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Temporal Trends in Coral Reef Fish Biodiversity from French Polynesia (2006–2015)

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1 Abstract

This study analyzes a 10-year coral-reef fish data-set from French Polynesia (BioTIME Study 45; 2006- 2019) to assess temporal biodiversity trends. Using a tidyverse workflow, I computed **species richness** and **total abundance** per year and fitted simple linear trends. Results indicate year-to-year variability, with richness showing a negative trend and abundance a increase trend. Richness ranged 205 - 223 species, while abundance ranged 15,212 - 25,793 individual. Overall, patterns suggest dynamic but resilient communities with short-term fluctuation rather than a strong directional change.

2 Introduction

Coral reefs sustain exceptional biodiversity but face threats from habitat degradation, ocean warming, and pollution. Monitoring long-term changes in reef fish communities helps assess reef health and resilience. Here, I analyze long-term coral reef fish data from the **BioTIME** database to address:

1. How have total fish abundance and species richness changed from 2006-2019?
2. Are family-level trends consistent with the whole-community patterns?

3 Methods

3.1 Data Source

Dataset: BioTIME Study 45 - Coral Reef Fish (2006-2019)

Region: French Polynesia (approx. 17.5°S, 149.8°W)

Key columns: YEAR, valid_name (species), ABUNDANCE, BIOMASS, LATITUDE, LONGITUDE.

3.2 Data Processing

- Summed **ABUNDANCE** per year and counted disticnt **valid_name** to obtain **total_abundance** and **species_richness**.
- Fitted simple linear models: lm(species_richness ~ YEAR) and lm(total_abundance ~ YEAR).
- Visualized temporal patterns with ggplot2 (points + lines and LOESS smoothers).
- Reproducibility: all codes below uses tidyverse functions and runs top-to-bottom.

```
# Recreate core processing
reef_yearly <- reef_fish %>%
  group_by(YEAR) %>%
  summarise(
    total_abundance = sum(ABUNDANCE, na.rm = TRUE),
    species_richness = n_distinct(valid_name),
    .groups = "drop"
  )

richness_trend  <- lm(species_richness ~ YEAR, data = reef_yearly)
abundance_trend <- lm(total_abundance  ~ YEAR, data = reef_yearly)

slope_rich <- unname(coef(richness_trend)["YEAR"])
slope_abun <- unname(coef(abundance_trend)["YEAR"])
```

4 Results

4.1 Annual Patterns of Abundance and Richness

```
ggplot(reef_yearly, aes(x = YEAR)) +
  geom_line(aes(y = total_abundance,
                color = "Total Abundance"), linewidth = 1) +
  geom_point(aes(y = total_abundance,
                 color = "Total Abundance"), size = 2) +
  geom_line(aes(y = species_richness * 10,
                color = "Species Richness (×10)"),
            linewidth = 1, linetype = "dashed") +
  scale_color_manual(values = c("Total Abundance" = "darkblue", "Species Richness (x10)"

  labs(
    title = "Abundance and Richness Over Time",
    x = "Year",
    y = "Count / Index", color = "Metric"
  ) +
  theme_minimal() +
  theme(
    plot.background = element_rect(color = "black", fill = "white"),
    legend.position = "bottom"
  )
```

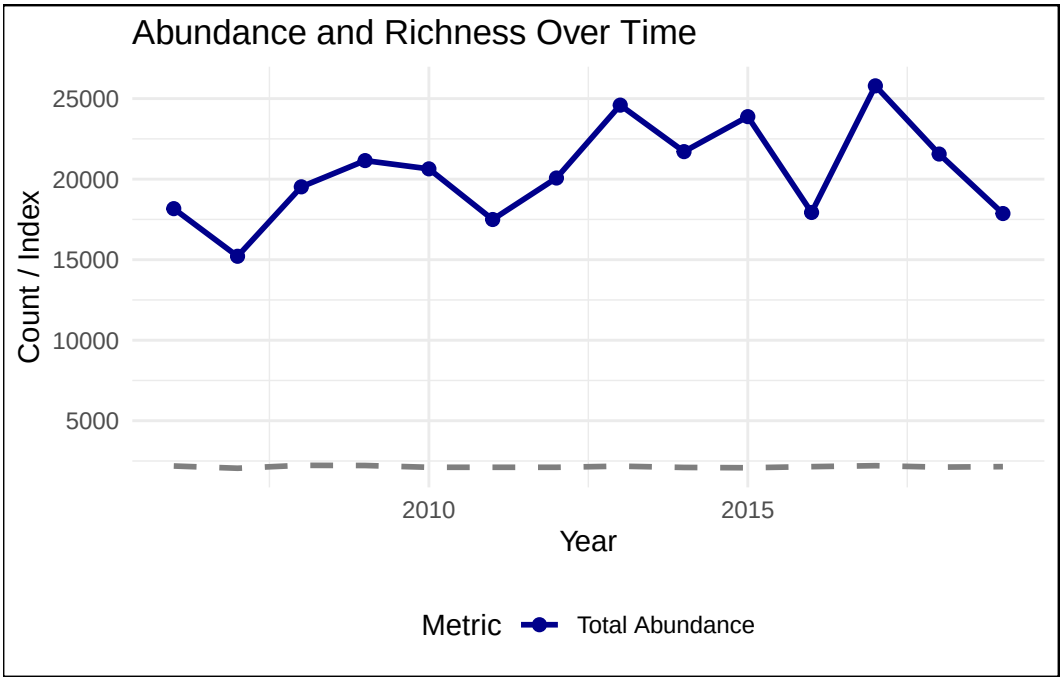


Figure 1: Temporal trends in total abundance (solid) and species richness (dashed). Dashed line = species richness ×10 (scaled).

This figure covers 2006-2019. See Figure 1 for overall patterns.

Species richness shows a **decline**, while abundance shows a **positive** linear tread.

5 Dominant Fish Families

```
top_families <- reef_fish %>%
  mutate(family = stringr::word(valid_name, 1)) %>%
  group_by(YEAR, family) %>%
  summarise(total_abundance = sum(ABUNDANCE, na.rm = TRUE), .groups = "drop") %>%
  group_by(family) %>%
  filter(mean(total_abundance, na.rm = TRUE) > 100) %>%
  ungroup()

# Quick check of families retained
unique(top_families$family)
```

```
 [1] "Abudefduf"          "Acanthurus"         "Balistapus"
 [4] "Caracanthus"        "Centropyge"         "Cephalopholis"
 [7] "Chaetodon"          "Chlorurus"          "Chromis"
[10] "Chrysiptera"        "Cirrhilabrus"       "Ctenochaetus"
[13] "Dascyllus"          "Gnathodentex"       "Gomphosus"
[16] "Halichoeres"        "Labroides"          "Lepidozygus"
[19] "Melichthys"         "Mulloidichthys"     "Naso"
[22] "Neocirrhites"       "Odonus"             "Paracirrhites"
[25] "Parupeneus"         "Plectroglyphidodon" "Pomacentrus"
[28] "Pomachromis"        "Pseudanthias"       "Pseudocheilinus"
[31] "Pycnochromis"       "Scarus"             "Stegastes"
[34] "Sufflamen"          "Thalassoma"         "Zebrasoma"
```

```
ggplot(top_families, aes(x = YEAR, y = total_abundance, color = family)) +
  geom_line(linewidth = 1) +
  labs(
    title = "Dominant Fish Families",
    x = "Year",
    y = "Total Abundance",
    color = "Family"
  ) +
  theme_minimal() +
  theme(
    plot.background = element_rect(color = "black", fill = "white"))
```

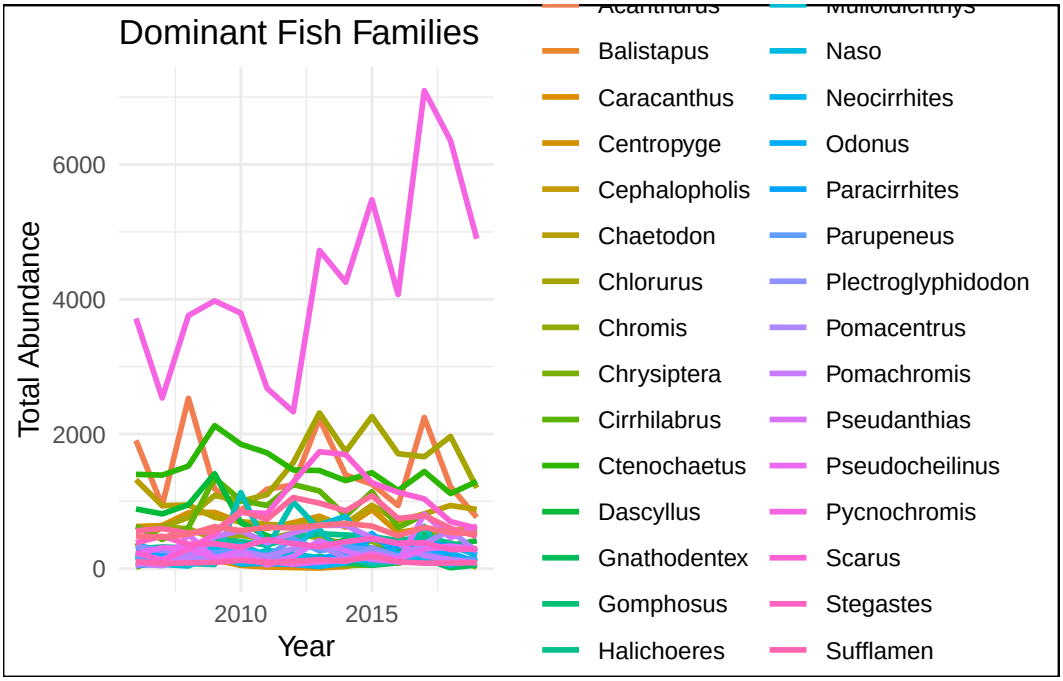


Figure 2: Yearly abundance trends for dominant coral-reef fish families.

Family-level patterns are shown in Figure 2.

6 Subfigures: LOESS Smoothing (A/B Panels)

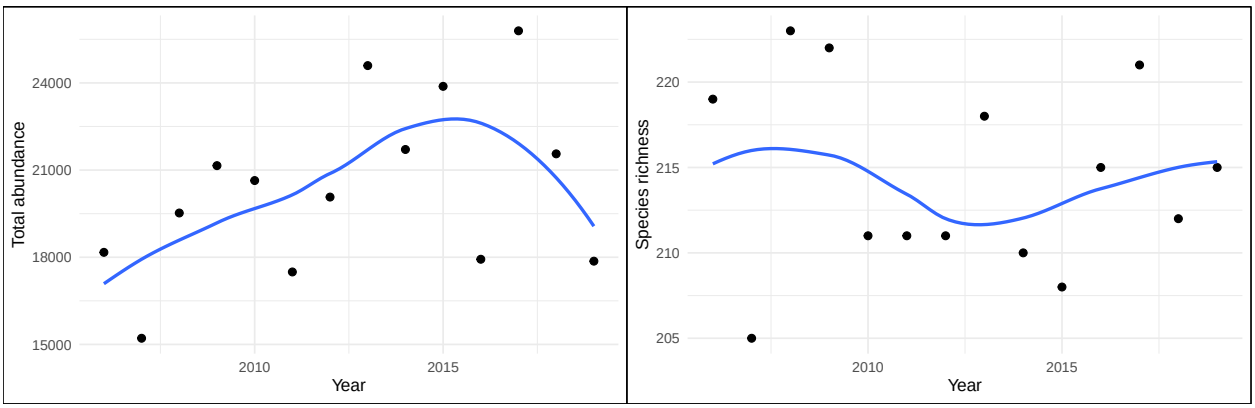
```
# First panel

p_abun <- ggplot(reef_yearly, aes(YEAR, total_abundance)) +
geom_point(size = 2) +
  geom_smooth(method = "loess", se = FALSE) +
  labs(x = "Year", y = "Total abundance") +
  theme_minimal() +
  theme(plot.background = element_rect(colour = "black", fill = "white"))

# Second panel

p_rich <- ggplot(reef_yearly, aes(YEAR, species_richness)) +
  geom_point(size = 2) +
  geom_smooth(method = "loess", se = FALSE) +
  labs(x = "Year", y = "Species richness") +
  theme_minimal() +
  theme(plot.background = element_rect(colour = "black", fill = "white"))

p_abun
p_rich
```



(a) Total abundance (LOESS) (b) Species richness (LOESS)

Figure 3: Yearly biodiversity metrics with LOESS smoothing.

See Figure 3 (panel A-B) for smoothed non-linear patterns.

7 Yearly Summary Table

```
knitr::kable(reef_yearly, align = "c")
```

Table 1: Yearly totals for abundance and species richness.

YEAR	total_abundance	species_richness
2006	18169	219
2007	15212	205
2008	19523	223
2009	21153	222
2010	20640	211
2011	17494	211
2012	20071	211
2013	24596	218
2014	21709	210
2015	23882	208
2016	17931	215
2017	25793	221
2018	21559	212
2019	17865	215

See Table 1 for the yearly summary.

8 Discussion

Both total abundance and species richness fluctuated across years, indicating short-term variability typical for coral-reef communities. Richness appears **decreasing**, while abundance shows a **positive** linear trend. The LOESS panels (A-B) suggest temporary dips and recoveries rather than a steady directional shift, consistent with environmental variability (e.g., temperature anomalies or disturbance-recovery cycles). Limitations include potential variation in sampling effort and taxonomic aggregation in the raw data. Integrating environmental covariates (e.g., sea surface temperature, bleaching events) could clarify drivers of observed dynamics.

9 Conclusion

From 2006-2019, species richness and abundance exhibit **moderate interannual variation** with modest linear trends **(richness: downward, abundance: upward)**. These finding suggest a **dynamic but resilient** coral-reef fish community. Future work should incorporate environmental predictors to better explain temporal patterns.

10 References

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- Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D. A., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T. L., Miller, E., Bache, S. M., Müller, K., Ooms, J., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). *Welcome to the tidyverse. Journal of Open Source Software, 4*(43), 1686. https://doi.org/10.21105/joss.01686
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