Age-based life history of Pacific longnose parrotfish *Hipposcarus longiceps* from New Caledonia

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**Abstract**
The Pacific longnose parrotfish, *Hipposcarus longiceps*, is a medium- to large-bodied scarine labrid that is among the most commonly harvested species in mixed reef fisheries across the Indo-Pacific. Despite its ecological and fisheries importance, assessments of stock status and development of appropriate management strategies for the species have been limited by an absence of biological information. To date, the only detailed studies of the biology of *H. longiceps* have occurred in tropical regions. This study examined the biology of *H. longiceps* in southern New Caledonia, towards the southernmost extent of the species’ distribution. In addition, resulting estimates of longevity and asymptotic length were compared against those derived for the species elsewhere in the Pacific, and regional patterns in these parameters were explored for correlation with sea surface temperature (SST). A total of 212 *H. longiceps* were collected from commercial fishers or fish markets between September 2015 and March 2017. Sampled individuals ranged from 28.2 cm fork length (*L*<sub>F</sub>) to 57.3 cm *L*<sub>F</sub>, and from 424 g to 3773 g. Examination of sectioned otoliths showed a clear pattern in increment formation, with opaque zones forming annually in most individuals between July and August (i.e., austral winter). Estimated longevities were similar between sexes, at ~18 years for females and ~19 years for males. These estimates extend the reported longevity of *H. longiceps* by at least 5 years. Despite this species being a diandric protogynous hermaphrodite, sex ratios were only slightly female biased, with 1 female:0.6 males. Primary males (i.e., those individuals that are male at first sexual maturity) constituted 30% of all sampled individuals and 79% of all males. A clearly defined, yet protracted, spawning season was evident, with peak spawning occurring from December–February, extending from November to April in some individuals. The estimated median length (*L*<sub>50</sub>) and age (*A*<sub>50</sub>) at female maturity were 38.9 cm *L*<sub>F</sub> and 5.7 years, respectively, while the estimated length at which females changed sex to secondary males was 52.5 cm *L*<sub>F</sub>. Reported longevity and asymptotic length were found to exhibit considerable regional variation, and both were negatively associated with SST. The results highlight the importance of geographically disparate studies into the species’ biology, inform future assessments for...
1 | INTRODUCTION

Parrotfish (Family Labridae, Subfamily Scarinae) are an abundant and diverse component of fish communities on coral reef ecosystems around the world. As a group, parrotfish fill a wide variety of functional roles within reef ecosystems. Through their feeding actions, parrotfish modify the benthic biota by reducing macroalgal growth, cropping epilithic algal turf and providing areas of bare substrate for coral recruitment (Bellwood, 1996; Green & Bellwood, 2009). Parrotfish also play an important role in the production, reworking and transport of sediments in reef ecosystems (Bellwood, 1996). Parrotfish also modify the benthic biota by reducing macroalgae growth, creating bare substrate through its feeding actions (Green & Bellwood, 2009; Taylor & Choat, 2014), raising concerns about the appropriateness of using life-history parameters from these locations for assessments elsewhere across the species distribution.

This paper examines the age-based life history of H. longiceps from reefs of southern New Caledonia, including growth, longevity, mortality, spawning seasonality, length and age at female maturation and length at sex change. In addition, regional variation in maximum observed age and asymptotic length are explored using data from the current study and the published literature, and patterns in these life-history variables are assessed for correlation with sea surface temperature (SST); a key driver of coral reef fish life history (Robertson et al., 2005; Taylor et al., 2019). Data from southern New Caledonia, towards the southernmost extent of the species distribution, provide an opportunity to contrast biological parameters against those observed from low-latitude locations. The derived results provide a preliminary insight to stock status, facilitate future stock assessments and the development of appropriate management strategies, and further the understanding of spatial variability in life-history traits of H. longiceps and parrotfish species more broadly.

2 | MATERIALS AND METHODS

2.1 | Study area and sample collection

Samples of H. longiceps were collected from commercial net fishers who fished in southern New Caledonia (Figure 1) or from two vendors at the Nouméa central fish market, where the fisher, location of

the species, provide key baseline information for comparative work and improve understanding of spatial patterns of the life history of parrotfish species.

KEYWORDS

fisheries management, growth, mortality, New Caledonia, parrotfish, reproduction
fishing and date of capture could be assured. Sampling was typically conducted once per week (occasionally twice per week) between September 2015 and March 2017. For each fish, the standard length ($L_S$, measured from the tip of the snout to the posterior edge of the last scale), $L_F$ (measured from the tip of the snout to the end of the middle caudal rays), total length ($L_T$, measured from the tip of the snout to the end of the longest caudal fin ray) and whole weight ($W_W$) were recorded, unless damaged. All fish length measurements were recorded to the nearest 0.1 cm and $W_W$ to the nearest 1 g. Sagittal otoliths (hereafter otoliths) were removed, cleaned, dried and stored in plastic vials. Gonads were dissected, weighed to the nearest 0.1 g, sexed and staged macroscopically. Gonads were classified into developmental stages adapted from Brown-Peterson et al. (2011): immature, developing, spawning capable, running ripe (i.e., actively spawning subphase), regressing, and regenerating, using criteria therein. Most gonads were fixed fresh in 10% buffered formalin for histological processing, although a small number were frozen prior to fixation. The colour phase (i.e., IP or TP) was recorded for each individual.

2.2 | Age determination

A single otolith from most individuals was embedded in casting resin and sectioned on the transverse axis through the primordium, in a direction perpendicular to the sulcus acusticus. Sections were cut using a modified high-speed gem-cutting saw with a diamond impregnated blade. Up to three sections were cut for each otolith, with otoliths cut thinly (c. 0.3 mm) to improve the clarity of the growth increments. Sections were cleaned, dried and mounted on glass slides with a cover slip using casting resin. Opaque increments were counted with a compound microscope using a combination of reflected and transmitted light, with enumeration following the approach of Taylor and Choat (2014) and Taylor and Cruz (2017) (Figure 2). Each otolith was read at least twice by the author. When there was agreement in the counts of opaque increment from these two reads, the count was taken as the number of opaque increments. A third count was performed when the two counts for an individual differed, and the final opaque increment number was assigned when any two of the three counts agreed. Counts for two individuals could not be agreed through this process. In each of these instances opaque increment counts differed by 1 (e.g., 6, 7, 8) so the middle value was taken, following Taylor and Cruz (2017).

The timing of opaque and translucent increment deposition in $H. longiceps$ otoliths was examined using edge-type analysis, following the approach by Moore (2019). The margin of each otolith was categorized as opaque, whereby an opaque band was evident around the edge of otolith, narrow translucent, whereby a translucent band comprising <50% of the width of the previous translucent band was encountered, or wide translucent, whereby a translucent band comprising ≥50% of the width of the previous translucent band was encountered. The proportion of fish with opaque margins was calculated for each month and plotted across the calendar year to assess the timing of opaque zone deposition in otoliths. Satellite-derived mean daily SSTs (in °C) were collated for the southern New Caledonia region between January 2000 and December 2015 (obtained from NOAA/OAR/ESRL PSL, Boulder, Colorado, USA; https://psl.noaa.gov/data/gridded/data.noaa.oisst.v2.highres.html) and were plotted alongside the proportion data to assess the relationship between opaque increment formation and SST.

Following confirmation of the timing of opaque zone deposition, a decimal age was calculated for each individual. Decimal ages were based on the assumed birth date, the peak of opaque increment deposition (i.e., 1 July; see Results), the number of opaque increments and

FIGURE 1 Map of New Caledonia showing the approximate area where $Hipposcarus longiceps$ were collected (dashed rectangle)

FIGURE 2 Photomicrographs of transverse otolith sections of $Hipposcarus longiceps$ under transmitted light. Top, a 42.0 cm fork length ($L_F$) female caught in June 2016 with four opaque increments (white circles) and a translucent otolith margin; bottom, a 51.5 cm $L_F$ female caught in May 2016 with 16 opaque increments and a translucent otolith margin. Black circles with white outlines indicate the presumed 6 month increment
the month of capture. An assumed birth date of 1 January (the peak of female spawning) was used for all samples, as determined from monthly patterns in gonadosomatic indices [GSI, (gonad weight/\(W_W\)) \times 100] and patterns of developmental stages of gonads. Accordingly, formation of the first opaque increment was considered to take place ~6 months after birth (Figure 2). This first increment was often difficult to delineate and thus the first counted opaque increment was considered to form one and a half years after birth. Thus, an individual with five annual bands and a narrow translucent otolith margin caught in July was considered to be 5.5 years old, while an individual caught in January with five annual bands was considered to be 6 years old. A full year was added to those individuals caught in July–August that had a wide translucent otolith margin.

2.3 | Gonad histology

Gonads from most individuals were subjected to histological examination to verify the macroscopic sex assignments. For females, a secondary goal was to determine the developmental stage for assessing maturity schedules and spawning seasonality. Transverse sections of gonads (up to three per individual) were embedded in paraffin wax, sectioned at 5 \(\mu\)m, mounted onto microscope slides and stained with haematoxylin and eosin. Slides were examined using both dissecting and compound microscopes with transmitted light. Female gonads were classified into the same developmental stages as used for the macroscopic assessments. Ovary development staging was based on criteria detailed by West (1990), using the terminology in Brown-Peterson et al. (2011). Following Taylor and Cruz (2017), consideration was given to (a) presence or absence of post-ovulatory follicles (POFs) as an indicator of prior spawning, (b) proliferating spermatogenic material in the presence of degenerative vitellogenic oocytes as an indicator of post-maturational sex change and (c) characteristics of an ovarian lumen in male testes signifying secondary versus primary male development, based on the criteria outlined in Sadovy and Shapiro (1987) and Shapiro and Rasotto (1993) (Figure 3). Additional features used to assess prior spawning and thus maturity of females included the structural appearance of lamellae, intra-lamellar stromal tissue, the presence of atretic oocytes and brown bodies, and the thickness of the ovarian wall (Sadovy & Shapiro, 1987).

2.4 | Growth and mortality

Relationships between \(L_S\), \(L_F\) and \(L_T\) were assessed using linear models. The relationship between \(L_F\) and \(W_W\) was modelled using a power function of the form \(W_W = a \times L_F^b\), where \(a\) is the coefficient of the power function and \(b\) is the exponent. Length and weight data were log-transformed prior to analysis to satisfy the assumption of linearity.

Growth of *H. longiceps* was initially modelled using the standard von Bertalanffy growth function (VBGF) fitted by nonlinear least-squares regression of \(L_F\) on the decimal age data. The VBGF took the form:

\[
L_t = L_\infty \left(1 - e^{-k(t-t_0)}\right)
\]

where \(L_t\) is the predicted mean \(L_F\) (cm) at age \(t\) (years), \(L_\infty\) is the hypothetical asymptotic length, \(k\) is the growth coefficient and \(t_0\) is the age at which fish would have a theoretical length of zero. Corresponding 95% confidence intervals (CIs) were generated by bootstrap resampling through 1000 iterations. Separate VBGFs were run using data for all individuals combined, primary males, and females and secondary males combined. A second series of VBGFs were run where growth curves were constrained (y intercept) to a common length at settlement (\(L_0\)) of 1.5 cm \(L_F\) to account for the growth of small juveniles which were missing from the dataset and to facilitate...
comparisons with studies in other regions (e.g., Taylor & Choat, 2014; Taylor & Cruz, 2017). Following the recommendation of Taylor et al. (2018b), a re-parameterized VBGF (rVBGF; Francis, 1988) was run in parallel to each unconstrained VBGF model. The parameters selected for the rVBGF were $L_5$, $L_{10}$ and $L_{15}$, providing estimates of mean length-at-ages 5, 10 and 15 years.

Support for developmental path (i.e., female and secondary male vs. primary male) specific VBGF growth curves was assessed using the approach of Kimura (2008), whereby development strategy was added as covariates ($\beta$) on each of the three VBGF parameters, such that:

$$\begin{align*}
\left( \begin{array}{c}
L_{\infty} \\
k_i \\
t_{\infty}
\end{array} \right) &= \left( \begin{array}{c}
\beta_{0u} + x_i\beta_{1u} \\
\beta_{0k} + x_i\beta_{1k} \\
\beta_{0t} + x_i\beta_{1t}
\end{array} \right)
\end{align*}$$

where $x_i$ is a dummy variable for developmental path, set to either 0 or 1, for the $i$th fish. To evaluate the occurrence of developmental path-specific differences in growth, the Akaike's Information Criterion corrected for small sample sizes (AICc; Burnham & Anderson, 2002) was calculated as the difference between the AICc of a standard VBGF model fitted with developmental path included as a covariate. Models with an AICc value within two of that of the best approximating model were considered of interest.

2.5 | Reproductive biology

Generalized linear models (GLMs) were used to model the length and age at maturity of female $H$. longiceps, and the length and age of female to secondary male sex change. All females with gonads in stages developing-regressing as verified by histology were considered to be mature. Maturity state (i.e., immature or mature) and sex (i.e., female or secondary male) were treated as binomial response variables and modelled as a function of $L_F$ and age with logit link. Corresponding 95% CIs for each parameter were derived by bootstrap resampling using 1000 iterations.

Monthly trends in the proportion of histologically verified mature females and GSI values of both mature females and mature males across the calendar year were examined to determine the seasonality of $H$. longiceps spawning in southern New Caledonia. GSI and stage data were aggregated by month across years.

2.6 | Regional variation in longevity and asymptotic length

Estimates of life span and asymptotic $L_F$ from the present study were compared against those derived for $H$. longiceps from the northern Great Barrier Reef (GBR), Australia (Choat & Robertson, 2002; J. Choat, pers. comm.), Guam (Taylor & Cruz, 2017), Palau (Kitalong & Dalzell, 1994), Pohnpei (Taylor & Choat, 2014) and the Solomon Islands (Sabetian, 2010) to examine regional variation in age-based life history. Where reported as $L_5$ or $L_F$, asymptotic length estimates were converted to $L_F$ using correlation coefficients of the present study (see Results). Following Taylor and Cruz (2017), maximum age and asymptotic $L_F$ estimates were regressed against satellite-derived SST data for each location using linear regression to explore correlations of each variable with SST.

All statistical analyses were conducted in R version 4.0.2 (R Core Team, 2020). All linear models, GLMs and nonlinear modelling of the VBGF were conducted using the stats package (R Core Team, 2020). The re-parameterized VBGFs were generated using the package fishmethods (Nelson, 2019).

3 | RESULTS

3.1 | Age determination

A clear annual periodicity in the formation of opaque increments in $H$. longiceps otoliths was evident from patterns of otolith edge classifications (Figure 4), indicating that increments were deposited annually. Opaque increment deposition was observed to begin towards the austral winter, commencing in May in some individuals, and peaking between July and August. Opaque increments were fully deposited by October (Figure 4).

3.2 | Length and age distributions

A total of 212 $H$. longiceps were collected during the sampling period. Catch samples were female biased, with a sex ratio of 1 female:0.6 males. The modal length class of all sampled individuals was 45 cm $L_F$ and the modal age class was 7 years (Figure 5). The largest individual sampled was 57.3 cm $L_F$ and weighed 3.73 kg, while the oldest individual was 19.8 years of age. Sampled female $H$. longiceps ranged from 28.2 to 55.1 cm $L_F$ and 3.3 to 18.9 years of age. Primary males constituted 79% of all males sampled and were observed across most length and age classes, and across both IP and TP colour forms. Secondary males ranged from 48.8 to 57.3 cm $L_F$ and 8.2 to 18.5 years (Figure 5).
3.3 | Growth and mortality

Relationships between $L_S$, $L_F$, and $L_T$ were defined as:

$$L_F = 1.118 \times L_S - 0.064 \quad (R^2 = 0.99)$$

$$L_T = 1.114 \times L_S + 1.026 \quad (R^2 = 0.99)$$

The relationship between $L_F$ and $W_W$ was defined as:

$$W_W = 0.020 \times L_F^{2.987}$$

The value of the slope exponent ($b \approx 3$) indicates that $H. \text{longiceps}$ exhibit an isometric growth pattern in which there is no change in body shape as they grow.

There was no significant effect of developmental path on growth of $H. \text{longiceps}$, with the AICc of the growth model including developmental path as a covariate on each of the three VBGF parameters within 2 of that of the growth model fitted excluding development path (927.14 and 926.06, respectively) (see also Table 1). Secondary males were generally larger for a given age than females or primary males (Figure 6). Constraining the growth curve to $L_0 = 1.5 \text{ cm} \ L_F$ resulted in a slightly reduced estimate of $L_\infty$ relative to the unconstrained growth curve (Table 1). The re-parameterized version of the unconstrained VBGF applied to all individuals irrespective of development path yielded $L_F$ estimates of 37.2 (95% CI = 36.3–38.1), 47.5 (95% CI = 47.0–48.0) and 51.2 (95% CI = 50.4–52.0) cm, at ages 5, 10 and 15, respectively (Table 1).

Total annual mortality ($Z$) for samples from 2016 was estimated as 0.27 (±0.03) year$^{-1}$. Natural mortality was estimated as 0.22 and fishing mortality estimated as 0.05 (±0.03).

3.4 | Reproductive biology

The estimated median length ($L_{50}$) and age ($A_{50}$) at female maturity were 38.9 cm $L_F$ (95% CI = 36.8–40.7 cm $L_F$) and 5.7 years (95%
CI = 4.8–6.6 years), while the estimated length and age at which 95% of females attained maturity was 42.5 cm \( L_F \) (95% CI = 40.7–45.3 cm \( L_F \)) and 7.4 years (95% CI = 6.5–8.8 years) (Figure 7). The lengths at which 50% and 95% of females changed sex were 52.5 (95% CI = 50.6–55.2 cm \( L_F \)) and 57.2 cm \( L_F \) (95% CI = 54.7–58.0 cm \( L_F \)), respectively. Due to the large proportion of females in the oldest age classes it was not possible to estimate the age at sex change (Figure 7).

Despite low sample sizes, monthly trends of both GSI and female gonad staging data showed a clear pattern of annual periodicity. Mean monthly GSI values for mature \( H. \ longiceps \) were highest from November to February for females and November to March for males, the latter coinciding with periods of highest SST (Figure 8). Individuals in the running ripe classification stage (i.e., as evidenced by the presence of oocytes undergoing late-stage germinal vesicle migration, germinal vesicle breakdown, hydration or ovulation; Brown-Peterson et al., 2011) were observed between November and April (Figure 8), although the latter month was represented by a single mature female.

### 3.5 | Regional variation in longevity and asymptotic length

There was a 5-fold geographic variation in maximum observed age among the six locations for which life-history information was available. Estimates of both maximum observed age and asymptotic \( L_F \) decreased with increasing SST (Figure 9). This relationship was significant for maximum age (\( R^2 = 0.89, P < 0.01 \)) but not for asymptotic length (\( R^2 = 0.55, P = 0.09 \)).

### 4 | DISCUSSION

The maximum age of \( H. \ longiceps \) reported in the current study (~19 years) extends the species’ reported life span by at least ~5 years. Previous longevity estimates for the species includes 14 years for an unknown location of the GBR (Sabetian, 2010; A. Sabetian, pers. comm.), 12 years from the northern GBR (based on 14 individuals from the Townsville and Lizard Island regions; Choat & Robertson, 2002; J. Choat, pers. comm.), 10 years from Guam (based on 279 individuals; Taylor & Cruz, 2017), 6 years from Pohnpei (based on 64 individuals; Taylor & Choat, 2014) and 5 years from Solomon Islands (based on 67 individuals; Sabetian, 2010). To our knowledge, this makes \( H. \ longiceps \) one of the longest lived parrotfish of the c. 100 currently recognized species to date (Fricke et al., 2020), behind Bolbometopon muricatum (~40 years; Andrews et al., 2015), Scarus trispinosus (~22 years; Freitas et al., 2019), Cetoscarus bicolor (~21 years; Taylor et al., 2018) and Scarus frenatus (~20 years; Choat et al., 1996).
The timing of opaque increment formation (i.e., ~winter) for *H. longiceps* in southern New Caledonia is consistent with that reported for the species in Guam by Taylor and Cruz (2017), yet often contrasts that observed of other scarid species. For example, from tetracycline marks, Choat et al. (1996) inferred that opaque increment formation occurs in spring–early summer for *Chlorurus sordidus* (now considered to be *C. spilurus* in the eastern Indian and western and central Pacific Oceans; Bray, 2020; Fricke et al., 2020), *Scarus frenatus*, *Scarus niger* and *Scarus rivulatus* on the neighbouring GBR, with the results for *S. rivulatus* supported by marginal increment analysis. Ebisawa et al. (2016) observed opaque increment formation to occur between June and August (i.e., summer) for *Chlorurus microrhinos* in southern Japan. These differences further highlight the need for species- and location-specific studies of parrotfish life history.

The large proportion of primary males (79% of all sampled males) observed in the present study contrasts with that reported for the
species in Guam, where primary males accounted for 16% of all males (Taylor & Cruz, 2017), but is similar to that observed for the species in Pohnpei, where primary males accounted for 61% of all males (Taylor & Choat, 2014). In diandric labrids, including parrotfish, the proportion of initial phase primary males has been demonstrated to have a strong social basis, with higher proportions of primary males associated with increased group size (Gust, 2004; Munday et al., 2006a). As such, the relatively high proportion of primary males observed in the current study potentially suggests that group sizes of *H. longiceps* in southern New Caledonia may be larger than those in populations sampled elsewhere. Such an effect may be exacerbated by the extended longevity and low mortality of *H. longiceps* in southern New Caledonia, coupled with the species’ mating strategy. For those species in which sex change is plastic and can respond to local conditions, sex allocation theory predicts that sex change should occur when an individual’s reproductive value would be greater for the opposite sex than for their current sex (Munday et al., 2006b). Like many diandric labrids, terminal phase male *H. longiceps* appear to patrol territories and adopt a harem mating system, engaging in courtship behaviour and spawning with individual or small groups of females (Colin, 2012; Colin & Bell, 1991). Accordingly, rather than competing for reproductive success with a large number of females for many years, it may be more advantageous for younger individuals in large, stable *H. longiceps* populations to become primary males to increase their individual reproductive value. Further studies into the spawning behaviour of *H. longiceps* in New Caledonia, and linkages

![Figure 8](image1)

**Figure 8** Monthly frequencies of mature *Hipposcarus longiceps* ovarian stages (left) and mean monthly gonadosomatic indices (GSI ± SE; right) for mature female and male *H. longiceps* from southern New Caledonia. The grey line depicts mean daily sea surface temperature (in °C) based on satellite-derived data between January 2000 and December 2015. Numbers represent sample sizes for females (normal text) and males (italics) in each month. Left: (□) developing; (■) spawning capable; (▲) spawning; (□) regressing; (□) regenerating; Right: (−○−) female; (−▲−) male

![Figure 9](image2)

**Figure 9** Linear regressions of sea surface temperature with maximum observed age (left) and asymptotic fork length (\(L_F\)) (right) across six populations of *Hipposcarus longiceps*. GBR, Great Barrier Reef; Gu, Guam; NC, New Caledonia; Pa, Palau; Po, Pohnpei; SI, Solomon Islands. Shaded areas represent 95% confidence intervals.
between group size, overall population size and the proportion of primary males within the population, are required to explore these hypotheses.

The strong negative correlation between maximum age and SST observed in the present study is consistent with the Metabolic Theory of Ecology (MTE), which predicts that much of the variation in life-history attributes can be accounted for by thermally-driven changes in metabolic performance (Brown et al., 2004; Munch & Salinas, 2009). Under the MTE, life span is predicted to increase with lower ambient SST due to reduced metabolism at lower temperatures (Clarke & Johnston, 2002). The results of the present study add to the growing body of literature documenting these associations in coral reef fishes, for example Acanthurus bahianus (Robertson et al., 2005), Centropyge bispinosa (Lowe et al., 2021), Ctenochaetus striatus (Trip et al., 2008), Naso unicornis (Taylor et al., 2019) and Scarus rubroviolaceus (Taylor & Cruz, 2017). For H. longiceps, failing to account for the relationship between life span and ambient SST in assessments could result in considerable over- or underestimates of mortality, exploitation and yield.

In parallel, growth rate, body size and maturation rate in ectotherms covary with temperature under the temperature–size rule (TSR; Atkinson, 1994). Under this rule, slower initial growth rates and increased asymptotic lengths are expected at lower temperatures. While regional patterns in H. longiceps asymptotic length displayed a negative correlation with SST, with larger asymptotic lengths observed at locations exposed to cooler water, the trend lacked statistical significance. This may be explained in part by the small sample sizes for some locations, as well as differences in reef geomorphology, productivity, resource availability and competition among sampling sites (Gust et al., 2002; Robertson et al., 2005; Munch & Salinas, 2009; Caselle et al., 2011; Barnett et al., 2017; Taylor et al., 2018; Lowe et al., 2021). For example, the northern GBR sampling location, where parrotfish are un-fished, showed the largest deviation from the expected asymptotic length, a likely artefact of the limited sampling at this location (n = 14; Choat & Robertson, 2002). Further sampling across geographically disparate locations encompassing gradients of latitude, reef geomorphology, SST and fishing pressure would help to disentangle the relative influence of various environmental and anthropogenic factors on H. longiceps longevity and life history (Taylor & Choat, 2014; Moore 2019).

The results of this study signal that at the time of sampling, H. longiceps in southern New Caledonia was unlikely to be subject to overfishing (i.e., fishing mortality was low). Nevertheless, the species’ extended life span, coupled with several behavioural aspects, indicate H. longiceps may be among the more susceptible of the parrotfish species that are harvested from this region. Accordingly, ongoing monitoring and regular evaluation of stock status is recommended. The life-history information supplied herein provides a foundation for improved assessments and the development of harvest strategies for this species in New Caledonia. Moreover, the extended longevity observed for H. longiceps in the current study relative to previous research further confirms the occurrence of large geographic variability of life-history traits and indicates that local management efforts for this species across the Indo-Pacific would greatly benefit from additional, geographically disparate, age-based research.

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