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 O1_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 FishLifeis 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		FolderContains raw data
	CombinedTrapData_2010_2019_	_AnonySpizædUkGeStlandings data
	FunctionalGroupKey_DietBased_	_Cond \$20125.dkilkre t developed for previous
		WCS studies assigning select
		species to diet-based
		functional groups
	Traits_MbaruEtAl2020.xls	Spreachshisett of species with
		categorizations by functional
		trait, developed by Mbaru et
		al. (2020).
	ValueByFamily.csv	Spreachshisett of fish families and
	v	their corresponding values in
		Kenya Shillings developed
		for previous WCS studies.

File/Folder	Enclosed File	Type Notes
01_CleanData_FishTrapsFoodS	Sec.R	R Cleans the data and saves an Scriptedited and more compact version. Produces three normalized output spreadsheets as found in 01_CleanData_Out.
01_CleanData_Out		FolderContains output files from eponymous R script
	$CatchData_GatedTraps_Galligan.csv$	Sprea@Sharetains landings data; each row is an individual fish
	SpeciesData_GatedTraps_Galligan.csv	Sprea Dhtæ tfor each species in the catch
	$TripData_GatedTraps_Galligan.csv$	Sprea Connectains landings data; each row is one fishing trip
01_CleanData_Temp		FolderContains temporary output files from eponymous R script
	SuspiciousPrices.csv	Spreadalisation price data from the original WCS spreadsheet that seemed suspicious. These prices have all been replaced.
	TrapData_Cleaned.csv	Spreadshideaned copy of the original WCS data sheet.
	Unique_Species.csv	Spreachslist of species found in the WCS landings data
$02_FishLife_FishTrapsFoodSec.R$		R Obtains estimates of life Scripthistory parameters for all species using Jim Thorson's FishLife package.
02 _FishLife_Out		FolderContains output files from eponymous R script
	$CatchData_GatedTraps_Galligan.csv$	Spreadspeates catch data to include life history parameters
	$Species Data_Gated Traps_Galligan.csv$	-
	$TripData_GatedTraps_Galligan.csv$	Spreadspheates trip data to include life history parameters
02_FishLife_Temp 03_FunctionalDiversity_FishTr	apsFoodSec.R	FolderEmpty R Workflow for the mFD Scriptpackage, which computes multidimensional functional diversity indices
$03_Functional Diversity_Out$		FolderContains output files from eponymous R script
	Functional Spaces Quality.png	FigurResults of PCoA analysis determining the quality of functional spaces
	Position Species Functional Axes.png	Figur@lots functional entities along pairs of functional axes

File/Folder	Enclosed File	Type Notes
	TraitsAndPCoAAxes.png	FigurePlots relationships between traits and PCoA axes
	${\bf TripData_GatedTraps_Galligan.csv}$	Spreadsphdettes trip data with functional diversity measures
03_FunctionalDiversity_Temp		FolderEmpty
04_DataExploration_FishTraps	FoodSec.R	R Explores data following
		Scriptprocedures of Zuur et al. (2010)
04_DataExploration_Out		FolderEmpty
	TripDataForAnalysis_GatedTraps_Ga	all Spaceassiper ata cleaned for
		analysis. Unreasonable
		values have been removed.
04_DataExploration_Temp		FolderEmpty
Archive		Folde:See below
README.md		Markd bhis document
$RWorkflow_FishTrapsFoodSec. I$	Rproj	RStudiets working directory,
		Projectource 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	TypeN	lotes
02_Stability_FishTrapsFoodSe	c.R	R A	analysis of the stability pillar
		Scriptor	f the food security framework
02_Stability_Out		FolderC	contains output files from the
		ej	ponymous R script
	$Catch Composition_DietCt_Model Composition_DietCt_D$	ıpSeprisedR	described the description of model comparisons
		fc	or an ANOVA testing effect of
		tr	cap type on catch composition
		(r	no. of fish, categorized by
		d	iet-based functional groups)
	$CatchComposition_DietCt_Results.csv$	v Sprea &	Seemander of ANOVA testing
		ef	ffect of trap type on catch
		co	omposition (no. of fish,
		Ca	ategorized by diet-based
		fu	unctional groups)
	$Catch Composition_DietMass_Model C$	o SpreaiR	sheets of model comparisons
		fc	or an ANOVA testing effect of
		tr	cap type on catch composition
		(t	piomass ratio, categorized by
		d	iet-based functional groups)
	$Catch Composition_Diet Mass_Results.$	c S ypreadR	Schements of ANOVA testing the
		ef	ffect of trap type on catch
		co	omposition (biomass ratio,
		Ca	ategorized by diet-based
		fu	inctional groups)
	$Catch Composition_Fun Gr Diet_Data.com$	m sSpread B	Chatestheet used to analyze
		Ca	atch composition by
		d	iet-based functional group

02_Stability_Temp		FolderContains temporary output files from the eponymous R
		script
	${\bf BrowserMassQQ.jpeg}$	ImageQQ plot of residuals for catch composition of browsers by mass
	${\bf Grazer Mass QQ. jpeg}$	ImageQQ plot of residuals for catch composition of grazers by mass
	${\bf Scraper Mass QQ.jpeg}$	ImageQQ plot of residuals for catch composition of scrapers by
$03_A vailability_F ishTrapsI$	m FoodSec.R	mass R Analysis of the availability Scriptpillar of the food security framework
03_Availability_Out		FolderContains output files from the eponymous R script
	$Length AOV_Model Comparison.csv$	Spread Schreen Spread Schreen Spread
	$Length AOV_Results.csv$	Spreadsficet of trap type on length ANOVA results
	LengthData.csv	Spreadslædtset of the Trap Data spreadsheet that only includes entries with length data
03_Availability_Temp		FolderContains temporary output files from the eponymous R script
	${\bf Length QQ.jpeg}$	ImageQQ plot of residuals for length distribution by trap type
04_Access_FishTrapsFoods	Sec.R	R Analysis of the access pillar of Scriptthe food security framework
04_Access_Out		FolderContains output files from the eponymous R script
	$CPUEBySite_pvalues.csv$	Spread shortstins p-values for ANOVAs of effect of trap type on CPUE at each site
	CPUE_Data.csv	Spread Shatteetfor CPUE by trip for trips that only used one trap type (gated or traditional)
	$CPUE_Model Comparison.csv$	Spread Some parison of four ANOVAs for finding effect of trap type on CPUE
	CPUE_Results.csv	Spreach of trap type on CPUE (ANOVA results)
04_Access_Temp		FolderContains temporary output files from the eponymous R script
	${\bf CPUEQQ.jpeg}$	ImageQQ plot of residuals for ANOVA of CPUE by trap type
$06_TabsFigs_FishTrapsFoodSec.R$		R Assembles tables and figures Script
$06_TabsFigs_Out$		FolderContains figures assembled so far

	BrowsersScrapersGrazers.jpeg	ImageEffect of trap type on catch composition (ratio of browsers, scrapers, and grazers by mass)
	CPUE.jpeg KeyHerbivores.jpeg	ImageEffect of trap type on CPUE ImageEffect of trap type on catch composition (ratio of key
06_TabsFigs_Temp	Length.jpeg	herbivores by mass) ImageEffect of trap type on length FolderEmpty
ExploratoryPlots.R		R Contains code to generate Scriptsome exploratory plots of the data
ExploratoryPlots		FolderContains exploratory plots of the data
	${\bf Browser Mass Ratio.jpeg}$	Figurdensity plots of catch composition of browsers (ratio by mass) across sites and trap types
	CPUE.jpeg	Figur Density plots of CPUE across sites and trap types
	${\it Grazer Mass Ratio.jpeg}$	Figur Density plots of catch composition of grazers (ratio by mass) across sites and trap types
	Key Her bivore Mass Ratio. jpeg	Figur Density plots of catch composition of key herbivores (ratio by mass) across sites and trap types
	${\bf Length Distributions.jpeg}$	FigureDensity plots of fish lengths across sites and trap types
	${\bf Scraper Mass Ratio. jpeg}$	Figur 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) Observer Researcher responsible for data Pisher Alphanumeric identifier for each fisher or crew (combination of fishers) TotalCrew Size of fishing crew TrapsOwned Number of traps owned by this fisher/crew TrapsPowned Number of traps deployment (meters) DosakTime_Days Duration of trap deployment (days) TrapType GapSize cm Bundulatus ProwserMass_g FrowserMass_g FrowserMassRatio Propertion of trorsowers in the catch (grams) BrowserMassRatio GrazerMass ag GrazerMassRatio GrazerMassRatio PredatorMass_g FredatorMassRatio FredatorMassRatio FredatorMassRatio FredatorMassRatio Froportion of grazers in the catch (grams) Prodottoal of grazers in the catch by mass Mass of piscivorous predators in the catch by mass Mass of piscivorous predators in the catch by mass FredatorMassRatio Froportion of grazers in the catch by mass Mass of piscivorous predators in the catch by mass FredatorMassRatio Froportion of grazers in the catch (grams) Proportion of piscivorous predators in the catch by mass FredatorMassRatio Froportion of grazers in the catch by mass FredatorMassRatio Froportion of piscivorous predators in the catch by mass FredatorMassRatio Froportion of piscivorous predators in the catch by mass Frodatch—g TotalValue_KSH Value_PUE Was the catch < 1 kg? (LowNoCatch / Catch) CPUE_kgPerTrap Catch per unit effort (kilograns) per trap) CPUE_bistFromMea&Catch stability (relative distance of CPUE from mean CPUE for each combination of site and trap type) TotalValue_KSH Value per unit effort (kilograns) per trap) Mean tropbic level Mean Vulnerability Mean tropbic level M		
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BrowserMassRatio ScraperMass_g ScraperMassRatio GrazerMass_g GrazerMass_g GrazerMassRatio PredatorMass_g PredatorMassRatio PredatorMassRatio TotalCatch_g LowNoCatch CPUE_kgPerTrap CPUE_DistFromMeaCatch stability (relative distance of CPUE from mean CPUE for each combination of site and trap type) TotalValue_KSH Value PUE MeanLLmat MeanTrophLevel MeanVulnerability Mean ratio of length to length at first maturity Mean rophic level MeanVulnerability Mean reperature of the catch (degrees Celsius) FECoun FRic Fiby Functional richness (count of unique functional entities in the catch) Functional richness (count of unique functional entities in the catch) Calcium per unit effort (milligrams per 100 grams) TotalPe_mg TotalFe_mg FePUE FeConc_mgPer100g FeConc_mgPer100g FreConc_mgPer100g FreConc_mgPer1	B.undulatus	Was Balistapus undulatus present in the catch? (yes/no)
ScraperMass_g ScraperMassRatio GrazerMassRatio GrazerMassRatio Proportion of scrapers in the catch by mass GrazerMassRatio PredatorMass_g PredatorMassRatio Proportion of grazers in the catch by mass PredatorMassRatio Proportion of grazers in the catch by mass PredatorMassRatio Proportion of piscivorous predators in the catch by mass Total Catch_g Total catch (grams) Proportion of piscivorous predators in the catch by mass Total catch (grams) Proportion of piscivorous predators in the catch by mass Total catch (grams) Proportion of piscivorous predators in the catch by mass Total catch (grams) Was the catch (Ignams) CPUE_bgPerTrap Catch per unit effort (Rilograms per trap) CPUE_DistFromMea*Catch stability (relative distance of CPUE from mean CPUE for each combination of site and trap type) Value of the catch (Kenya Shillings) Value per unit effort (Kenya Shillings per trap) Mean TrophLevel MeanTrophLevel Mean trophic level Mean trophic level Mean species vulnerability (0-100) Mean temperature of the catch (degrees Celsius) FECount FRic Functional richness (count of unique functional entities in the catch) FRic FEVe Functional richness (count of unique functional entities in the catch) FRic Functional evenness FDiv Total calcium (milligrams) CaPUE CaConc_mgPer100g CaPue Calcium per unit effort (milligrams per trap) Calcium concentration (milligrams per trap) Total Feyne Total iron (milligrams) FePUE FEConc_mgPer100g Total calcium (Kenya Shillings per milligram) Total iron (milligrams) FePUE FEConc_mgPer100g Total calcium (milligrams per trap) FeConc_mgPer100g Total calcium (milligrams per trap) FeConc_mgPer100g Total cancentration (milligrams per trap) Total iron (milligrams) FePUE FEConc_mgPer100g Total cancentration (milligrams per trap) Total iron (milligrams) Total iron (milligrams) Total iron (milligrams) Total cancentration (milligrams per trap)	$BrowserMass_g$	
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FePrice_KSHPermg Value of iron (Kenya Shillings per milligram)	_	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
	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_gPer10	Omega-3 concentration (grams per 100 grams)
$Omega3Price_KSHP$	ekgalue of omega-3 (Kenya Shillings per gram)
$TotalProtein_g$	Total protein (grams)
ProteinPUE	Protein per unit effort (grams per trap)
ProteinConc_gPer10	Orotein concentration (grams per 100 grams)
ProteinPrice_KSHPe	ergalue 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)
$\overline{\text{ZnPrice}_\text{KSHPerug}}$	Value of zinc (Kenya Shillings per microgram)

Catch Data

 ${\bf Filepath:~O2_FishLife_Out/CatchData_GatedTraps_Galligan.csv}$

Number of variables: 11

Number of **observations**: 25789

 $\mathbf{Missing\ data\ code:\ NA}$

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

 ${\bf Filepath:~02_FishLife_Out/SpeciesData_GatedTraps_Galligan.csv}$

Number of variables: 44

Number of **observations**: 215

 $\mathbf{Missing\ data\ code:\ NA}$

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)
$TempPrefMean_degC$	C 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)
$VitamA_ugPer100g$	
$VitaminA_L95$	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"

- 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

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Thorson, J. T., Munch, S. B., Cope, J. M., & Gao, J. (2017). Predicting life history parameters for all fishes worldwide. $Ecological\ Applications,\ 27(8),\ 2262-2276.$ https://doi.org/10.1002/eap.1606

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