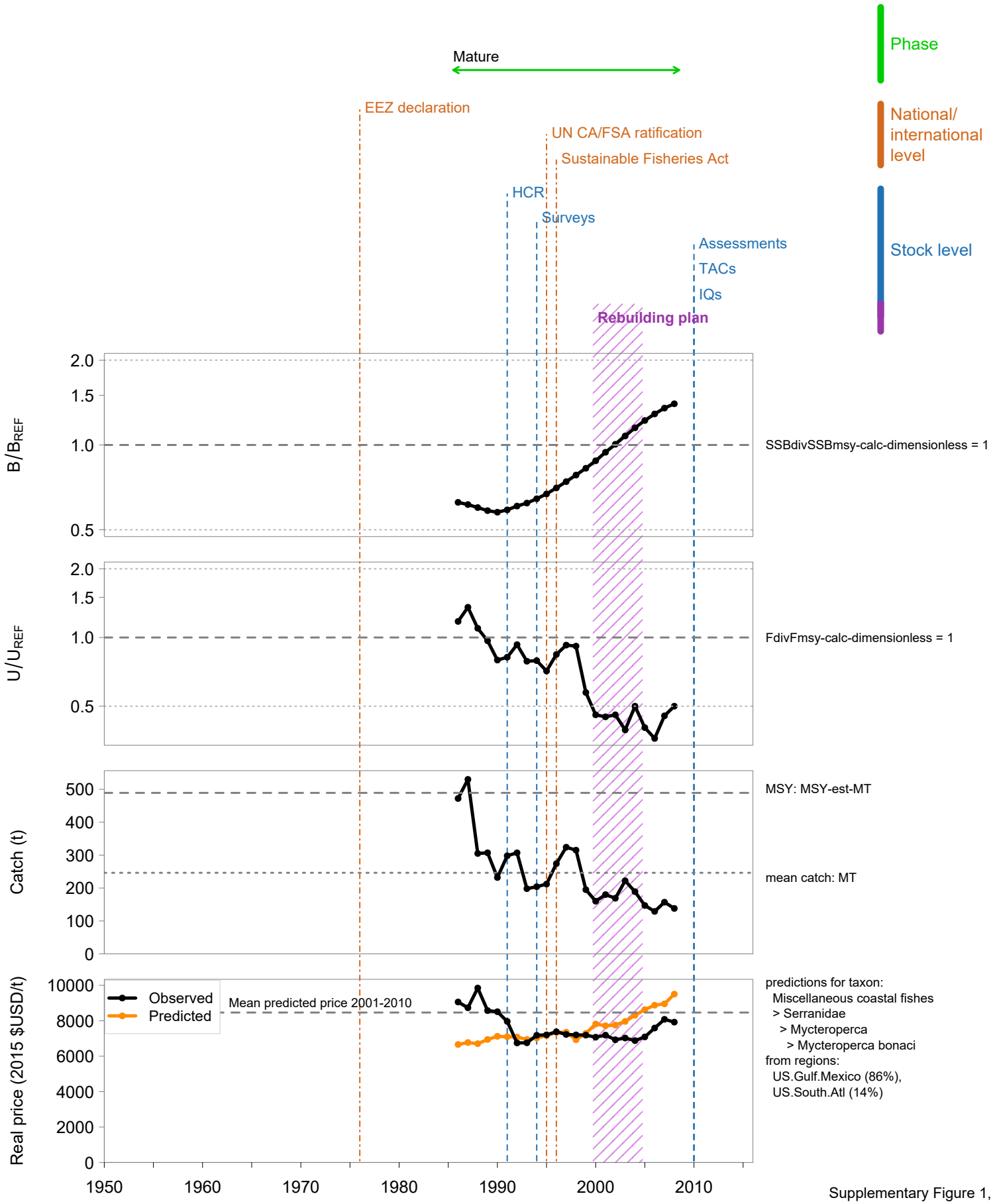
US-Southeast -- BHEADSHARATL -- Bonnethead shark Atlantic

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: USA



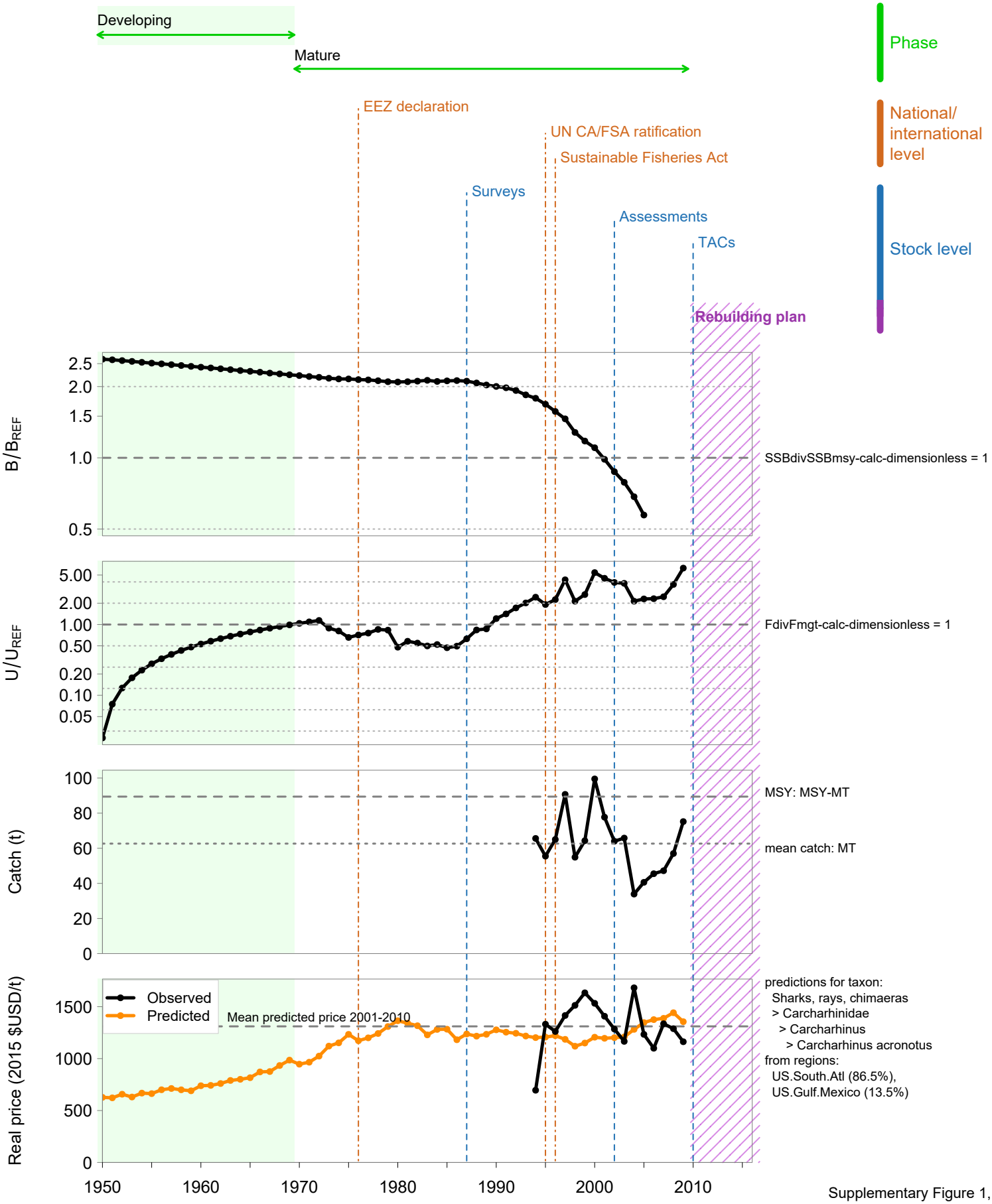
US-Southeast -- BLACKGROUPERGMSATL -- Black grouper Gulf of Mexico and South Atlantic

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



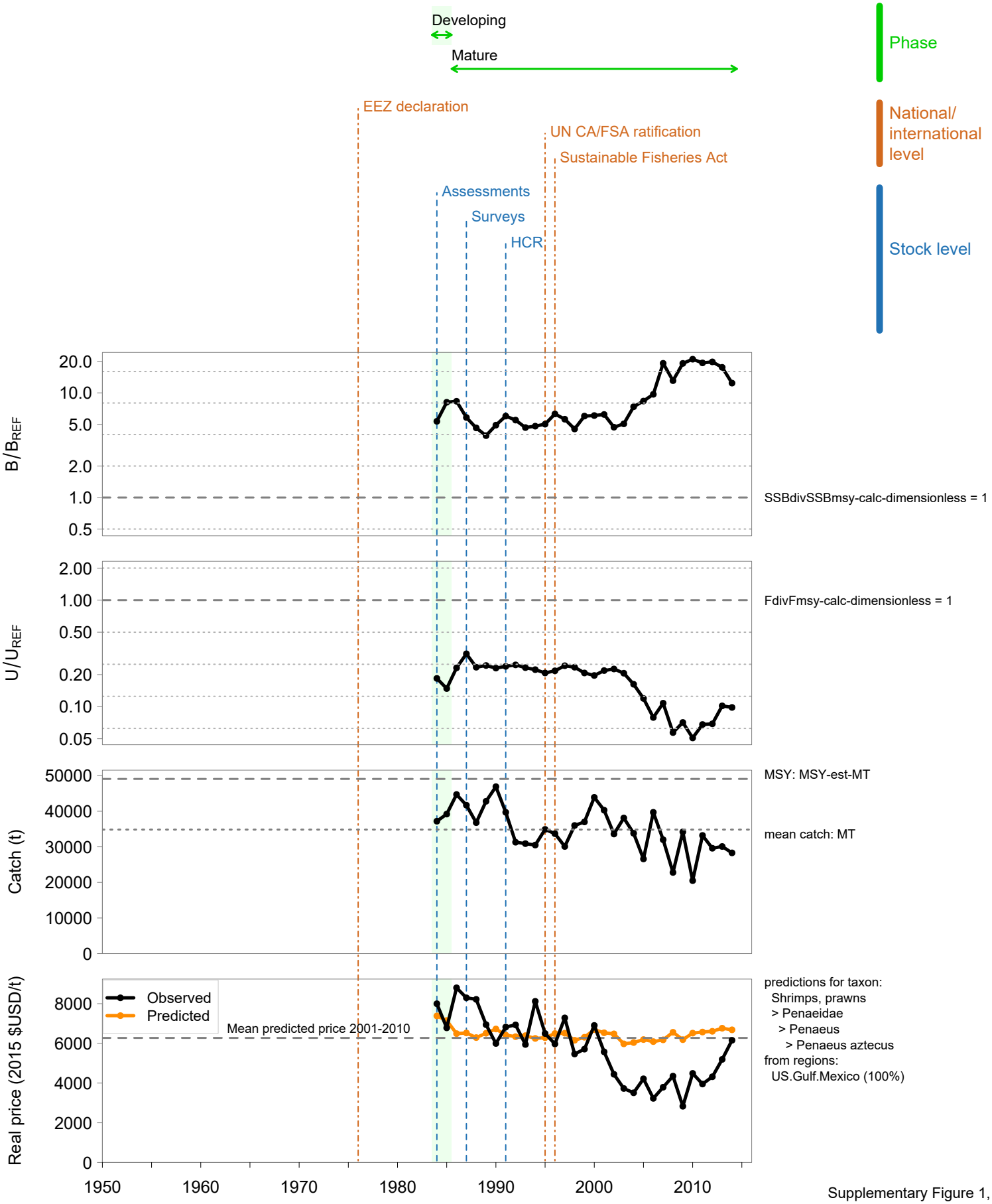
US-Southeast -- BNOSESHARATL -- Blacknose shark Atlantic

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: USA



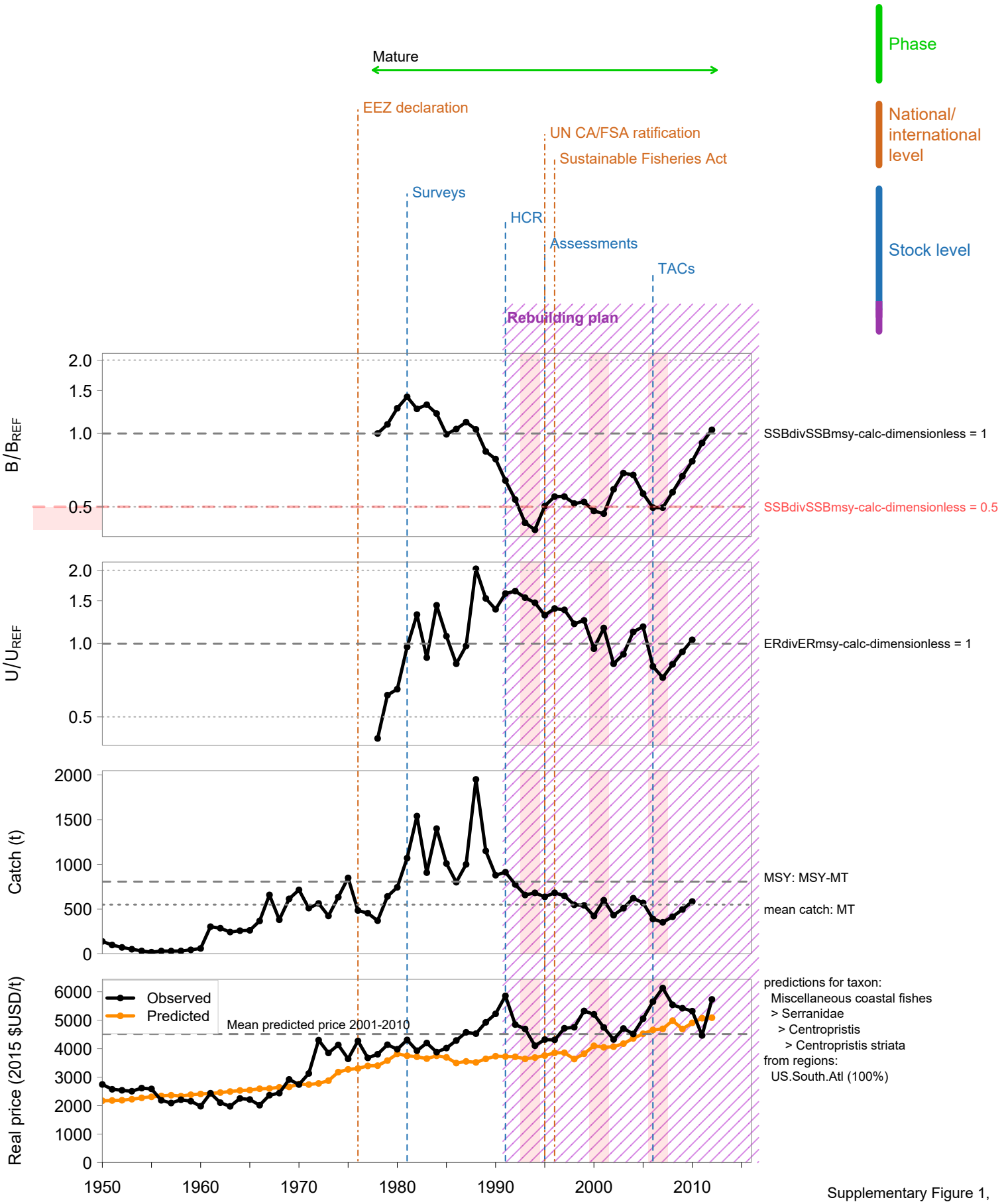
US-Southeast -- BRNSHRIMPGM -- Brown shrimp Gulf of Mexico

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: USA



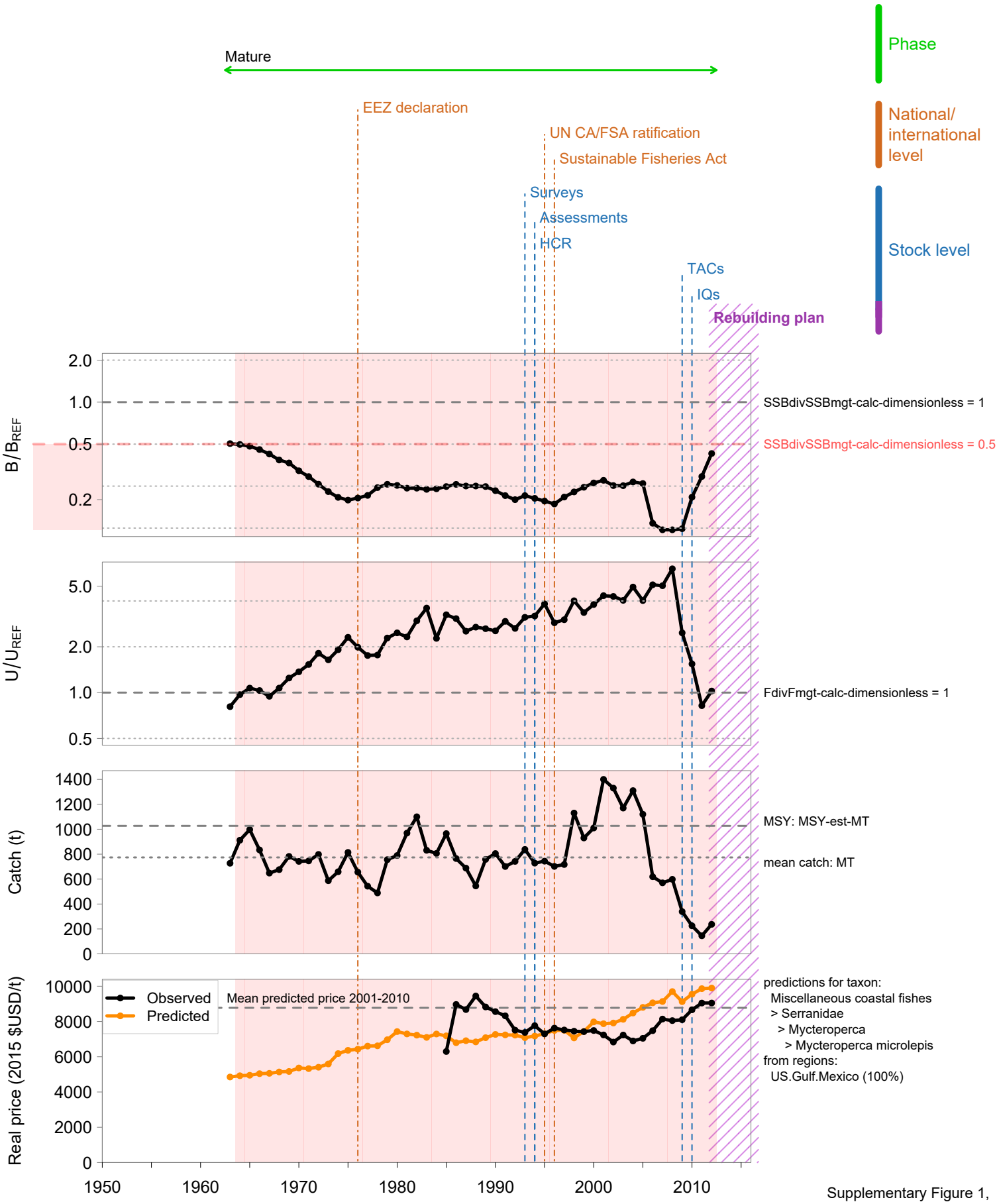
US-Southeast -- BSBASSSATL -- Black sea bass South Atlantic

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



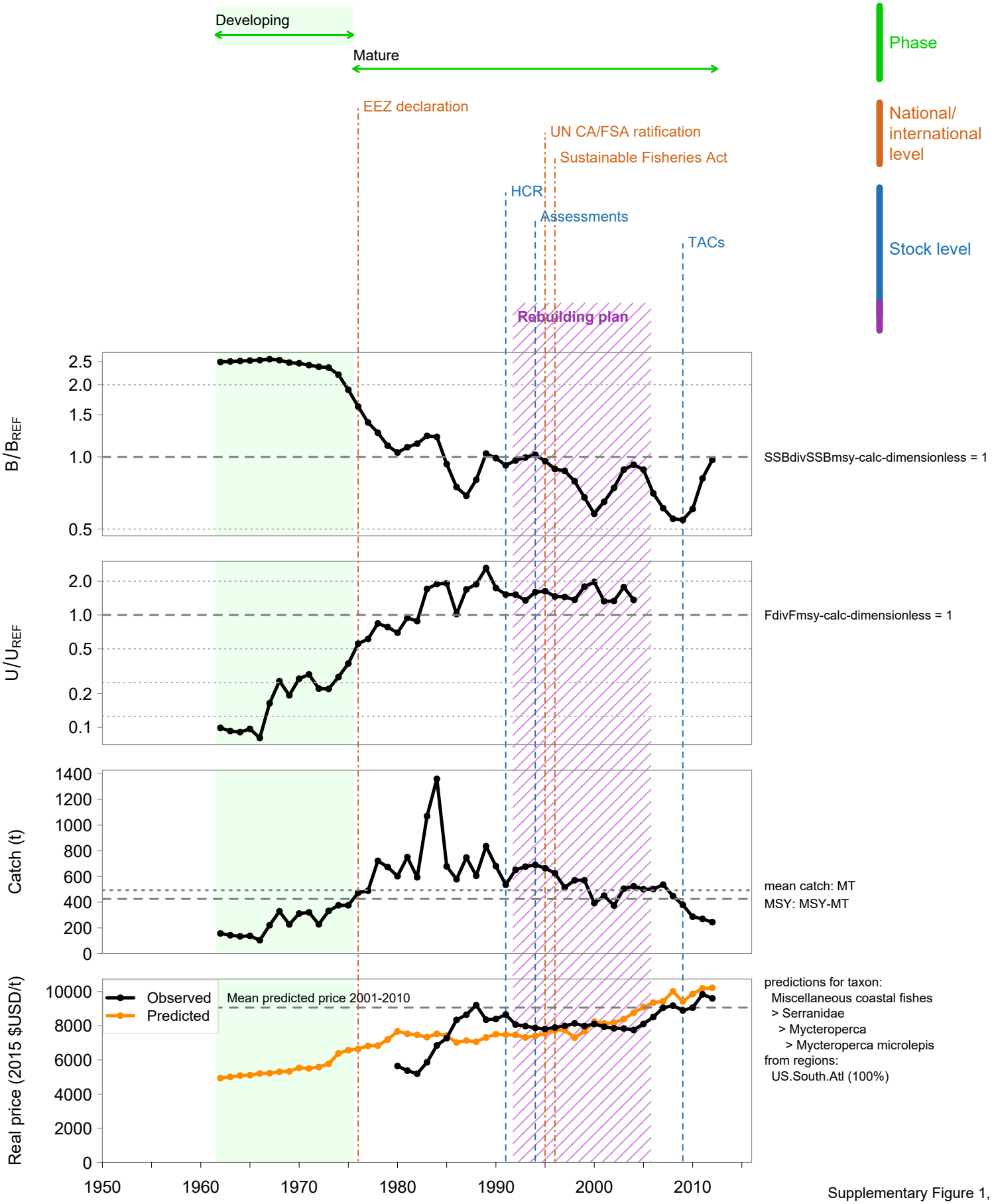
US-Southeast -- GAGGM -- Gag Gulf of Mexico

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



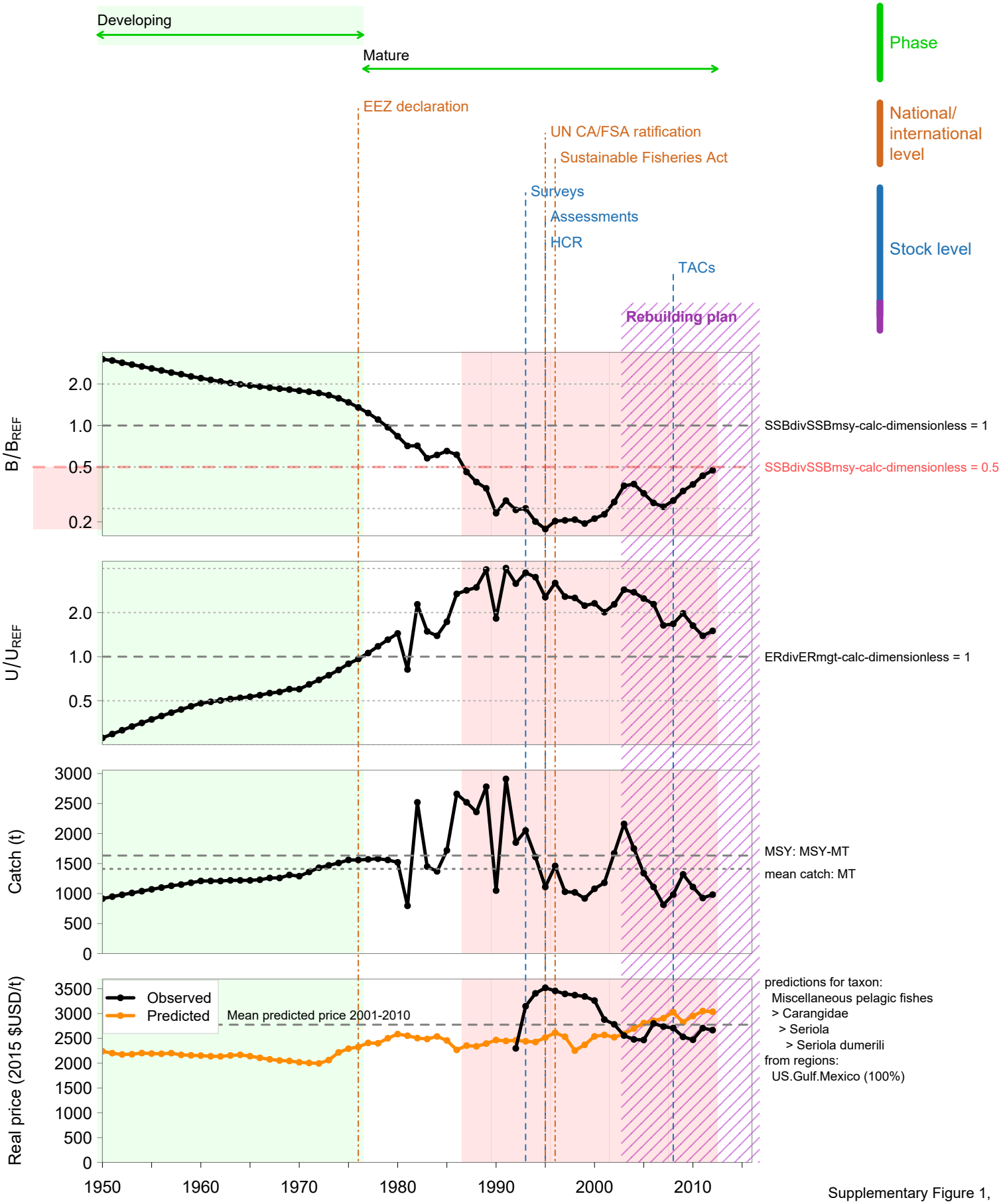
US-Southeast -- GAGSATLC -- Gag Southern Atlantic coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



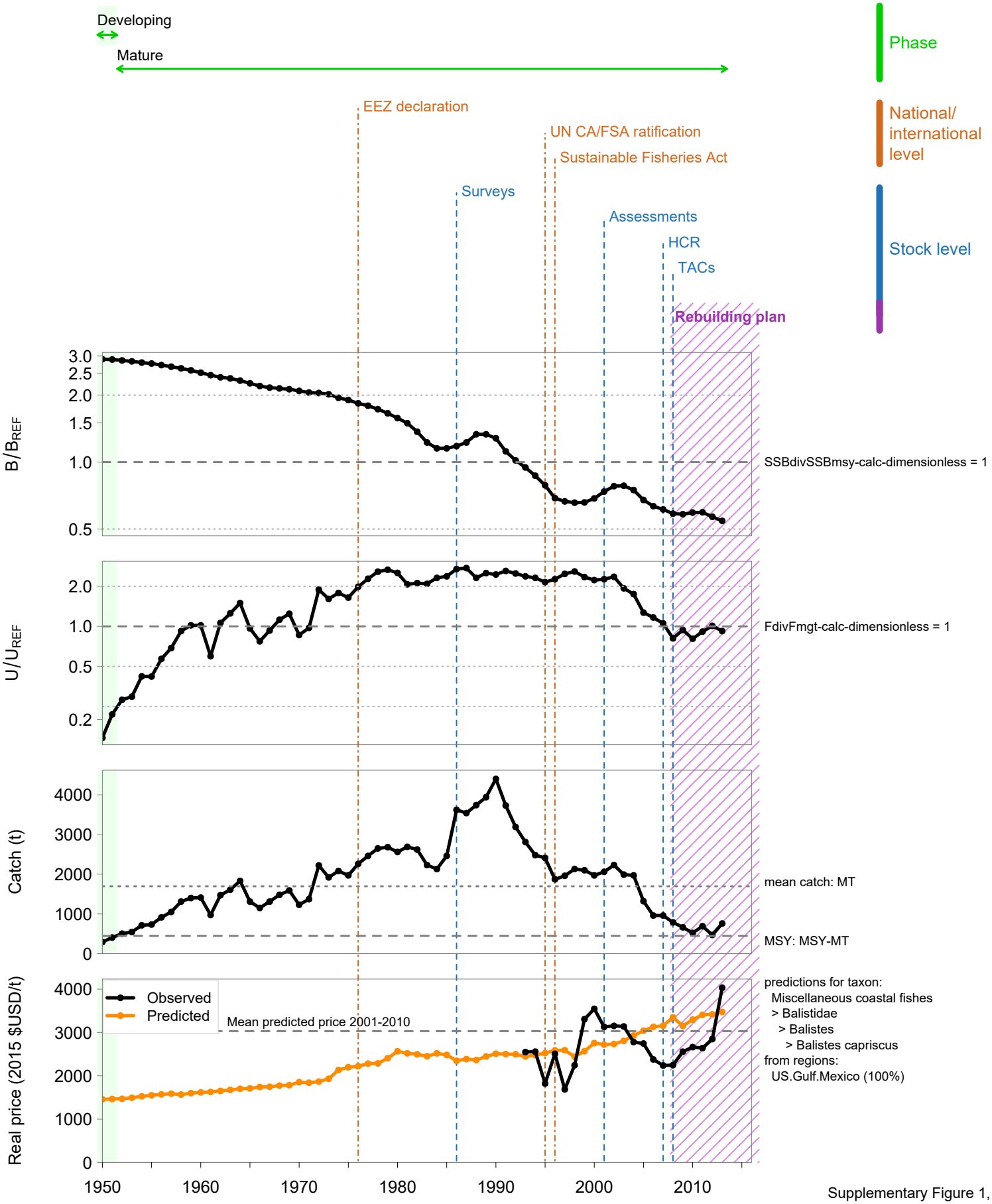
US-Southeast -- GRAMBERGM -- Greater amberjack Gulf of Mexico

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: USA



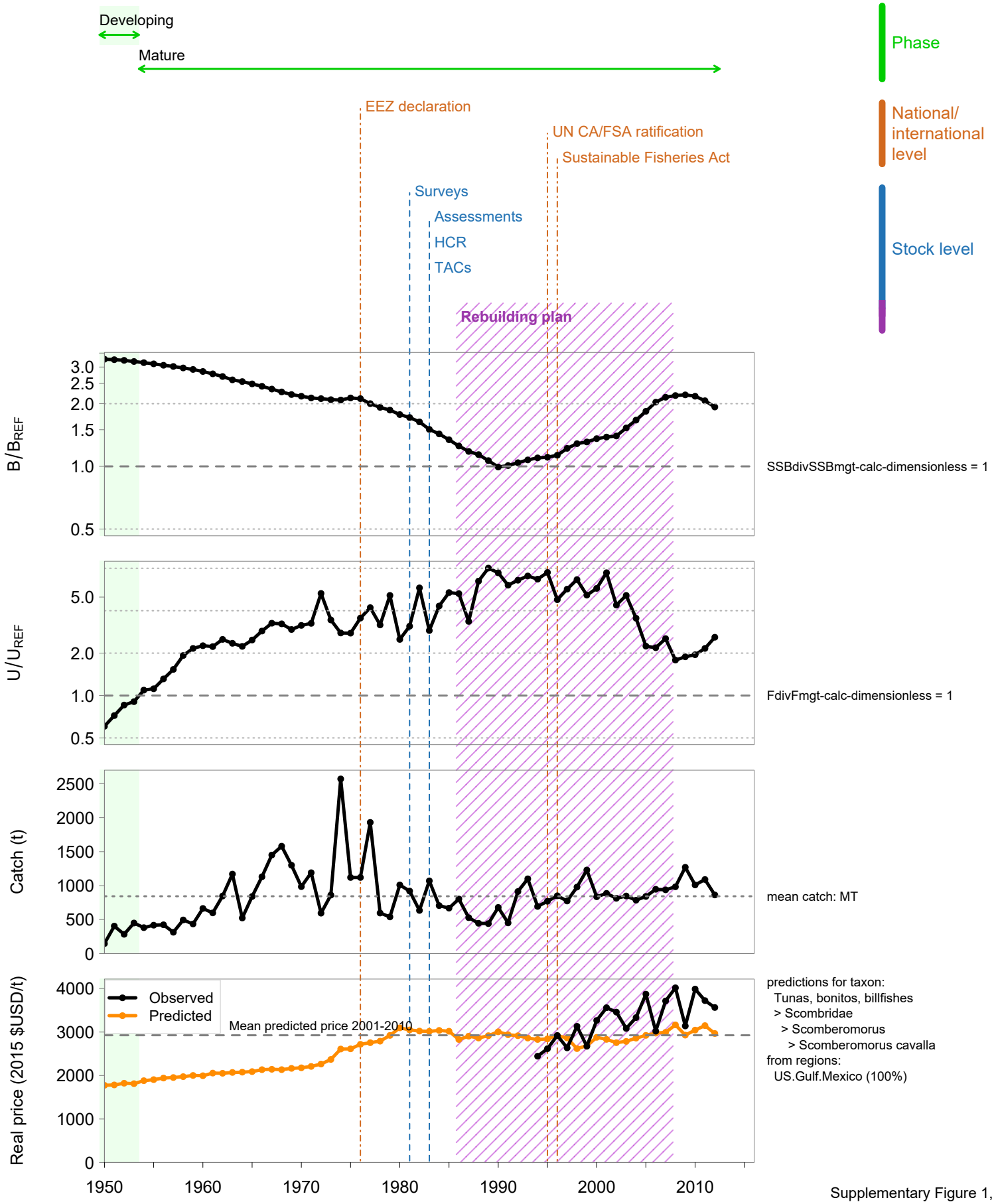
US-Southeast -- GTRIGGM -- Gray triggerfish Gulf of Mexico

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: USA



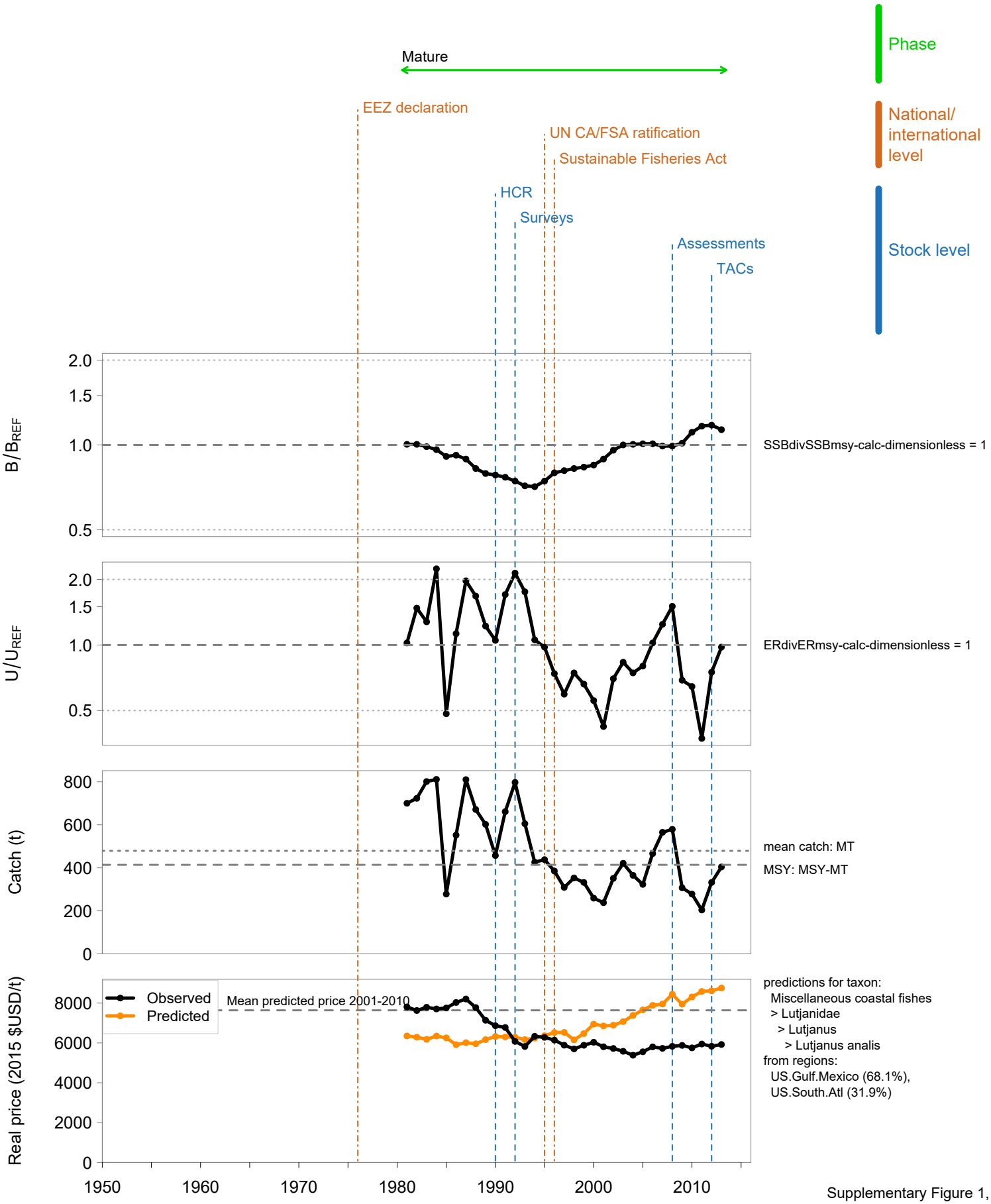
US-Southeast -- KMACKGM -- King mackerel Gulf of Mexico

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: USA



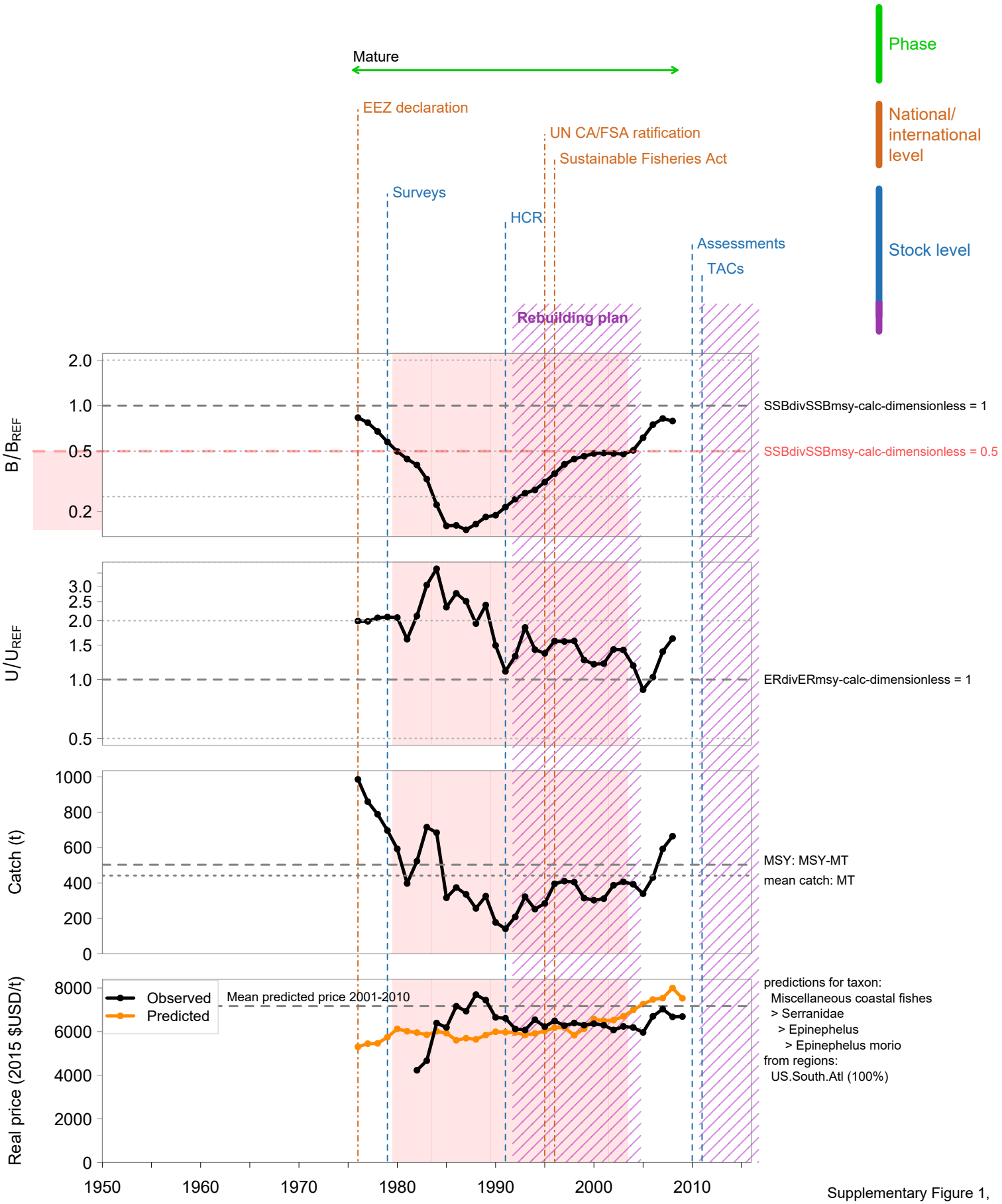
US-Southeast -- MUTSNAPSATLCGM -- Mutton snapper Southern Atlantic coast and Gulf of Mexico

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



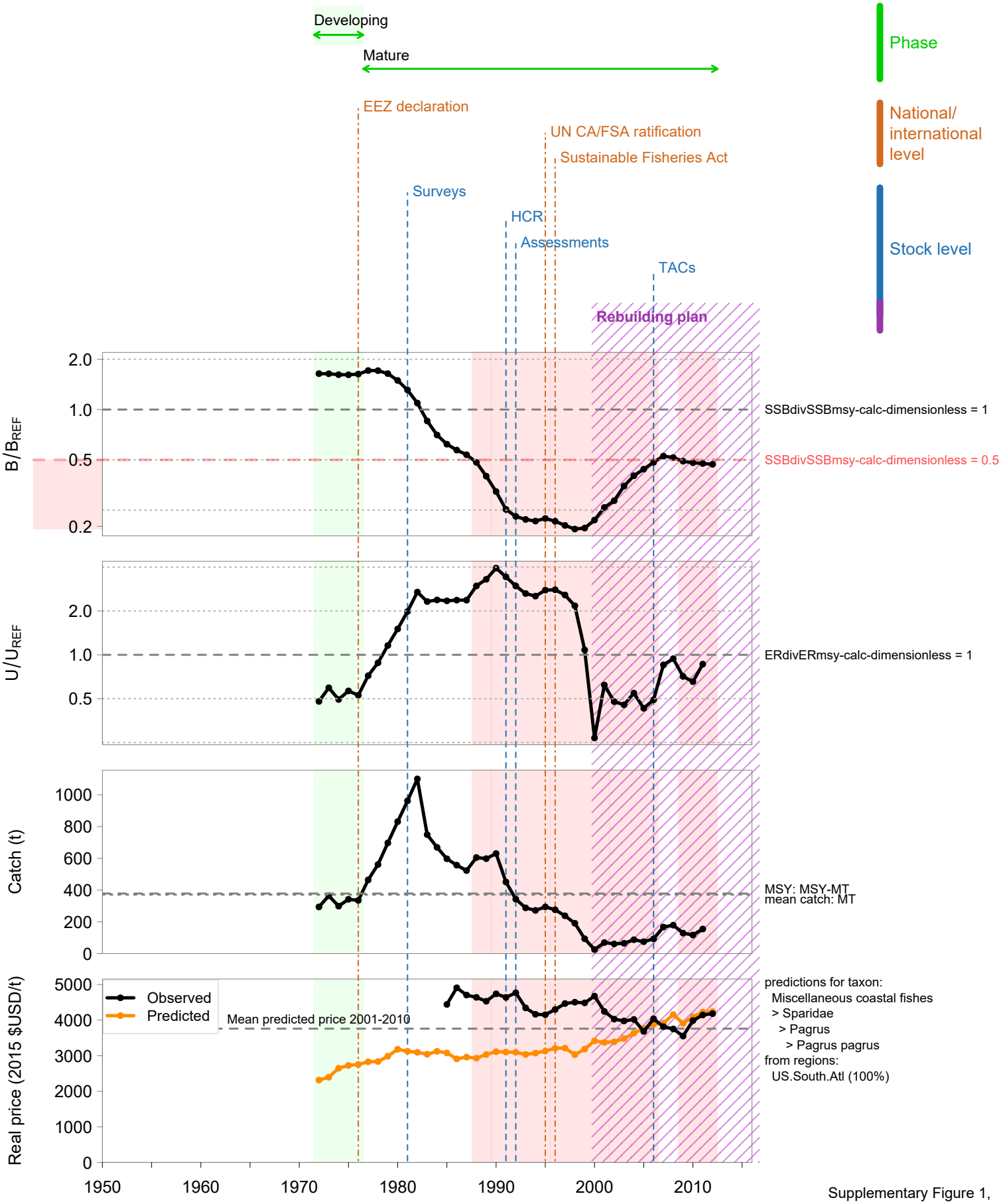
US-Southeast -- RGROUPSATL -- Red grouper South Atlantic

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



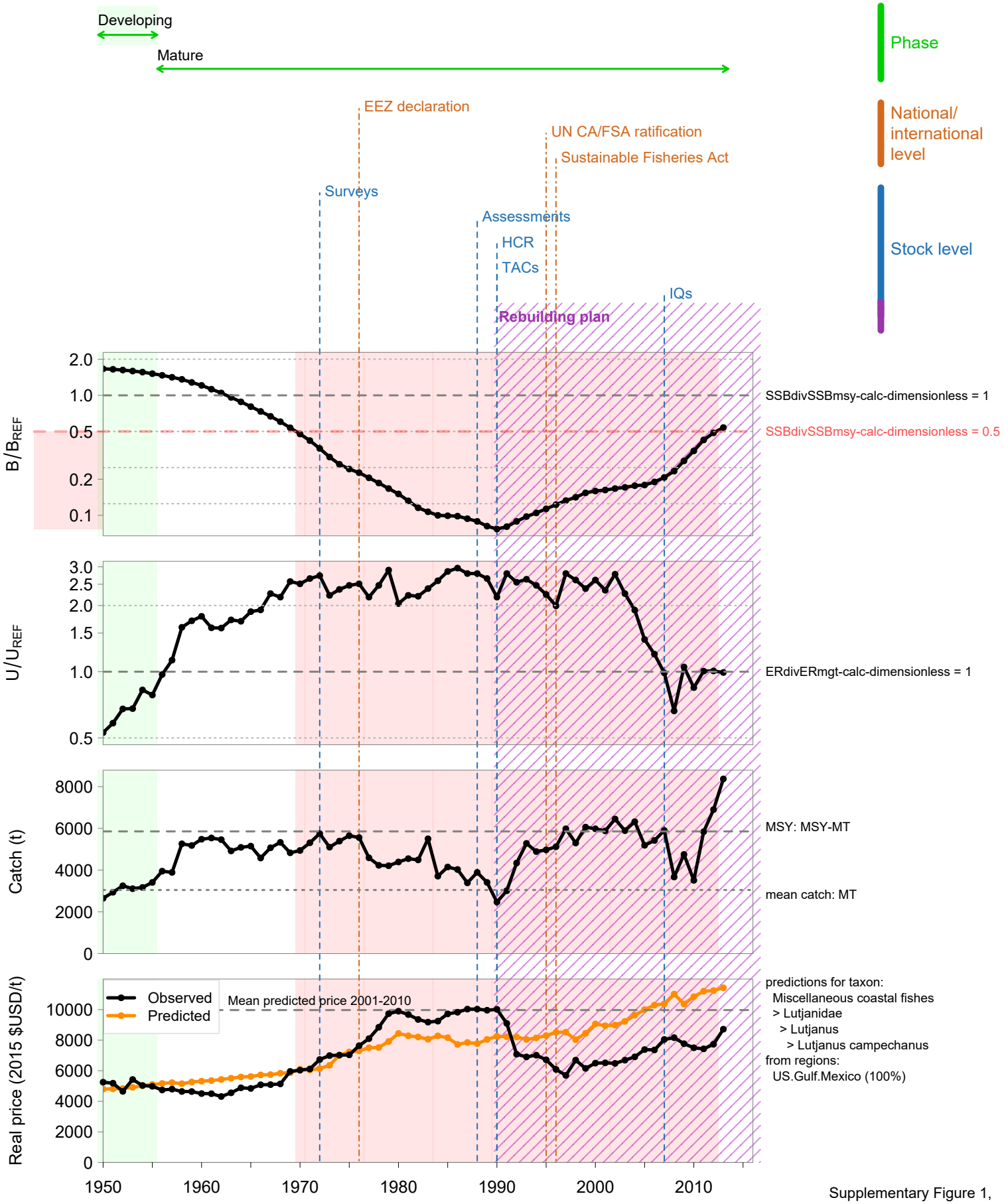
US-Southeast -- RPORGYSATLC -- Red porgy Southern Atlantic coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



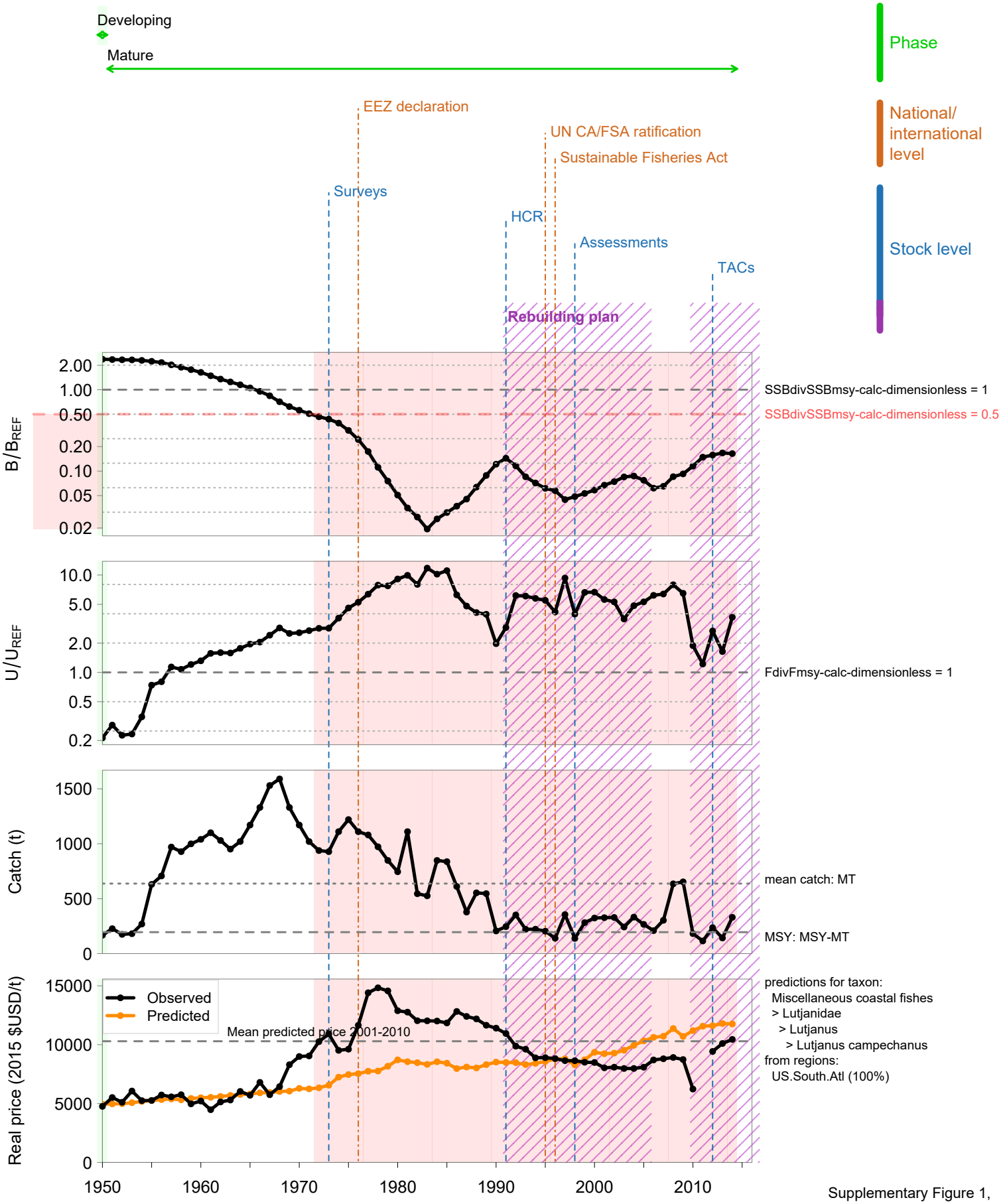
US-Southeast -- RSNAPGM -- Red snapper Gulf of Mexico

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



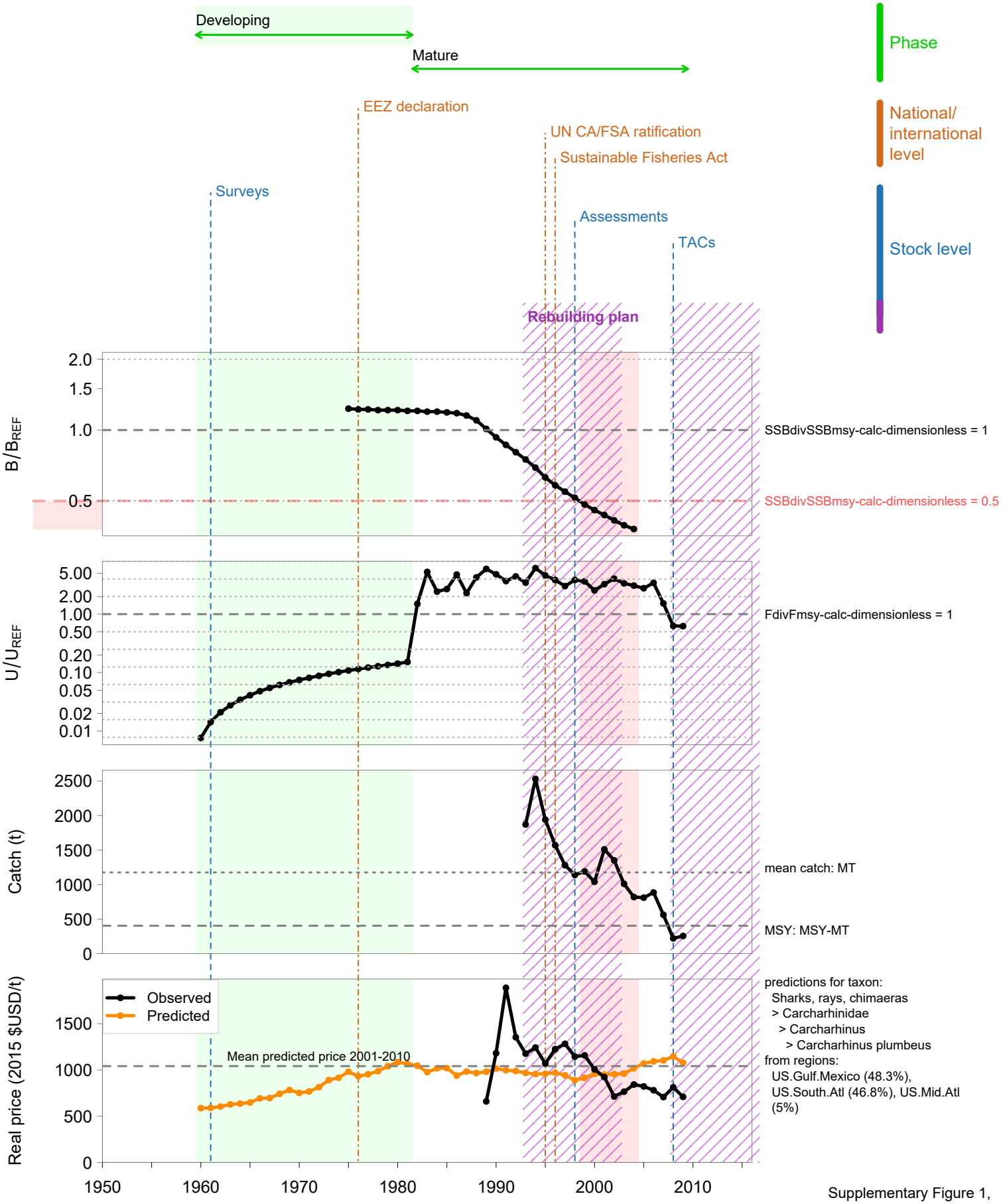
US-Southeast -- RSNAPSATLC -- Red snapper Southern Atlantic coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



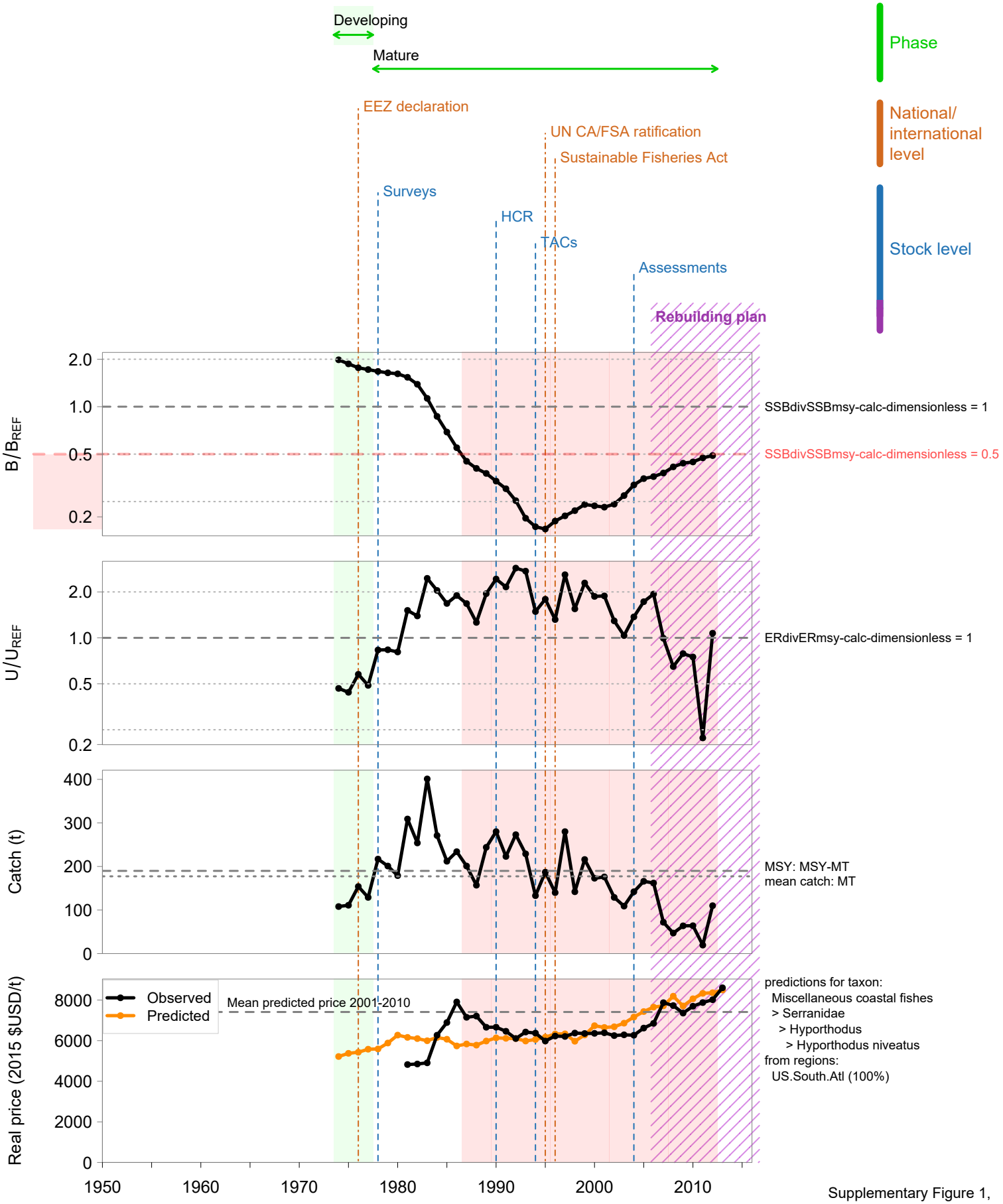
US-Southeast -- SBARSHARATL -- Sandbar shark Atlantic

taxonomic group: demersal fish (Other marine fish), predominant fishery type: mixed-species, primary country: USA



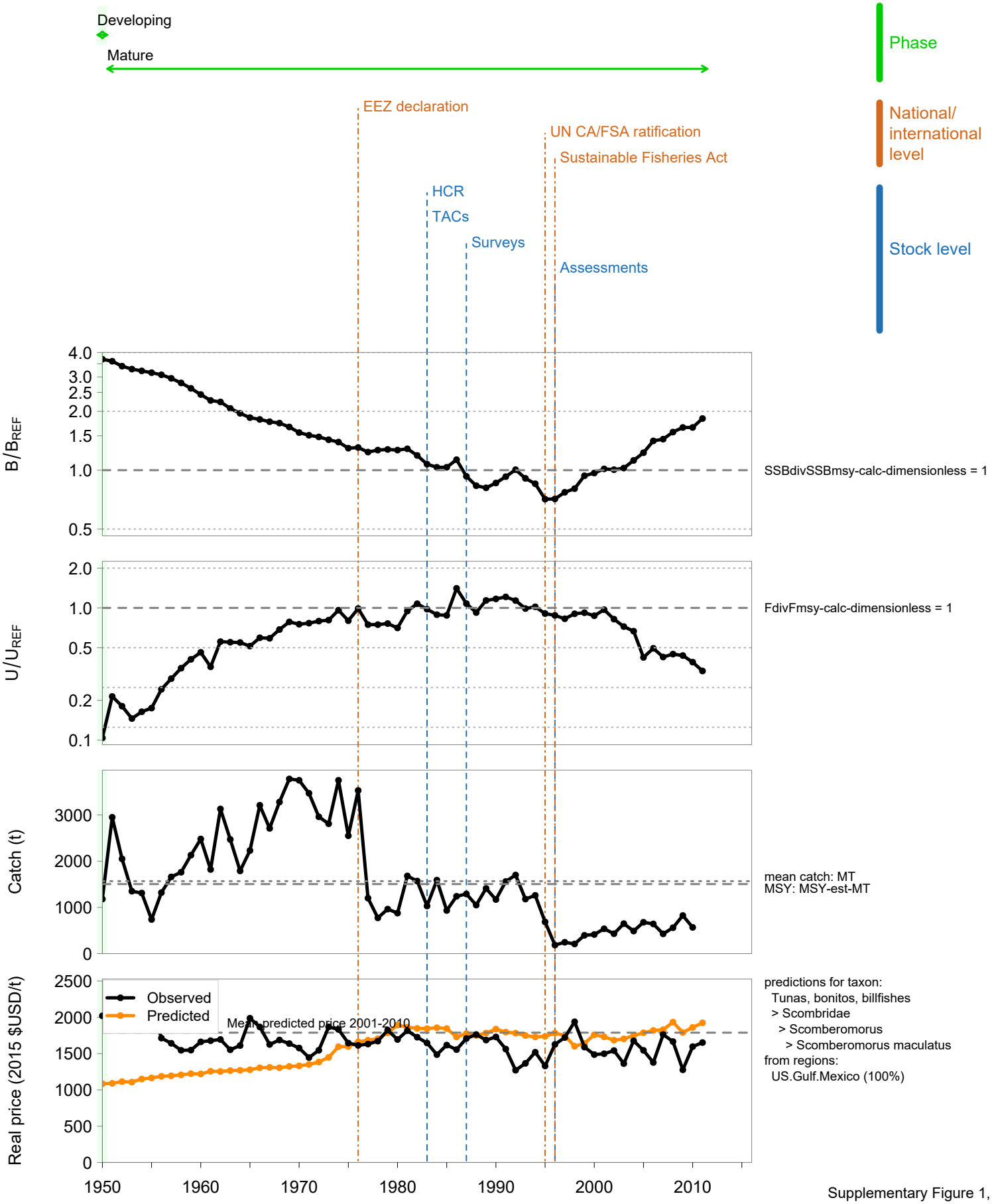
US-Southeast -- SNOWGROUPSATLC -- Snowy grouper Southern Atlantic coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



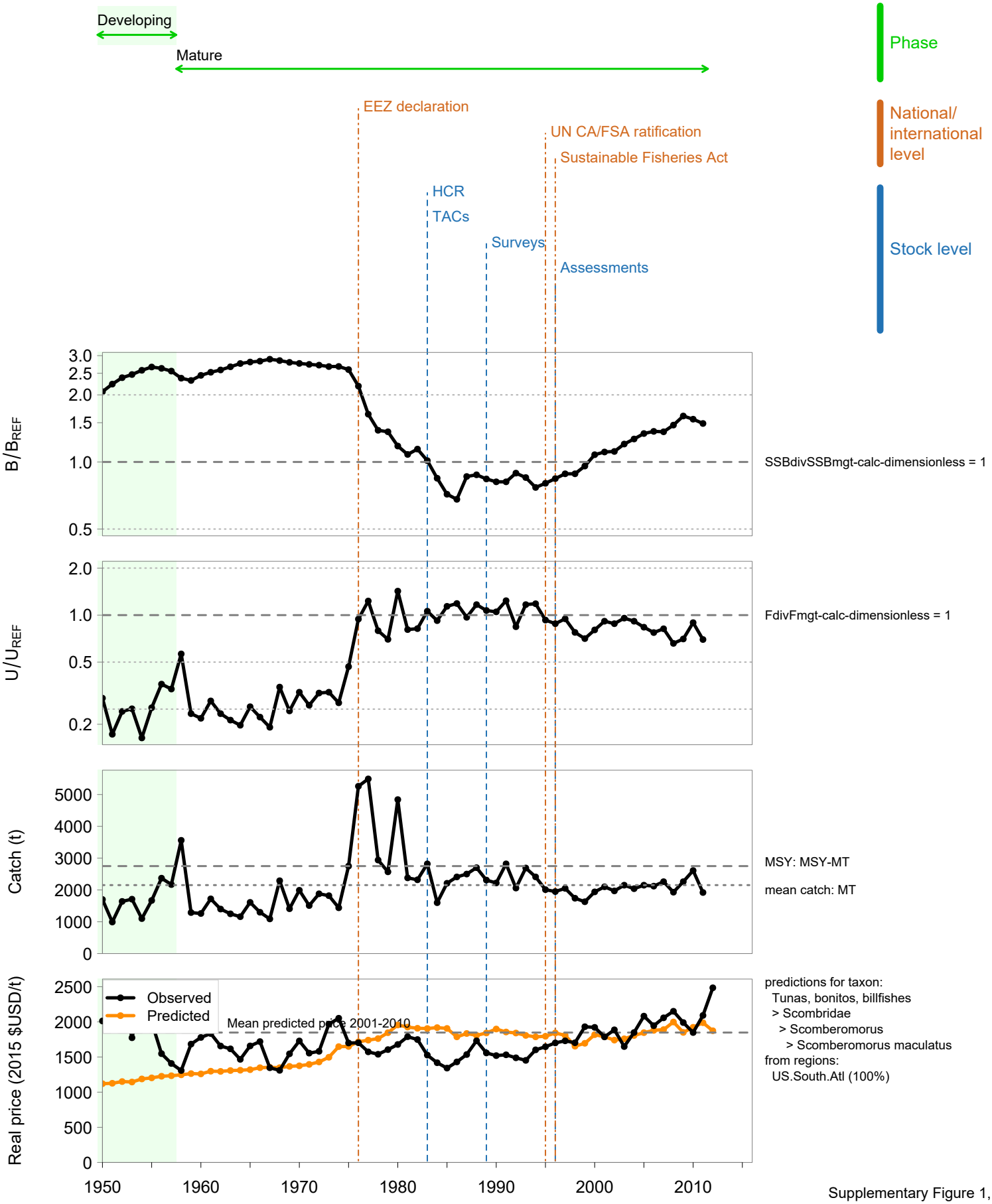
US-Southeast -- SPANMACKGM -- Spanish mackerel Gulf of Mexico

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: USA



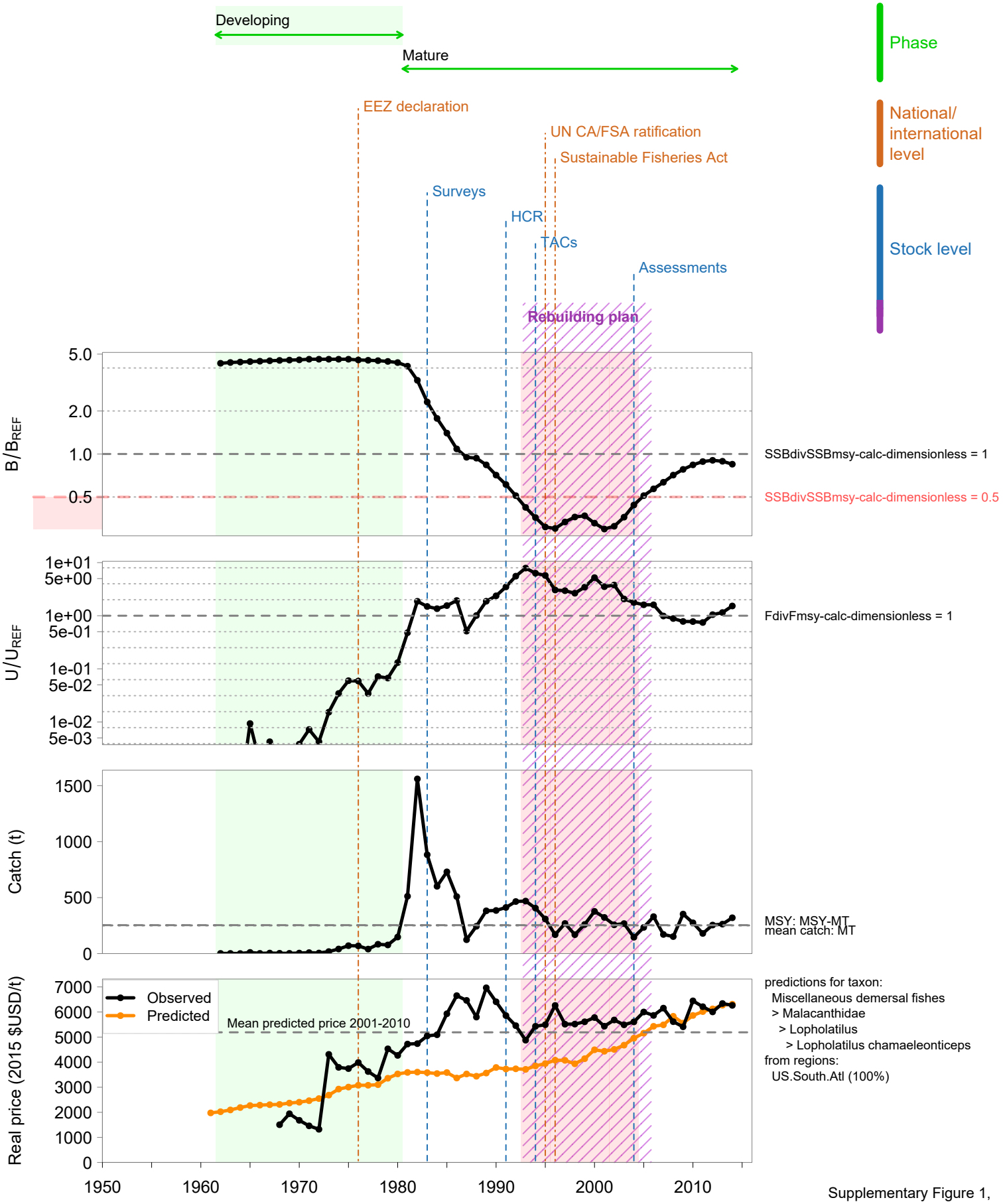
US-Southeast -- SPANMACKSATLC -- Spanish mackerel Southern Atlantic coast

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: USA



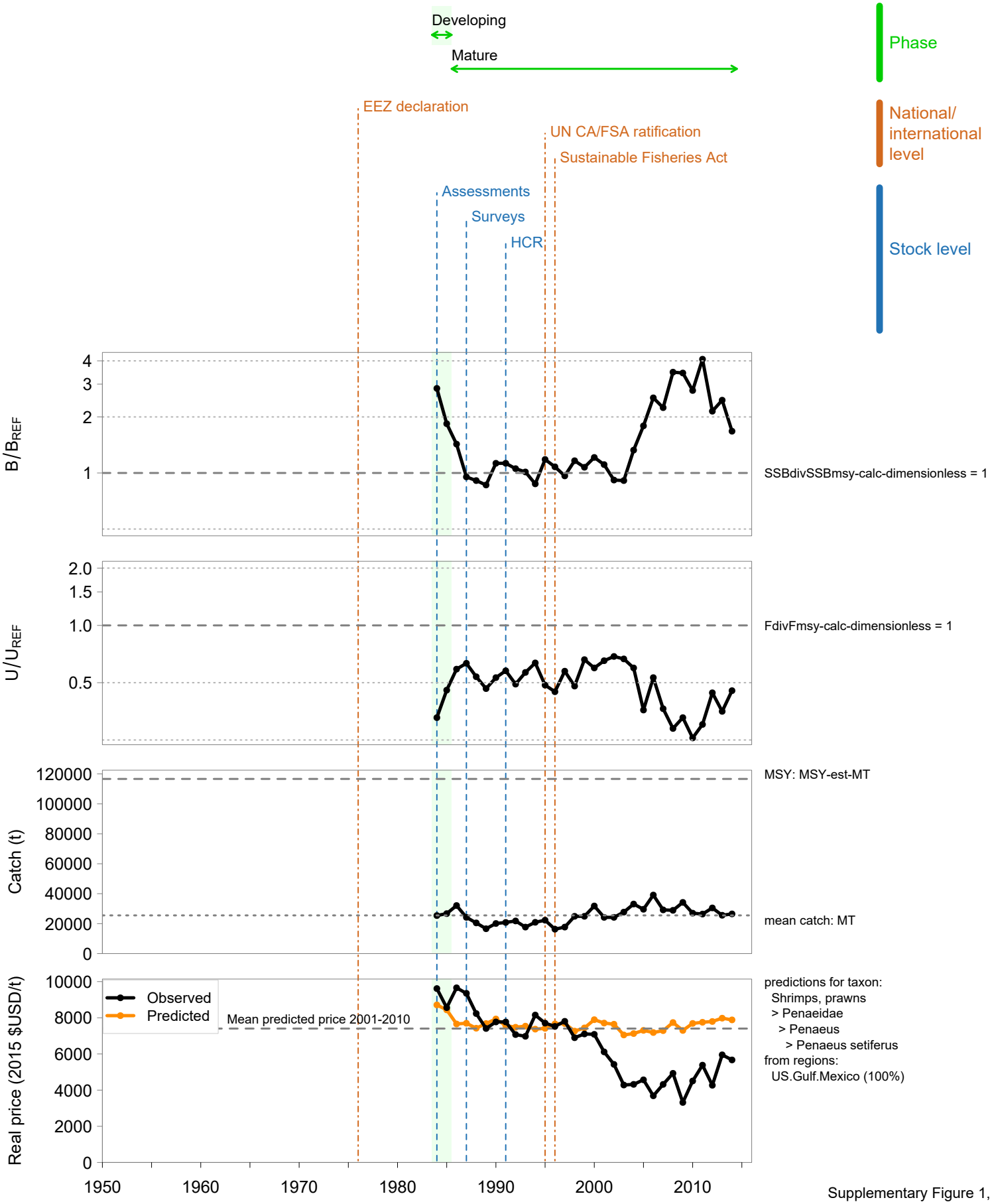
US-Southeast -- TILESATLC -- Tilefish Southern Atlantic coast

taxonomic group: demersal fish (Other marine percoidids), predominant fishery type: mixed-species, primary country: USA



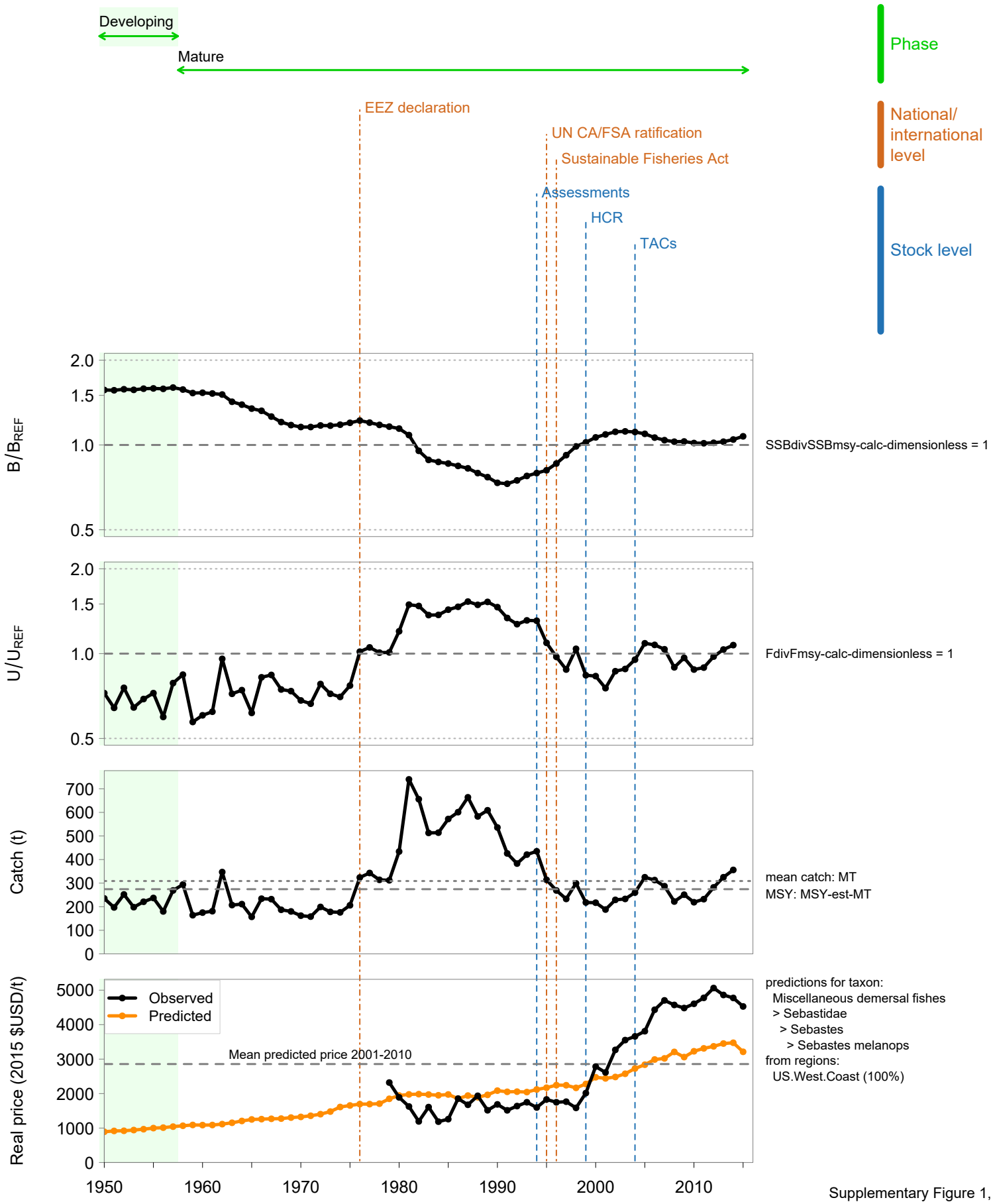
US-Southeast -- WSHRIMPGM -- White shrimp Gulf of Mexico

taxonomic group: invertebrate (Crustaceans), predominant fishery type: mixed-species, primary country: USA



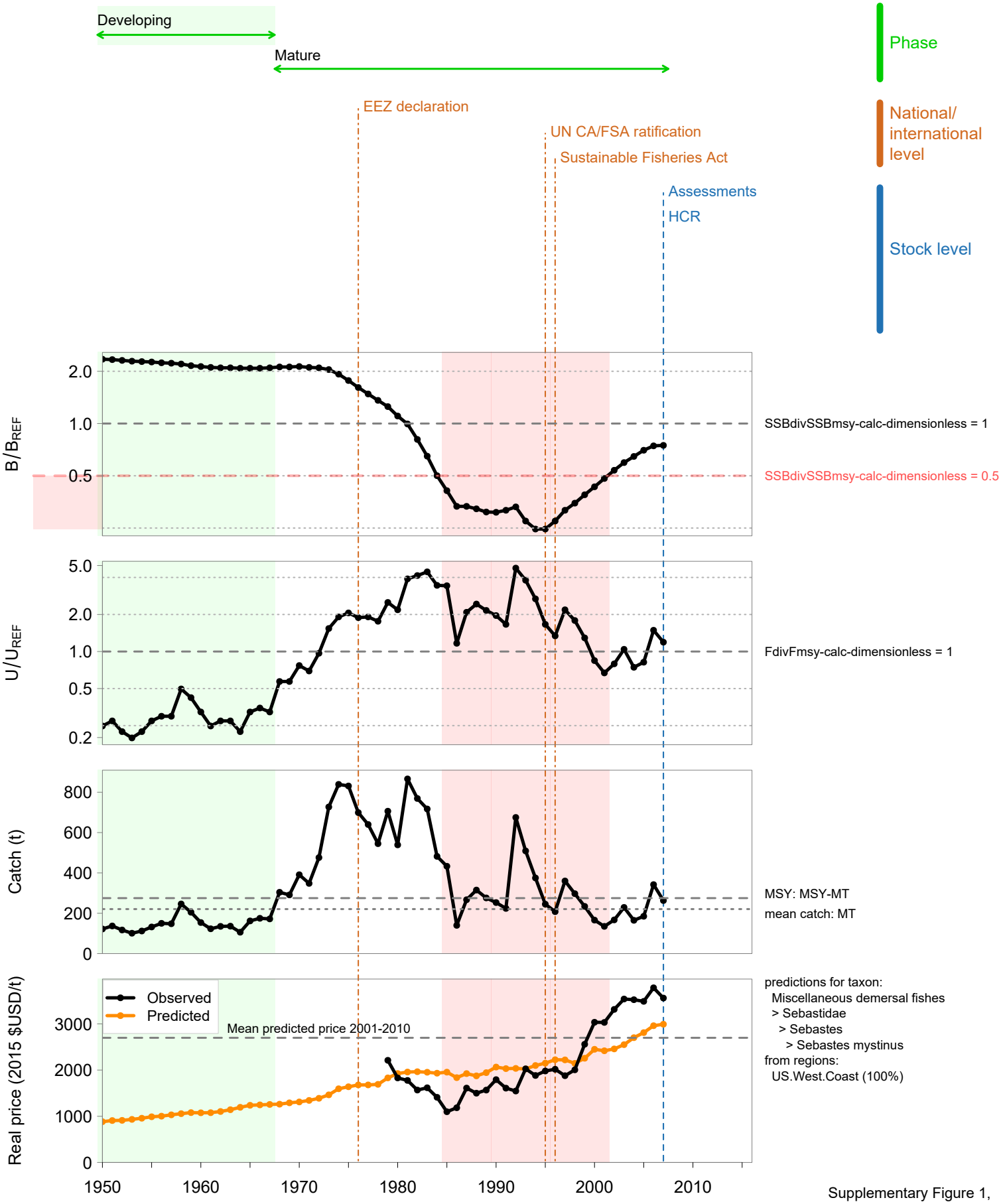
US-West Coast -- BLACKROCKWASH -- Black rockfish Washington

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



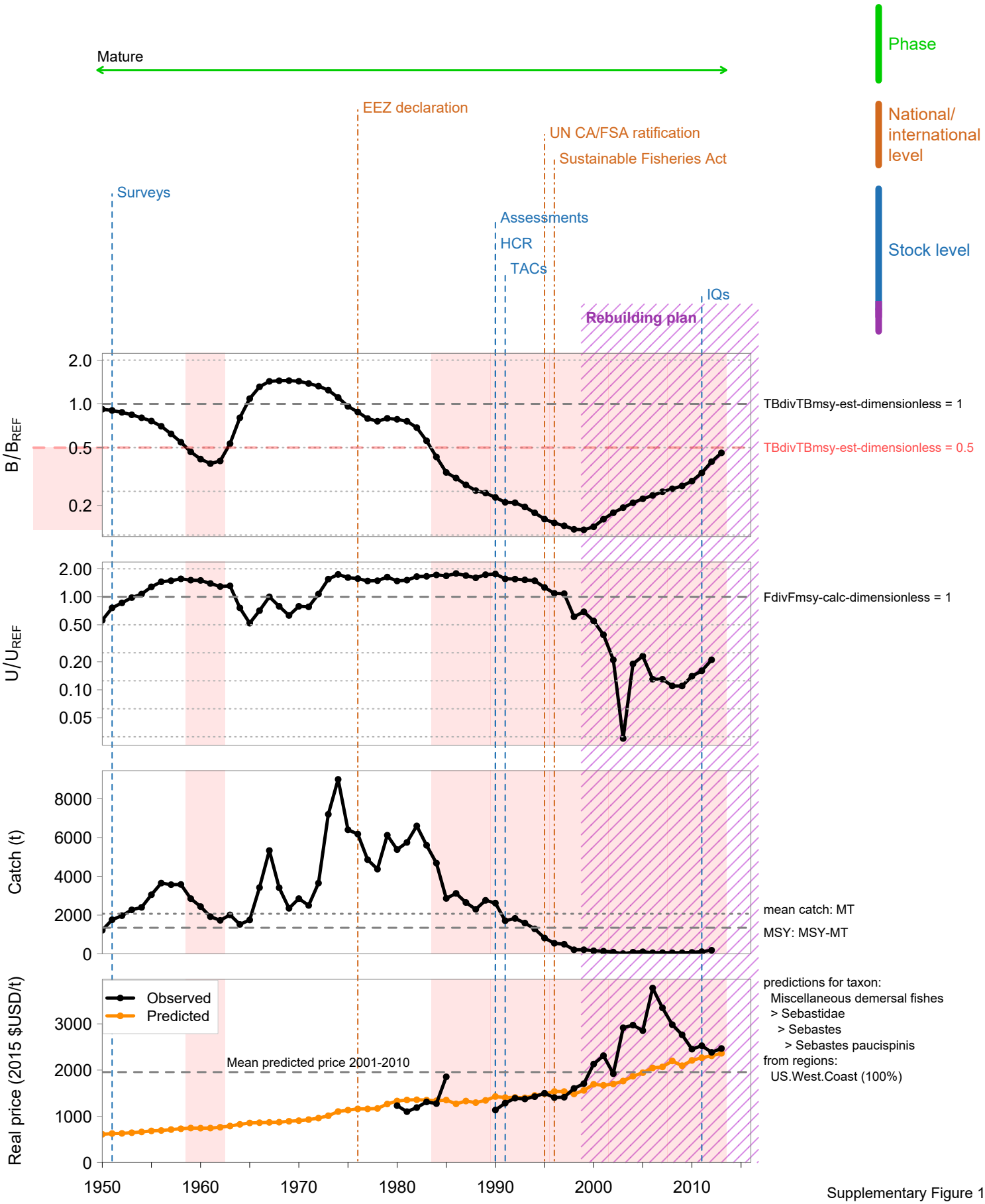
US-West Coast -- BLUEROCKCAL -- Blue rockfish California

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



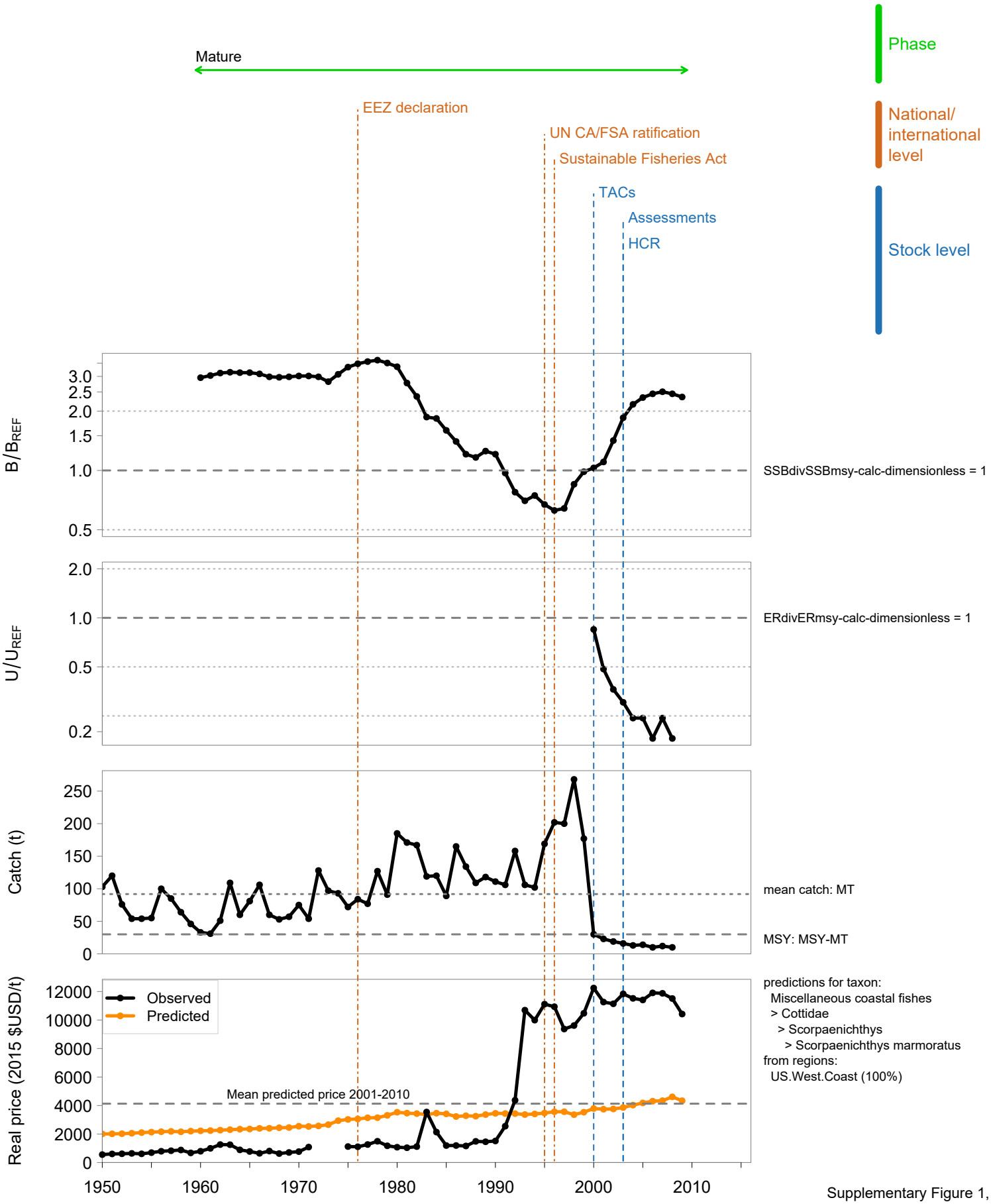
US-West Coast -- BOCACCSPCOAST -- Bocaccio Southern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



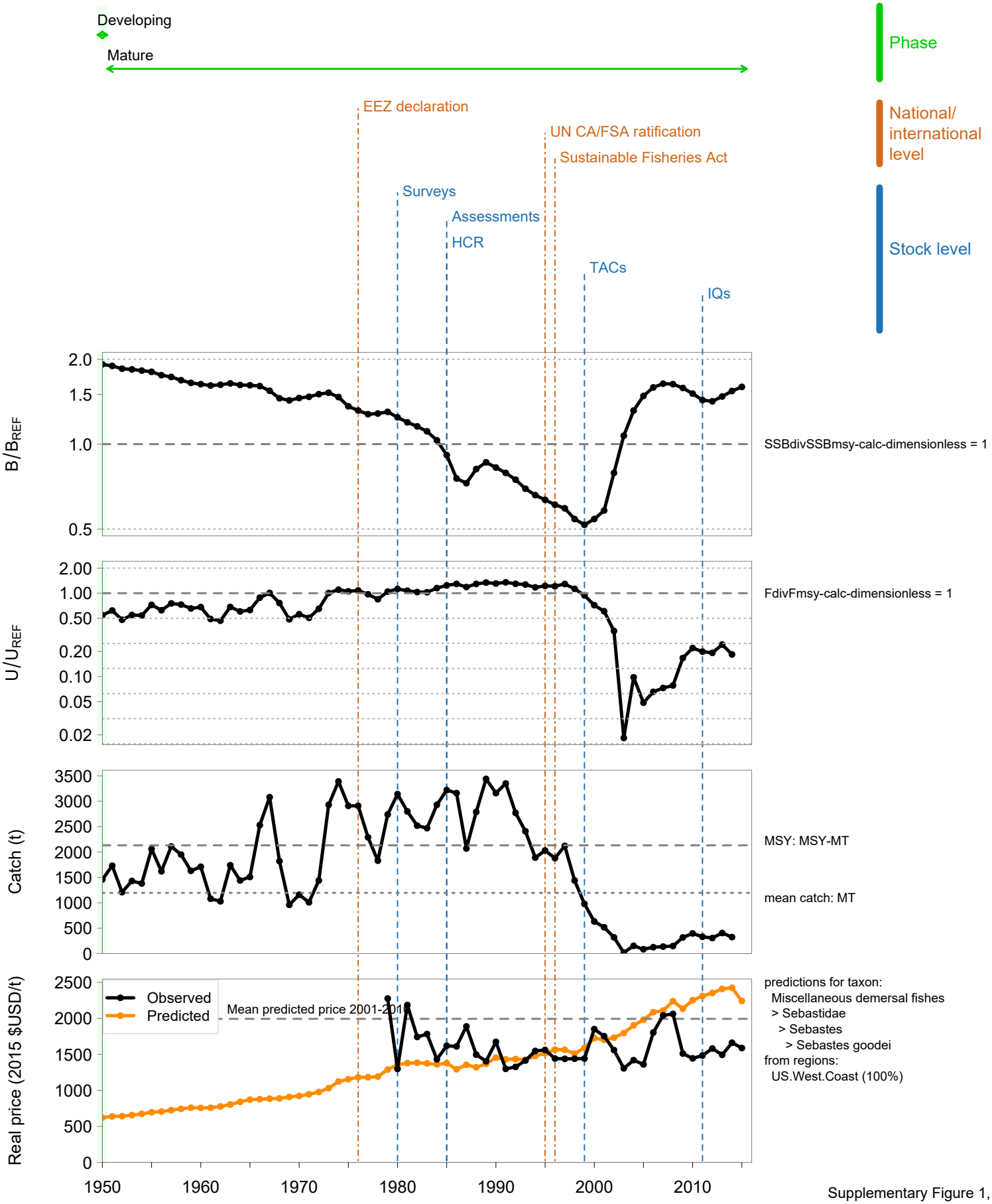
US-West Coast -- CABEZSCAL -- Cabezon Southern California

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



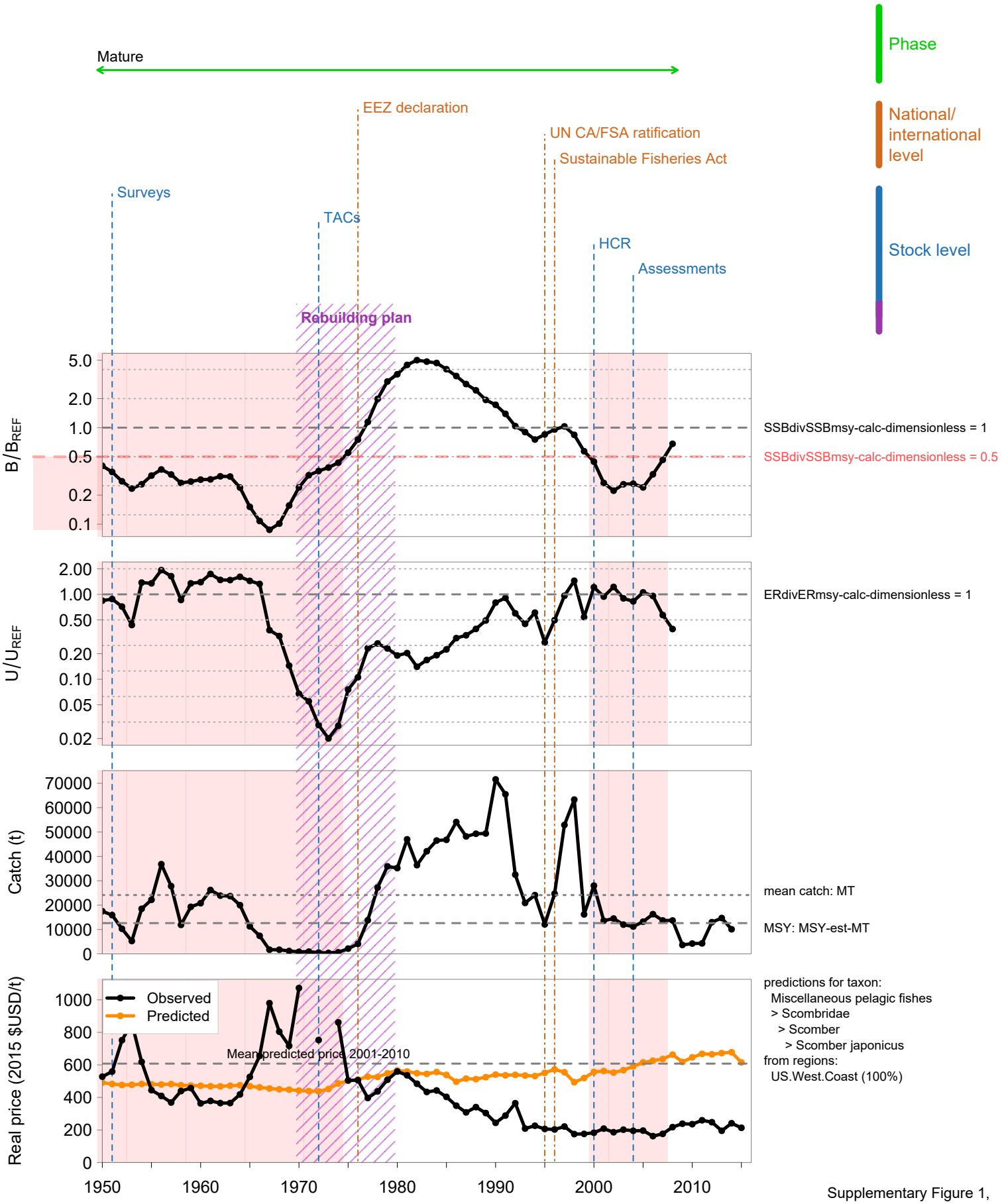
US-West Coast -- CHILISPCOAST -- Chilipepper Southern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



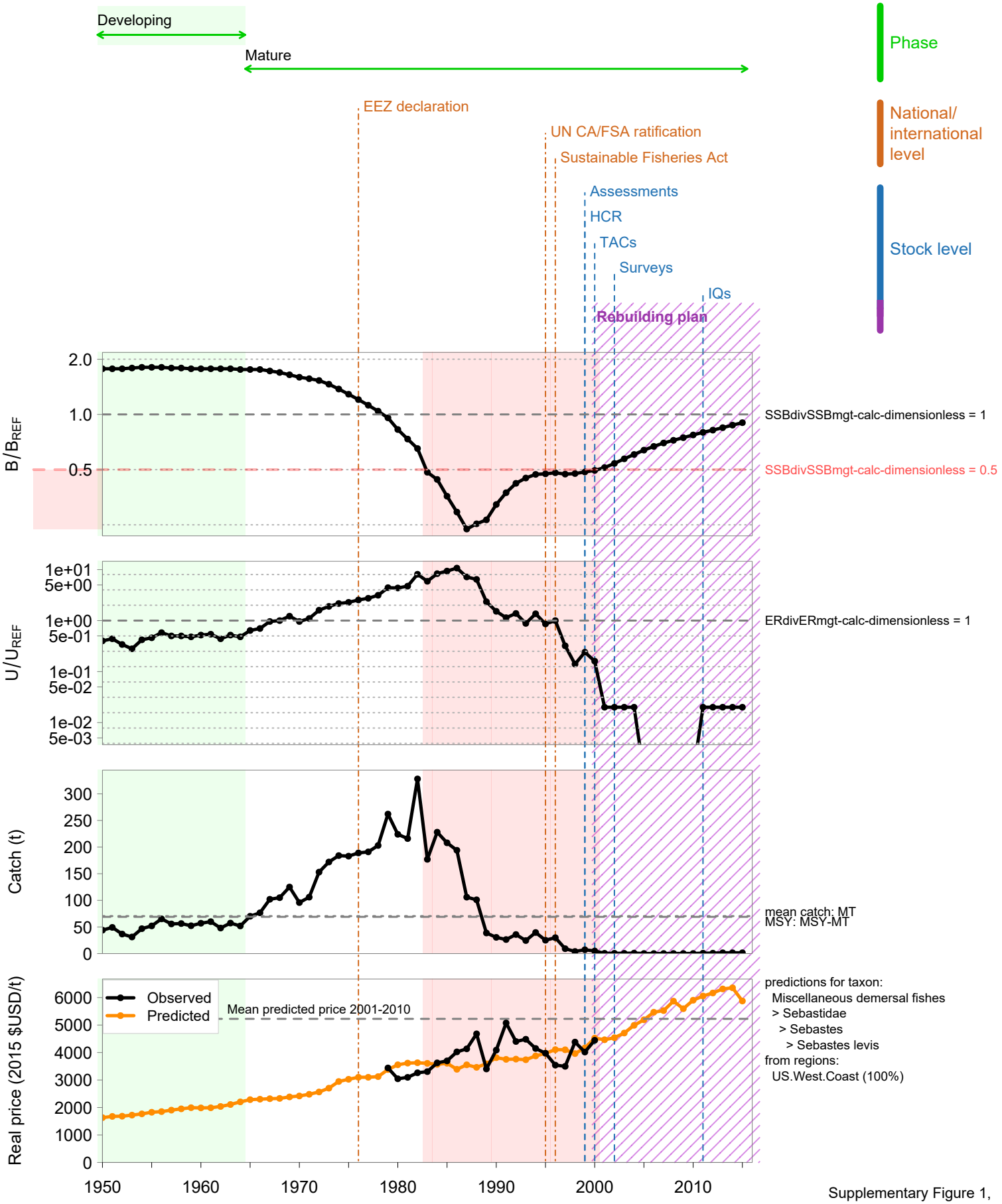
US-West Coast -- CMACKPCOAST -- Pacific chub mackerel Pacific Coast

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: USA



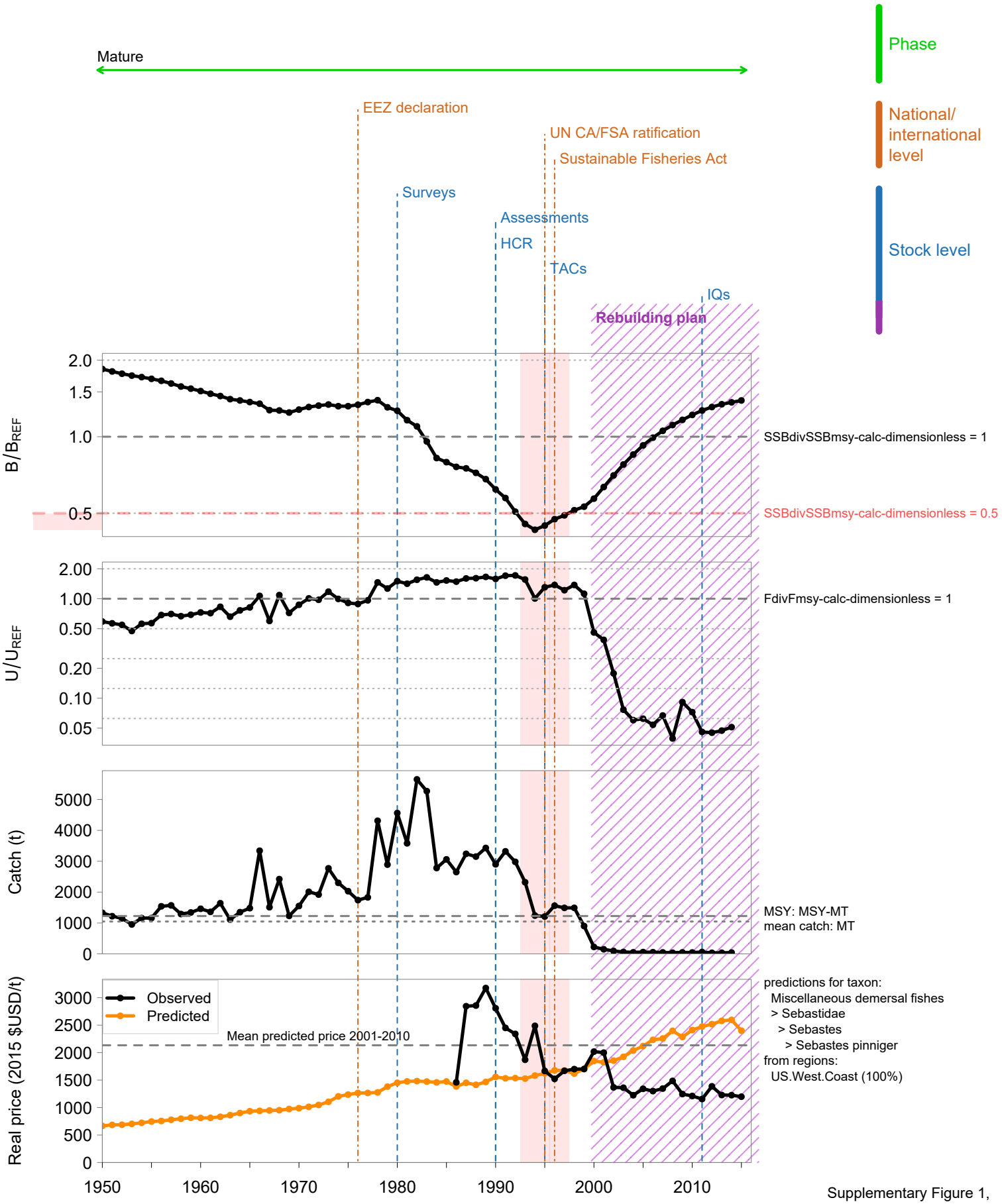
US-West Coast -- COWCODSCAL -- Cowcod Southern California

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



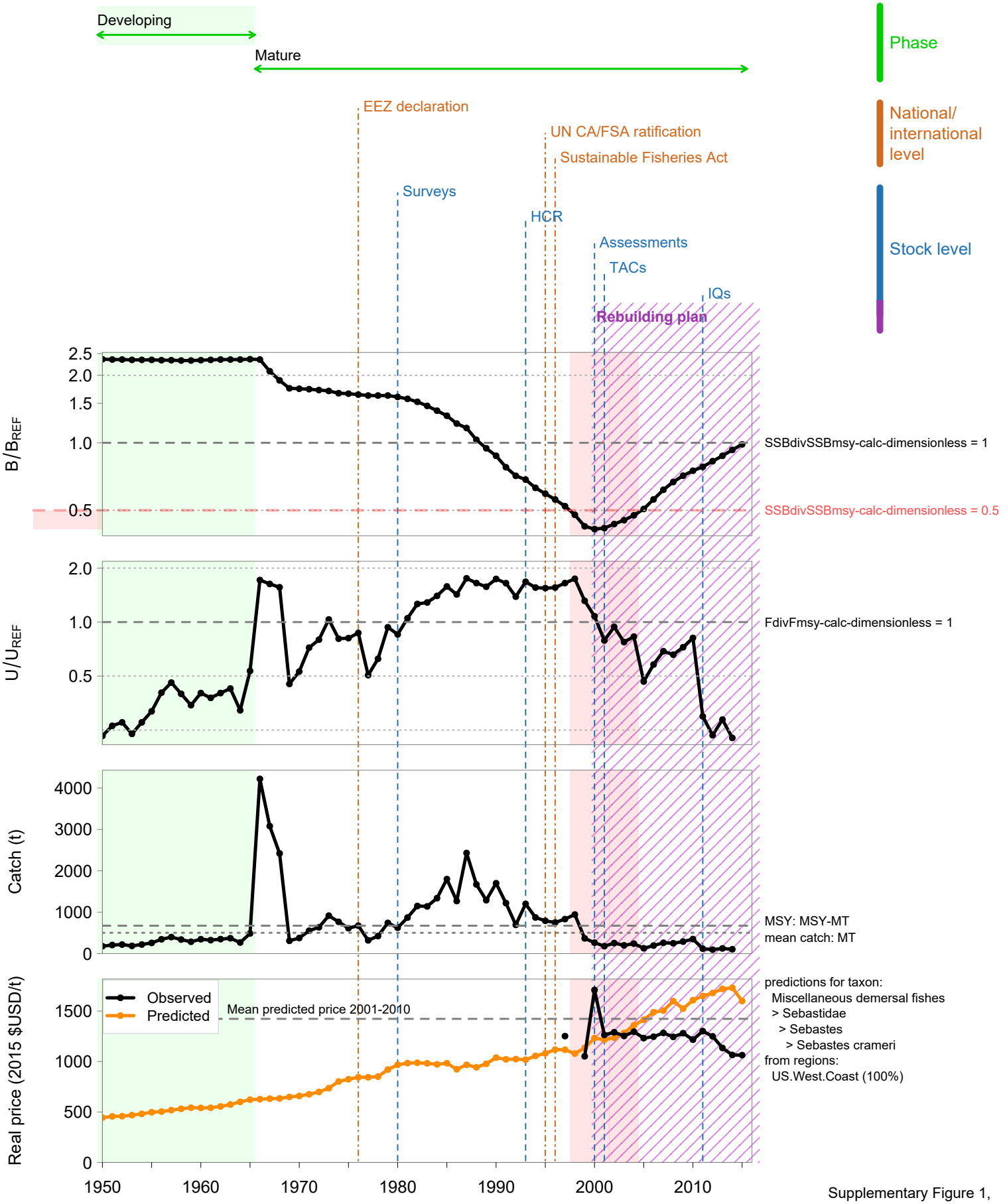
US-West Coast -- CROCKPCOAST -- Canary rockfish Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



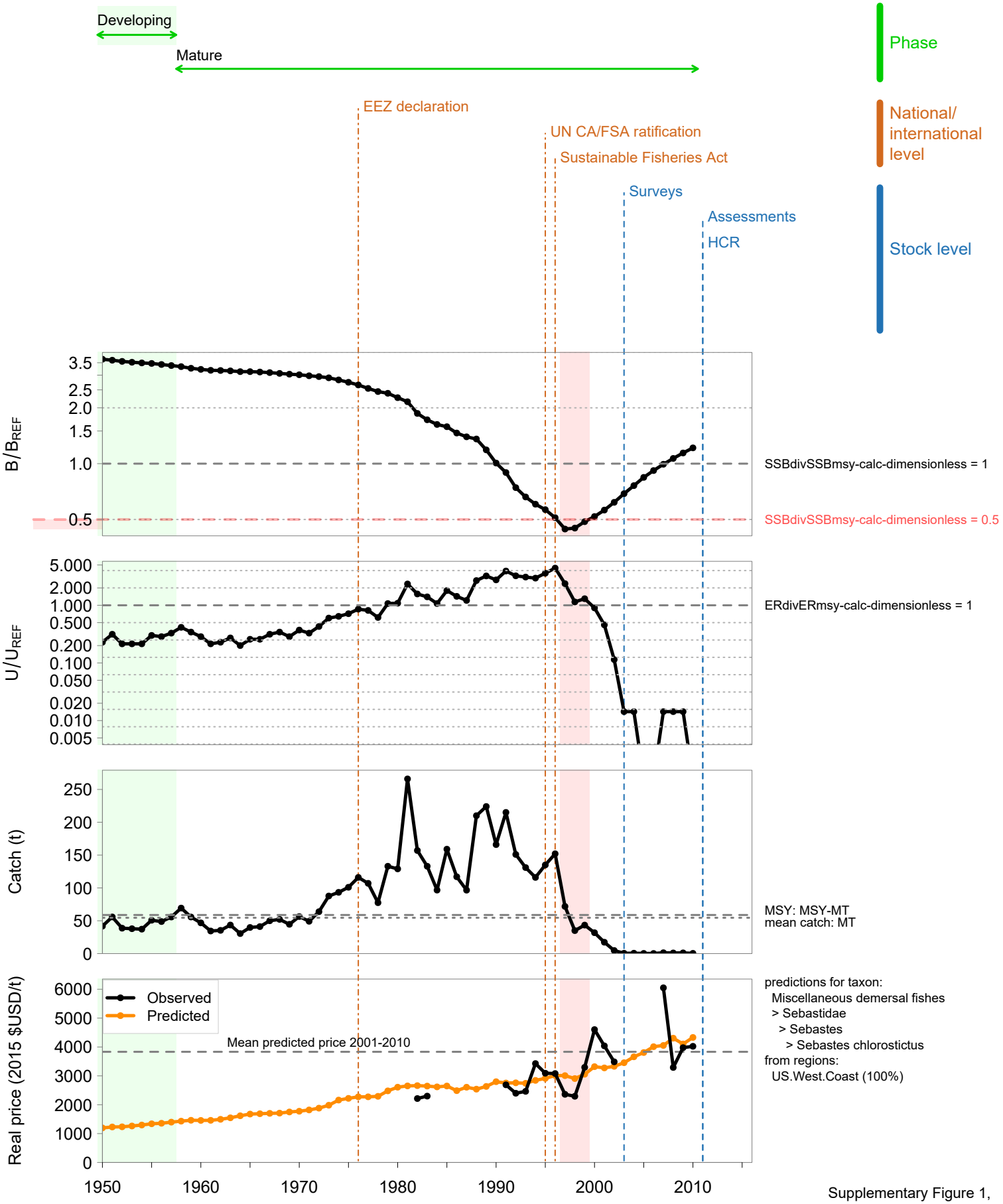
US-West Coast -- DKROCKPCOAST -- Darkblotched rockfish Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



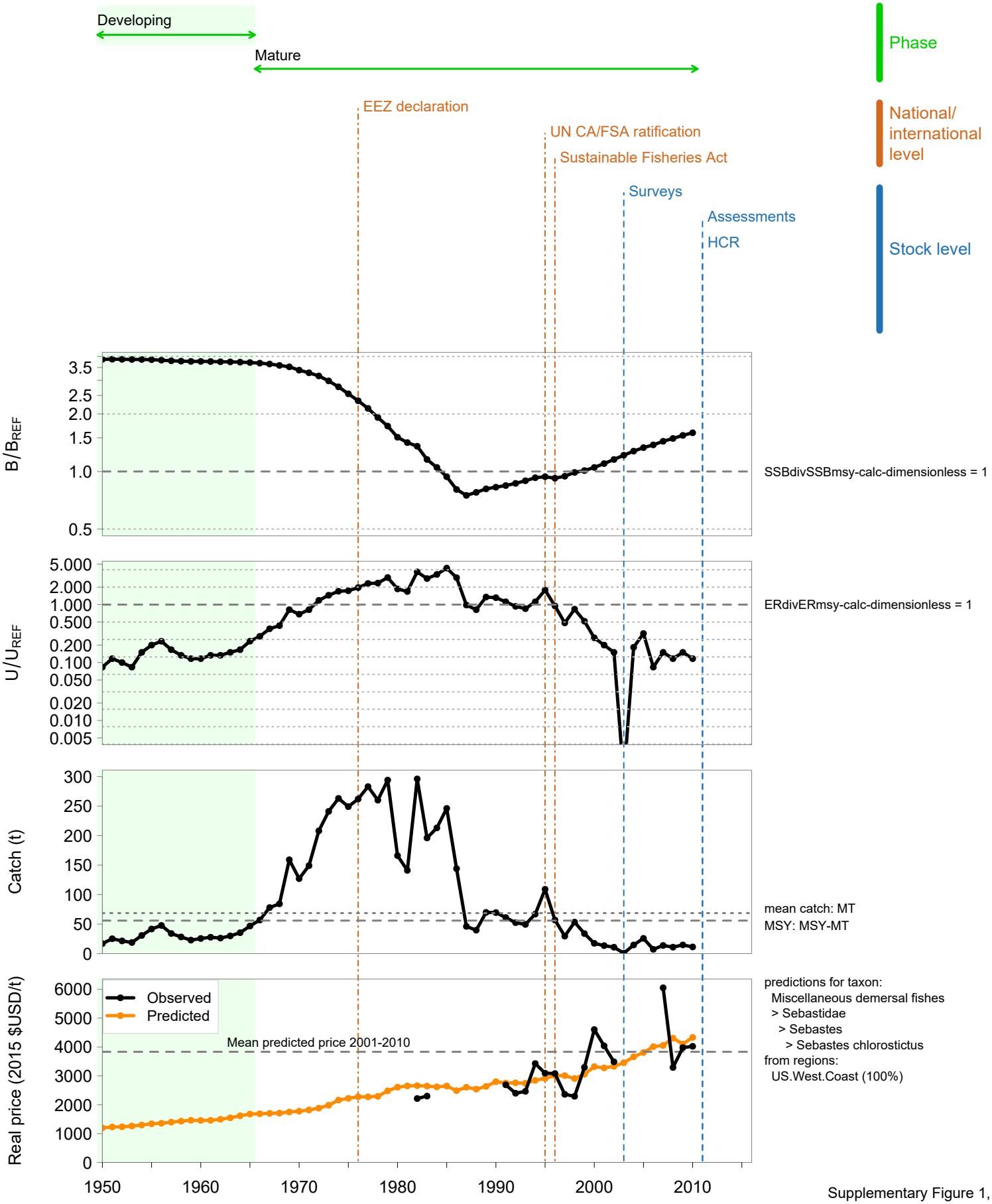
US-West Coast -- GRSPROCKNCAL -- Greenspotted rockfish Northern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



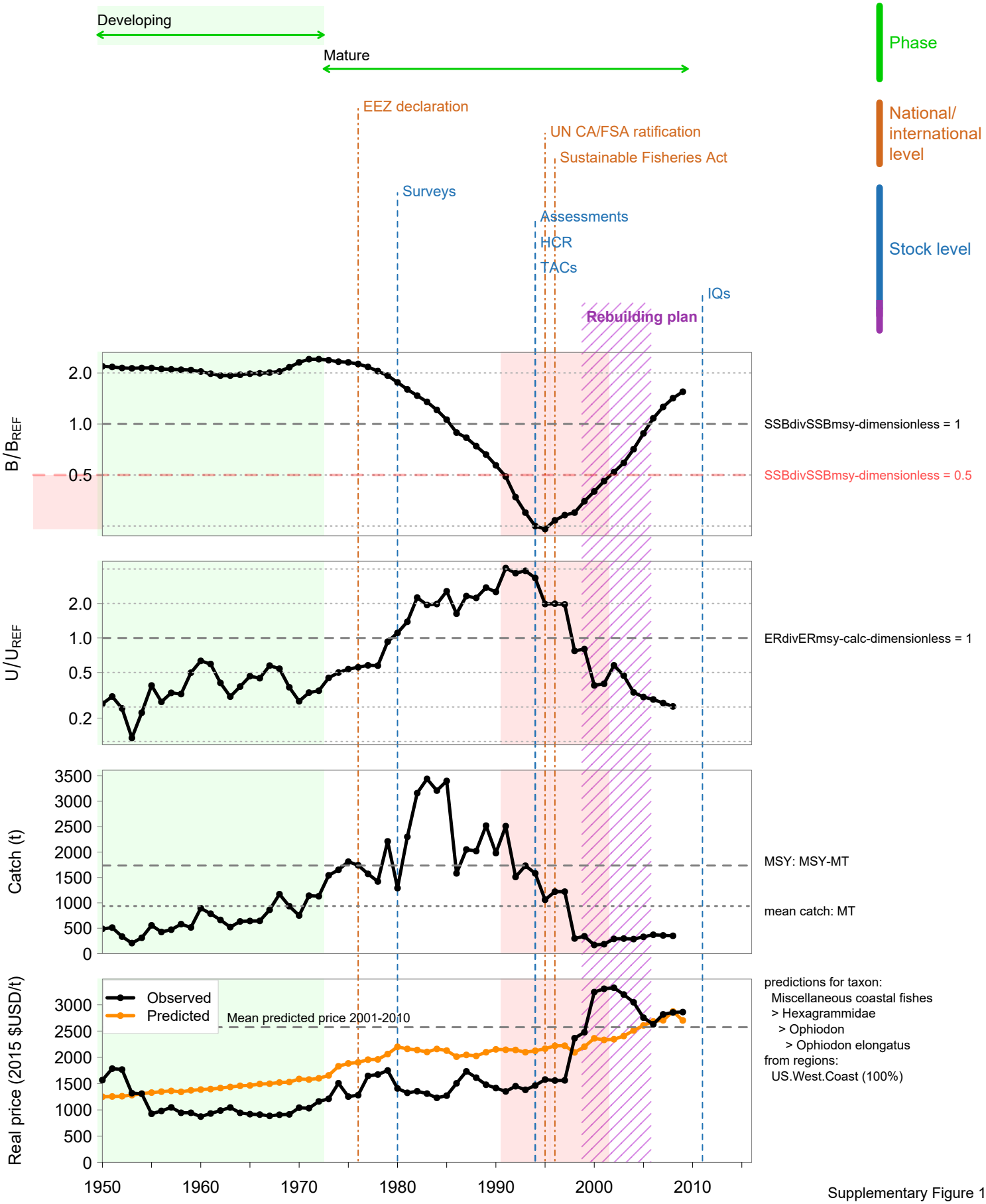
US-West Coast -- GRSPROCKSCAL -- Greenspotted rockfish Southern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



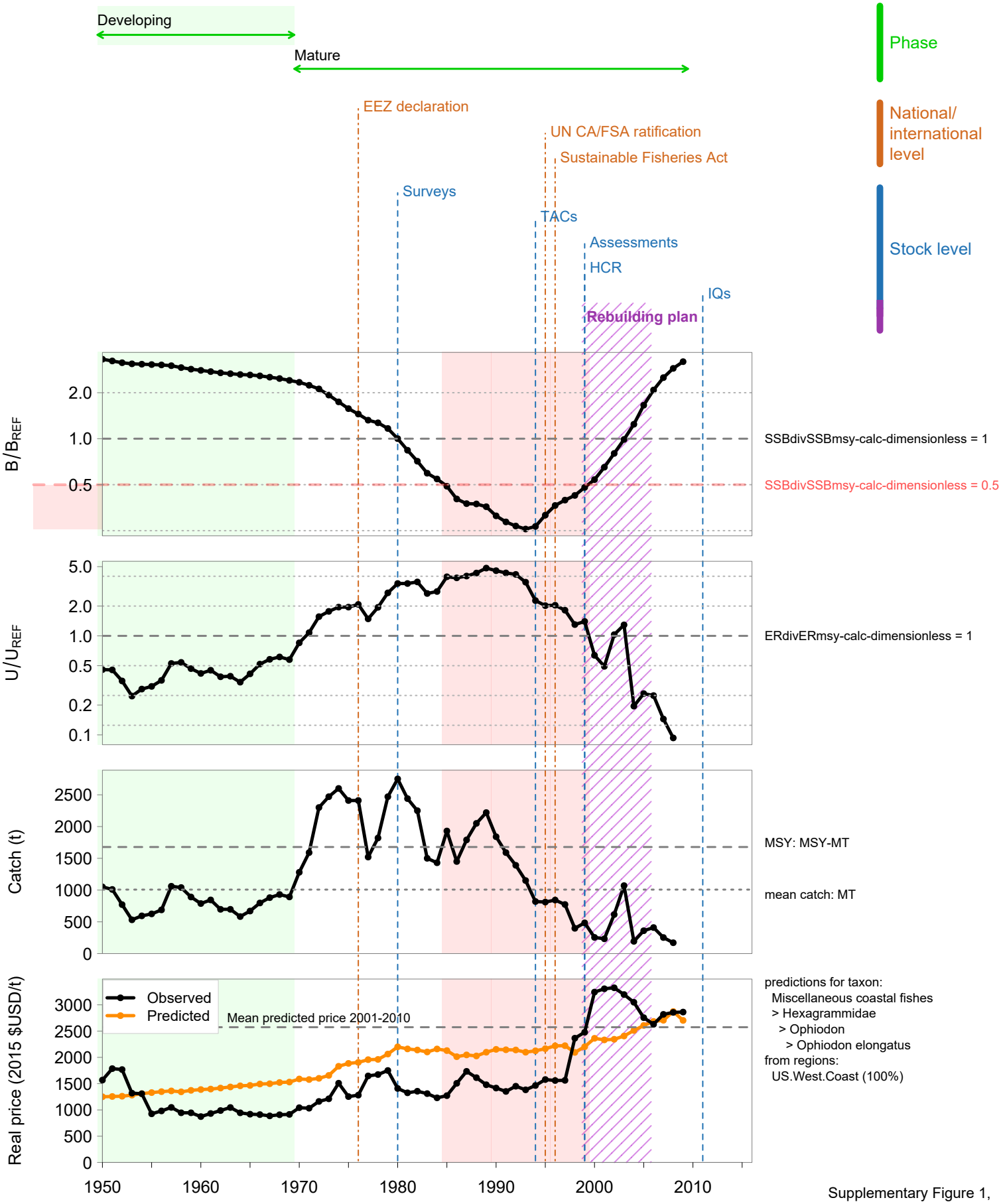
US-West Coast -- LINGCODNPCOAST -- Lingcod Northern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



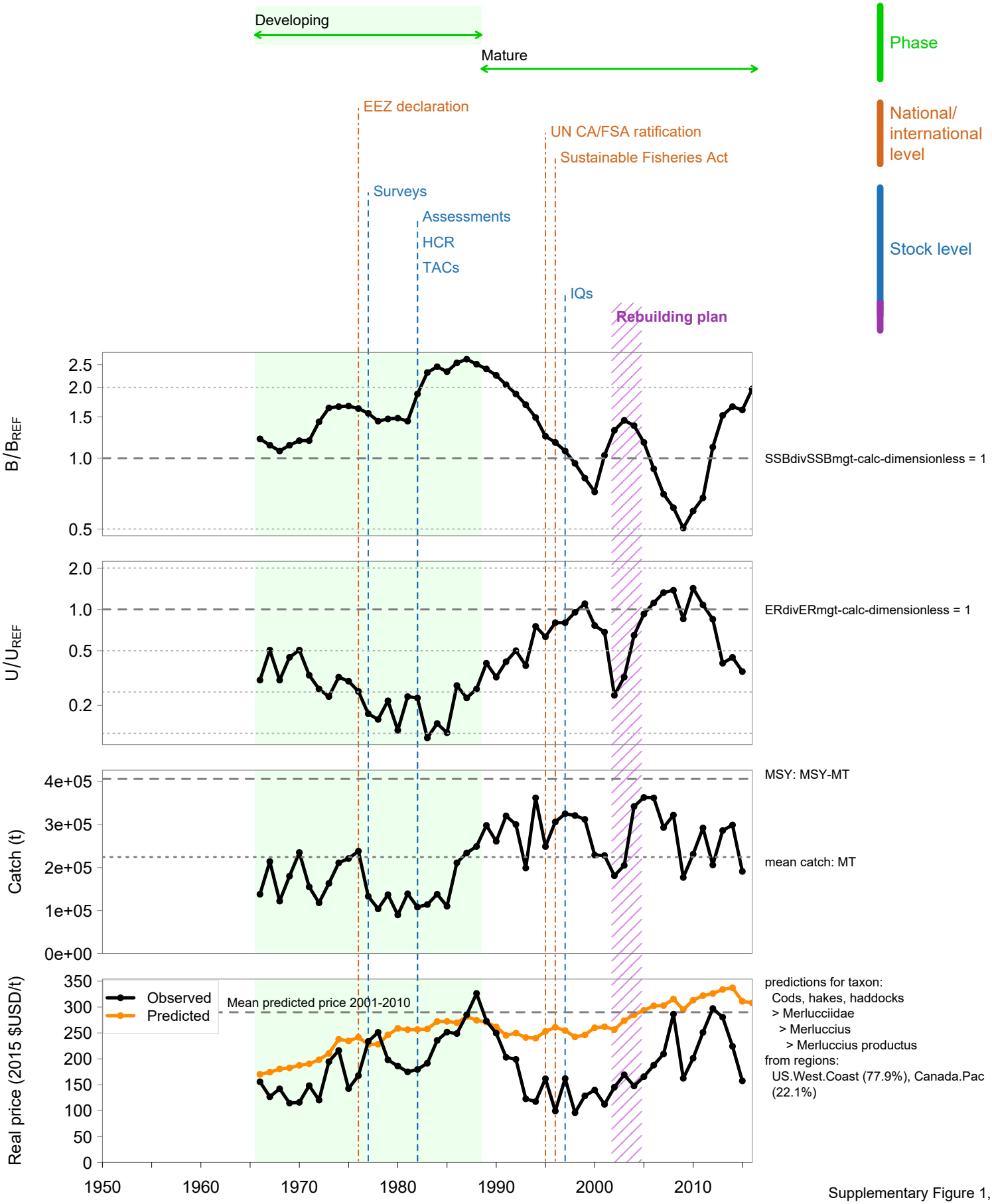
US-West Coast -- LINGCODSPCOAST -- Lingcod Southern Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



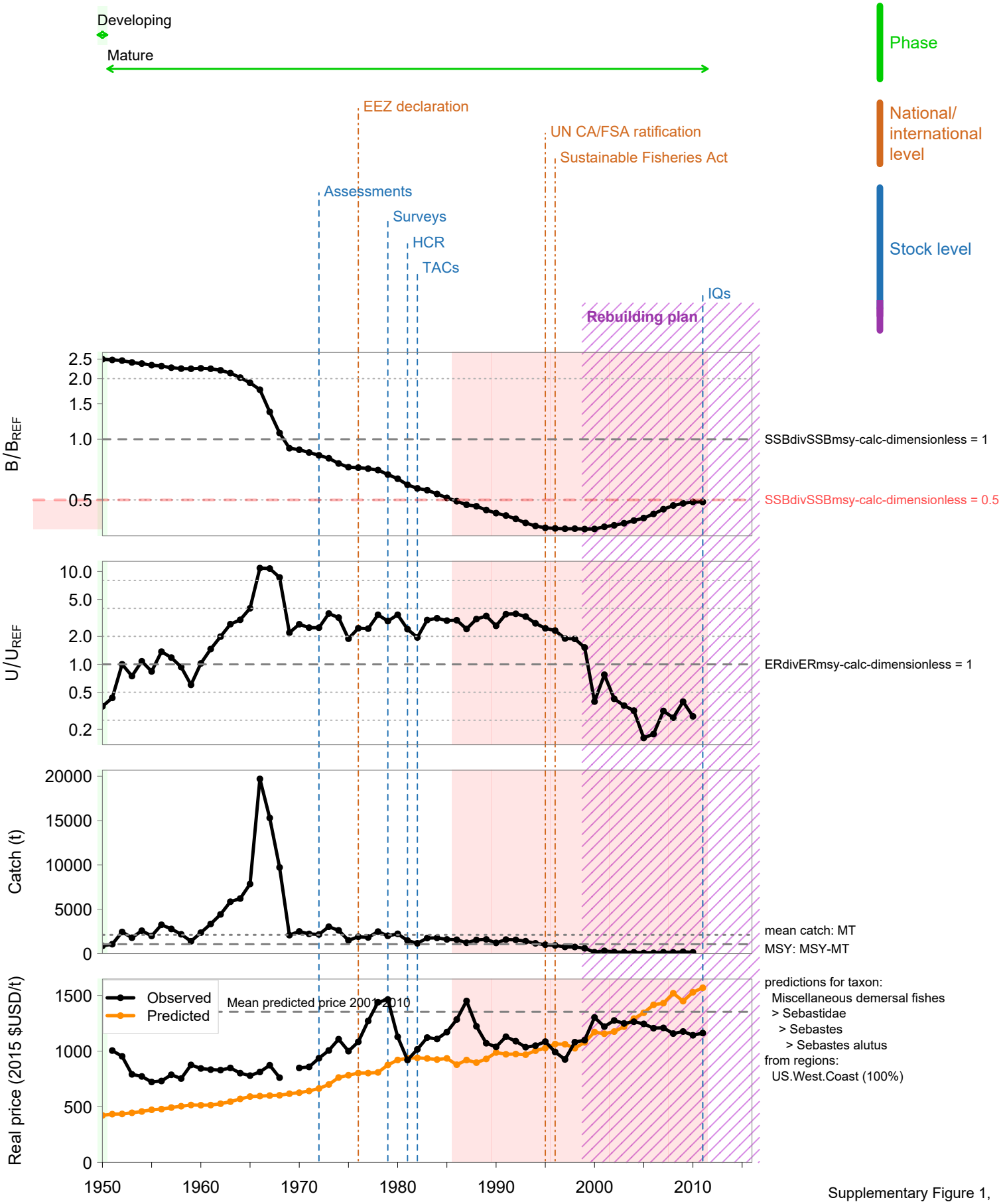
US-West Coast -- PHAKEPCOAST -- Pacific hake Pacific Coast

taxonomic group: demersal fish (Gadids), predominant fishery type: single-species, primary country: USA



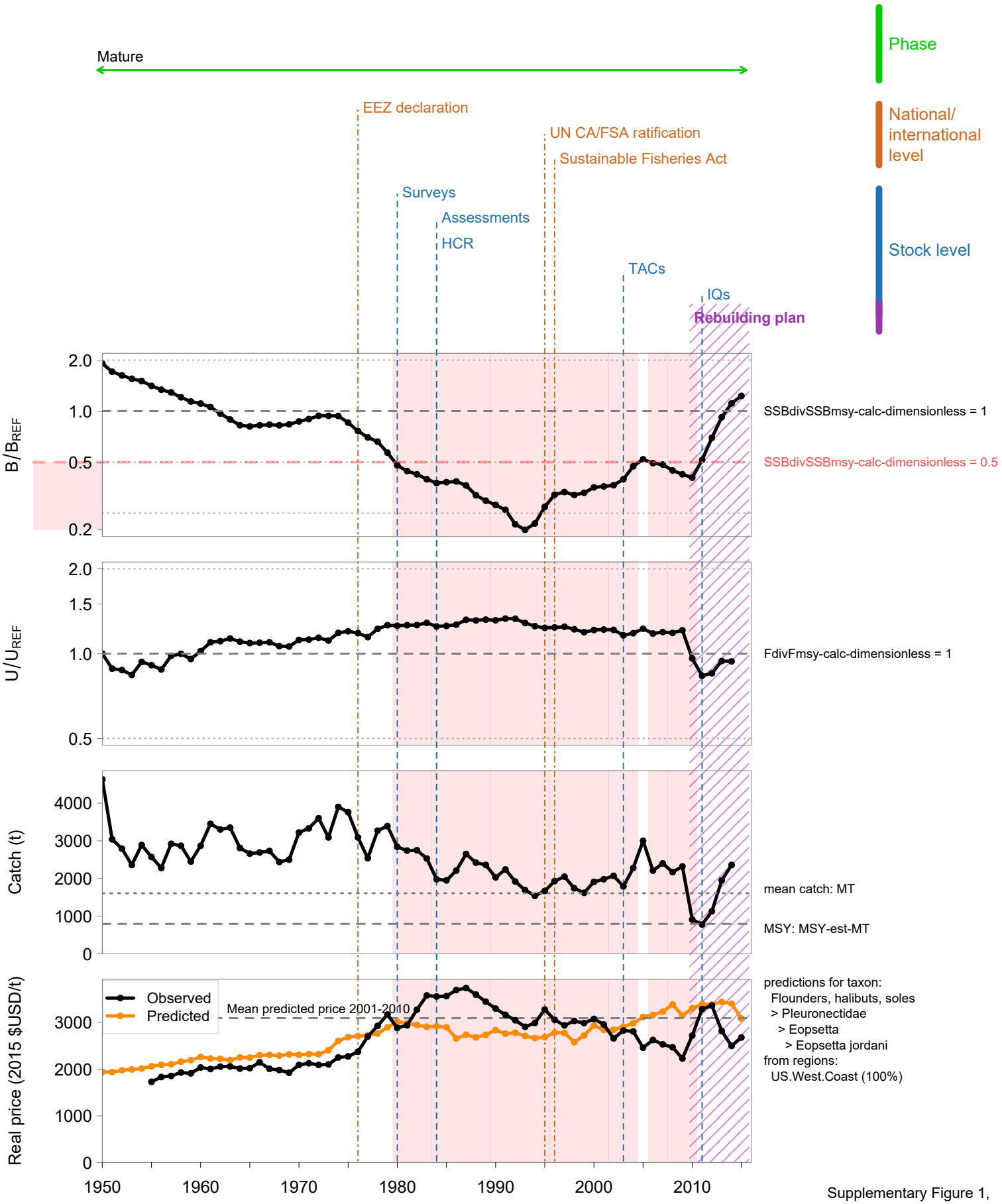
US-West Coast -- POPERCHPCOAST -- Pacific ocean perch Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



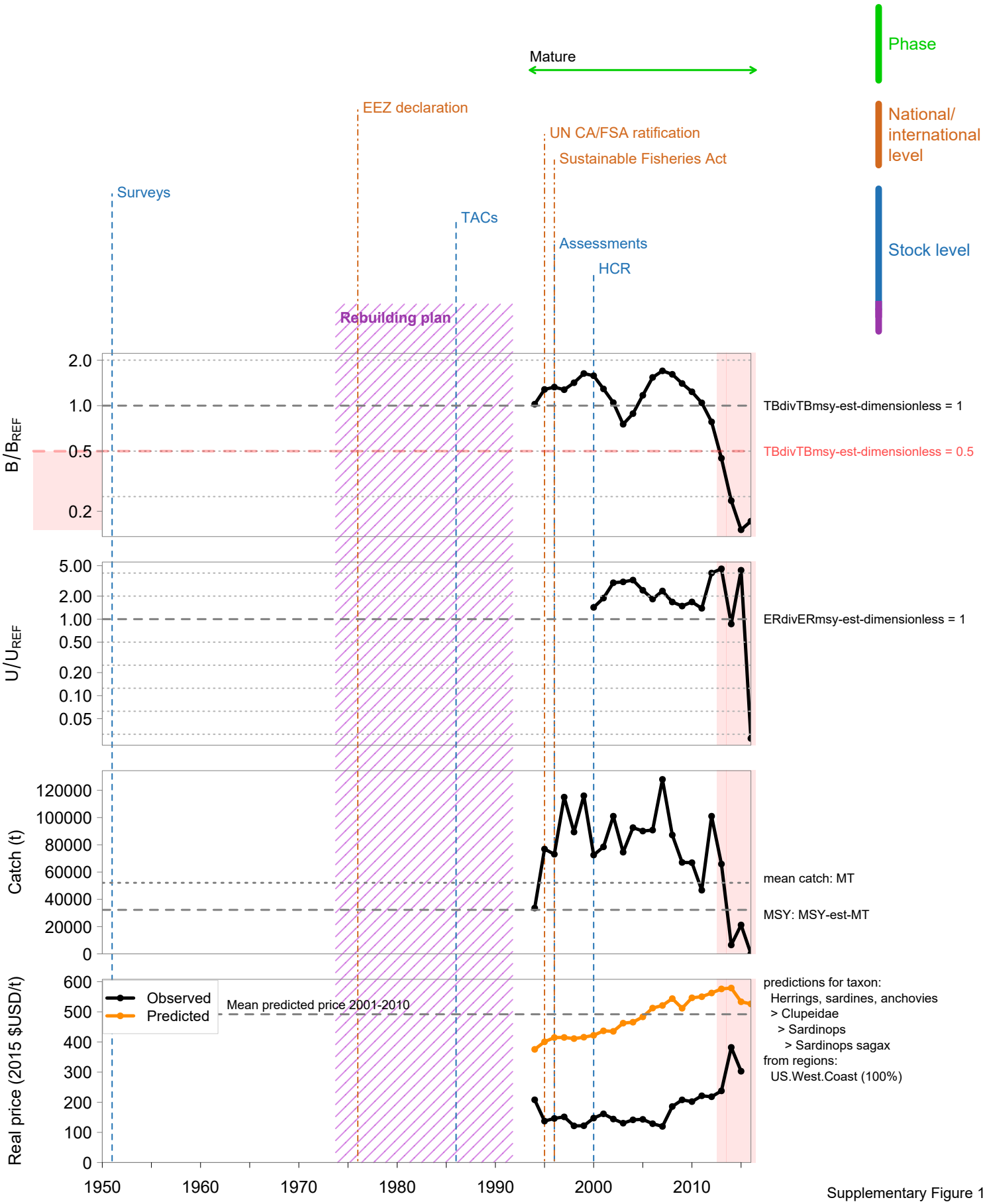
US-West Coast -- PSOLEPCOAST -- Petrale sole Pacific Coast

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



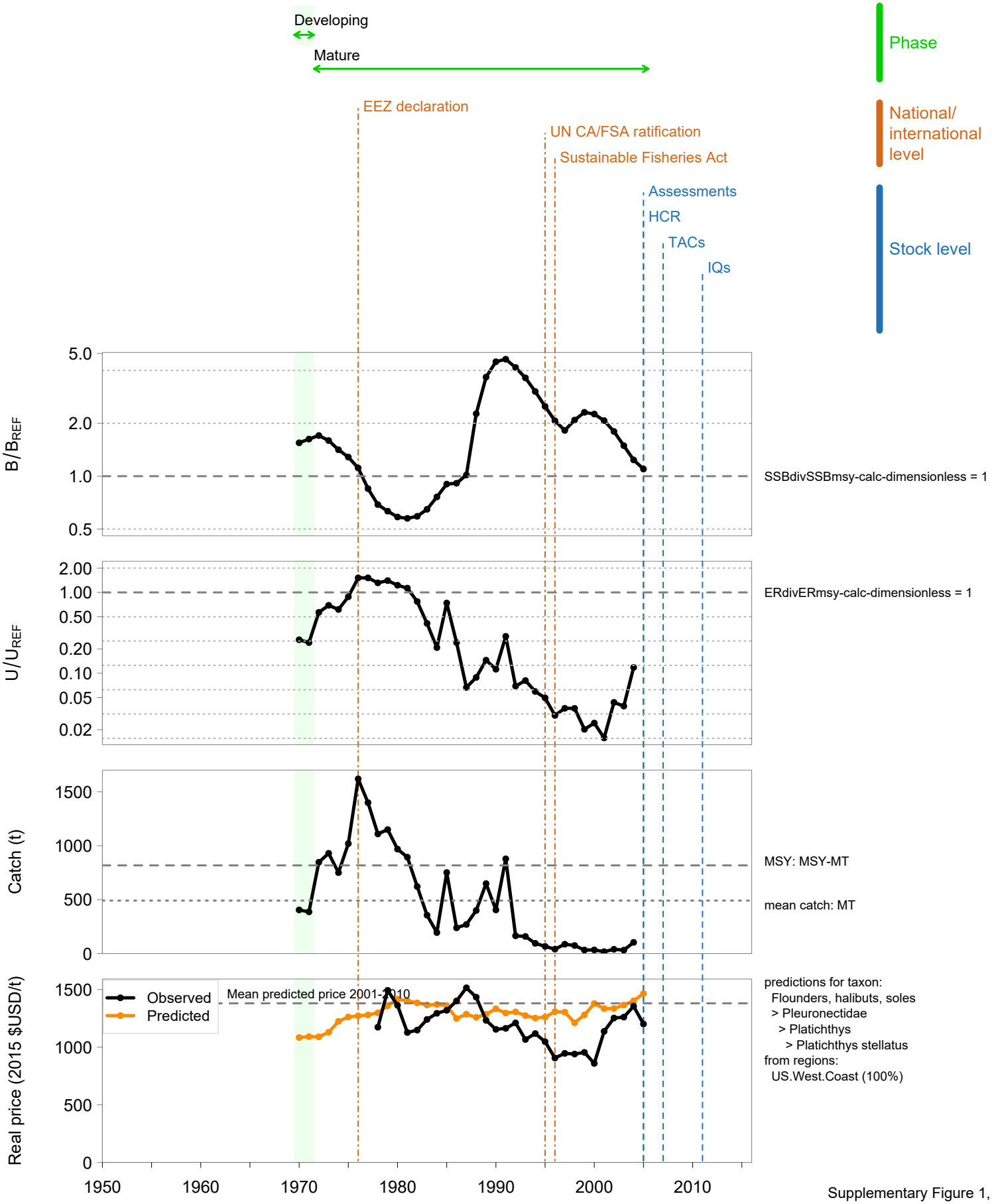
US-West Coast -- SARDPCOAST -- Pacific sardine Pacific Coast

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: USA



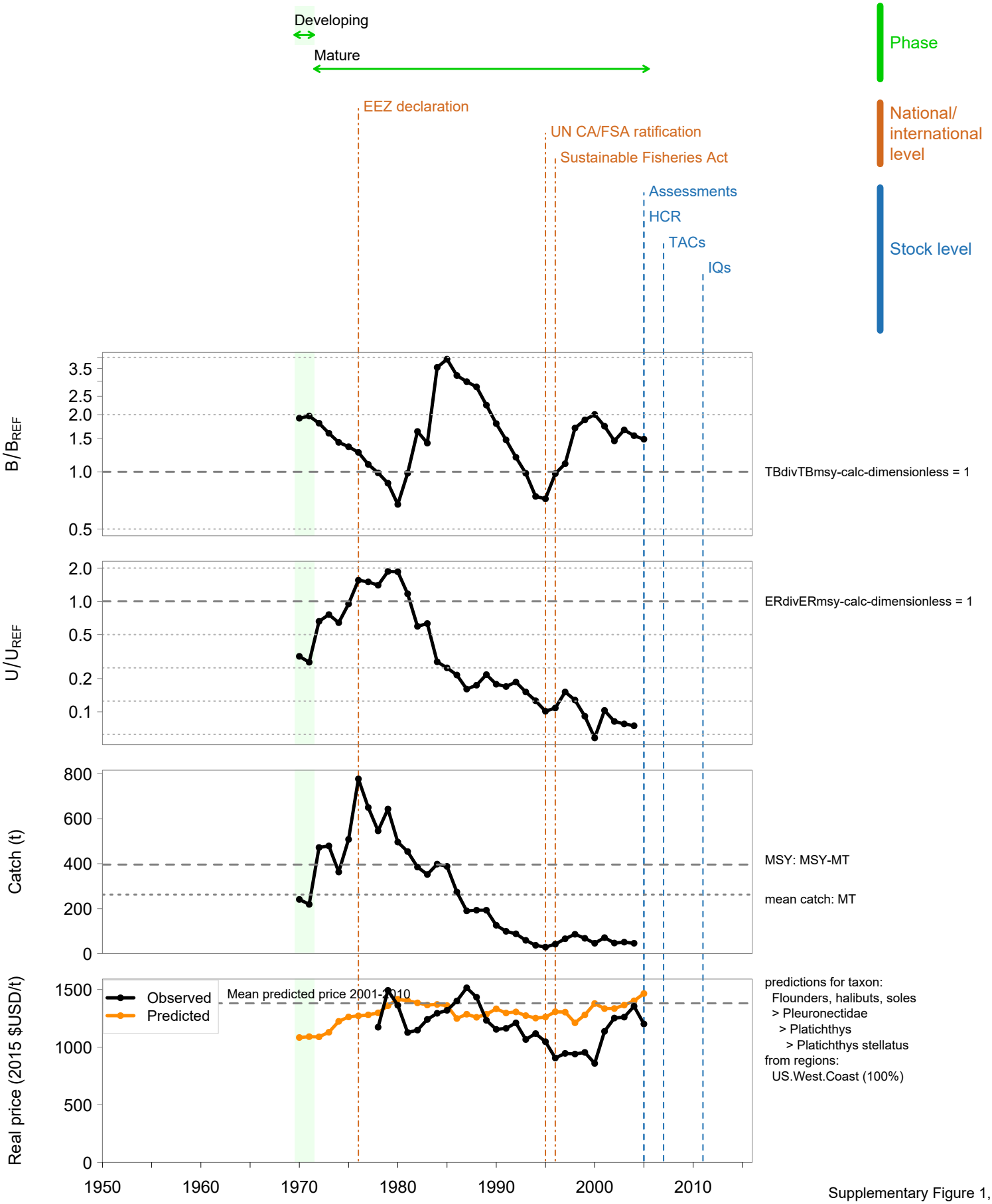
US-West Coast -- STFLOUNNPCOAST -- Starry flounder Northern Pacific Coast

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



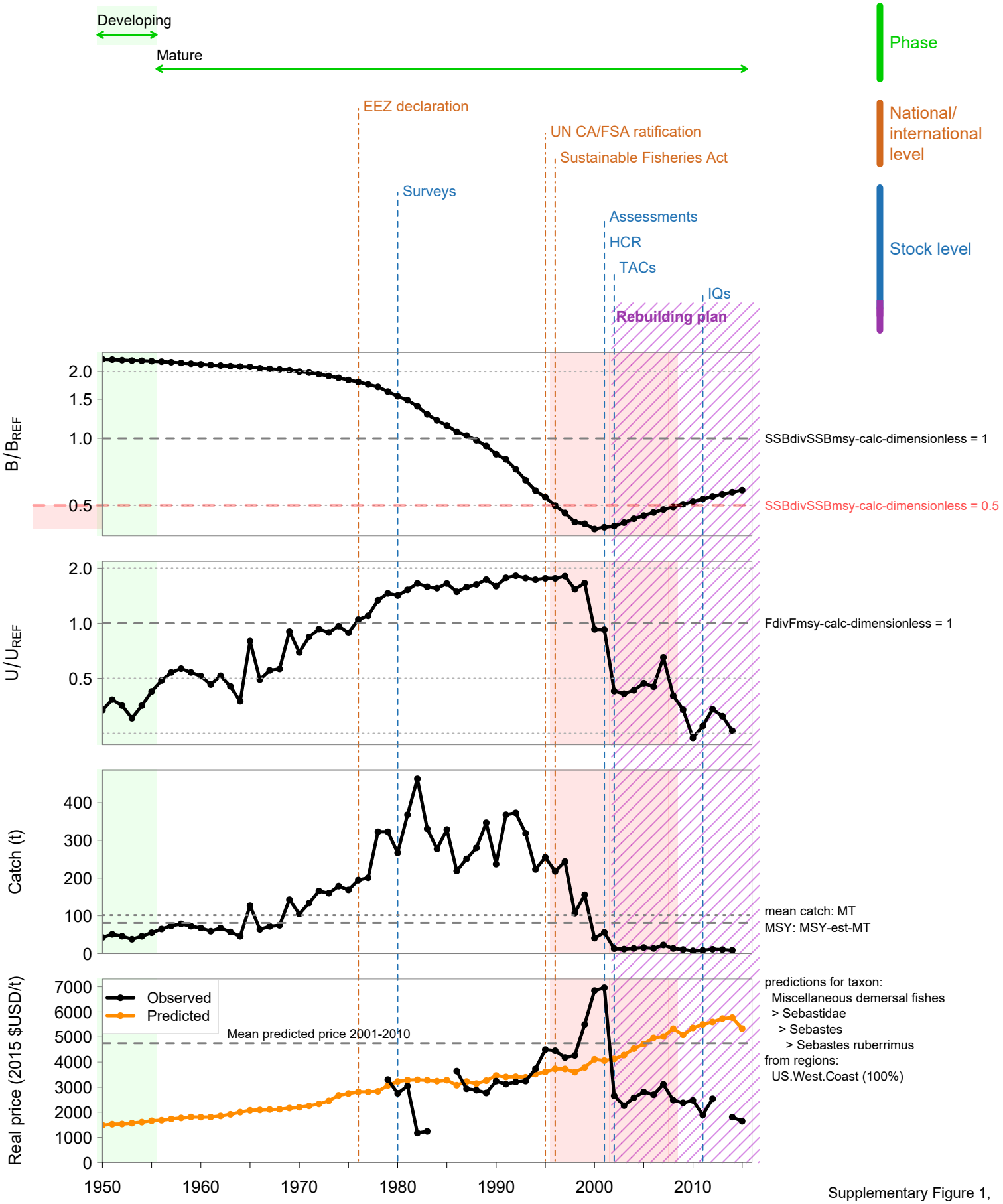
US-West Coast -- STFLOUNSPCOAST -- Starry flounder Southern Pacific Coast

taxonomic group: demersal fish (Pleuronectids), predominant fishery type: mixed-species, primary country: USA



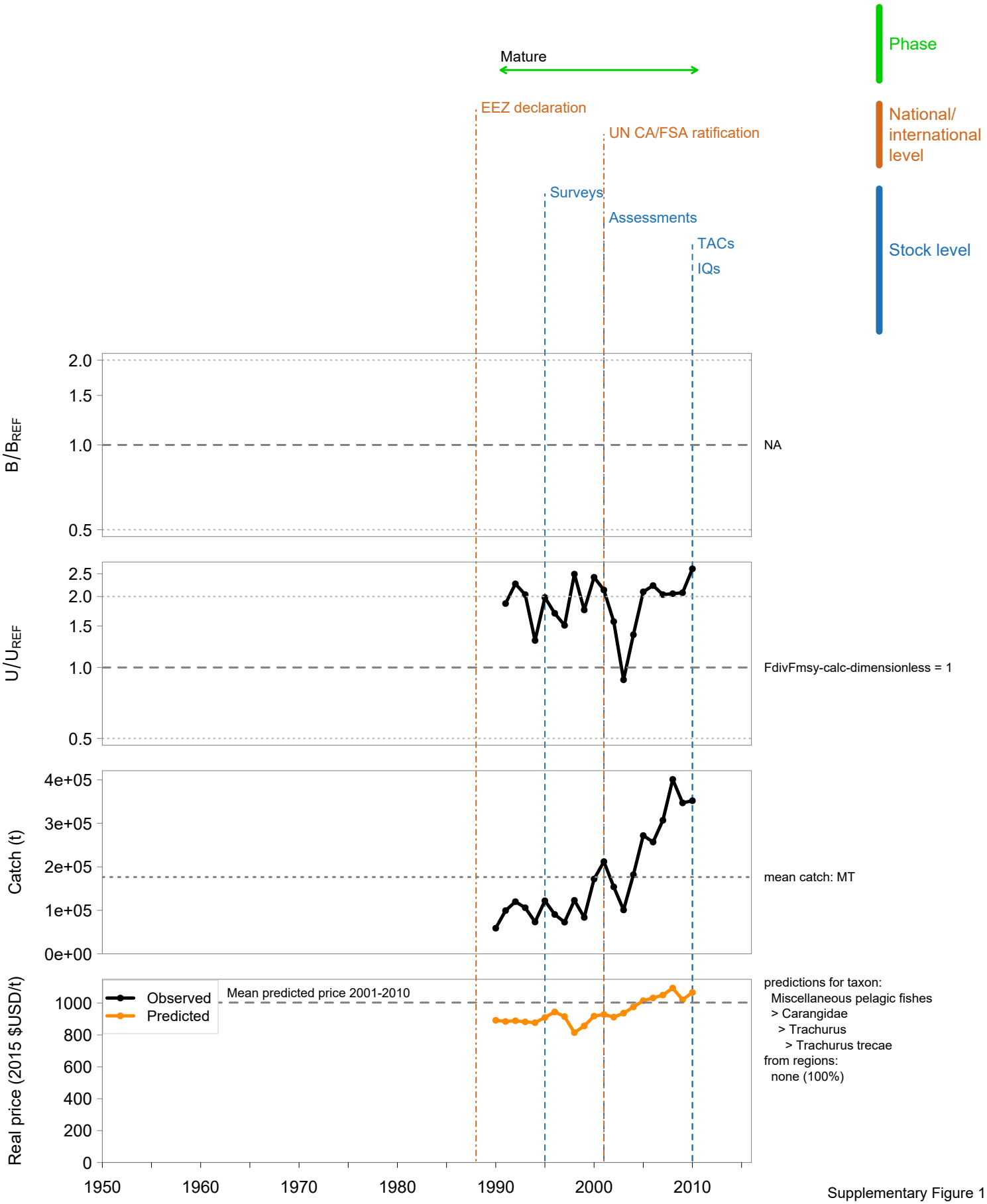
US-West Coast -- YEYEROCKPCOAST -- Yelloweye rockfish Pacific Coast

taxonomic group: demersal fish (Scorpaenids), predominant fishery type: mixed-species, primary country: USA



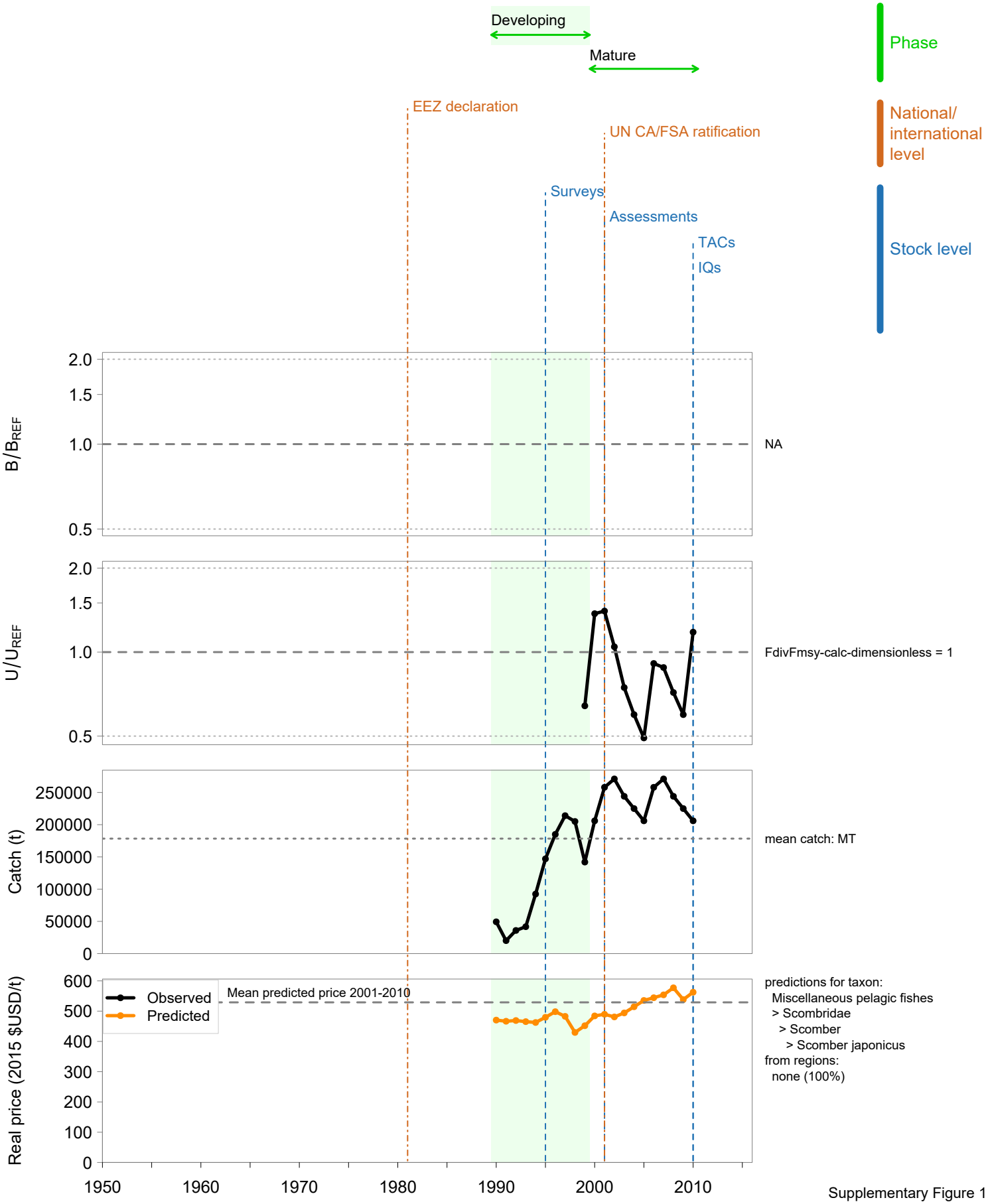
West Africa -- CHMACKWA -- Cunene horse mackerel West Africa

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Mauritania



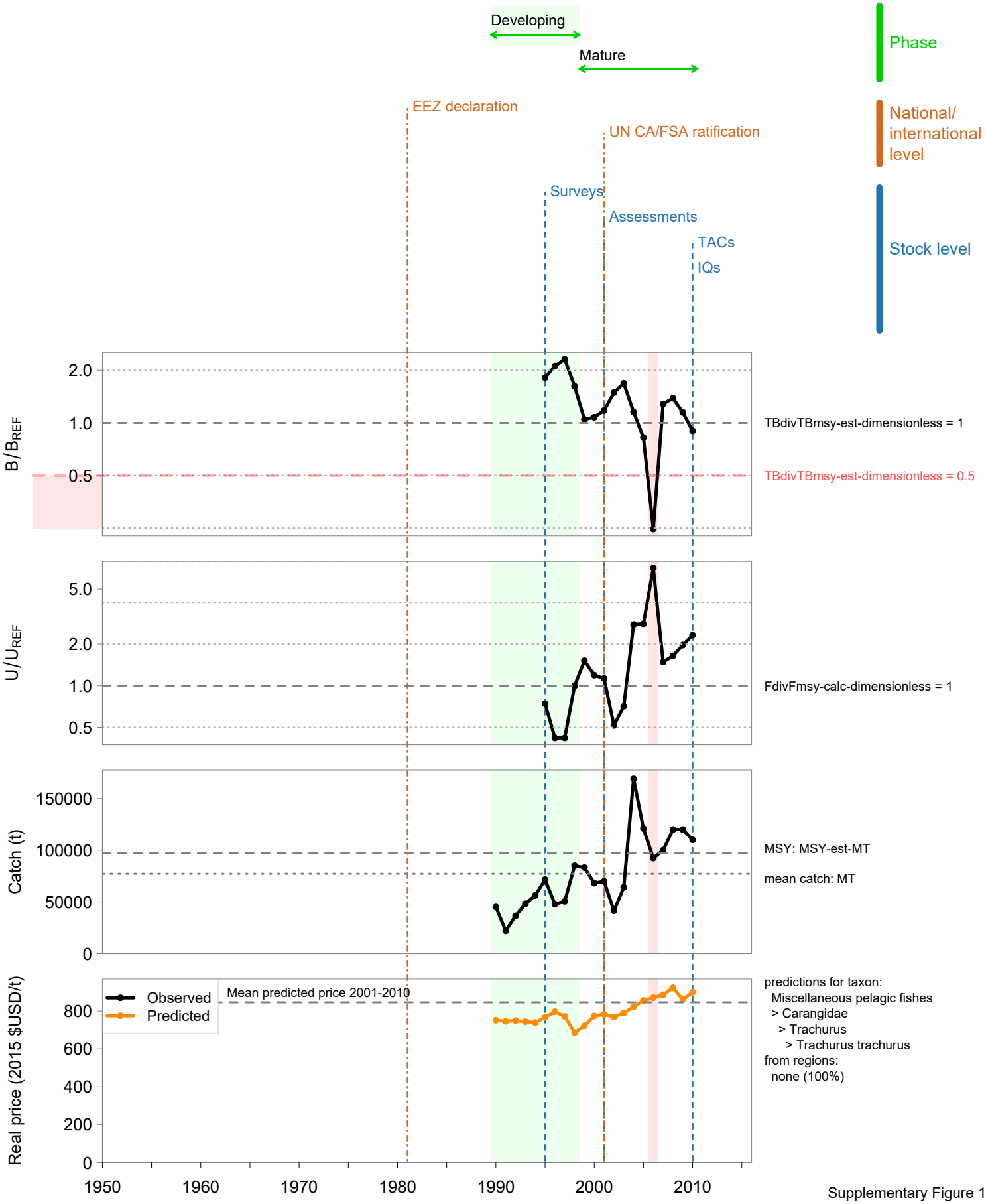
West Africa -- CMACKWA -- Chub mackerel West Africa

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Morocco



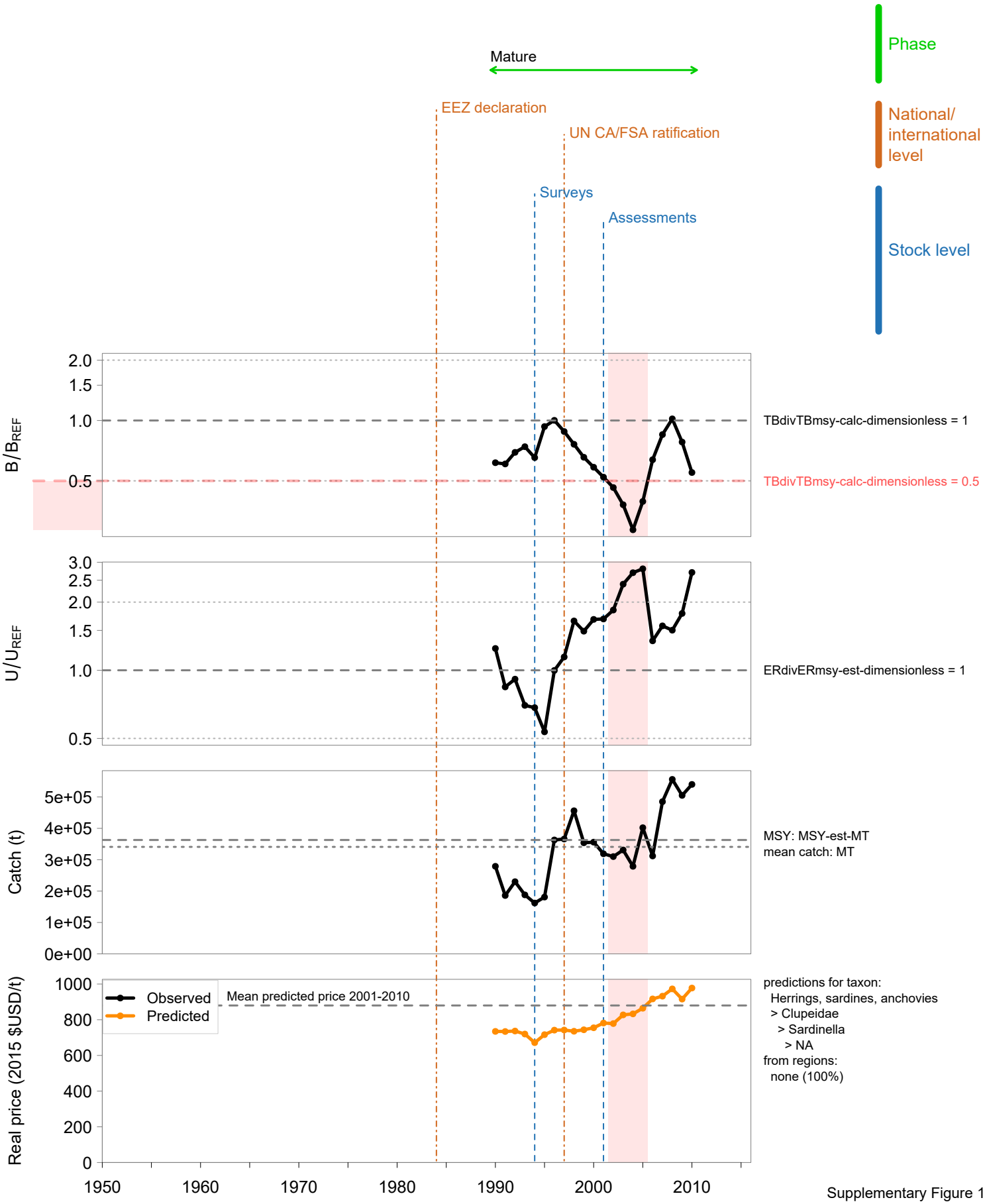
West Africa -- HMACKWA -- Horse mackerel West Africa

taxonomic group: pelagic fish (Carangids and mackerels), predominant fishery type: mixed-species, primary country: Morocco



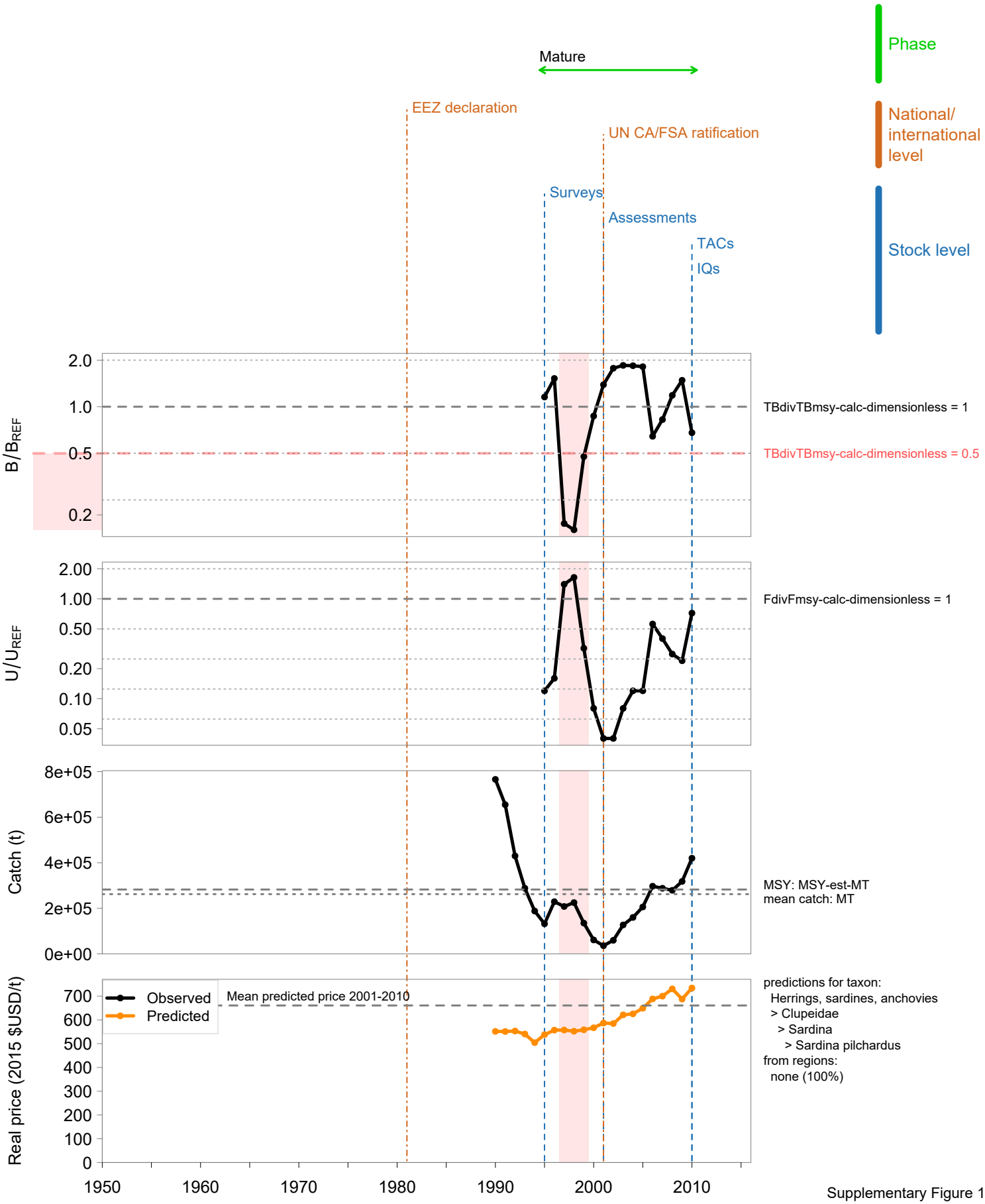
West Africa -- SARDINWA -- Sardinella West Africa

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Senegal



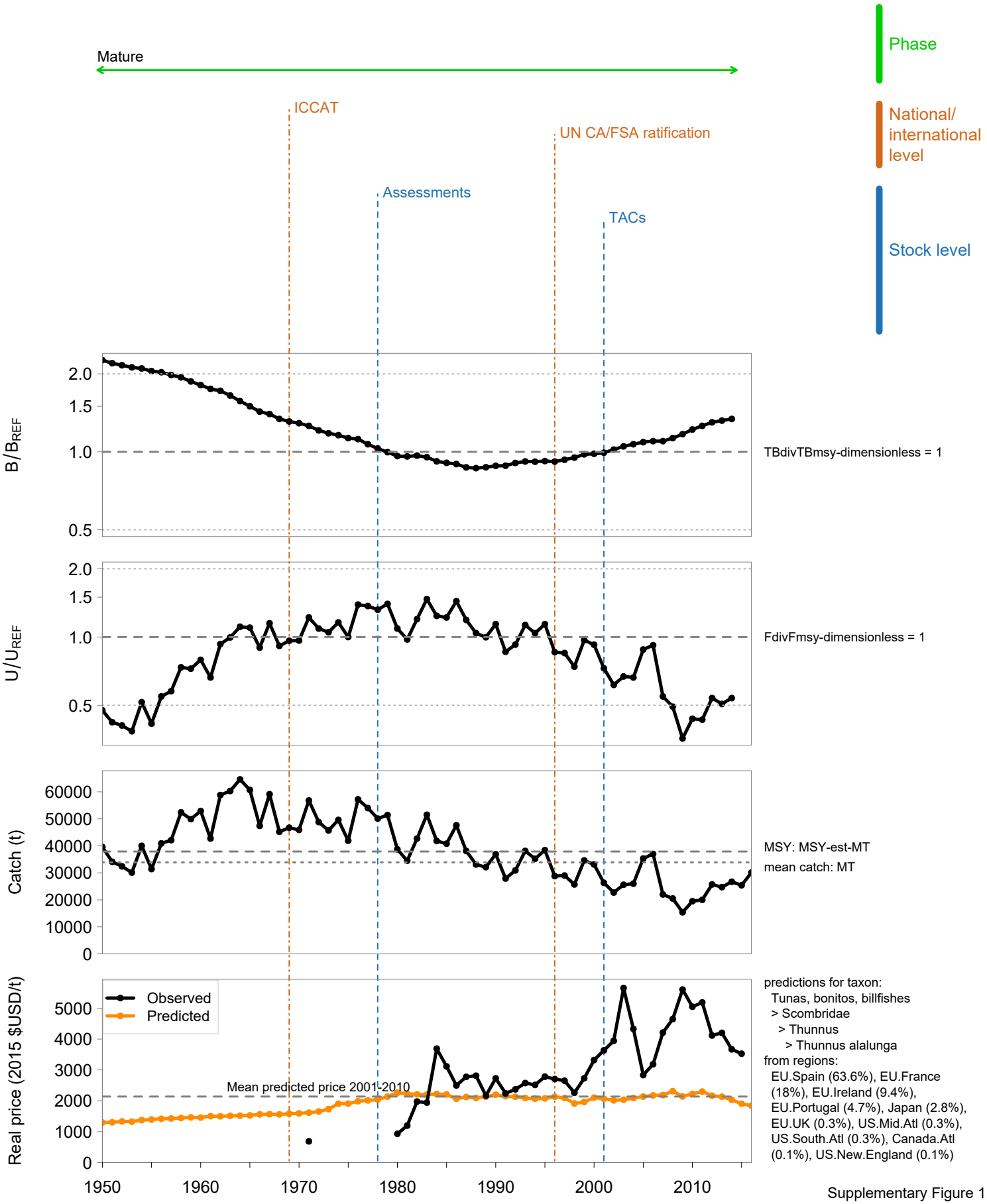
West Africa -- SARDWAZC -- Sardine West Africa Zone C

taxonomic group: pelagic fish (Forage fish), predominant fishery type: mixed-species, primary country: Morocco



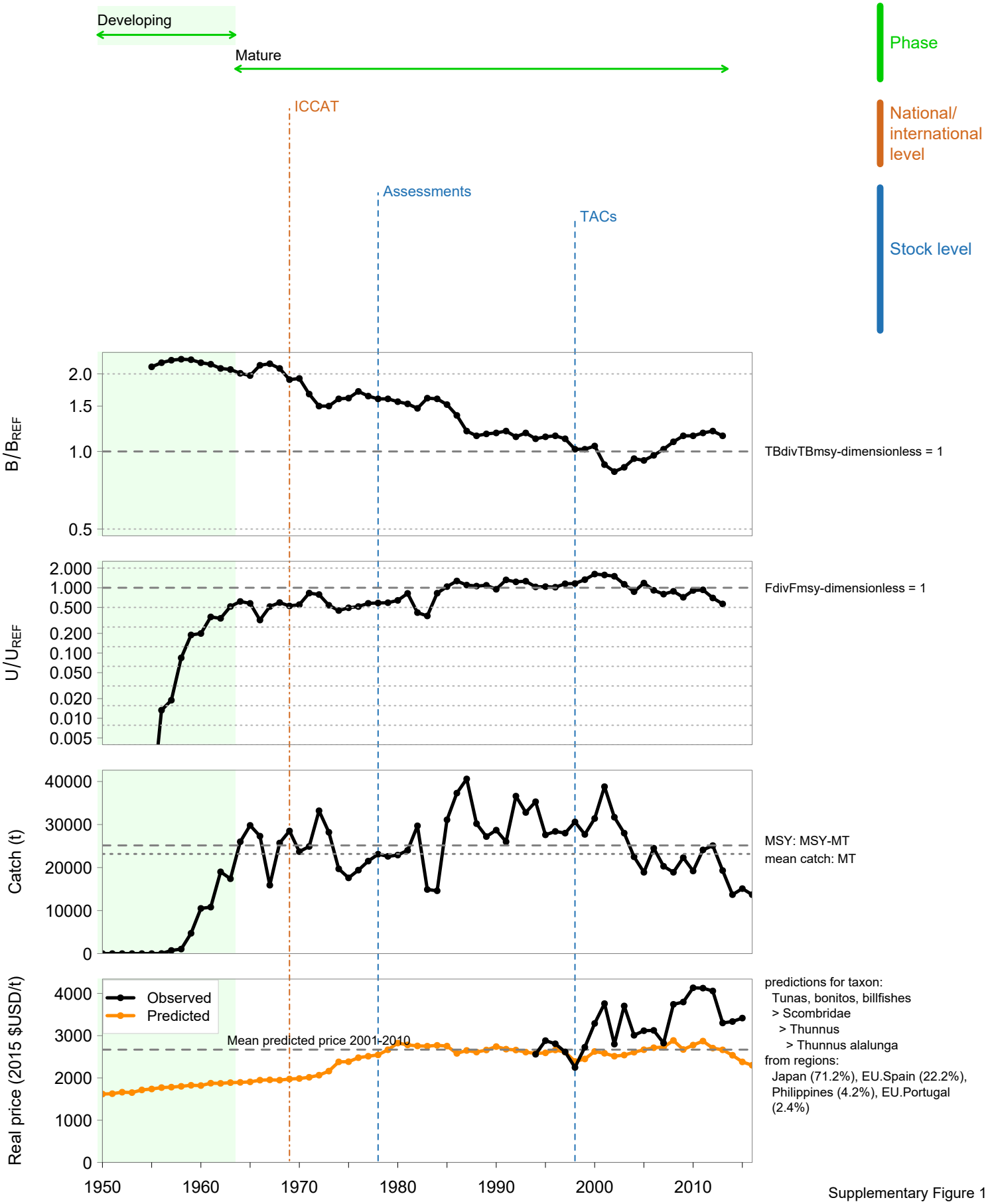
Tuna RFMOs -- ALBANATL -- Albacore tuna Northern Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Spain



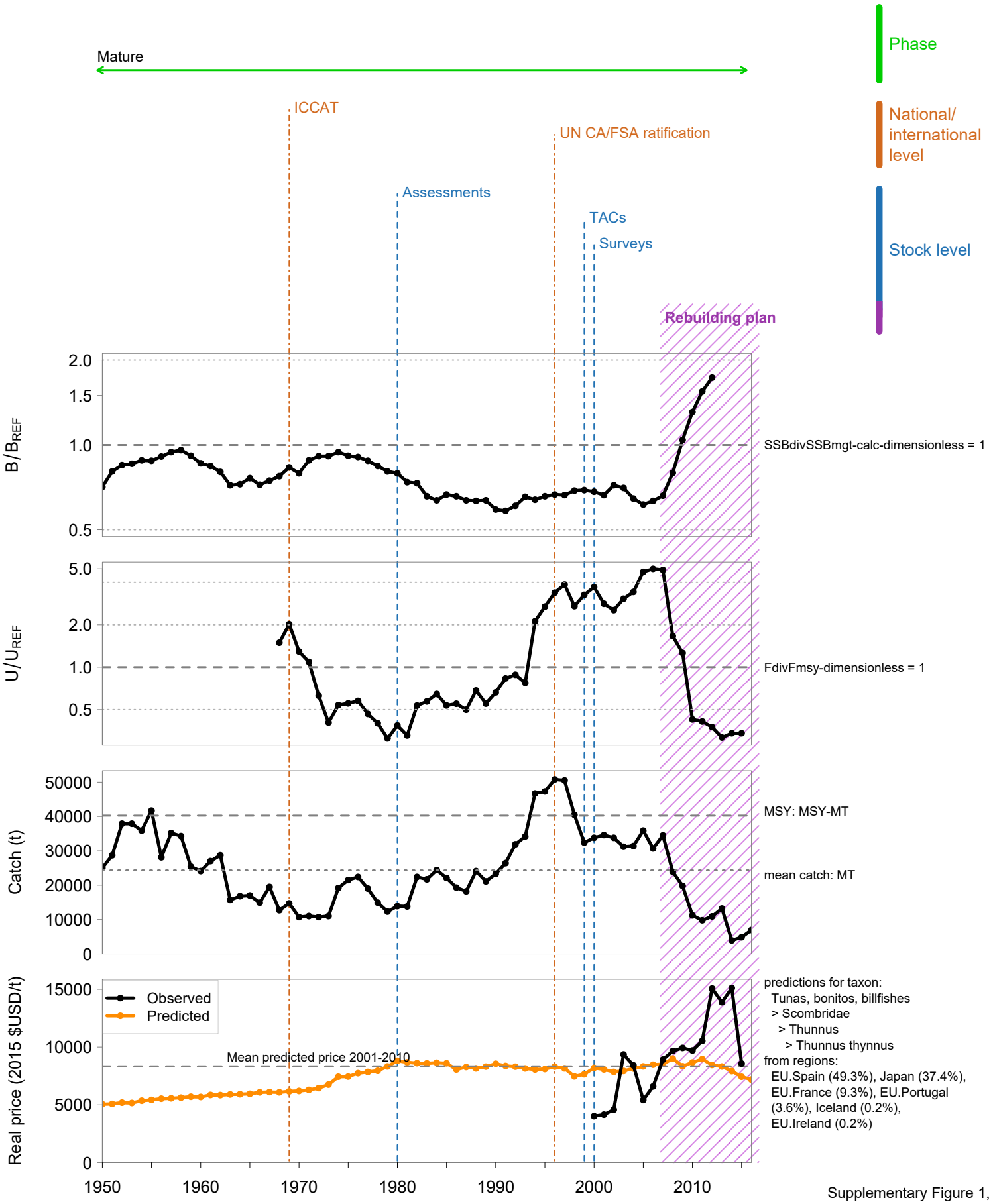
Tuna RFMOs -- ALBASATL -- Albacore tuna South Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Taiwan



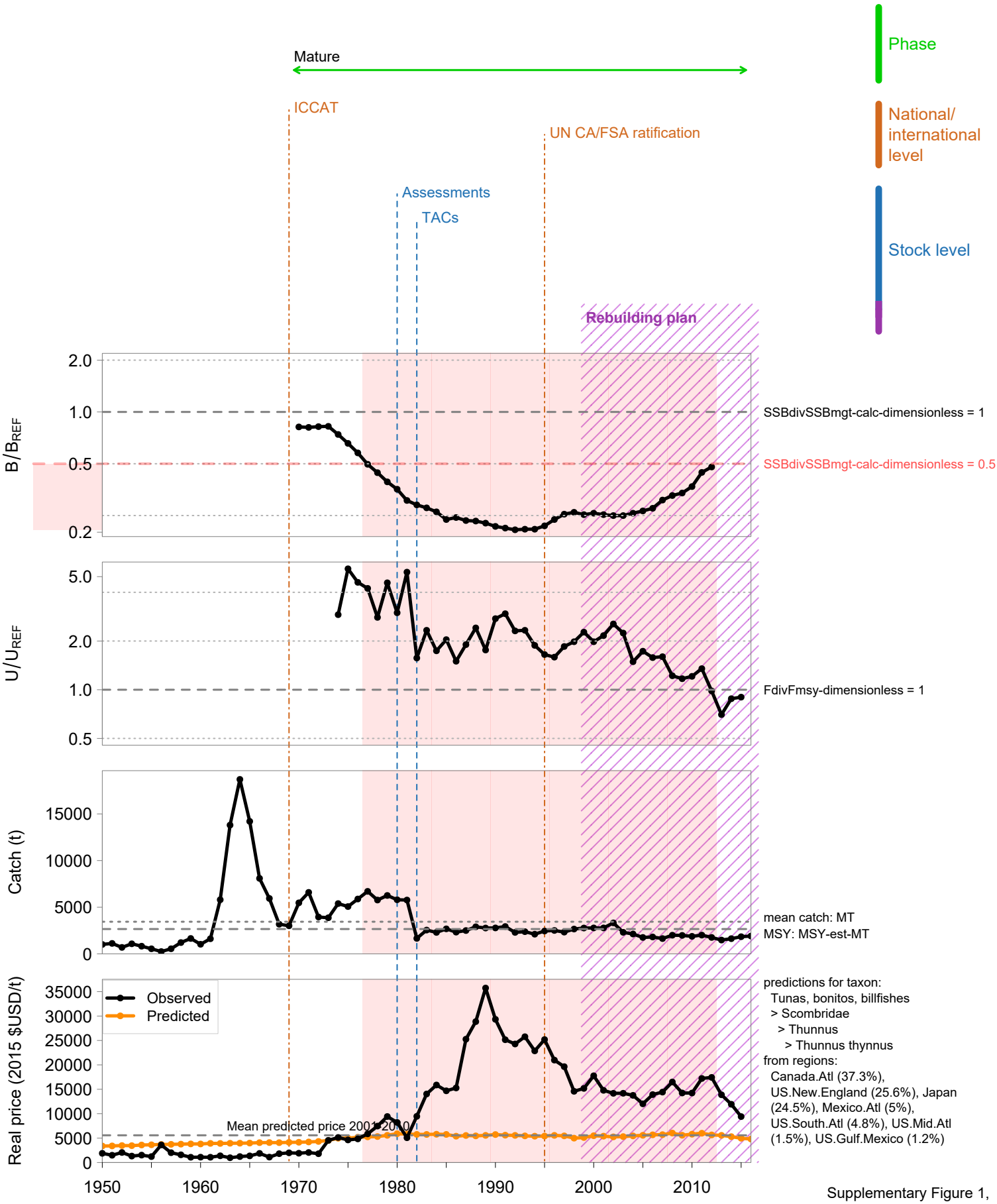
Tuna RFMOs -- ATBTUNAEATL -- Atlantic bluefin tuna Eastern Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: single-species, primary country: Spain



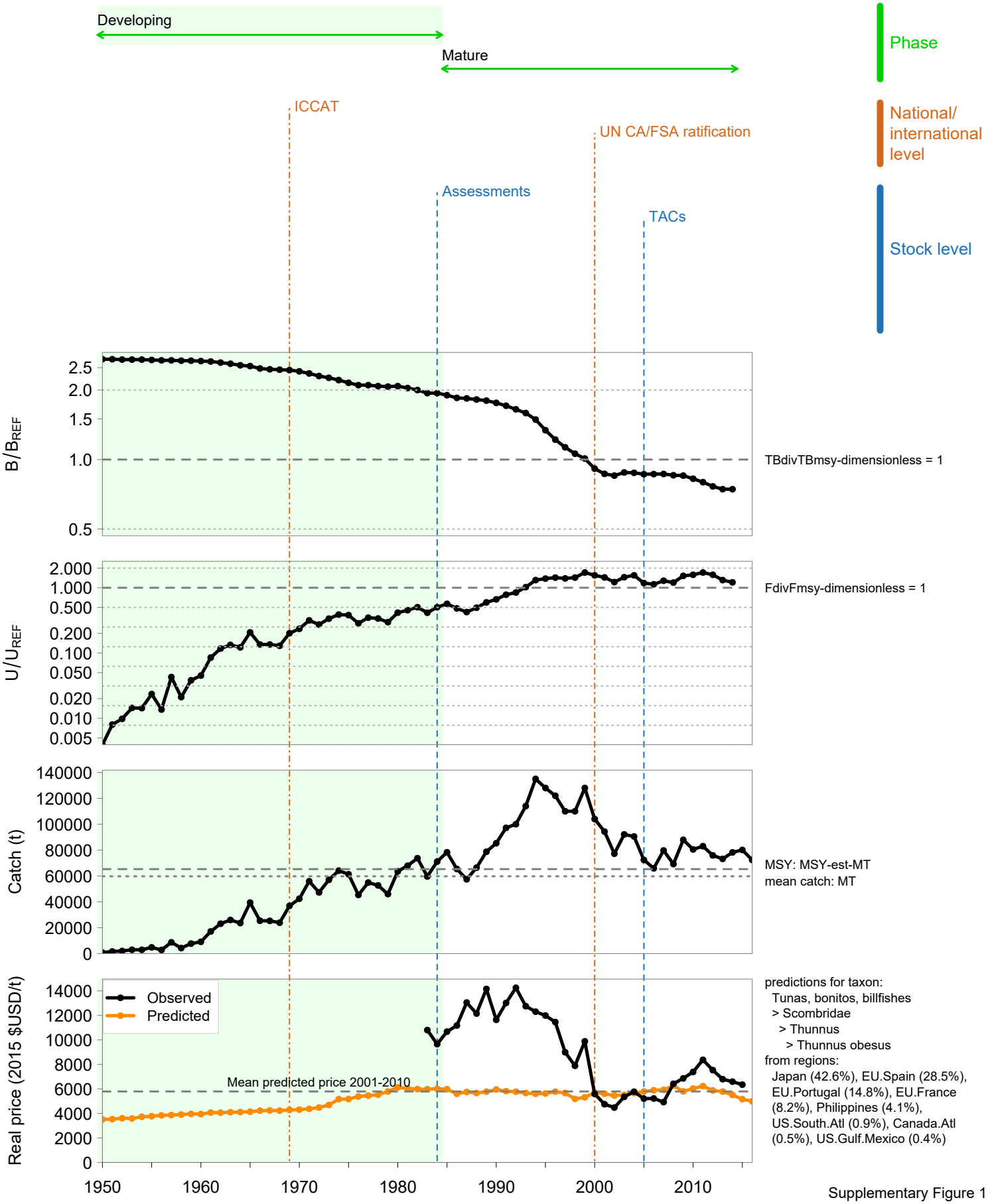
Tuna RFMOs -- ATBTUNAWATL -- Atlantic bluefin tuna Western Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: single-species, primary country: USA



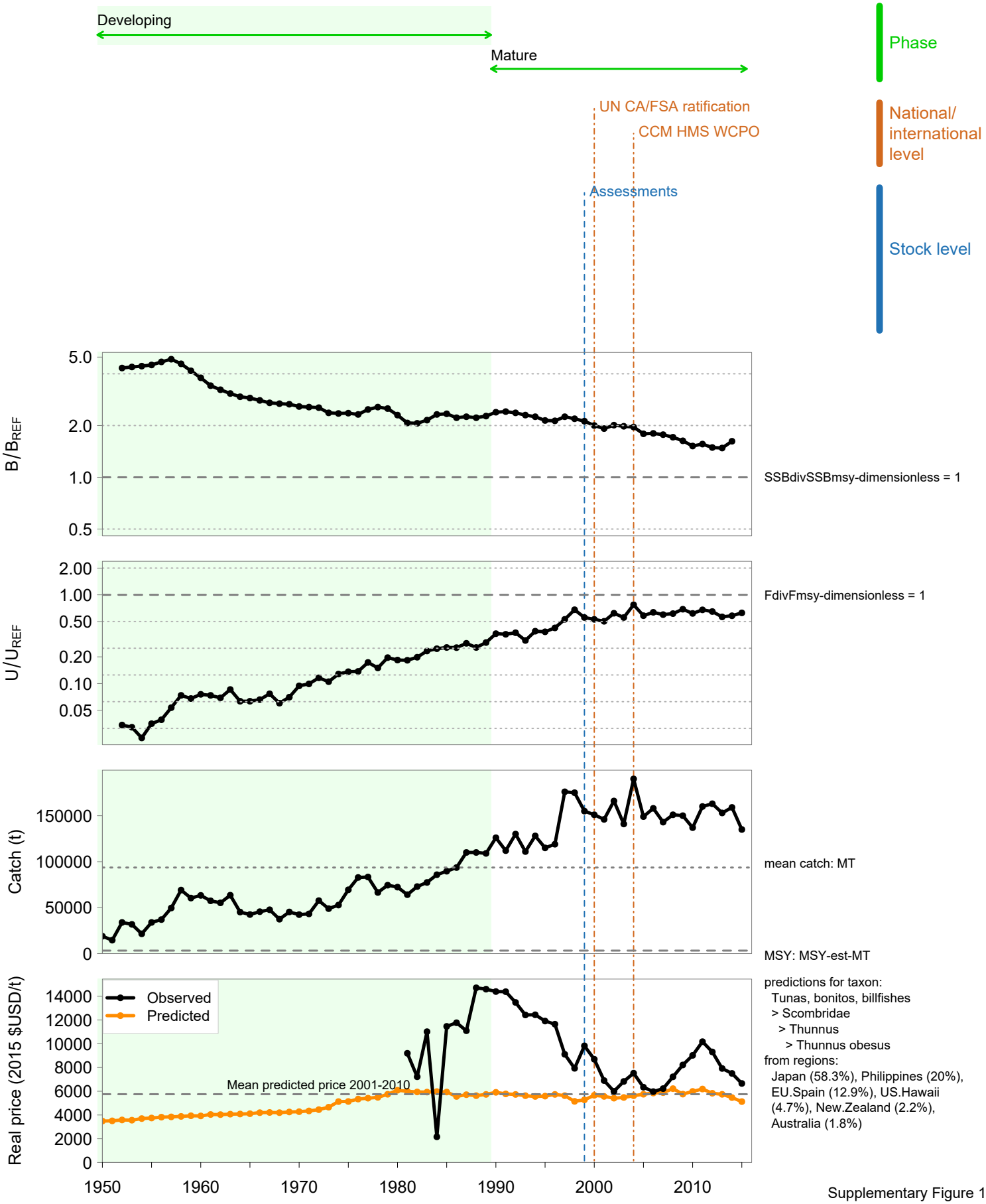
Tuna RFMOs -- BIGEYEATL -- Bigeye tuna Atlantic Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Japan



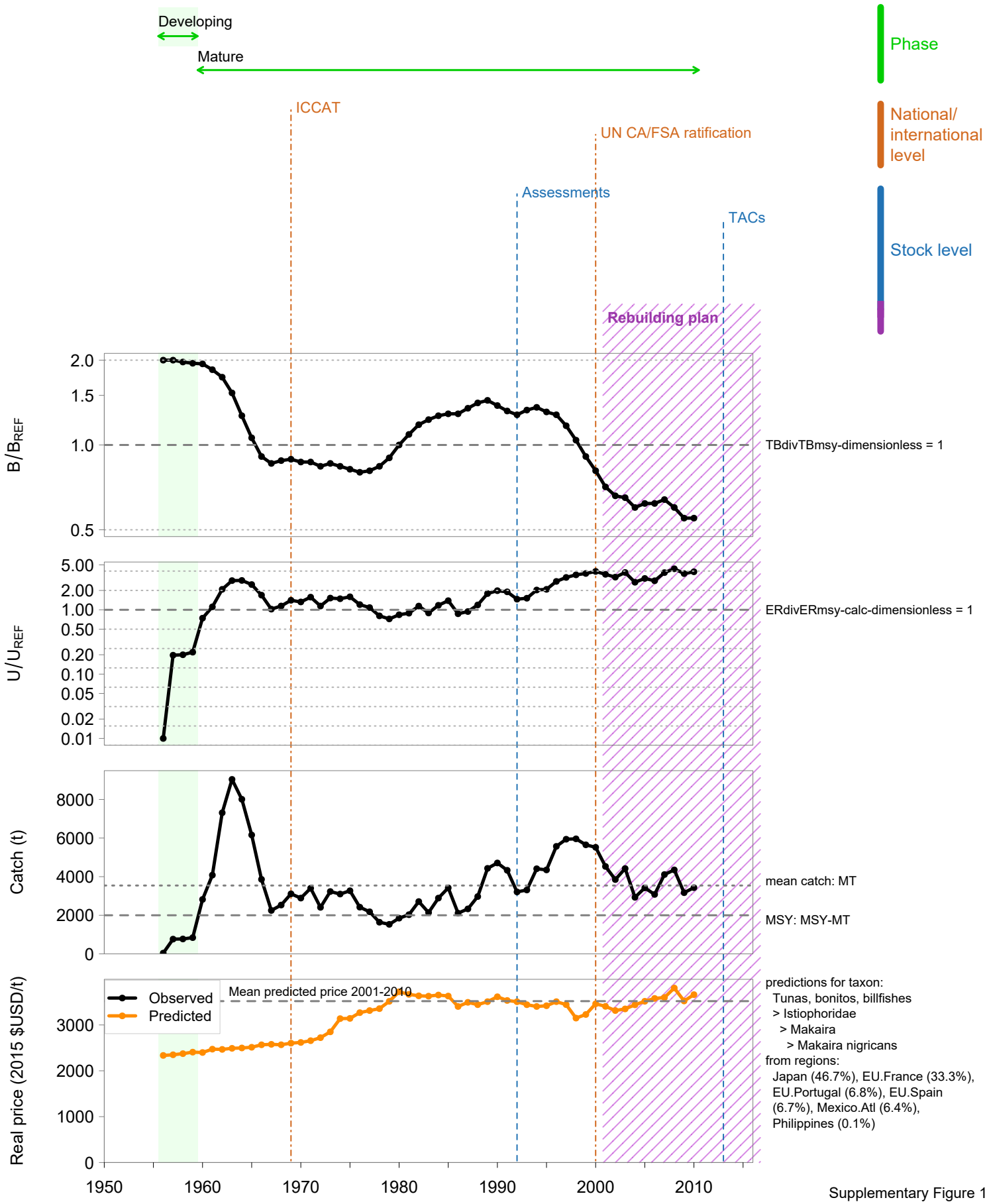
Tuna RFMOs -- BIGEYECWPAC -- Bigeye tuna Central Western Pacific Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Japan



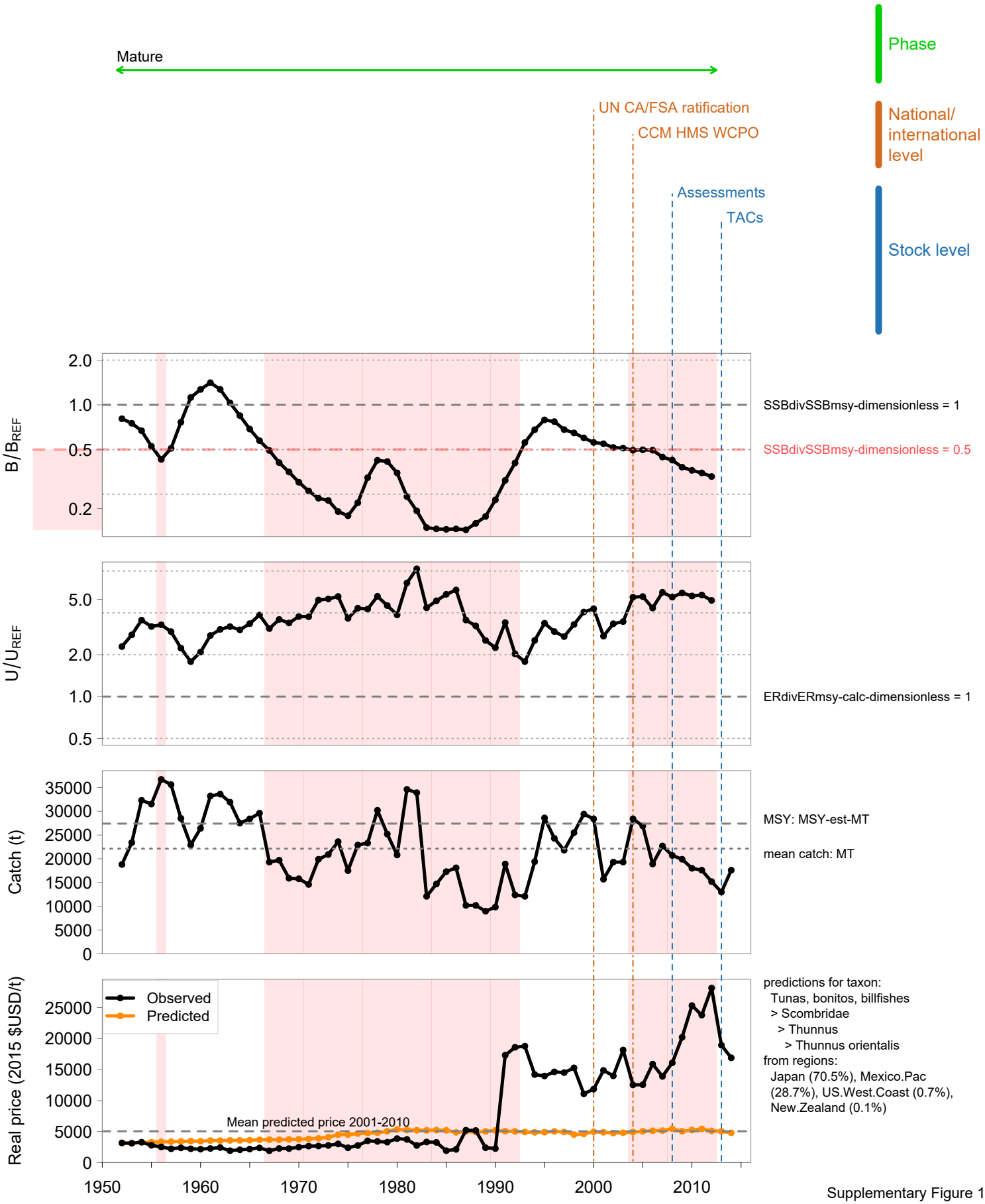
Tuna RFMOs -- BMARLINATL -- Blue marlin Atlantic Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Japan



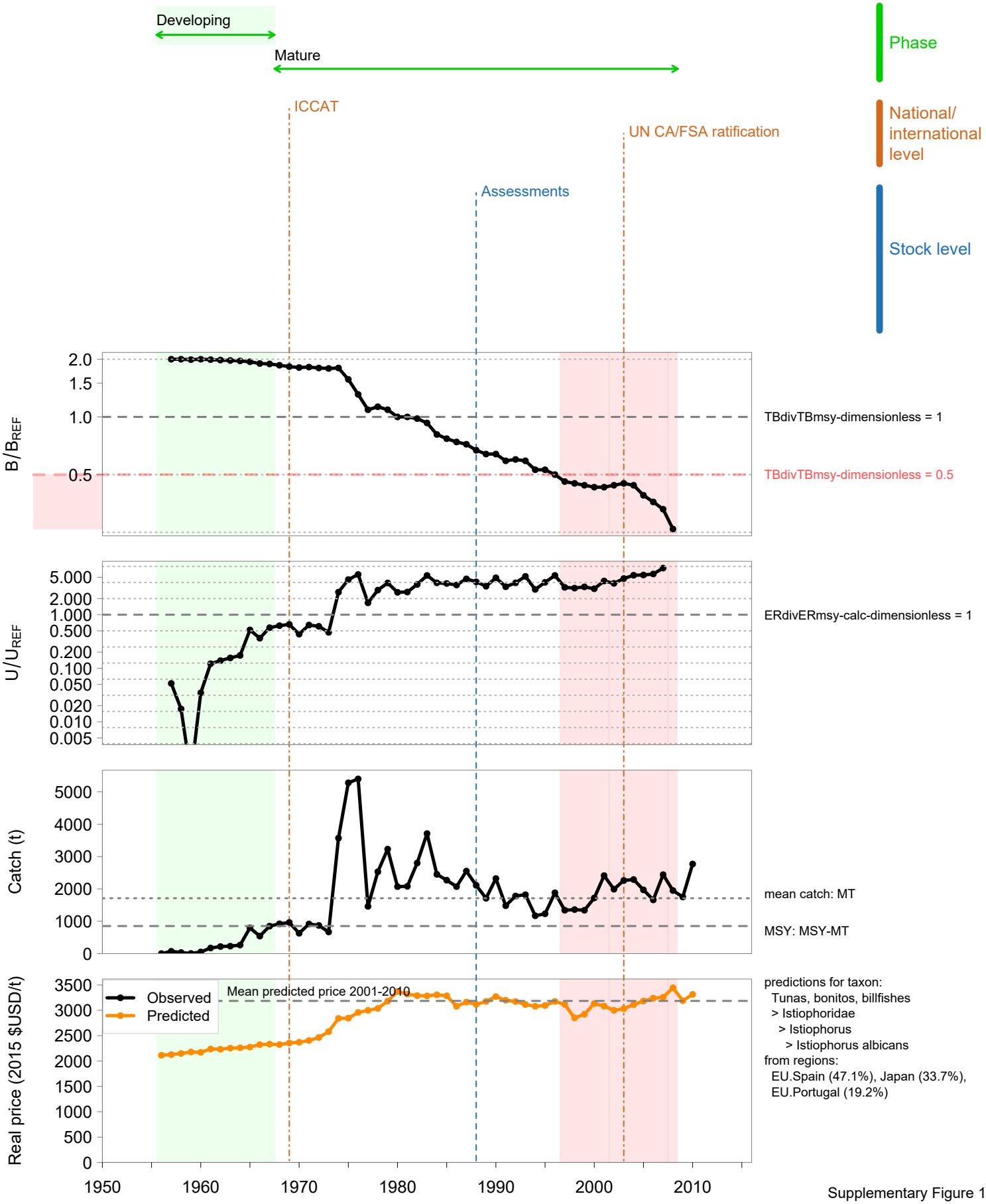
Tuna RFMOs -- PACBTUNA -- Pacific bluefin tuna Pacific Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: single-species, primary country: Japan



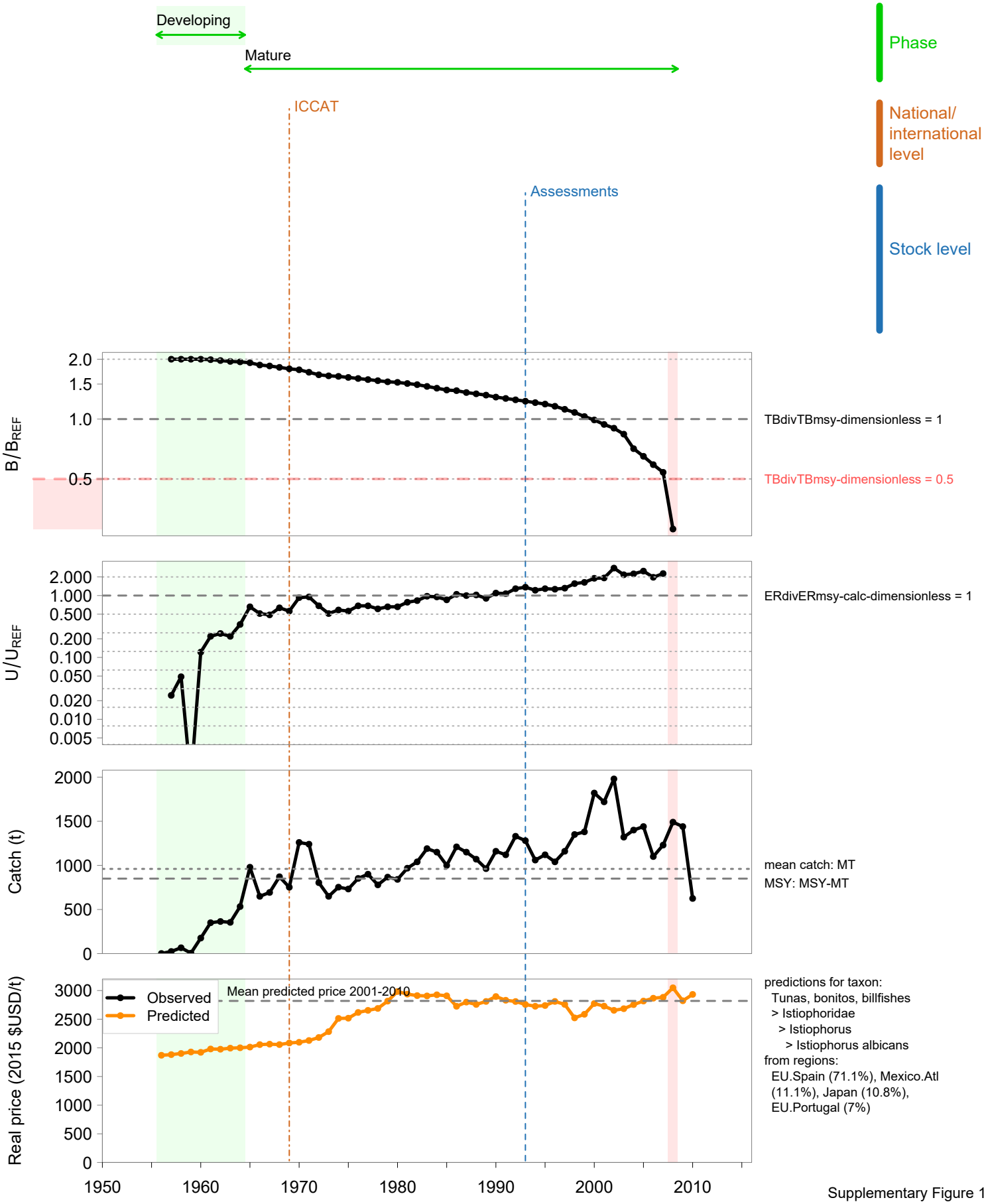
Tuna RFMOs -- SAILEATL -- Sailfish Eastern Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Ghana



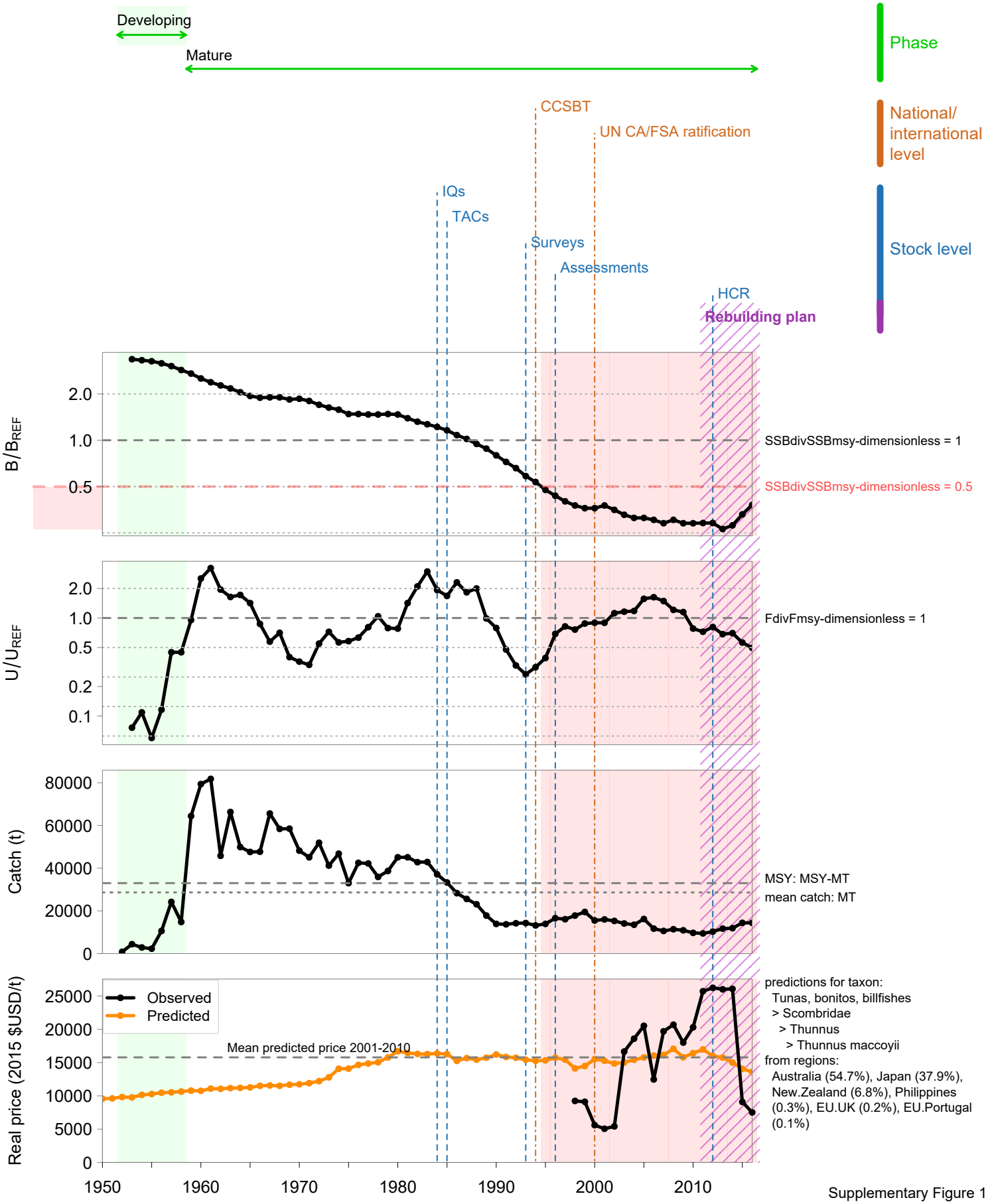
Tuna RFMOs -- SAILWATL -- Sailfish Western Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Venezuela



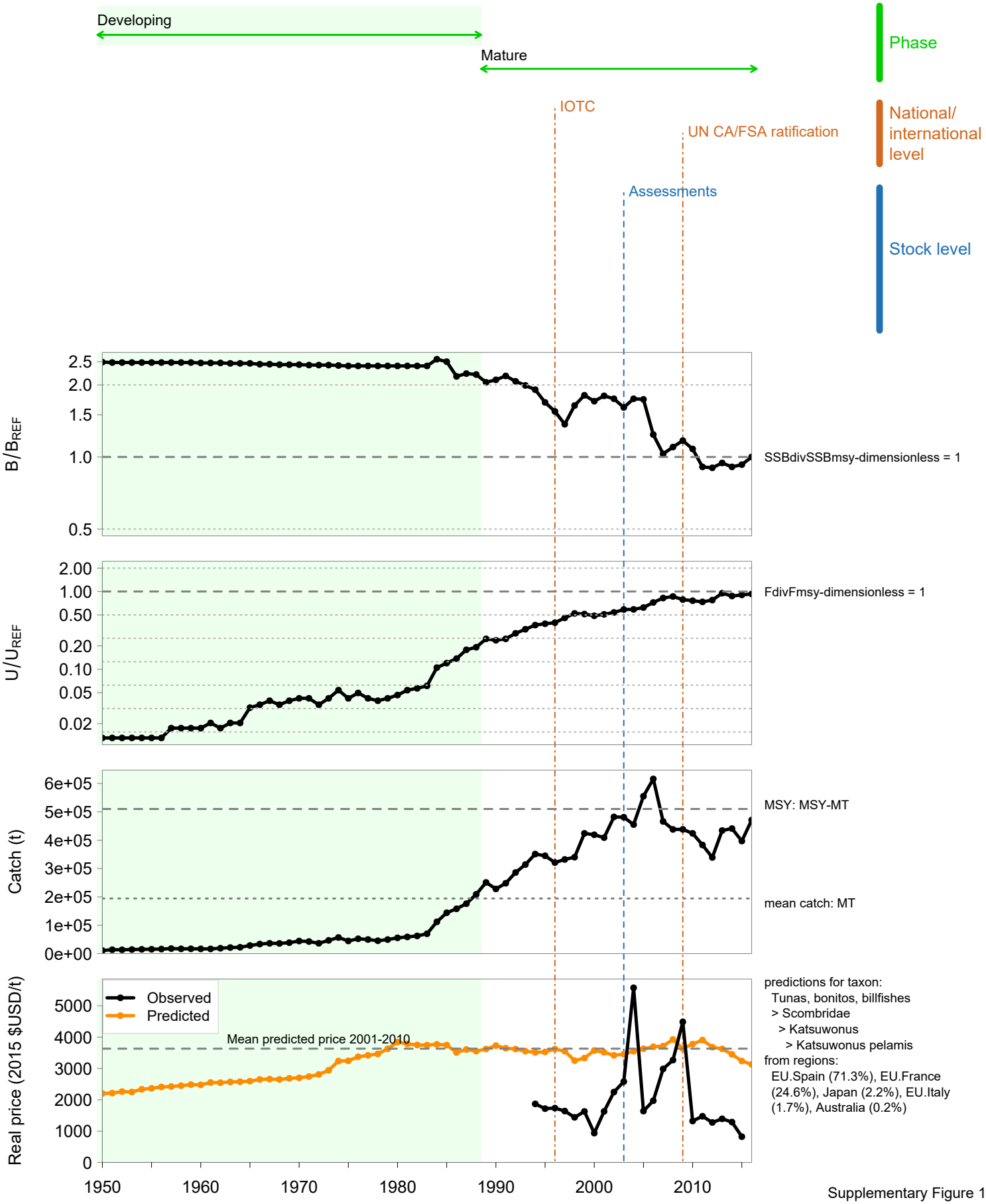
Tuna RFMOs -- SBT -- Southern bluefin tuna Southern Oceans

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: single-species, primary country: Japan



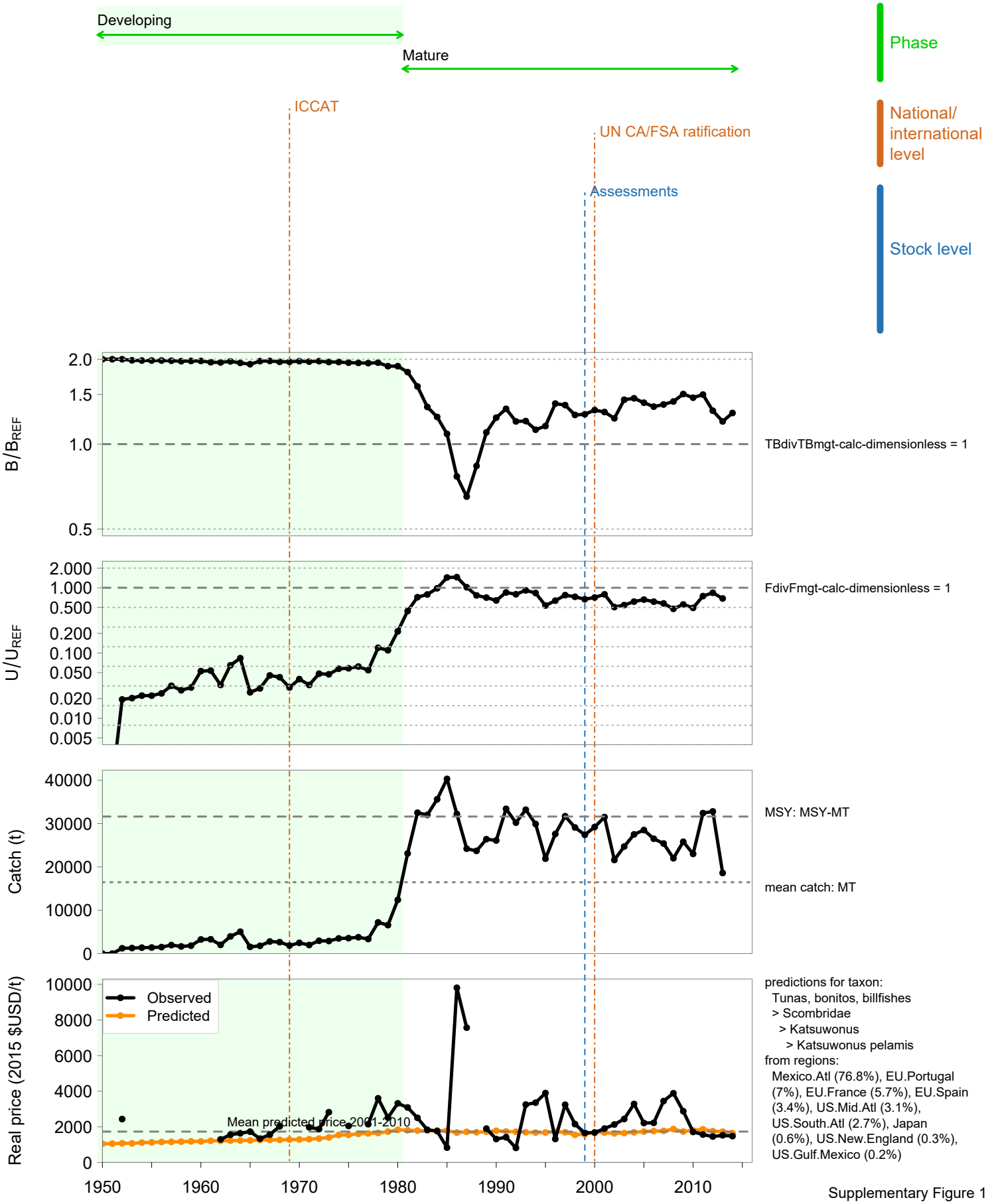
Tuna RFMOs -- SKJCIO -- Skipjack tuna Indian Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Indonesia



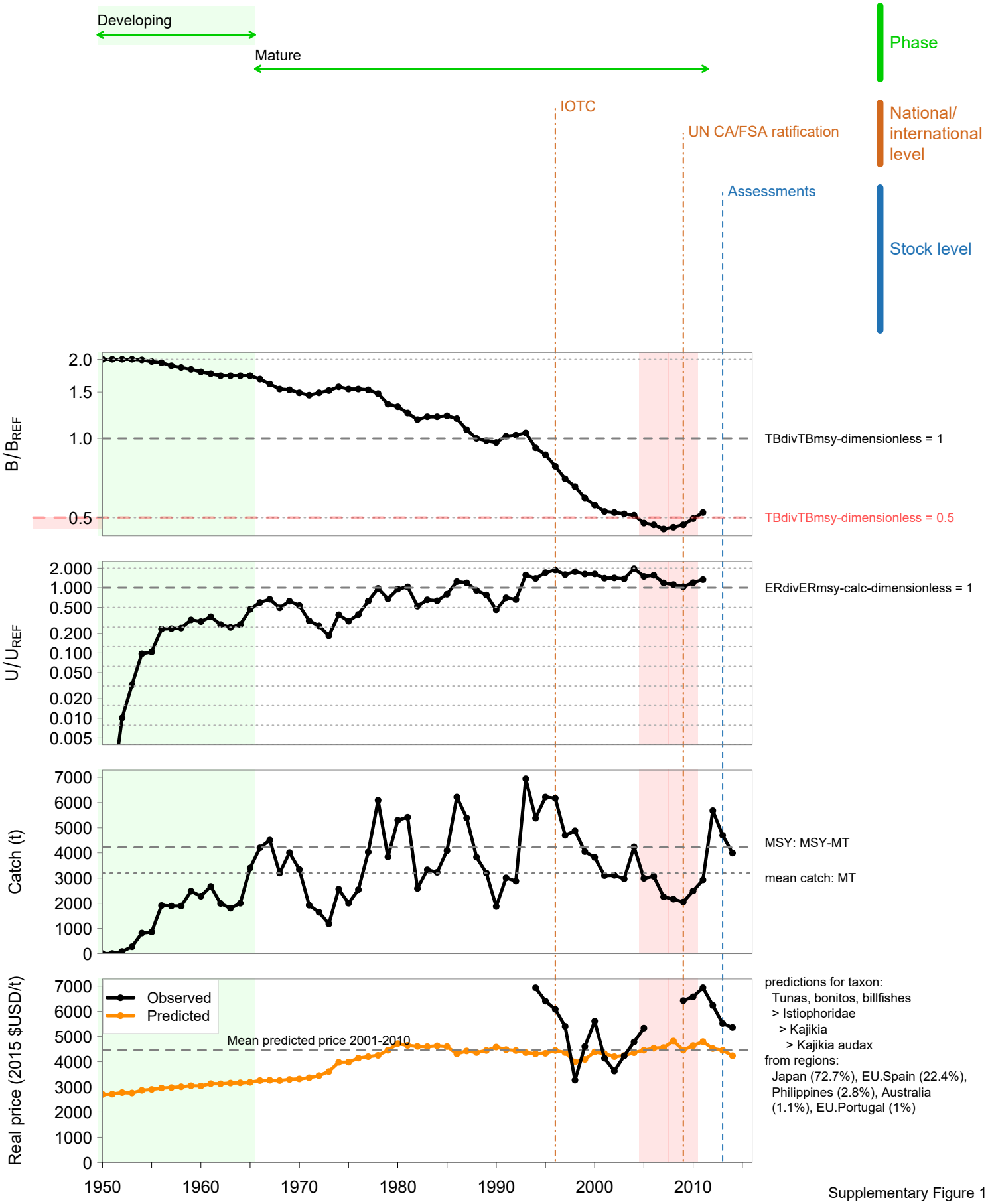
Tuna RFMOs -- SKJWATL -- Skipjack tuna Western Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Brazil



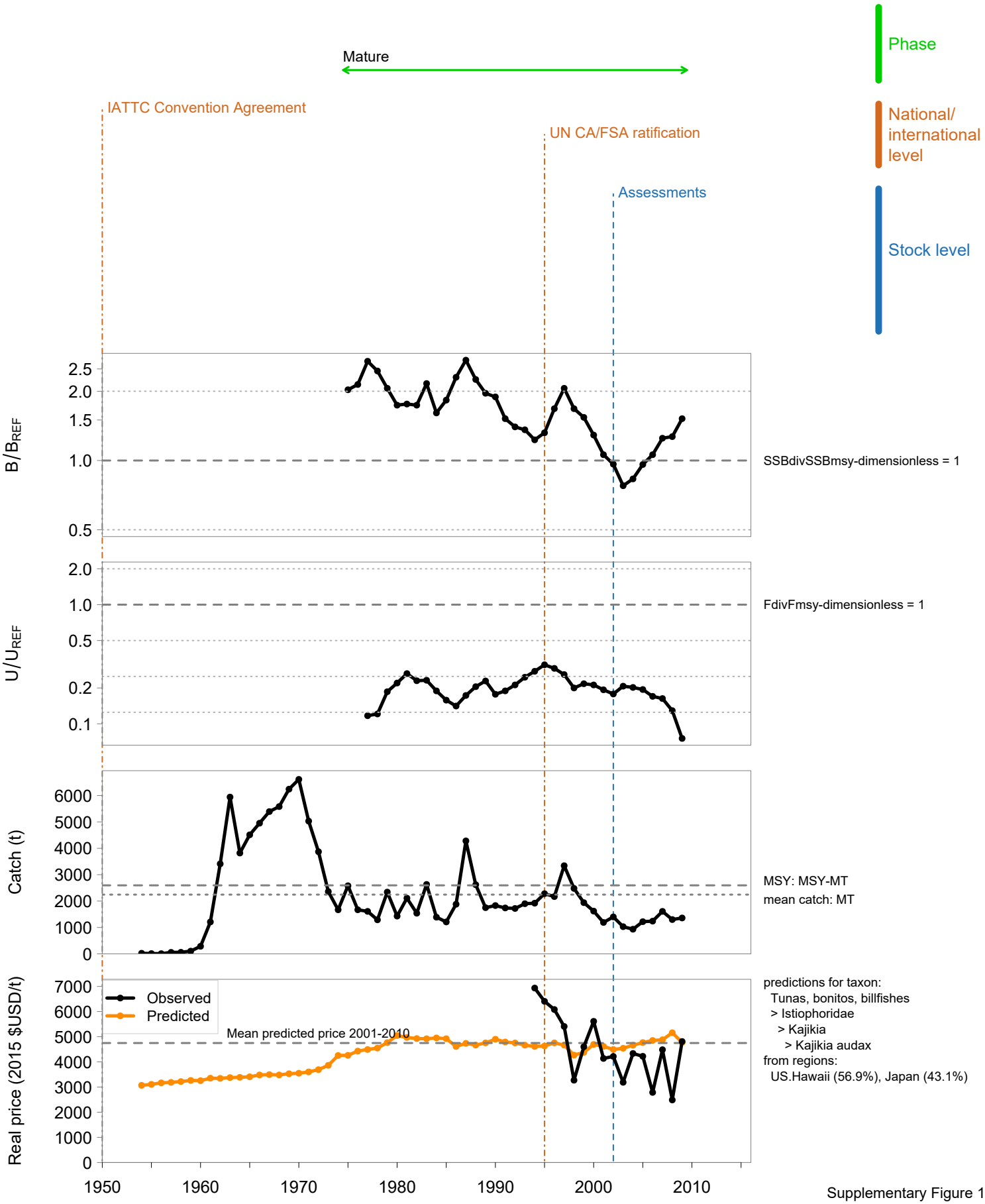
Tuna RFMOs -- STMARLINIO -- Striped marlin Indian Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Indonesia



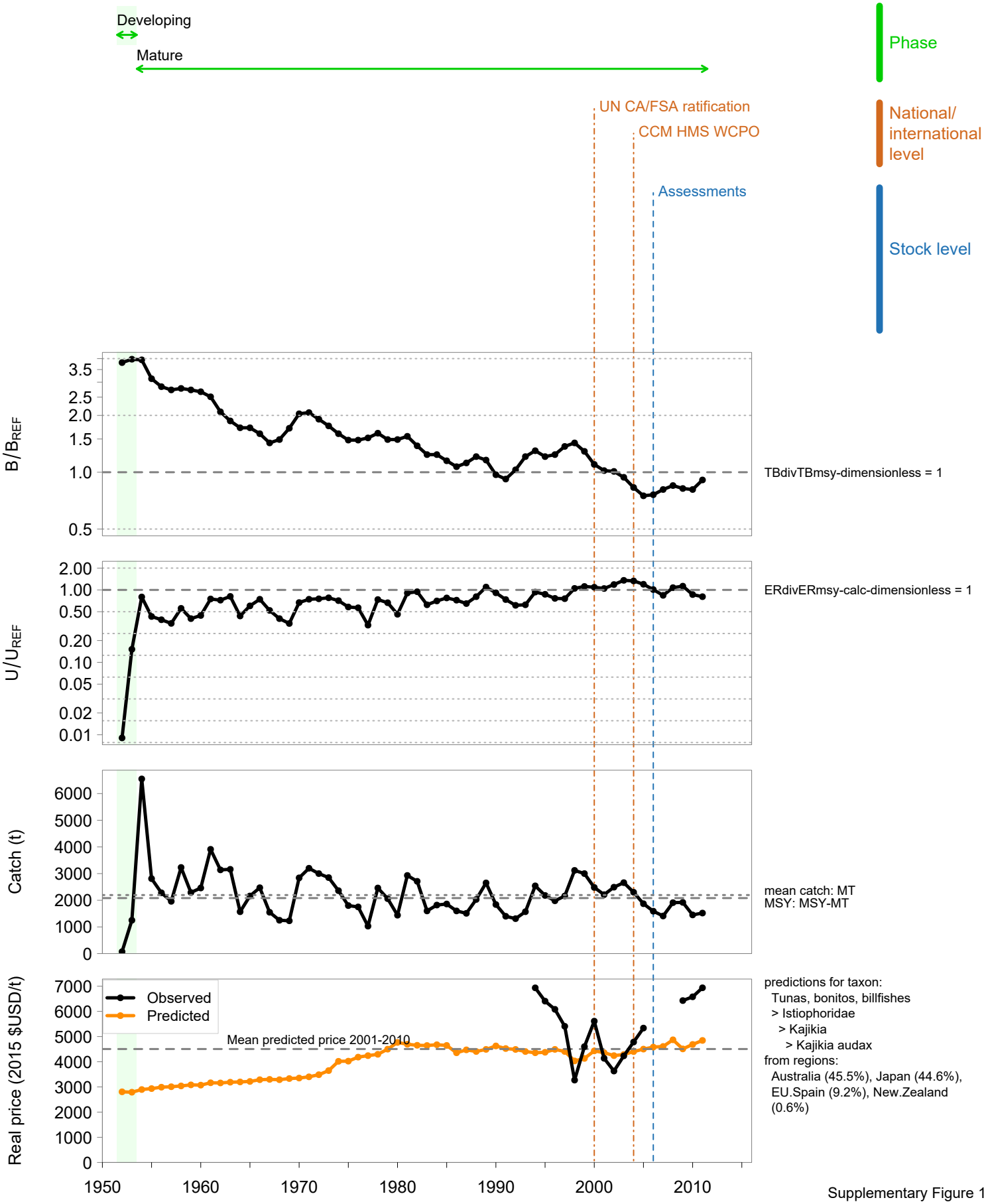
Tuna RFMOs -- STMARLINNEPAC -- Striped marlin Northeast Pacific

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: USA



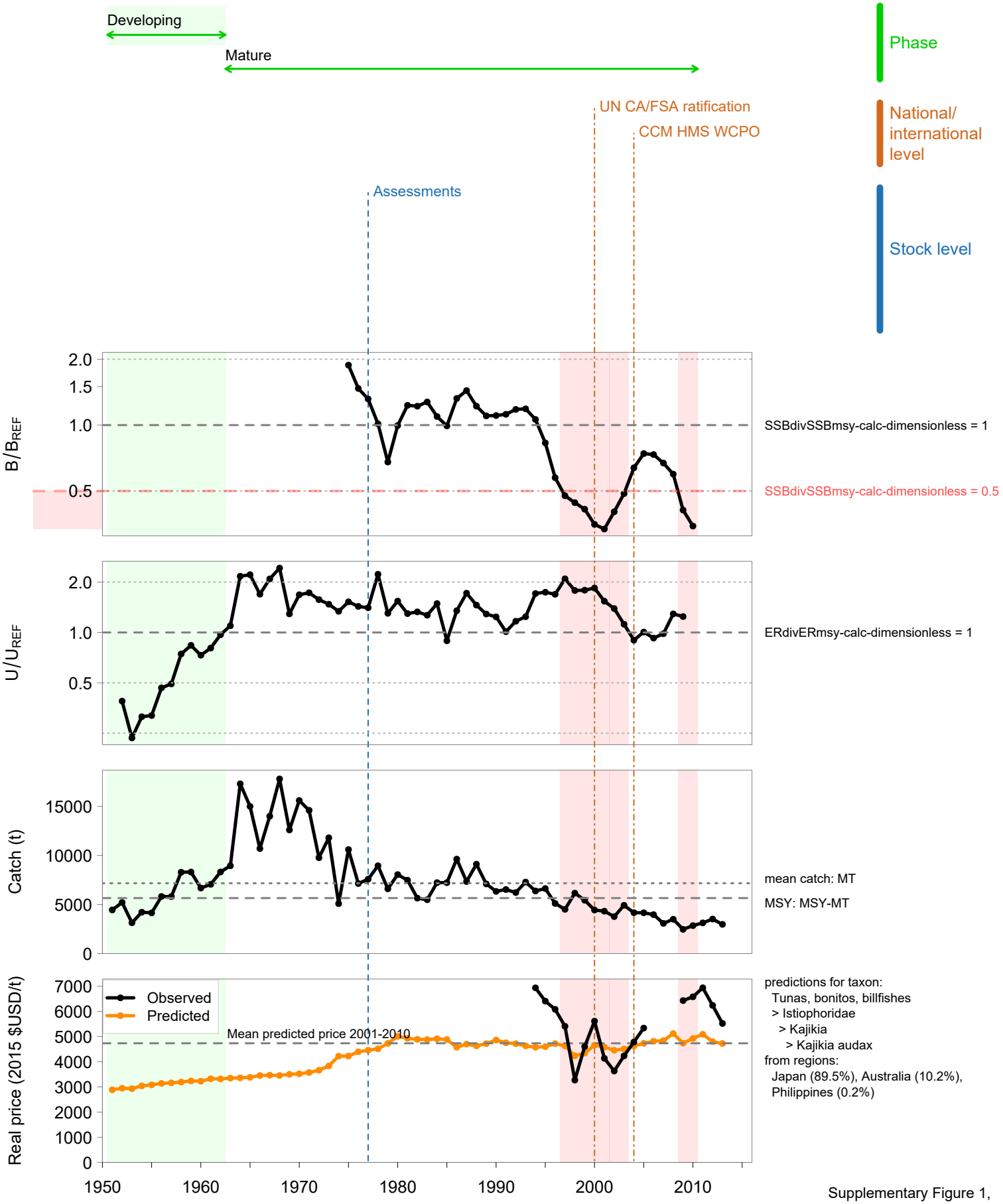
Tuna RFMOs -- STMARLINSWPO -- Striped marlin Western Pacific Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Japan



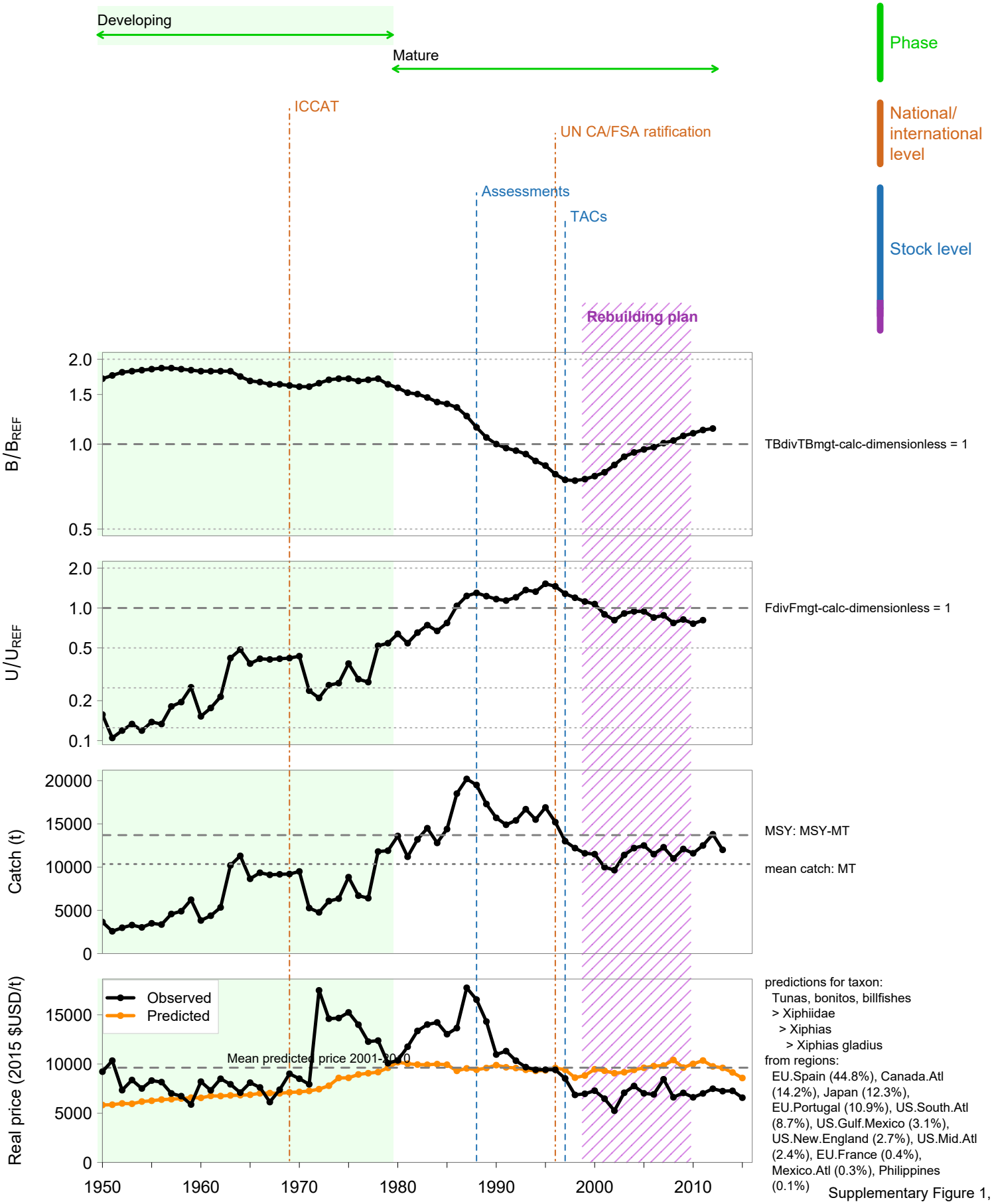
Tuna RFMOs -- STMARLINWCNPAC -- Striped marlin Western and Central North Pacific

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Japan



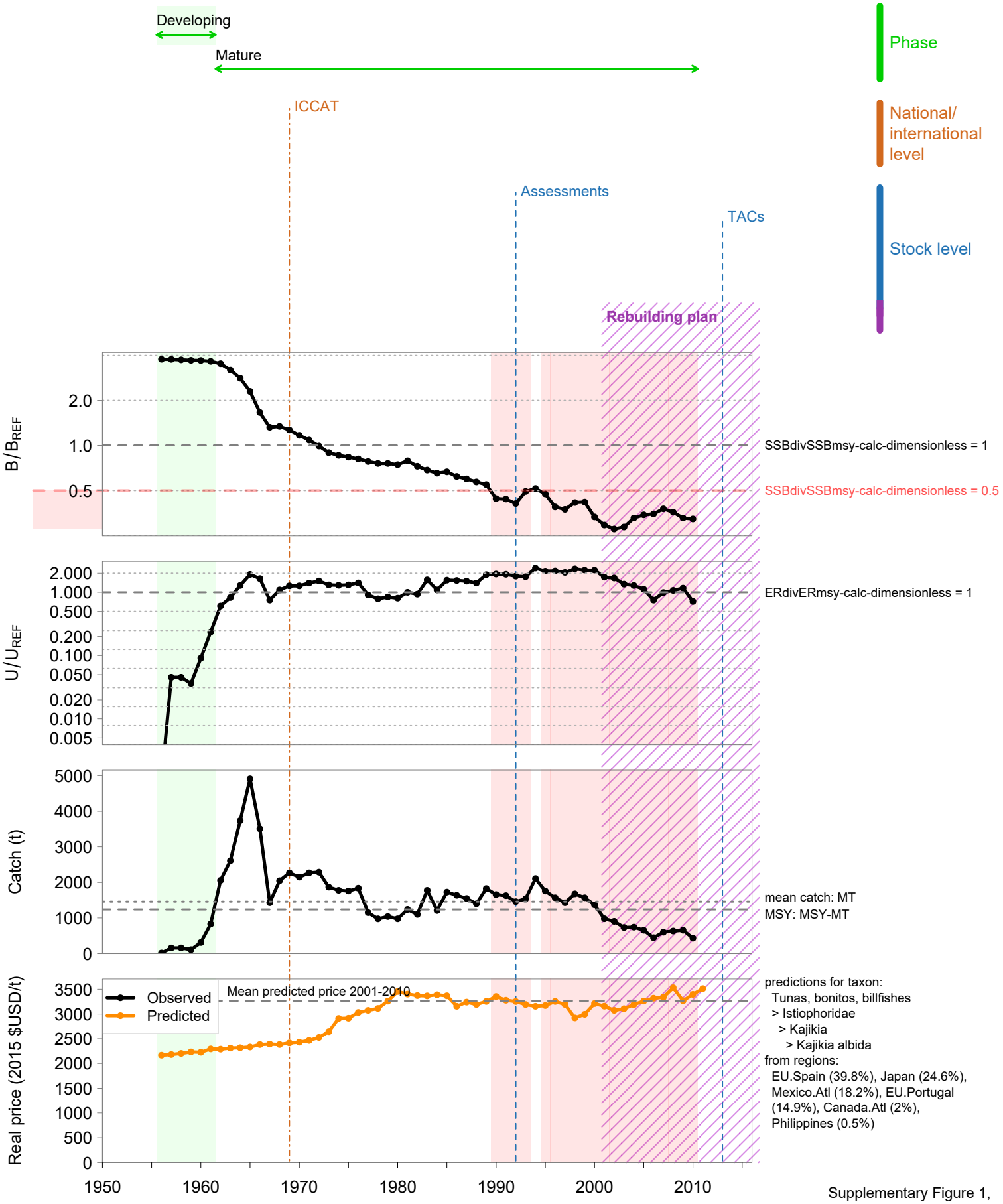
Tuna RFMOs -- SWORDNATL -- Swordfish Northern Atlantic

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Spain



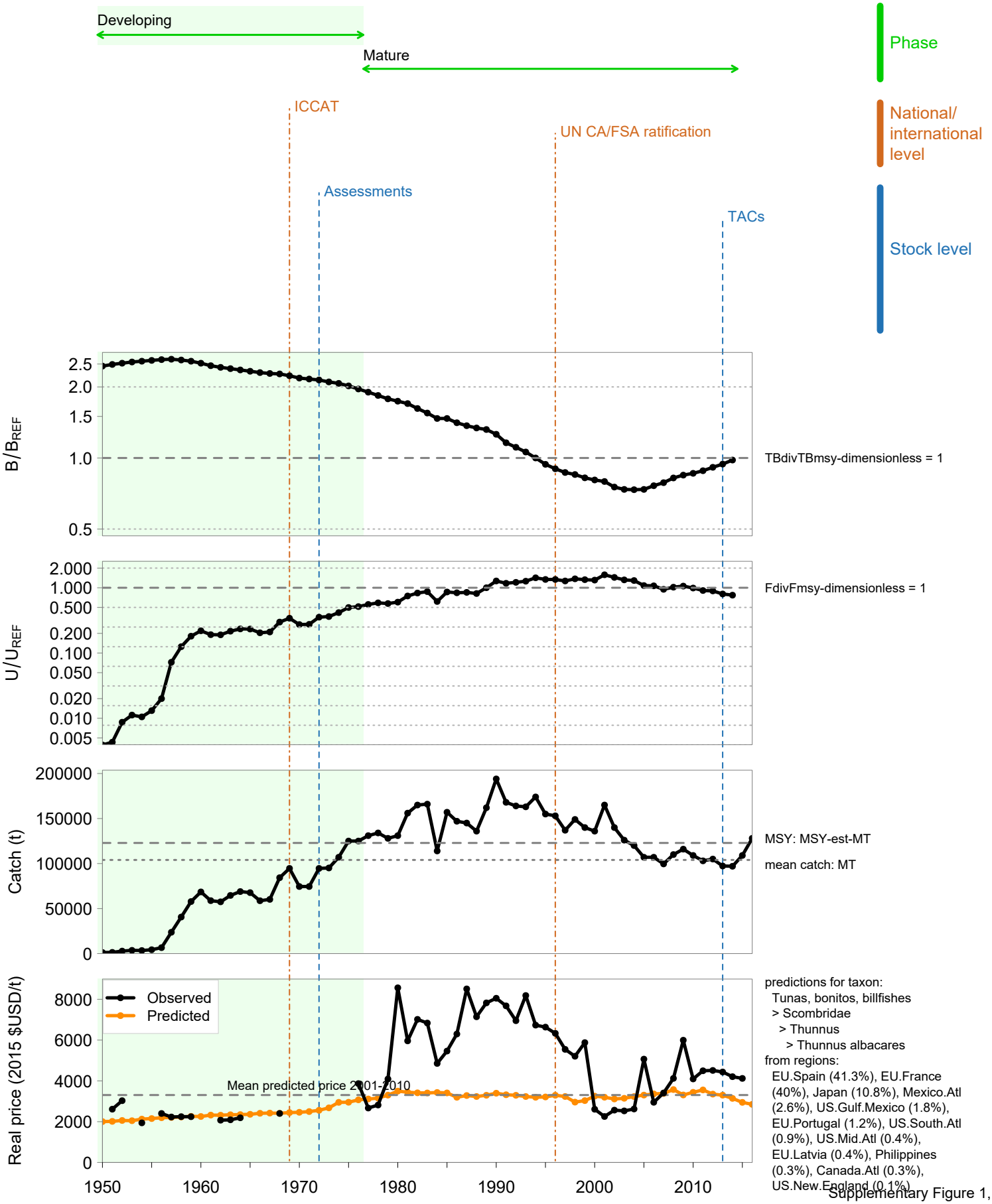
Tuna RFMOs -- WMARLINATL -- White marlin Atlantic Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Taiwan



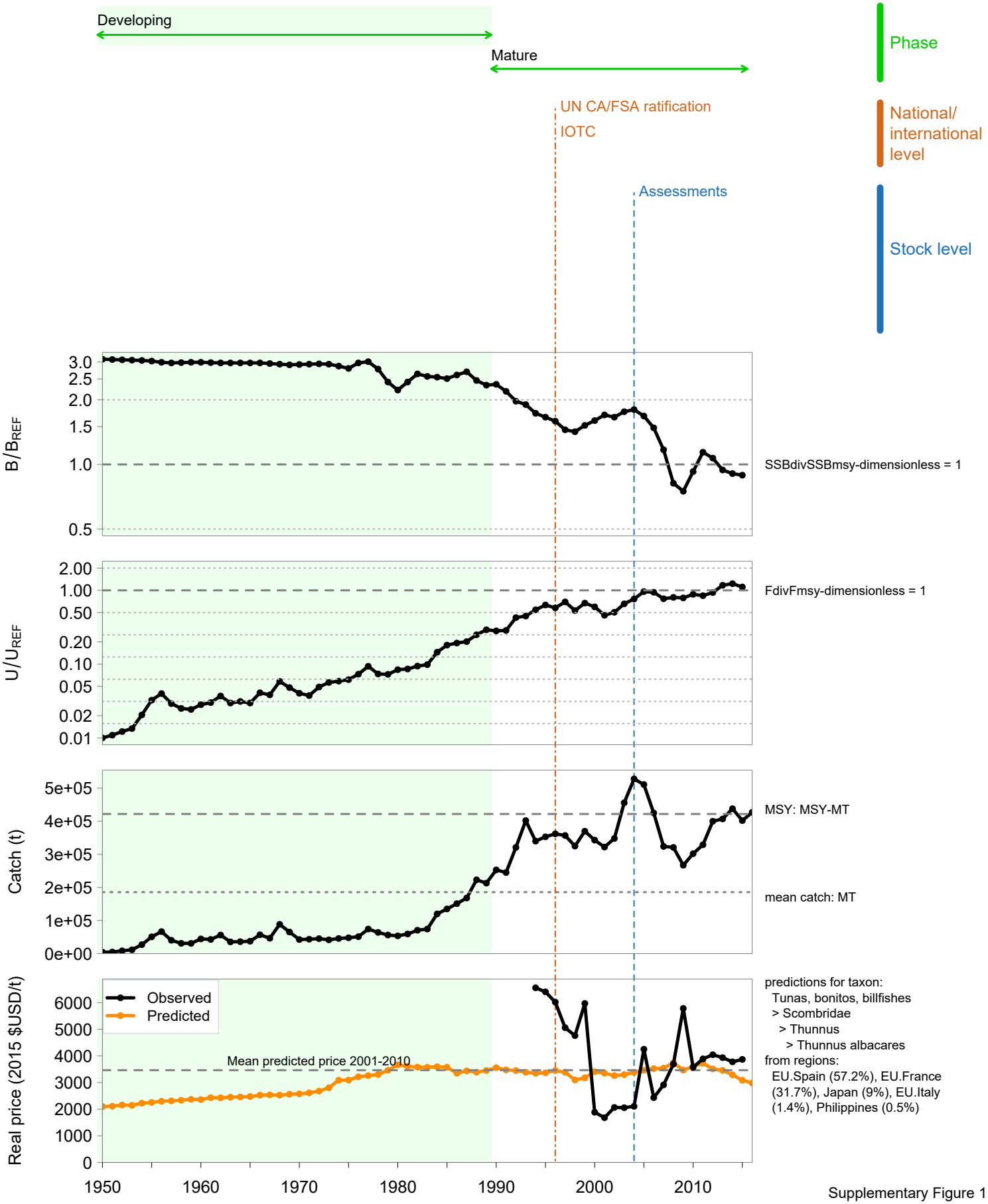
Tuna RFMOs -- YFINATL -- Yellowfin tuna Atlantic Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Spain



Tuna RFMOs -- YFINEIO -- Yellowfin tuna Indian Ocean

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Spain



Tuna RFMOs -- YFINEPAC -- Yellowfin tuna Eastern Pacific

taxonomic group: pelagic fish (Tuna and billfish), predominant fishery type: mixed-species, primary country: Mexico

