FishTrapsFoodSec

Escape gaps contribute to ecosystem health and food security in an artisanal coral reef trap fishery.

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Overview

This repository is the data management and analysis workflow of a research project investigating the ecosystem and food security benefits and tradeoffs of adding escape gaps to traditional African fish traps. It includes 10 years of landings data from artisanal fishers operating in the inshore waters of Kenya and Tanzania.

Instructions

R scripts should be run in numeric order, beginning with `01_CleanData_FishTrapsFoodSec.R`. Each script has two corresponding folders in the repository, one called `temp` and one called `out`. The `temp` folder contains temporary output files that are not needed for further analysis or reference. The `out` folder contains output files that will be used by subsequent scripts, kept for future reference, or formatted as data tables for publication.

The R script `02_FishLife_FishTrapsFoodSec.R` retrieves estimated life history parameters for all species in the catch using Jim Thorson's `FishLife` package (Thorson, 2020; Thorson et al., 2017). **You must restart R twice while running this script**, once after running the first line, which installs an older version of `rfishbase`, and once at the end of the script, which re-installs the newest version of `rfishbase`. This is necessary because `FishLife`is only compatible with earlier versions of `rfishbase`. These instructions are commented in the script itself.

Repository Files

File/Folder	Enclosed File	Type	Notes
00_RawData		Folder	Contains raw data
	CombinedTrapData_2010_2019_Anonymized.xlsx	Spreadsheet	WCS landings data
	FunctionalGroupKey_DietBased_Condy2015.xlsx	Spreadsheet	A key developed for previous WCS studies assigning select species to diet-based functional groups
	Traits_MbaruEtAl2020.xls	Spreadsheet	A list of species with categorizations by functional trait, developed by Mbaru et al. (2020).
	ValueByFamily.csv	Spreadsheet	A list of fish families and their corresponding values in Kenya Shillings developed for previous WCS studies.

File/Folder	Enclosed File	Type	Notes
01_CleanData_FishTrapsFoodSec.R		R Script	Cleans the data and saves an edited and more compact version. Produces three normalized output spreadsheets as found in `01_CleanData_Out`.
01_CleanData_Out		Folder	Contains output files from eponymous R script
	CatchData_GatedTraps_Galligan.csv	Spreadsheet	Contains landings data; each row is an individual fish
	SpeciesData_GatedTraps_Galligan.csv	Spreadsheet	Data for each species in the catch
	TripData_GatedTraps_Galligan.csv	Spreadsheet	Contains landings data; each row is one fishing trip
01_CleanData_Temp		Folder	Contains temporary output files from eponymous R script
	SuspiciousPrices.csv	Spreadsheet	A list of price data from the original WCS spreadsheet that seemed suspicious. These prices have all been replaced.
	TrapData_Cleaned.csv	Spreadsheet	A cleaned copy of the original WCS data sheet.
	Unique_Species.csv	Spreadsheet	A list of species found in the WCS landings data
02_FishLife_FishTrapsFoodSec.R		R Script	Obtains estimates of life history parameters for all species using Jim Thorson's `FishLife` package.
02_FishLife_Out		Folder	Contains output files from eponymous R script
	CatchData_GatedTraps_Galligan.csv	Spreadsheet	Updates catch data to include life history parameters
	SpeciesData_GatedTraps_Galligan.csv	Spreadsheet	Updates species data to include life history parameters
	TripData_GatedTraps_Galligan.csv	Spreadsheet	Updates trip data to include life history parameters
02_FishLife_Temp		Folder	Empty
03_FunctionalDiversity_FishTrapsFoodSec.R		R Script	Workflow for the `mFD` package, which computes multidimensional functional diversity indices
03_FunctionalDiversity_Out		Folder	Contains output files from eponymous R script
	FunctionalSpacesQuality.png	Figure	Results of PCoA analysis determining the quality of functional spaces
	PositionSpeciesFunctionalAxes.png	Figure	Plots functional entities along pairs of functional axes

File/Folder	Enclosed File	Type	Notes
	TraitsAndPCoAAxes.png	Figure	Plots relationships between traits and PCoA axes
	TripData_GatedTraps_Galligan.csv	Spreadsheet	Updates trip data with functional diversity measures
03_FunctionalDiversity_Temp		Folder	Empty
04_DataExploration_FishTrapsFoodSec.R		R Script	Explores data following procedures of Zuur et al. (2010)
04_DataExploration_Out		Folder	Empty
	TripDataForAnalysis_GatedTraps_Galligan.csv	Spreadsheet	Trip Data cleaned for analysis. Unreasonable values have been removed.
04_DataExploration_Temp		Folder	Empty
Archive		Folder	See below
README.md		Markdown	This document
RWorkflow_FishTrapsFoodSec.Rproj		RStudio Project	Sets working directory, source documents, etc. in RStudio

Archived Files

These files have been kept for posterity, but are not used in the current analysis. They are located in the `Archive` folder.

File/Folder	Enclosed File	Type	Notes
02_Stability_FishTrapsFoodSec.R		R Script	Analysis of the stability pillar of the food security framework
02_Stability_Out		Folder	Contains output files from the eponymous R script
	CatchComposition_DietCt_ModelComparison.csv	Spreadsheet	Results of model comparisons for an ANOVA testing effect of trap type on catch composition (no. of fish, categorized by diet-based functional groups)
	CatchComposition_DietCt_Results.csv	Spreadsheet	Results of ANOVA testing effect of trap type on catch composition (no. of fish, categorized by diet-based functional groups)
	CatchComposition_DietMass_ModelComparison.csv	Spreadsheet	Results of model comparisons for an ANOVA testing effect of trap type on catch composition (biomass ratio, categorized by diet-based functional groups)
	CatchComposition_DietMass_Results.csv	Spreadsheet	Results of ANOVA testing the effect of trap type on catch composition (biomass ratio, categorized by diet-based functional groups)
	CatchComposition_FunGrDiet_Data.csv	Spreadsheet	Datasheet used to analyze catch composition by diet-based functional group

File/Folder	Type	Description
02_Stability_Temp	Folder	Contains temporary output files from the eponymous R script
BrowserMassQQ.jpeg	Image	QQ plot of residuals for catch composition of browsers by mass
GrazerMassQQ.jpeg	Image	QQ plot of residuals for catch composition of grazers by mass
ScraperMassQQ.jpeg	Image	QQ plot of residuals for catch composition of scrapers by mass
03_Availability_FishTrapsFoodSec.R	R Script	Analysis of the availability pillar of the food security framework
03_Availability_Out	Folder	Contains output files from the eponymous R script
LengthAOV_ModelComparison.csv	Spreadsheet	Comparison of four ANOVAs for finding effect of trap type on length
LengthAOV_Results.csv	Spreadsheet	Effect of trap type on length ANOVA results
LengthData.csv	Spreadsheet	A subset of the Trap Data spreadsheet that only includes entries with length data
03_Availability_Temp	Folder	Contains temporary output files from the eponymous R script
LengthQQ.jpeg	Image	QQ plot of residuals for length distribution by trap type
04_Access_FishTrapsFoodSec.R	R Script	Analysis of the access pillar of the food security framework
04_Access_Out	Folder	Contains output files from the eponymous R script
CPUEBySite_pvalues.csv	Spreadsheet	Contains p-values for ANOVAs of effect of trap type on CPUE at each site
CPUE_Data.csv	Spreadsheet	Data for CPUE by trip for trips that only used one trap type (gated or traditional)
CPUE_ModelComparison.csv	Spreadsheet	Comparison of four ANOVAs for finding effect of trap type on CPUE
CPUE_Results.csv	Spreadsheet	Effect of trap type on CPUE (ANOVA results)
04_Access_Temp	Folder	Contains temporary output files from the eponymous R script
CPUEQQ.jpeg	Image	QQ plot of residuals for ANOVA of CPUE by trap type
06_TabsFigs_FishTrapsFoodSec.R	R Script	Assembles tables and figures
06_TabsFigs_Out	Folder	Contains figures assembled so far

	BrowsersScrapersGrazers.jpeg	Image	Effect of trap type on catch composition (ratio of browsers, scrapers, and grazers by mass)
	CPUE.jpeg	Image	Effect of trap type on CPUE
	KeyHerbivores.jpeg	Image	Effect of trap type on catch composition (ratio of key herbivores by mass)
	Length.jpeg	Image	Effect of trap type on length
06_TabsFigs_Temp		Folder	Empty
ExploratoryPlots.R		R Script	Contains code to generate some exploratory plots of the data
ExploratoryPlots		Folder	Contains exploratory plots of the data
	BrowserMassRatio.jpeg	Figure	Density plots of catch composition of browsers (ratio by mass) across sites and trap types
	CPUE.jpeg	Figure	Density plots of CPUE across sites and trap types
	GrazerMassRatio.jpeg	Figure	Density plots of catch composition of grazers (ratio by mass) across sites and trap types
	KeyHerbivoreMassRatio.jpeg	Figure	Density plots of catch composition of key herbivores (ratio by mass) across sites and trap types
	LengthDistributions.jpeg	Figure	Density plots of fish lengths across sites and trap types
	ScraperMassRatio.jpeg	Figure	Density plots of catch composition of scrapers (ratio by mass) across sites and trap types

Processed Data

Date of data collection: 2010-2019

Geographic **location** of data collection: southern coast of Kenya, northern coast of Tanzania

Information about **funding** sources that supported the collection of the data: data were collected by Wildlife Conservation Society, Mombasa, Kenya

Restrictions placed on the data: Please contact Tim McClanahan before using data.

Portions of this data have been **used by** Condy et al. (2015), Gomes et al. (2014), Mbaru et al. (2020), and Mbaru and McClanahan (2013).

Trip Data

Filepath: 03_FunctionalDiversity_Out/TripData_GatedTraps_Galligan.csv

Number of **variables**: 67

Number of **observations**: 2734

Missing data code: `NA`

Variable List

Variable	Notes
TripID	Alphanumeric identifier for each fishing trip
Date	Sampling date
Country	Sampling location (country)
Site	Sampling location (landing site)
Latitude	Sampling location (decimal degrees)
Longitude	Sampling location (decimal degrees)
Observer	Researcher responsible for data
Fisher	Alphanumeric identifier for each fisher or crew (combination of fishers)
TotalCrew	Size of fishing crew
TrapsOwned	Number of traps owned by this fisher/crew
TrapsFished	Number of traps fished on this trip
TrapLocation	Fishing location
Depth_m	Depth of trap deployment (meters)
SoakTime_Days	Duration of trap deployment (days)
TrapType	Type of trap used on this fishing trip (traditional, gated, or multiple)
GapSize_cm	Size of escape gap on traps used (centimeters or multiple)
B.undulatus	Was *Balistapus undulatus* present in the catch? (yes/no)
BrowserMass_g	Mass of browsing herbivores in the catch (grams)
BrowserMassRatio	Proportion of browsers in the catch by mass
ScraperMass_g	Mass of scraping herbivores in the catch (grams)
ScraperMassRatio	Proportion of scrapers in the catch by mass
GrazerMass_g	Mass of grazers in the catch (grams)
GrazerMassRatio	Proportion of grazers in the catch by mass
PredatorMass_g	Mass of piscivorous predators in the catch (grams)
PredatorMassRatio	Proportion of piscivorous predators in the catch by mass
TotalCatch_g	Total catch (grams)
LowNoCatch	Was the catch < 1 kg? (LowNoCatch / Catch)
CPUE_kgPerTrap	Catch per unit effort (kilograms per trap)
CPUE_DistFromMean	Catch stability (relative distance of CPUE from mean CPUE for each combination of site and trap type)
TotalValue_KSH	Value of the catch (Kenya Shillings)
ValuePUE	Value per unit effort (Kenya Shillings per trap)
MeanLLmat	Mean ratio of length to length at first maturity
MeanTrophLevel	Mean trophic level
MeanVulnerability	Mean species vulnerability (0-100)
MTC_degC	Mean temperature of the catch (degrees Celsius)
FECount	Functional richness (count of unique functional entities in the catch)
FRic	Functional richness (proportion of hull volume)
FEve	Functional evenness
FDiv	Functional diversity
TotalCa_mg	Total calcium (milligrams)
CaPUE	Calcium per unit effort (milligrams per trap)
CaConc_mgPer100g	Calcium concentration (milligrams per 100 grams)
CaPrice_KSHPermg	Value of calcium (Kenya Shillings per milligram)
TotalFe_mg	Total iron (milligrams)
FePUE	Iron per unit effort (milligrams per trap)
FeConc_mgPer100g	Iron concentration (milligrams per 100 grams)
FePrice_KSHPermg	Value of iron (Kenya Shillings per milligram)

Variable	Notes
TotalOmega3_g	Total Omega-3 polyunsaturated fatty acids (grams)
Omega3PUE	Omega-3 per unit effort (grams per trap)
Omega3Conc_gPer100g	Omega-3 concentration (grams per 100 grams)
Omega3Price_KSHPerug	Value of omega-3 (Kenya Shillings per gram)
TotalProtein_g	Total protein (grams)
ProteinPUE	Protein per unit effort (grams per trap)
ProteinConc_gPer100g	Protein concentration (grams per 100 grams)
ProteinPrice_KSHPerug	Value of protein (Kenya Shillings per gram)
TotalVA_ug	Total vitamin A (micrograms)
VAPUE	Vitamin A per unit effort (micrograms per trap)
VAConc_ugPer100g	Vitamin A concentration (micrograms per 100 grams)
VAPrice_KSHPerug	Value of vitamin A (Kenya Shillings per microgram)
TotalSe_ug	Total selenium (micrograms)
SePUE	Selenium per unit effort (micrograms per trap)
SeConc_ugPer100g	Selenium concentration (micrograms per 100 grams)
SePrice_KSHPerug	Value of selenium (Kenya Shillings per microgram)
TotalZn_ug	Total zinc (micrograms)
ZnPUE	Zinc per unit effort (micrograms per trap)
ZnConc_ugPer100g	Zinc concentration (micrograms per 100 grams)
ZnPrice_KSHPerug	Value of zinc (Kenya Shillings per microgram)

Catch Data

Filepath: `02_FishLife_Out/CatchData_GatedTraps_Galligan.csv`

Number of **variables**: 11

Number of **observations**: 25789

Missing data code: `NA`

Variable List

Variable	Notes
TripID	Alphanumeric identifier for each fishing trip
TrapType	Type of fish trap (gated / traditional)
TrapLocation	Fishing location
SoakTime_Days	Duration of trap deployment (days)
GapSize_cm	Size of escape gap on traps used (centimeters)
Species	Species of fish caught (scientific name)
FD_HC	Is this fish destined for a fish dealer (FD) or household consumption (HC)?
Length_cm	Standard length of fish, from tip of snout to last vertebrae (centimeters)
Depth_m	Depth of trap deployment (meters)
Weight_g	Weight (grams)
LLmat	Ratio of length to length at first maturity (Lmat)

Species Data

Filepath: `02_FishLife_Out/SpeciesData_GatedTraps_Galligan.csv`

Number of **variables**: 44

Number of **observations**: 215

Missing data code: `NA`

Variable List

Variable	Notes
Species	Species (scientific name)
Family	Taxonomic family
FishGroups	Coarse fish groupings
EnglishName	Species (common name in English)
KiswahiliName	Species (common name in Kiswahili)
Bycatch	Is this species considered bycatch? (yes/no)
Price_KSHPerkg	Price (Kenya Shillings per kilogram)
FunGr_Diet	Coarse diet-based functional groups (Condy et al., 2015; FishBase)
TrophLevel	Trophic level based on food items (FishBase)
SE_TrophLevel	Standard error of trophic level estimate (FishBase)
Vulnerability	Vulnerability (0-100) (FishBase)
Lmat_cm	Length at first maturity (centimeters) (FishLife)
Lopt_cm	Optimum length (centimeters) (FishLife)
Linf_cm	Asymptotic length (centimeters) (FishLife)
SizeCategory	Functional trait: size (Mbaru et al., 2020)
Diet	Functional trait: diet (Mbaru et al., 2020)
Mobility	Functional trait: mobility (Mbaru et al., 2020)
Active	Functional trait: period of activity (Mbaru et al., 2020)
Schooling	Functional trait: schooling behavior (Mbaru et al., 2020)
Position	Functional trait: position in water column (Mbaru et al., 2020)
TempPrefMin_degC	Minimum temperature preference (degrees Celsius) (FishBase)
TempPrefMean_degC	Mean temperature preference (degrees Celsius) (FishBase)
TempPrefMax_degC	Maximum temperature preference (degrees Celsius) (FishBase)
Calcium_mgPer100g	Calcium concentration (milligrams per 100 grams) (FishBase)
Calcium_L95	Lower 95% confidence interval for calcium estimate (FishBase)
Calcium_U95	Upper 95% confidence interval for calcium estimate (FishBase)
Iron_mgPer100g	Iron concentration (milligrams per 100 grams) (FishBase)
Iron_L95	Lower 95% confidence interval for iron estimate (FishBase)
Iron_U95	Upper 95% confidence interval for iron estimate (FishBase)
Omega3_gPer100g	Omega-3 polyunsaturated fatty acid concentration (grams per 100 grams) (FishBase)
Omega3_L95	Lower 95% confidence interval for omega-3 estimate (FishBase)
Omega3_U95	Upper 95% confidence interval for omega-3 estimate (FishBase)
Protein_gPer100g	Protein concentration (grams per 100 grams) (FishBase)
Protein_L95	Lower 95% confidence interval for protein estimate (FishBase)
Protein_U95	Upper 95% confidence interval for protein estimate (FishBase)
VitamA_ugPer100g	Vitamin A concentration (micrograms per 100 grams) (FishBase)
VitaminA_L95	Lower 95% confidence interval for vitamin A estimate (FishBase)
VitaminA_U95	Upper 95% confidence interval for vitamin A estimate (FishBase)
Selenium_ugPer100g	Selenium concentration (micrograms per 100 grams) (FishBase)
Selenium_L95	Lower 95% confidence interval for selenium estimate (FishBase)
Selenium_U95	Upper 95% confidence interval for selenium estimate (FishBase)
Zinc_ugPer100g	Zinc concentration (micrograms per 100 grams) (FishBase)
Zinc_L95	Lower 95% confidence interval for zinc estimate (FishBase)
Zinc_U95	Upper 95% confidence interval for zinc estimate (FishBase)

Built With

- R version 4.1.2 (2021-11-01) – "Bird Hippie"

- RStudio 2021.09.1+372 "Ghost Orchid" Release (8b9ced188245155642d024aa3630363df611088a, 2021-11-08) for macOS

- The following R packages:
  - `AICcmodavg`
  - `data.table`
  - `dplyr`
  - `FishLife`
  - `ggplot2`
  - `ggpubr`
  - `magrittr`
  - `mFD`
  - `rcurl`
  - `readr`
  - `readxl`
  - `rfishbase`
  - `rstatix`
  - `strex`
  - `stringr`
  - `taxize`
  - `tidyr`

Links

- The GitHub repository for this project

References

Condy, M., Cinner, J. E., McClanahan, T. R., & Bellwood, D. R. (2015). Projections of the impacts of gear-modification on the recovery of fish catches and ecosystem function in an impoverished fishery. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *25*(3), 396–410. https://doi.org/10.1002/aqc.2482

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Gomes, I., Erzini, K., & McClanahan, T. R. (2014). Trap modification opens new gates to achieve sustainable coral reef fisheries: Escape gaps in African traditional trap fisheries. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *24*(5), 680–695. https://doi.org/10.1002/aqc.2389

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Mbaru, E. K., & McClanahan, T. R. (2013). Escape gaps in African basket traps reduce bycatch while increasing body sizes and incomes in a heavily fished reef lagoon. *Fisheries Research*, *148*, 90–99. https://doi.org/10.1016/j.fishres.2013.08.011

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Zuur, A. F., Ieno, E. N., & Elphick, C. S. (2010). A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution*, *1*, 3–14. https://doi.org/10.1111/j.2041-210X.2009.00001.x