Reference points to improve effective management of fish stocks in lakes Edward, George, and Kazinga channel

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Summary

Reference points are benchmarks that scientists and managers use to determine or know the status of a fish stock or fishery. The reference points can be used to set management objectives, harvest strategies and control rules, and evaluate their success. The most common reference point used in fisheries management in Uganda is length at maturity (L_{50}), the total length at which 50% of individuals of a fish species attain maturity. This has been used to set mesh size, hook size, or slot size limits so that the fish captured are of a length that is equal to or more than L_{50}. This allows the chances of capturing fish after contribution to the fish population through reproduction. Apart from this, the use of other reference points in management of fisheries in Uganda is limited.

Research efforts at the National Fisheries Resources Research Institute (NaFIRRI) are ongoing to determine reference points of all fish stocks in all major waterbodies to:

i. Determine their exploited status,
ii. Evaluate the success of current management approaches, and
iii. Establish a basis for developing effective management objectives, harvest strategies and control rules
iv. Promote proper monitoring of fisheries and evaluation of management activities.

This policy brief is intended at highlighting observations from the studies on fish stocks exploited in lakes Edward, George and Kazinga channel. The aim is to use selected reference points to clarify the status of the stocks in the waterbodies and the impact of the current management approaches that commenced in 2018. Based on the results, recommendations to improve the status of the stocks are made.

Introduction and approach

Improved knowledge of the status of fish stocks is a priority requirement to promote better

Key messages

1. The status of exploited fish species in lakes Edward, George, and Kazinga channel is generally poor, with the status of the assessed species classified as collapsed or recruitment impaired.
2. Current catches are below Maximum Sustainable Yield (MSY), indicating that more catches can be attained under good management.
3. Although the impact of the new management regime in place since 2018 is not significant, values (qualitative and quantitative) of selected reference points show evidence that the management is benefitting populations of the exploited fish species. If maintained, this could result into better outcomes such as increased catches.
4. To improve the status of the fish stocks, management should strengthen enforcement to completely avoid capture of fish before maturity, and control fishing effort.

management of fisheries. This knowledge enables those involved in management to decide on the best management objectives, strategies, and control rules. Unfortunately, many fisheries lack standard monitoring, and as a result, decision making is not reliable. To support efforts to strengthen management, we aggregated secondary data and supplemented it with new data gillnet surveys, catch assessment and frame surveys, to assess the status of exploited fish species in lakes Edward, George and Kazinga channel using various indicators. The indicators used, also called reference points, are the common reference points used to assess the status of exploited fish species (Table 1). However, these were not available or outdated for the species in the waterbodies.

The assessments were conducted using an approach that utilizes data collected over years on catches and catch per unit effort (CPUE) to generate reference points useful for making inferences on the status of fish stocks and guide management. This approach was accompanied with the determination of life history parameters for the main species that appear in catches of the waterbodies. Using data from gillnet surveys and catch assessment surveys, major life history parameters estimated included size structure, coefficients of length-weight relationships, and length at which 50% of individuals in a population of a species attain maturity (L50).

Observations

For these waterbodies, the status of the stocks is poor, with the species assessed classified as collapsed or recruitment impaired (Tables 2 and 3). The status of the stocks was based on the values of B/B_{msy} , a reference point commonly used to classify stocks into different status categories. High fishing pressure, depicted in the values of F/F_{msy} or exploitation, is the reason for the poor status of the stocks. The values of F/F_{msy} were greater than one for the stocks, indicating that the prevailing F was higher than F that supports maximum sustainable yield (MSY). The impact of the high fishing pressure was demonstrated in the values of B/B_{msy} that were less than one, indicating that current biomass was less than B_{msy}. This is an indicator of degradation of biomass, resulting into the poor status of the stocks. Based on the values of F/F_{msy}, species in Lake Edward appeared to be exposed to more fishing pressure than those in Lake George and the Kazinga channel. Within species, more fishing pressure is on Nile tilapia in the three waterbodies. Trends in values of F/F_{msy} demonstrate that high fishing pressure is persistent, at least over the period covered by the data used in the assessment (See Figure 1 for example) It shows that exploitation has been above the reference level since 2006 for Nile tilapia in Lake Edward. This corresponds to persistent degradation in biomass.

In these waterbodies, catches for the species are consistently below MSY. This can be explained by the consistent high fishing pressure and low stock size shown in the trends of F/Fmsy and B/Bmsy respectively (Figure 2). This shows that catches could be increased under good management which should be a motivation for strengthening enforcement (Table 3).

Even though the status of the stocks is poor, the overall status has improved or remained unchanged since 2019 for the stocks assessed, apart from Semutundu in Lake Edward. In addition, observations on life history parameters of fish indicate evidence of gains from the current management efforts since 2018, though not significant. These are demonstrated in increasing mean length and proportion of mature individuals in catches. Apart from Semutundu, the proportion of mature individuals in catch since 2018 has improved compared to observations made in 2013 (Table 4). However, reference points that indicate presence of immature individuals in catches show that indeed, immature fish are caught for all species, indicated by values of L_{mean}/L_{opt} and $L_c/Lc_{\_opt}$ that were less than 1 for all the species assessed. These suggest that capture of immature fish for these species may be undergoing but not reported in catches (Semutundu is an exception).

Recommendations

Strengthen enforcement: Although there are gains in the current management approach, the status of stocks remains poor due to high fishing effort, and capture of immature fish. Acknowledging that reducing fishing effort in terms of number of boats is difficult, the aim should be to eliminate capture of immature fish especially for Nile tilapia, and fishing in breeding areas. These could contribute to the rebuilding of biomass for the stocks until the level that supports maximum sustainable yield is attained (Table 3). The capture of immature fish for Semutundu is a challenge because the fish is captured in gillnets allowed for Nile tilapia. Meanwhile, the species can also benefit from control of illegal fishers and the elimination of fishing in breeding areas.

Enhance monitoring: Many species could not be assessed because of lack of suitable data. In addition, there are data gaps in catches and parameters of fish life history because monitoring is not frequent. Considerations should be made to support frequent catch assessment and flame surveys (at least every two years) and gillnet surveys. A study to determine biomass of fish species in these waterbodies using swept area methods is needed. Strengthening monitoring and assessment will meet requirements of annual reporting on the status of the stocks and establish knowledge to support proper evaluation of management activities thus facilitating changes to make them more effective.

Table 1 Common reference points used in fisheries management.

Reference point	Definition
L_{50}	length at which 50% of individuals in a population of a species attain maturity
L_c	Length at first capture for a species
$L_{c\text{-}opt}$	the optimal length at first capture that maximizes catch and biomass at the prevailing fishing effort
L_{opt}	the mean optimal length in catch that maximizes unexploited biomass
L_{mean}	Mean length in catch
L_{mean}/L_{opt}	L_{mean} relative to L_{opt}
L_c/L_{c_opt}	L_c relative to L_{c_opt}
Mature	Proportion of mature individuals in catch
Biomass	total weight of a given species of fish in a waterbody
B_{msy}	Biomass that can support MSY
B_0	unexploited biomass
B/B_0	the current exploited biomass (B) to unexploited biomass ratio (B_0), an indicator of fish stock depletion
MSY	Maximum sustainable yield, the largest yield that can be taken from a species' stock over an indefinite period
B/B_{msy}	Current biomass relative (B) to biomass that supports MSY (B_{msy})
F	Fishing mortality in a year
F_{msy}	Fishing mortality that can support maximum sustainable yield (MSY)
F/F_{msy}	Exploitation or F relative to F_{msy}

Table 2 Estimates for assessed fish species in Lakes Edward, George and Kazinga channel. Estimates for F_{msy}, MSY and B_{msy} are long-term averages while others are for the last year in the dataset (2020). See table 1 for the description of the terms used.

Stock	F_{msy} (1/year)	MSY (1000 tonnes/year)	B_{msy} (1000 tonnes)	B (1000 tonnes)	F (1/year)	Exploitation (F/F_{msy})
Lake Edward						
Semutundu	0.0643(0.035-0.121)	2.04(1.31-3.15)	32(18-54.4)	4.17(2.36-7.23)	0.18(0.0971-0.341)	10.6(4.19-28.7)
North African catfish	0.0998(0.0524-0.184)	0.612(0.411-0.919)	6.22(3.11-12.1)	1.47(0.791-2.6)	0.204(0.108-0.399)	4.43(1.85-10.7)
Nile tilapia	0.105(0.0585-0.195)	2.01(1.34-3.06)	19.6(9.91-34.5)	19.6(9.91-34.5)	0.298(0.156-0.582)	9.41(3.06-27.9)
Lake George						
Semutundu	0.141(0.0698-0.268)	1.5(0.992-2.29)	10.6(5.35-21.5)	3.88(2.06-7.11)	0.233(0.119-0.462)	2.24(1.02-6.17
North African catfish	0.131(0.068-0.249)	1.29(0.856-1.94)	9.75(4.97-19.5)	3.46(1.83-6.51)	0.199(0.0986-0.407)	2.13(0.98-5.52)
Nile tilapia	0.124(0.0616-0.238)	2.15 (1.42-3.23)	17.4(8.85-36.2)	4.33(2.19-8.47)	0.146(0.0715-0.308)	2.33(0.823-8.37)
Kazinga channel						
Semutundu	0.151(0.0831-0.265)	0.396(0.259-0.616)	2.64(1.3-5.32)	0.93(0.48-1.87)	0.239(0.111-0.51)	2.24(0.964-5.55
North African catfish	0.133(0.07-0.24)	0.213(0.141-0.338)	1.62(0.816-3.31)	0.41(0.22-0.80)	0.301(0.144-0.593)	4.44(1.75-12.8)
Nile tilapia	0.123(0.0619-0.241)	0.188(0.125-0.29)	1.54(0.787 - 3.11)	0.3(0.133-0.634)	0.322(0.145-0.759)	6.55(1.92-31.6)

Table 3 Stock status based on the classification of B/B_{msy} values, maximum sustainable yield (MSY) and catches of 2020 in lakes Edward, George and Kazinga channel. Gains in catches was obtained as the difference between MSY and catches in 2020 and expressed as a percentage.

Stock			MSY (1000 tonnes/year)	Catch (1000 tonnes/year)	Gains in catches (1000 tonnes/year)	Percentage change (%)
Lake Edward	B/B_{MSY}	Status				
Semutundu	0.13(0.08-0.20)	Collapsed	2.04	0.67	1.37	204.5
North African catfish	0.24(0.15-0.37)	Collapsed	0.612	0.29	0.32	110.4
Nile tilapia	0.15(0.09-0.271)	Collapsed	2.01	1.26	0.75	59.5
Lake George						
Semutundu	0.36 (0.22-0.56)	Recruitment impaired	1.5	1.19	0.31	26.1
North African catfish	0.36(=0.23-0.54)	Recruitment impaired	1.29	0.76	0.53	69.7
Nile tilapia	0.25(0.13-0.42)	Recruitment impaired	2.15	0.81	1.34	165.4
Kazinga channel						
Semutundu	0.36(0.23-0.55)	Recruitment impaired	0.40	0.27	0.13	48.2
North African catfish	0.25(0.16-0.40)	Recruitment impaired	0.21	0.19	0.02	10.5
Nile tilapia	0.20(0.09-0.35)	Recruitment impaired	0.19	0.15	0.04	26.7

Table 4. Values of length-based reference points and proportion of mature individuals in catches of fish stocks in lakes Edward (LE), and George (LG)

Parameter	Nile tilapia_LE	Nile tilapia_LG	North African catfish_LG	Marbled lungfish_LG	Semutundu_LG	Semutundu_LE
L_{opt} (cm)	33.0	40.0	99.0	91.0	-	-
L_{c_opt} (cm)	32.0	39.0	94.0	82.0	-	-
L_{mean}/L_{opt}	0.77	0.72	0.71	0.92	0.8	0.69
L_c/L_{c_opt}	0.85	0.75	0.58	0.9	0.73	0.65
Mature	100%	100%	93%	97%	32%	30%

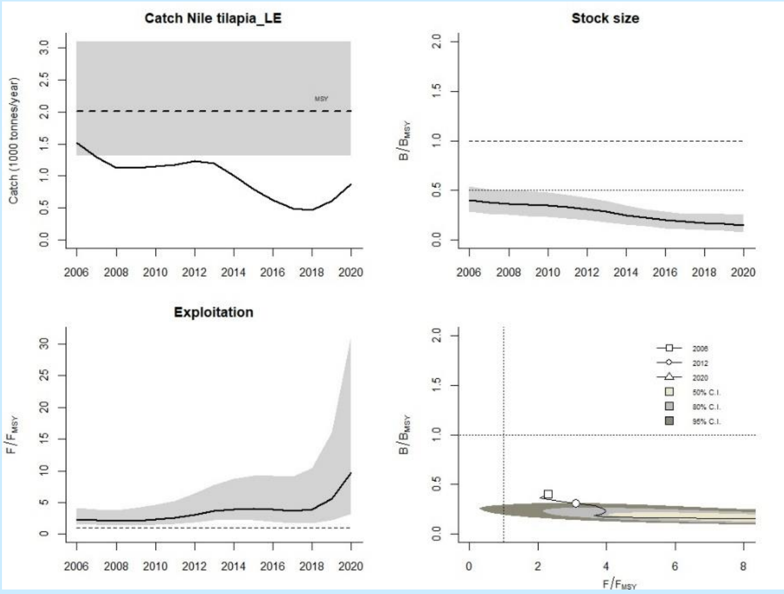

Figure 1 Trends in key management aspects of the Nile tilapia fishery in Lake Edward, Uganda

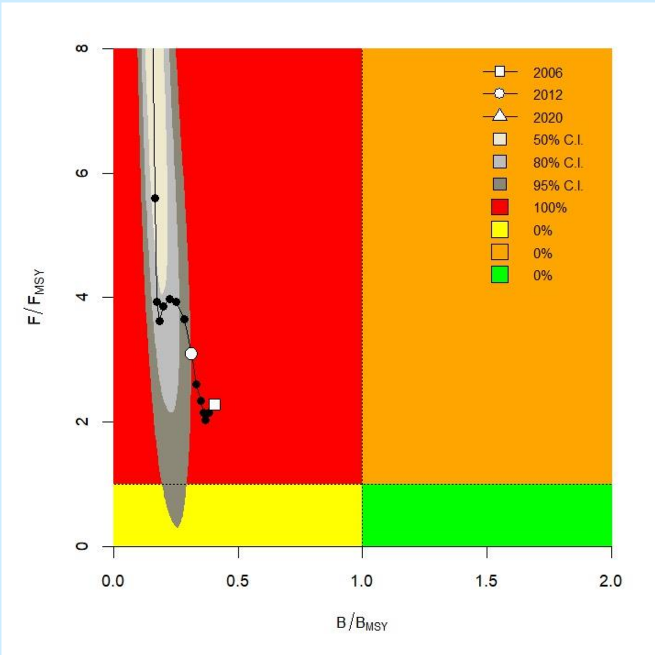

Figure 2 A Kobe plot for the Nile tilapia in the Lake Edward, Uganda based on estimates of B/B_{msy} and F/F_{msy}. A stock in the orange area is health but vulnerable to depletion by overfishing. In the red area, a stock is overfished and is undergoing overfishing, with too low biomass levels to produce maximum sustainable yield (MSY). In the yellow area, a stock is under reduced fishing pressure but recovering from too low biomass levels. The green area is the target area for management, indicating sustainable fishing pressure and healthy stock size capable of producing high yields close to MSY. The probabilities of the stock being in any of these areas are given. The 50, 80 and 95% are confidence levels around the year of final assessment.