ALLIANCE™
(https://www.globalseafood.org)

Responsible Seafood ADVOCATE

Fisheries

Catch & Culture Review: How climate warming affects length-based methods for assessing data-limited fisheries

23 November 2026
By Darryl Jory, Ph.D.

Framework enables the identification of species for which length indicators are most likely to respond to warming



A recent study demonstrated interactions among temperature, natural mortality and fishing mortality on length indicators, revealing overlooked divergences. Lower fishing mortality produces greater length indicators and accurate temperature-adjusted references in non-stationary assessments. Photo of emperor red snapper (*Lutjanus sebae*) in uShaka Sea World – one of the species in this study – by Amada44 (https://creativecommons.org/licenses/by/3.0, CC BY 3.0, via Wikimedia Commons).

Length-based assessments are a practical and basic technique for managing the many fisheries that lack detailed catch histories, age data, or survey time series. Methods that track fish mean length, the proportion of large individuals, or related indicators are relatively inexpensive to collect and can be turned into reference levels for management and conservation.

A **study** (https://doi.org/10.1016/j.fishres.2026.107772) by Richard Takyi and colleagues – at the University of Tasmania, the Commonwealth Scientific and Industrial Research Organisation, and the Institute for Marine and Antarctic Studies (Australia) – examines what happens to these indicators when ocean temperatures are rising and key demographic rates are no longer stationary.

The authors show that temperature, natural mortality and fishing mortality interact in ways that reshape length distributions. Because warmer conditions typically alter growth and survival, the same fishing pressure can produce different length indicators than would be expected under historical temperature regimes. When assessments ignore this non-stationarity and treat temperature as constant, the resulting indicators can diverge from the true status of the stock. That divergence is easy to overlook if analysts simply compare current length metrics against fixed reference points derived under cooler conditions.

A particular finding concerns scaled fish species. Fishing mortality exerts a strong influence on the model outputs used to generate length indicators for these fishes. Under lower fishing mortality rates, length indicators tend to be larger and the temperature-adjusted reference levels more accurate when

non-stationary conditions are explicitly included. Higher fishing pressure, by contrast, can mask or exaggerate temperature-driven shifts, making it harder to separate climate effects from exploitation effects.



(https://info.globalseafood.org/get-certified)

The study results provide a practical framework that can be used to screen species and identify those for which length indicators are most likely to be influenced by warming. Species with life-history traits that make them sensitive to temperature changes in growth or natural mortality rise to the top of that list. The overall conclusion is that length-based tools remain valuable for data-poor settings, but they need to be applied with an awareness that climate warming is already modifying the relationship between fishing mortality and the size structure of catches.

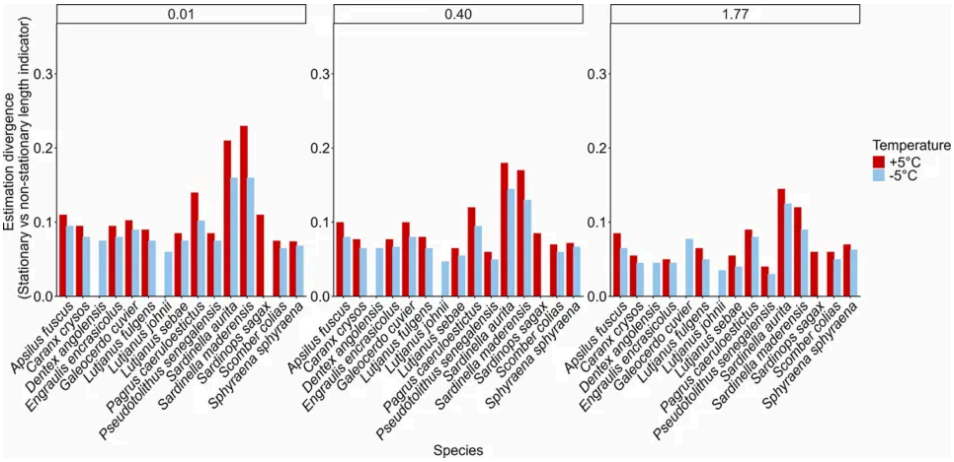


Fig. 1: Estimation divergence (between stationary and non-stationary assessments) in length indicators at temperatures of + 5 degrees-C and −5 degrees-C, across low (0.01/yr), medium (0.40/yr) and high fishing mortality rates (1.77/yr). Greater differences are observed at low fishing mortality rates compared to higher fishing mortality rates. Adapted from the original.

Relevance of research findings to the industry

For the commercial and small-scale fishing sectors that rely on data-poor stocks, the findings have direct operational consequences. Many such fisheries use simple length rules –such as minimum sizes, slot limits, or targets for mean length – as the main control for keeping exploitation sustainable. If those rules were calibrated under cooler historical temperatures, they may now be either too permissive or unnecessarily restrictive once warming is considered. Overly optimistic reference levels could allow fishing pressure to push stocks closer to depletion before managers notice; overly pessimistic ones could forgo yield that is still available.

The interaction with fishing mortality is especially relevant to fleets that can adjust effort. Where managers or fishers are able to keep fishing mortality relatively low, the length indicators become more informative and the temperature-adjusted benchmarks more dependable. That creates a practical incentive: reducing fishing pressure not only protects the stock but also improves the quality of the size-based information that industry and managers use to track status. Conversely, fleets operating under high mortality regimes may find that their length data are less trustworthy guides to climate impacts, increasing the risk of misreading stock health.

Industry groups that participate in data collection can also benefit. Because the framework highlights which species are most sensitive, sampling programs can prioritize those stocks for more frequent length monitoring or for the collection of ancillary temperature or growth information. In regions where multiple data-poor species are caught together, the same length samples can be used both for routine management and for detecting which species are already showing climate-driven shifts in size structure. Over time this reduces the chance that climate effects are misattributed to changes in fishing behavior, which is a common source of friction between industry and regulators.

Perspectives

This study highlights a wider change already underway in fisheries science: Assessments that treat life-history parameters as unchanging are becoming harder to justify. Length-based methods will not disappear, as they are still among the most feasible options for the majority of global stocks, but they will need to be run with temperature-sensitive mortality and growth relationships, or at least with sensitivity tests that explore non-stationary scenarios. The framework offered here is a useful starting point for deciding where those extra steps are most urgent.

One practical next step is to evaluate the framework against real time series from regions that have already experienced substantial warming, to confirm how well the predicted divergences match observed length changes. Because fishing mortality remains a controllable factor, there is also scope for adaptive strategies that deliberately lower exploitation on the most temperature-sensitive species, thereby preserving both stock resilience and the reliability of the length indicators themselves.

Climate change does not only shift fish distributions or recruitment, but it also quietly alters the very metrics we use to decide how hard those fish can be fished and ignoring that interaction risks setting the wrong reference levels for management and conservation. Incorporating temperature and non-stationarity, while paying attention to the moderating role of fishing mortality, gives data-poor fisheries a better chance of remaining both productive and sustainable as the ocean continues to warm.

Integrating environmental DNA and fishery surveys to map critical spawning habitats of a threatened marine fish

For many endangered marine species, spawning habitats remain poorly mapped because the animals are scarce, mobile, or simply hard to catch without damaging the very habitats we hope to protect. The large yellow croaker (*Larimichthys crocea*), once one of China's most valuable marine fishes, is a classic example. Decades of heavy fishing collapsed its wild stocks; it is now listed as endangered, and managers urgently need reliable ways to locate any remaining spawning grounds.

In a **study** (https://doi.org/10.1016/j.seares.2026.102732) by Min Li and coworkers at the South China Sea Fisheries Research Institute in China, the researchers combined three complementary tools: conventional bottom-trawl surveys, eDNA metabarcoding (technology to identify which species are present in an environment just by reading the DNA they leave behind in water, soil, or air), and droplet



The study demonstrates that using molecular techniques together with fishery surveys improves the reliability of identifying critical spawning habitat for an endangered marine fish while minimizing disturbance. Photo of yellow croakers (*Larimichthys crocea*) by Darryl Jory.

digital PCR (ddPCR; a way of counting tiny pieces of DNA in a water or tissue sample with high precision; it is especially useful for detecting rare DNA signals, such as the genetic traces an endangered fish leaves in seawater). They sampled in both autumn and spring, focusing on the South China Sea. The objective was to determine when and where the species concentrates to spawn, and test whether molecular methods could reveal patterns that trawls alone miss.

The results point to a clear seasonal signal. In autumn the species appeared to form aggregations within a relatively narrow depth band of roughly 20–41 m. Spring surveys, by contrast, showed little evidence of spawning activity. This pattern suggests that the fish use seasonally available, localized spawning habitats – possibly shaped by local current conditions that concentrate adults or early life stages in those intermediate depths. The depth window is narrow enough to be useful for management yet broad enough that it would be easy to overlook without targeted sampling.

Methodologically, eDNA proved more sensitive than the trawl surveys. It detected the species in places and at times when the nets came up empty, confirming that molecular signals can pick up low-density or transient presence. Within the molecular toolkit, ddPCR outperformed metabarcoding for resolving fine-scale spatial differences, as it gave a clearer picture of where the strongest signals occurred. Importantly, the molecular and fishery datasets were broadly consistent. Where trawls caught fish, eDNA was usually present, but eDNA also flagged additional potential distribution areas that the nets missed. That combination – agreement where both methods work, plus extra detections from eDNA – increases confidence that the mapped aggregations are real rather than sampling artefacts.

Overall, the results show that integrating eDNA with traditional fishery surveys improves the reliability of habitat identification. It also offers a practical, largely non-invasive route to locating critical spawning areas for endangered marine fishes, especially in regions where direct observation is difficult or destructive sampling is undesirable. For a species as depleted as the large yellow croaker, knowing that autumn aggregations occur in a defined depth band in the South China Sea is a concrete step toward habitat-based protection.

Fig. 2: Standard length distribution across gonadal maturity stages of the Naozhou stock of large yellow croaker (*Larimichthys crocea*) in autumn. Stages IV–VI represent sexually mature individuals. Additional information in, and adapted from, the original publication.

Relevance of research findings to the industry

For the commercial fishing sector and for aquaculture-linked stock-enhancement programs, the findings have practical importance and significance. Large yellow croaker remains culturally and economically important in southern China; restocking and limited wild capture still occur, yet the wild spawning stock is fragile. Identifying a likely autumn aggregation zone in 20–41 meters gives managers and industry a spatial target. Seasonal closures or effort reductions focused on that depth band during autumn could protect spawning adults without blanketing entire fishing grounds year-round; this is an approach that is more palatable to fleets than broad, poorly targeted restrictions.

The higher sensitivity of eDNA also matters operationally. Traditional trawl surveys are expensive, weather-dependent, and can damage habitat. eDNA sampling is cheaper, faster, and non-destructive. Industry or management programs that already collect water samples during routine operations could add species-specific ddPCR assays at modest extra cost, generating near-real-time maps of where croaker are concentrating. Because ddPCR resolves spatial differences more clearly than broad metabarcoding, it is better suited for deciding which specific grounds merit temporary protection or reduced fishing pressure.

For stock-enhancement programs, the results help evaluate whether released fish are finding or contributing to natural spawning areas. If eDNA signals rise in the identified depth band after releases, managers gain evidence that enhancement is supporting wild reproduction rather than merely adding temporary biomass. Conversely, persistent absence of signals in historical grounds can flag areas that no longer function as spawning habitat and should be deprioritized for release or protected differently. The study's integrated approach provides the industry and regulators with a clearer, less intrusive picture of where the remaining reproductive capacity sits, and this information can guide both conservation rules and the timing and location of fishing or enhancement effort.

Perspectives

This research illustrates a wider shift in how we monitor depleted marine fishes. Purely catch-based surveys will continue to under-sample rare or patchy spawners, with eDNA filling some of that gap but being strongest when it is cross-checked against traditional data. The autumn signal in a defined depth range is encouraging, yet it remains a snapshot. Multi-year sampling would show whether the aggregation zone is stable or shifts with changing currents, temperature, or oxygen conditions. Pairing the molecular results with larval or egg surveys in the same 20–41-meter band would further confirm that the eDNA peaks reflect actual spawning rather than simply adult presence.

The non-invasive character of the methods is especially valuable for other endangered sciaenids (drums) or aggregating species in the region. Once the assays are validated, the same water-sampling framework can be applied more widely without repeating intensive trawl campaigns. At the same time, managers should treat the depth band as a working hypothesis rather than a fixed boundary, because oceanographic conditions change and fish can adjust. Adaptive management that re-samples key sites each autumn with a mix of eDNA and limited targeted surveys could potentially keep the maps current.

The results demonstrate that critical spawning habitat for an endangered marine fish can be identified more reliably and with less disturbance when molecular tools and fishery surveys are used together. For the large yellow croaker in the South China Sea, that means a clearer autumn focus in intermediate depths; this is information that can support habitat protection, more precise fishery rules, and better evaluation of recovery efforts as the species continues its slow road back from collapse.

"Methods for quantifying gear density for fixed-gear commercial fisheries in the U.S. Atlantic (https://www.globalseafood.org/advocate/methods-for-quantifying-gear-density-for-fixed-gear-commercial-fisheries-in-the-u-s-atlantic/)"

Smart tuna-fishing buoys adapted to provide real-time insights for marine conservation and ocean science

This study outlines a practical way to incorporate recovered fishing equipment into marine observatories, while underscoring that longer deployments, wider replication, quantitative habitat description, and independent biological calibration are still required before solid ecological conclusions can be drawn. Photo of a school of albacore tuna gathered by a seine net, off the Seychelles, by Marc Taquet (CC BY 4.0, via Wikimedia Commons).

Global ocean sustainability goals require expanded monitoring, especially in data-poor regions. Industrial tuna fleets have deployed millions of echosounder smart-buoys that now form a vast acoustic sensor network. Repurposing end-of-use units through circular-economy programs such as **Satlink's ReCon** (https://satlink.es/en/science-and-sustainability/proyecto-recon) turns this fishing technology into affordable, real-time platforms for conservation, ocean observatories, and blue-economy verification.

A **study** (https://doi.org/10.1038/s41598-026-72665-x) by Mario Lebrato and colleagues – at the Bazaruto Center for Scientific Studies, and Underwater Africa (Mozambique); and Satlink S.L., and Universal Plastic (Spain) – partnered under the circular-economy initiative Project ReCon. More than twenty recovered and refurbished Satlink smart buoys were deployed in the Bazaruto Archipelago in the Western Indian Ocean during June and July 2025.

The buoys were used in both fixed-point (moored) and drifting configurations across a shelf test site, two coral reefs, and two seamount or pinnacle systems. Each buoy carried a downward-looking echosounder that profiled relative acoustic biomass and backscatter in roughly 11-meter depth layers down to about 115 meters. Position and acoustic data were transmitted in near real time via the INMARSAT satellite network to shore-based systems at the Bazaruto Center for Scientific Studies (BCSS) station on Benguerra Island, Mozambique. Fixed-point deployments produced continuous records lasting between roughly 51 and 96 hours per site. In total the team collected 393 time-stamped acoustic records and 1,281 depth-layer observations.

These acoustic time series were placed in context by simultaneous data from the long-running BCSS Ocean Observatory (more than twenty environmental variables, including temperature, chlorophyll-a and weather) and by independent scuba surveys that recorded 14–20 megafauna taxa per site. The acoustic records showed a clear diel pattern: nighttime relative biomass/backscatter values were consistently 20–40 percent higher than daytime values. Exploratory comparisons also suggested co-occurrence of higher signals with cooler bottom-water pulses and short-lived chlorophyll-a increases. Site-to-site differences in both acoustic indices and megafauna assemblages were evident, although the authors emphasize that the short deployments cannot yet support claims about ecological baselines, reef health, fishing impacts or absolute biomass.

The study therefore functions as a technology-transfer and feasibility demonstration. It shows that industrial fishing hardware, once refurbished, can generate high-frequency acoustic information in remote, data-poor waters and can be integrated with an existing ocean observatory. At the same time the authors mention the limitations of longer deployments, broader replication, quantitative habitat characterization and independent biological calibration will be required before the data can support robust ecological inference or management decisions.

Fig. 3: Repurposed smart-buoy acoustic monitoring framework and spatial deployment context in the Bazaruto Archipelago. Additional information in, and adapted from, the original.

Relevance of research findings to the industry

For the tuna industry and the wider marine-technology sector the findings illustrate a practical circular-economy pathway. Thousands of instrumented echosounder buoys are deployed each year on drifting fish aggregating devices (FADs); many eventually wash ashore or reach end-of-life. Project ReCon recovers these units, refurbishes them and redirects them to scientific use rather than allowing them to become marine waste. The Mozambique pilot shows that the same hardware that once guided purse-seine sets can now supply near-real-time acoustic profiles useful for conservation monitoring.

Industry partners could gain several concrete benefits. First, the work extends the useful life of sophisticated, already-paid-for sensors and satellite telemetry, improving the environmental return on the original investment. Second, it creates a documented example of technology transfer that can support corporate sustainability reporting, blue-bond verification and ESG metrics. Third, the same data streams that help managers track relative biomass patterns can, in principle, inform more selective fishing or dynamic spatial management if the systems are later scaled. Finally, the collaboration model – recovery networks involving coastal communities, refurbishment at a research station, and integration into an observatory – offers a replicable template for other fleets and technology providers operating in the Indian, Atlantic and Pacific Oceans.

Fig. 4: Blue economy framework for smart-buoy applications across local to global scales. Conceptual framework designed to support marine monitoring from local to global scales. Additional information in, and adapted from, the original.

Perspectives

This pilot feasibility study opens a realistic route for denser, lower-cost ocean observation in regions where research vessels are scarce. Networks of refurbished buoys could complement traditional moorings, gliders and satellite products by providing frequent vertical acoustic snapshots at fixed reefs, seamounts or inside marine protected areas. Because the data arrive via existing satellite links and can be co-visualized with observatory time series, the approach is relatively easy to scale once calibration and quality-control protocols are strengthened.

Several practical next steps follow directly from the study's own caveats. Multi-month or seasonal deployments would reveal whether the strong diel signal and site differences persist or shift with monsoons, upwelling or fishing pressure. Independent ground-truthing – like trawl or video surveys, or calibrated scientific echosounders – would allow conversion of relative backscatter into more quantitative biomass estimates and species-group discrimination. Standardized recovery and refurbishment protocols could then be shared across the Western Indian Ocean and beyond, turning occasional beach clean-ups into a steady supply of monitoring nodes.

Repurposed tuna buoys could become a regular component of blue-economy observation systems by helping to verify the performance of marine protected areas, supporting restoration monitoring, and supplying transparent data for biodiversity-credit or blue-bond frameworks. The Mozambique results already demonstrate that the technical leap from industrial fishing tool to conservation sensor is feasible; the remaining work is to turn short, successful pilots into sustained, calibrated observation networks.

Author



DARRYL JORY, PH.D.

Editor Emeritus

darryl.jory@globalseafood.org (mailto:darryl.jory@globalseafood.org)

Copyright © 2026 Global Seafood Alliance

All rights reserved.