Supplementary Materials for

**Effectively regulating foreign fishing to improve food security and fishery sustainability in Africa**

**Estimation of FVF catches**

We estimated the catches by foreign vessels fishing (FVF) in African waters (Fig.1d) directly from the FAO fishery and aquaculture statistic database by summing up all catches taken by countries geographically outside an FAO Major Fishing Area28. With this area-based approach, vessels from a country that belongs to the Fishing Area fishing outside its EEZ but within the same Fishing Area are not considered foreign vessels, so that the FVF landings are somewhat underestimated.

There is another country-based study9 (Fig.S1) that surveyed the publicly available data from 1950 to 2011 on fisheries agreements between countries such as fisheries agreements between the European Union and African States is publicly available on the Internet29 and reports on distant water fishing from Regional Fishery Bodies. In addition, this study also incorporates opinions of local experts from African coastal states9. In general, the country-based approach is more specific and should provide more reliable estimates. However, its estimation is only up to 2011 and not reproducible, and more importantly the disparity in estimates between the two methods were minimal in the last decade from 2000 to 2011. Fig.S1 presents a comparison that shows the two sets of estimates are highly correlated with R2=0.99 and that overall and that our FVF estimates are 10% lower than the country-based estimates, mainly happened between 1980 and 2000 (Fig.S1). Statistical results of a linear model that estimates FVF catches from area-based estimation were presented in Table 1.

Table 1 The results of the linear regression model

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |  |
| Intercept |  |  |  |  |  |
| Slope | 0.89961 | 0.00434 | 207.3 | <2e-16 | \*\*\* |
| Multiple R-squared: 0.9986, Adjusted R-squared: 0.9986 | | | | |  |
| Source | df | MS | F | P |  |
| Regression | 1 | 2.70E+14 | 42963 | 2.20E-16 | \*\*\* |
| Residual | 61 | 6.29E+09 |  |  |  |

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Fig.S1 Comparison of the catch estimates for Foreign Vessels Fishing (FVF) in African waters between the area-based (blue dots) and country-based methods9.

**Estimation of IUU catches in African EEZs**

The IUU catch estimates in African countries’ EEZs were based on data from Pauly et al.32 and presented in Fig.S2. The total IUU catch experienced a rapid increase before 1970 and fluctuated between 3.0 and 4.2 million tonnes. Foreign vessels’ IUU fishing dominated over most years, reaching 75% in 1967 and declining since to 48% in 2016 (Fig.S3)

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Fig.S2 IUU catch estimates in a million tonnes (mt) from African countries’ EEZs.

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Fig.S3. Shares of foreign vessels in IUU fishing of African countries’ EEZs.

**Average prices of import and export fish products from African countries**

The average prices of imported and export fish products were directly estimated from the food balance sheets of fish and fishery products8. Clearly, export prices are always higher than import prices, more than doubled in some years (Fig.S4). This is a common practice in many developing countries, exporting valuable products that can fetch a high price and importing low-valued fish to meet the quantitative needs of domestic markets.



Fig.S4 Prices of imported and exported fish and fishery products in Africa extracted from FAO8

**The vicious circle of overfishing in Africa**

Both science and experience have shown that overfishing will result in declining stocks which, once below a certain level, will impair fish stocks’ reproductivity and reduce the long-term catch a stock can produce35. The declining stock will in turn, intensify competition among fishers to catch the limited stock and lead to the fall of catch, which will push up fish price in the market. The higher price and lower abundance will subsequently motivate more investment in additional uncontrolled inputs and fishing efforts. Fig.S3 shows the trajectory of price, fishing effort and overfishing from 1974 to 2017 of the African marine fisheries. Increasing fishing will ultimately deplete stocks and reduce landings, although such consequences often appear in a time lag26.

This vicious cycle of declining resources and increasing fishing effort is a double whammy for the fishing industry and can only be stopped by introducing strict regulations36. Effective management can rebuild overfishing stocks, sustain social and economic benefits and protect the fishery resources and environment37.

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Fig.S5. The Vicious circle of overfishing in African fisheries. Overfishing is in the percentage of overfished stocks from10,16–19. Price data was derived from8 and effort data from38.