Mobilizing local ecological knowledge and mass public datasets to assess historical shifts in the Lower Keys tarpon fishery

Movilizando el conocimiento ecológico local y conjuntos masivos de datos públicos para evaluar cambios históricos en la pesquería de tarpon de Lower Keys

Solicitation des savoirs locaux et des données halieutiques pour estimer les mutations antérieures de la pêcherie du tarpon dans les Keys de Floride

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EXTENDED ABSTRACT

Data limited fisheries pose a challenge for traditional stock assessment and management strategies, with harvest data lacking or entirely absent. In recreational fisheries that are legislatively managed or stakeholder managed to be catch-and-release only, fisheries dependent and independent data are not readily stored in a SQL database, and thus the human dimension of fisheries management comes to the forefront. Local Ecological Knowledge (LEK)—the institutional knowledge of practices and observations made by local resource users over time—is increasingly becoming a core component of managers' and researchers' efforts to better understand the historical and current state of a resource (Gilchrist et al. 2005; Anadon et al. 2009). Interview-based recall typically lends LEK datasets to be qualitative, and thus a coarse representation of resource and population trends. Coarse, qualitative LEK data in the form of Likert Scores—the numerical ranking of quality—have been compared to finer resolution quantitative trends in traditional stock assessments (i.e., spawning stock biomass SSB) in the Celtic Sea, and the trends observed in the LEK data were tightly correlated to SSB (Shephard et al. 2021). In so that coarse LEK trends correlate with traditional stock assessment methods, inferences can be made using LEK data in instances where standard fisheries dependent and independent data are absent, such as the flats catch-and-release fisheries of the Caribbean. These data can then be incorporated into models used to identify abiotic and biotic correlates of shifts in population decline and recovery. Here, we present an ongoing application of leveraging LEK interviews and publicly available abiotic and biotic datasets to identify influencers of spatiotemporal changes and decline in the Lower Florida Keys tarpon fishery, and the concept of actionable knowledge to provide spatially explicit suggestions for management.

The highest priority in LEK studies is a foundation of trust and mutual goal of sustainability. Such a partnership requires a significant investment of time by all parties, and constant and continued communication from problem identification, to study conception and execution, and through the development of action plans to ameliorate the disturbances to resource prosperity. The partnership for this study has been a long-standing relationship between fishing guides and Bonefish & Tarpon Trust, as many of the guides involved with this study were integral to the founding and persistence of the organization. However, personal relationships and researcher integration into the community long before research activities begin is foundational to LEK study success. To ensure trust, LEK interviews were conducted one-on-one at a location of the guide's choosing, and a non-disclosure agreement was signed to protect the sensitive information discussed. Interviews were conducted with as many guides that could accommodate the time investment and had an extensive history (>10 years) of fishing the area of interest (n=9). The interviews were conducted around a nautical navigation map with a 6 km x 5.4 km grid overlaid to divide the area into statistical units. The grid was unbiased and adjusted to align with marine environments and regional breaks were assigned according to jurisdictional spatial management zones. The maps were presented on a tablet running the software Procreate (Savage Interactive, Tasmania, Australia), allowing for data layers to be created, toggled, modified, and exported as .tif files for ingestion into ArcPro (Esri, Redlands, CA, USA).

Guides were asked to recall the fishery in five-year bins from 2022 to back when they entered the fishery, and two response types were requested and provided by drawing atop the gridded areas: 1) a two-dimensional representation of fishing areas according to tarpon size-class, and 2) a Likert Score from 1–5 (Poor–Exceptional) representing the quality of the fishery relating to the number of shots on and sightings of tarpon. The drawn layer .tif files representing fishing spots and Likert Scores were exported from Procreate and georeferenced in ArcPro using a Python script to replicate georeference anchors from example georeferenced maps that were manually georeferenced. Pixels representing different size classes were classified in ArcPro using a maximum likelihood model trained on example drawings using the same colors as the interviews. Classifications were cleaned up using a contiguous pixel threshold of ≥50 and the Nibble tool to remove erroneously classified pixels. Pixels per classification were calculated for each map and grid using the Tabulate Area tool. These processes were also written into a Python tool for process automation and replicability.

Data partnerships—where data and insights from analyses looking at data through applications that differ from the originator—were established in support of identifying abiotic and biotic drivers of shifts in the Lower Keys tarpon fishery. Additionally, public datasets were accessed through online databases and websites, as well as purchased satellite imagery. In total, more than 140 data sources were evaluated for applicability and spatiotemporal alignment with guide interview data. Physical water quality monitoring data (temperature, dissolved oxygen, turbidity, and chlorophyll a) were shared most frequently by partners, and identifiable data important to ongoing partner research were protected through aggregating multiple data sources into kriged surfaces using empirical Bayesian kriging in ArcPro. Other data compiled include boating and water access (i.e., satellite imagery to derive boat traffic patterns, AIS boat track, boating access survey and location data), spatial management boundaries, wastewater infrastructure, benthic structure and composition, and weather and climatological patterns and events. These data were summarized into their respective grid cells and year-bins. Analyses are ongoing, summarizing changes over time and leveraging boosted regression trees for analyzing spatial changes to the fishery (two-dimensional pixel counts) and boosted classification trees to analyze changes in the quality of the fishery (Likert Score changes). Results from the analyses will provide spatially explicit ranked variable importance in which targeted management and remediation strategies can be developed and proposed to stakeholders and resource managements.

KEYWORDS: Local Ecological Knowledge, Data Limited Fishery, Data Science, Spatial Management, Study Design

LITERATURE CITED

Adams, A.J., Horodysky, A.Z., McBride, R.S., Guindon, K., Shenker, J., MacDonald, T.C., Harwell, H.D., Ward, R., and Carpenter, K. 2014. Global conservation status and research needs for tarpons (Megalopidae), ladyfishes (Elopidae) and bonefishes (Albulidae). *Fish and Fisheries* ***15***(2):280–311. doi: 10.1111/faf.12017

Adams, A.J., Lewis, J.P., Kroetz, A.M., and Grubbs, R.D. 2021. Bonefish (*Albula vulpes*) home range to spawning site linkages support a marine protected area designation. *Aquatic Conservation: Marine and Freshwater Ecosystems* **31**(6): 1346–1353. doi: 10.1002/aqc.3534

Haak, C.R., Power, M., Cowles, G.W., and Danylchuk, A.J. 2019. Hydrodynamic and isotopic niche differentiation between juveniles of two sympatric cryptic bonefishes, *Albula vulpes* and *Albula goreensis. Environmental Biology of Fishes* **102**: 129–145. doi: 10.1007/s10641-018-0810-7

Lombardo, S.M., Adams, A.J., Danylchuk, A.J., Luck, C.A., and Ajemian, M.J. 2020. Novel deep-water spawning patterns of bonefish (*Albula vulpes*), a shallow water fish. *Marine Biology* **167**: 1–11. doi: 10.1007/s00227-020-03799-3

Lombardo, S.M., Chérubin, L.M., Adams, A.J., Shenker, J.M., Wills, P.S., Danylchuk, A.J., and Ajemian, M.J. 2022. Biophysical larval dispersal models of observed bonefish (*Albula vulpes*) spawning events in Abaco, The Bahamas: An assessment of population connectivity and ocean dynamics. *PLOS ONE* **17**(10): p.e0276528. doi: 10.1371/journal.pone.0276528