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Population trends and vital rates for the American Oystercatcher (*Haematopus palliatus pitanay*) in Central Chile

Tendencias poblacionales y tasas vitales de *Haematopus palliatus pitanay* en el centro de Chile

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ABSTRACT. The American Oystercatcher (*Haematopus palliatus pitanay*) was recently classified as Near Threatened in Chile because of concerns about low recruitment at some breeding sites. However, long-term monitoring in central Chile suggests stable populations. A potential explanation for the latter disagreement might have to do with the concept of extinction debt, the delayed population decline following habitat loss/disturbance. This delayed response complicates viability assessments, especially in species with long life spans such as the American Oystercatcher, where low recruitment may fail to offset adult mortality, thus masking impending declines. We tested this hypothesis using data from monitoring, eBird observations, and banding, with which we assessed population trends. We found annual fluctuations with predictable cycles and an overall positive trend. As expected for a long-lived species, adult survival was high ($\phi a = 0.87$), but reproductive success in estuary populations was low (fertility rate = 0.20). Our findings failed to find support for the extinction debt hypothesis, but suggest that some estuaries may act as population sinks in a regional source-sink system. However, more data are needed to confirm this mechanism. Understanding these dynamics is crucial for proactive conservation efforts to prevent delayed declines and ensure the persistence of this species.

RESUMEN. *Haematopus palliatus pitanay* fue recientemente categorizado como Casi Amenazado en Chile debido a la preocupación por el bajo reclutamiento en algunos sitios de reproducción. Sin embargo, el monitoreo a largo plazo en el centro de Chile sugiere que las poblaciones se mantienen estables. Una posible explicación para este desacuerdo podría estar relacionada con el concepto de deuda de extinción, es decir, el retraso en la disminución de la población tras la pérdida o alteración del hábitat. Esta respuesta retardada complica las evaluaciones de viabilidad, especialmente en especies de larga vida como el ostrero americano, en las que un bajo reclutamiento podría no compensar la mortalidad adulta, enmascarando así declives inminentes. Para probar esta hipótesis, utilizamos datos de monitoreo, observaciones de eBird y anillamiento, con los cuales evaluamos las tendencias poblacionales. Encontramos fluctuaciones anuales con ciclos predecibles y una tendencia general positiva. Como era de esperar en una especie longeva, la supervivencia adulta fue alta ($\phi a = 0.87$), pero el éxito reproductivo en poblaciones de estuarios fue bajo (tasa de fertilidad = 0.20). Nuestros resultados no respaldaron la hipótesis de deuda de extinción, pero sugieren que algunos estuarios podrían actuar como sumideros en un sistema regional fuente-sumidero. Sin embargo, se necesitan más datos para confirmar este mecanismo. Comprender estas dinámicas es crucial para desarrollar esfuerzos de conservación proactivos que prevengan declives retardados y aseguren la persistencia de esta especie.

Key Words: *beach nesting; Chile; mark-recapture; oystercatcher; shorebirds; survival*

INTRODUCTION

Coastal ecosystems are under significant pressure globally because of various anthropogenic activities, including urban development, tourism, and pollution, which lead to habitat loss and degradation (Millennium Ecosystem Assessment 2005, Dugan et al. 2008). These disturbances can profoundly impact species reliant on these habitats, such as coastal birds (McGowan and Simons 2006). Specifically, habitat loss and fragmentation are leading causes of biodiversity decline and species extinction (Krauss et al. 2010). However, population declines often exhibit a time lag following initial habitat disturbance, a phenomenon known as "extinction debt," where species continue to persist for some time despite being destined for local extinction (Tilman et al.1994, Kuussaari et al. 2009, Jackson and Sax 2010).

The American Oystercatcher (*Haematopus palliatus*) is a coastal species widely distributed throughout the Americas and serves as a bioindicator in sandy beach ecosystems because of its sedentary nature and vulnerability to ecological impacts during the reproductive season (Leseberg et al. 2000). This species is closely associated with community-level variables, such as bird species diversity (Cepeda 2015), and faces numerous threats across different life stages, including predation by dogs, disturbance from off-road vehicles, land-use change, and extreme high tides (Maslo et al. 2016, Martínez et al. 2018, Griffin et al. 2023). Given their longevity, adult survival is a critical vital rate influencing population size and stability (Sagar et al. 2002). A potential effect of a reduced recruitment may go undetected for extended periods because populations can persist with minimal reproductive success, highlighting the importance of monitoring adult survival to detect declines in a timely manner (Schulte 2012).

Understanding vital rates such as survival, fecundity, and movement is fundamental to assessing population growth and resilience (Frederiksen et al. 2014). These rates are shaped by extrinsic factors, including predation and habitat conditions, as well as intrinsic factors like population density (Aars and Ims 2002). Robust demographic data, typically obtained through

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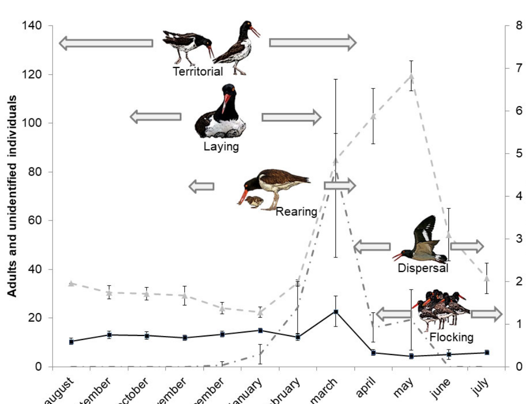
capture-mark-recapture methods, are essential for tracking population trends and evaluating environmental impacts (Pollock 1991, Nichols et al. 2000). For long-lived species, such as the American Oystercatcher, prioritizing adult survival is particularly important for maintaining population stability (Sæther and Bakke 2000). Thus, understanding how disturbances affect these vital rates is critical for effective conservation planning (Felton et al. 2017).

The American Oystercatcher has five recognized subspecies (Clay et al. 2014). On the coasts of the South Pacific, from Ecuador to southern Chile, the American Oystercatcher is represented by the *Haematopus palliatus pitanay* subspecies, characterized by being the smallest subspecies in general size except for bill length, and which lacks the inner white markings at the end of its primary feathers (Murphy 1925). In Chile, threats such as habitat degradation, disturbance by human activities, and predation have increasingly been documented as factors impacting reproduction (Aguirre 1997, Cepeda 2015). Although García-Walter et al. (2017) suggested apparent population stability, in 2019 the species was classified as Near Threatened because of concerns that its long lifespan may obscure declines driven by insufficient recruitment (MMA 2019).

Our observations of more than a decade show that *Haematopus palliatus pitanay* exhibit seasonal movement dynamics. During the breeding season (September–March), local pairs establish and defend territories, primarily in estuarine zones and sandy beaches, where they nest and rear chicks. After the breeding season, breeding pairs in estuaries tend to remain close to their territories (Fig. 1). At the same time, estuarine areas experience an influx of adult and juvenile birds, likely arriving from nearby coastal regions. These non-territorial individuals, together with resident pairs that have completed their breeding efforts, form aggregations in preparation for the autumn and winter months. This behavior highlights the importance of these habitats as both breeding grounds and seasonal refuges for the species.

Fig. 1. Monthly average (mean ± SE) number of American Oystercatchers (*Haematopus palliatus pitanay*) in the Itata River estuary from 2016 to 2022. Adult individuals are represented by a solid black line, individuals of undetermined age by a dark gray dashed line, and juveniles by a light gray dashed line. This graph illustrates the reproductive and social behavior of the species recorded in the central-southern region of Chile.



In this study, we examine whether the Chilean population of *Haematopus palliatus pitanay* is undergoing a delayed decline consistent with the concept of "extinction debt." To evaluate this hypothesis, we compare long-term census data from two monitoring sources with a population model informed by preliminary estimates of vital rates from estuarine populations in central Chile.

METHODS

Study area

The study area covered the central coast of Chile, between the administrative regions of Valparaíso (32° 54′ S) in the north and Bío-Bío to the south (37° 14′ S; Fig. 2). In general, the area has a temperate climate with dry summers and with rain concentrated in winter between April and August (Hajek and Di Castri 1975). Within this geographical range, several estuaries of different sizes exist with different degrees of anthropogenic impact (Soazo et al. 2009), where American Oystercatchers breed.

Population time series

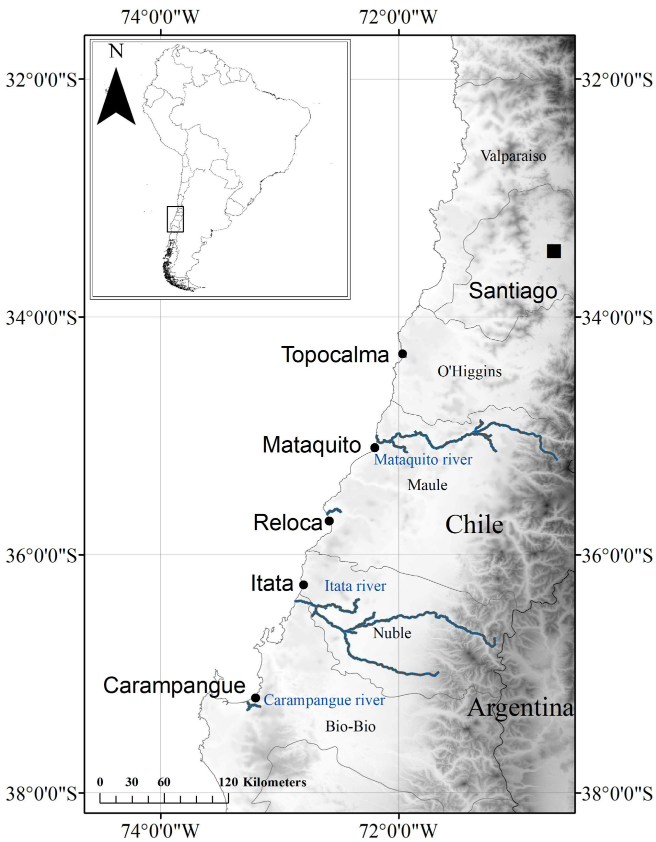
We used two sources of information on the abundance of the American Oystercatcher in Central Chile:

Estuary monitoring program: Since 2006 we conducted a long-term waterbird monitoring program (PROMNA) in four estuaries of Central Chile (Topocalma, Mataquito, Reloca, and Itata; Fig. 2). For Itata the sampling protocol included 10 visits per year and for the other sites, 8 visits were conducted (see Estades and Vukasovic 2013 for more details). We censused all birds present in each estuary using a 20-60X telescope. Whenever possible, individuals were identified and classified according to age, using bill and eye colors (juvenile or adult; Kaufman 1996, Jaramillo 2003, American Oystercatcher Working Group et al. 2020). Additionally, we recorded the existing reproductive pairs of oystercatchers through behavioral observations and analysis. At the Itata site, we also mapped the spatial locations of breeding territories using a GPS handheld device.

eBird data: We analyzed the population data for the species in central Chile stored in the eBird citizen science database (EBD: eBird Basic Dataset). Data were obtained through the "auk" package (Strimas-Mackey et al. 2018), filtering by species and administrative region of Chile (Valparaíso, O'Higgins, Maule, Ñuble, and Bío-Bío; Fig. 2). For each of the five regions, we identified and recorded the highest monthly abundance values reported within the region. These regional maxima were then summed across the five regions for each month to generate a monthly abundance index for the species. This index reflects an aggregate measure of abundance across the regions and provides a standardized way to track population trends over time. Using these data, we constructed a time series spanning the period 2010–2022.

Times series analysis: Time series were processed for basic analyses. First, for our census data (188 months), we addressed data gaps using a simple monthly linear interpolation method. Linear interpolation is well-suited for filling data gaps when sampling intervals are small and processes are relatively stationary, as is the case for our study (Gnauck 2004). We later used the pooled abundance for the four estuaries as an abundance index. For 144 months of eBird data no adjustments were made. To assess time series stationary an augmented Dickey-Fuller test

Fig. 2. Location of the study area. Reference to the estuaries visited.



was performed using the "tseries" package (Trapletti and Hornik 2022). Time series were decomposed to extract trend and seasonality. Finally, we used the "forecast" package (Hyndman et al. 2023) in order to estimate the population index for the following 24 months after data collection for each data set. Specifically, we applied the "auto arima" function to identify the best-fitting autoregressive integrated moving average (ARIMA) model based on the observed time series data, and used this model to generate forecasts.

Vital rates

Our study concentrated on two primary sites to estimate demographic parameters: the southern side of the mouth of the Itata river (2015–2021) and the western sector of the mouth of the Carampangue River (2019–2021; Fig. 2). During the American Oystercatcher breeding season, which in the study area spans from September through March each year, we monitored oystercatcher breeding for at least 21 days during seven independent visits.

Nest searches were conducted at two key locations, each with distinct characteristics. In Itata, surveys covered a sandbar approximately 1.2 km in length, featuring sparse vegetation and separating the ocean from an estuarine zone. In Carampangue, we surveyed a 1.5 km beach strip west of the river mouth, which had greater vegetation cover in the dune zone between the ocean and an estuarine lagoon. All nests were georeferenced to facilitate continued monitoring, and we recorded the total number of chicks hatched by each pair during their nesting attempts, as well as the number of chicks that successfully reached the fledgling stage. To better understand the breeding biology of the species, we estimated several key parameters, including clutch size, the number of nesting attempts, hatch rate (defined as the number of clutches from which at least one chick hatched), and fertility rate (defined as the number of fledglings, i.e., chicks over 35 days old, produced per pair; Simons and Stocking 2011, Schulte 2012).

During our visits we captured and marked some birds for survival analysis, 85% and 70% of breeding individuals for Itata and Carampangue, respectively. Adult (> 3 years) oystercatchers were captured using whoosh nets and walk-in traps, and chicks were captured manually. Standard body measurements of all captured individuals were recorded. Captured individuals were marked with metal bands provided by the Chilean wildlife authority SAG (Servicio Agrícola y Ganadero, Government of Chile) under capture permit #1056/2014. In addition, we identified individual birds by using unique combinations of up to two colored tarsal bands and a numbered flag on the tibia.

We minimized disturbance to chicks by handling them only once during the banding process. Evidence from other species suggests that banding alone does not negatively affect chick survival. For example, Roche et al. (2010) found no detrimental effects of banding on Piping Plover (*Charadrius melodus*) chick survival prior to fledging. Similarly, Sharpe et al. (2009) reported that color bands did not adversely impact chick survival of Lapwings (*Vanellus vanellus*), although frequent handling in radio-tagged broods did result in reduced body condition and higher mortality rates. Because our study involved only a single disturbance event during banding, we consider the potential impact on chick survival to be negligible.

Observations of banded oystercatchers were made monthly throughout the study period, both in Itata and at other estuaries. We built the encounter history of ringed individuals by compiling the presences and absences recorded during our monitoring. We used a single-state model based on Cormack-Jolly-Seber live recaptures in the MARK program (White and Burnham 1999) to estimate apparent survival (ϕ) and probability of encounter (p) using maximum-likelihood procedures (Lebreton et al. 1992). Using age at banding (g) and period of time between sampling events (t) as predictors of apparent survival probability (ϕ) and recapture probability (p), as well as their interaction and constant survival and recapture probabilities, we constructed and ran all models that reflected all possible combinations.

In addition, we performed a goodness-of-fit analysis of the data on the global model (ϕ(g*t) p (g*t)), using Mark's bootstrap GOF test to calculate the variance inflation factor ($\hat{c}$) to estimate and account for any overdispersion in our models. We used the Akaike information criterion corrected for small sample size (AICc) approach to identify the most parsimonious model.

Finally, we compared the results of a population model based on our estimated vital rates with the population numbers obtained from eBird and our own monitoring program. For this purpose, we used a simplified version of the three-stage population model developed by Felton et al. (2017). This model considers the following transition functions:

$Im_{t+1} = Ad_t * pcfr * \phi_j$

$Sad_{t+1} = Im_t * \phi_i + Sad_t * \phi_s * (1 - \psi_{sa})$

$Ad_{t+1} = Sad_t * \phi_s * \psi_{sa} + Ad_t * \phi_a$

where,

Im = Immatures

Sad = Subadults

Ad = Adults

pcfr = per capita Fecundity rate

ϕ_j = Juvenile Annual Survival rate

ϕ_i = Immature Annual Survival rate

ϕ_s = Subadult Annual Survival rate

ϕ_a = Adult Annual Survival rate

ψ_{sa} = Annual probability of transition between subadult and adult

t = time (year)

Given the absence of specific vital rate estimates for *Haematopus palliatus pitanay*, for the parameters not studied by us ($\phi_j \phi_j$, ψ_{sa}) we relied on estimates from the closely related subspecies *Haematopus palliatus palliatus*. These values were obtained from the work of Felton et al. (2017), which provides key demographic parameters for the American Oystercatcher (Table 1). In order to generate an estimation of the discrete population growth rate ($\lambda = N_{t+1}/_{Nt}$) we ran the model for 100 iterations and recorded the value at which λ stabilized.

Table 1. Vital rates estimates for American Oystercatcher (*Haematopus palliatus pitanay*) in central Chile used for a population model. Estimates from Felton et al. (2017) and this study.

Parameter	Source	
	Felton et al. (2017)	This study
pcfr (per capita Fecundity rate)	0.19	0.195*
ϕ_j (Juvenile Annual Survival rate)	0.50*	-
ϕ_i (Immature Annual Survival rate)	0.80*	-
ϕ_s (Subadult Annual Survival rate)	0.92	0.87*
ϕ_a (Adult Annual Survival rate)	0.92	0.87*
ψ_{sa} (Transition between subadult and adult)	0.15*	-

* parameter values used in the calculations.

RESULTS

The population time series obtained from our data at four estuaries show a clear seasonal effect (Fig. 3A), with maximums occurring during the fall (April–May) and minimums usually happening during the late spring (November–December). The eBird data for the same general region (Fig. 3B) show a less clear pattern. When controlling for the seasonal effect, both times series show a positive long-term trend, with slopes of m = 1.1135 for PROMNA and m = 1.0489 for eBird data (Figs. 3C and 3D). The estimated forecast for future population sizes of each of the regional data sets shows, in general, great stability for the citizen science data (Fig. 4). On the other hand, the data obtained through long-term monitoring predict a population size that fluctuates in the same way as the values observed historically.

The survival analysis carried out on a total of 56 individuals, 21 adults and 35 chicks, banded over five years, showed that the most parsimonious model (ΔQAICc= 0) was ϕ(g) p(g) (Table 2), where both parameters are determined by the group, that is, if they were banded as chicks or as adults. The apparent annual survival of adults was $\phi_a = 0.87$ (95% C.I.: 0.72, 0.94) and the probability of re-sighting was $p_a = 0.68$. In the case of individuals banded as chicks their apparent annual survival was $\phi_c = 0.53$ (95% C.I.: 0.36, 0.67), with a probability of re-encounter of $p_c = 0.12$.

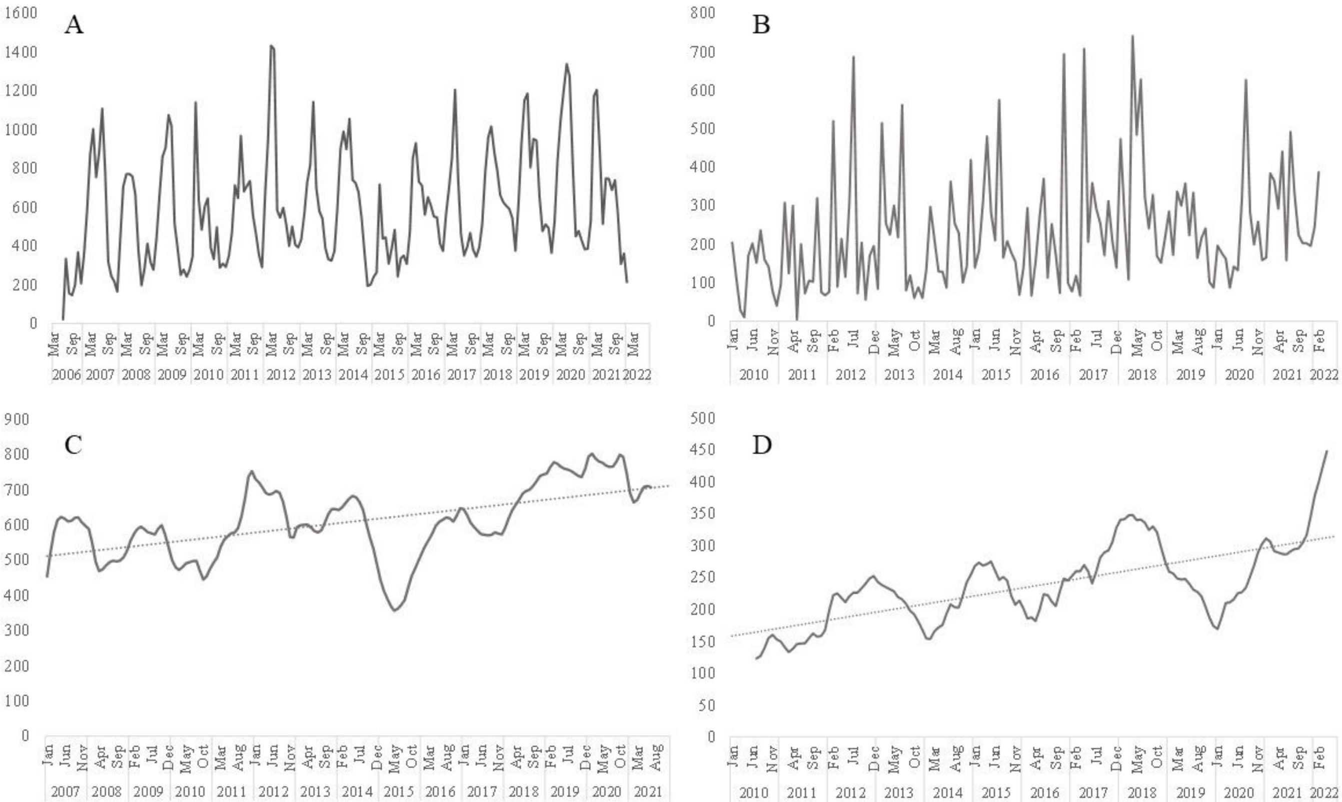
Between 2016 and 2021 we followed the breeding success of 33 pairs (11 pairs in Carampangue and 22 pairs in Itata), which managed to produce 13 fledglings, which is equivalent to a fledgling success of 0.39, or a per capita fecundity rate (pcfr) of 0.195. Using the parameters shown in Table 1, we estimated that the oystercatcher population in central Chile is declining with a discrete growth rate (λ) of 0.93.

DISCUSSION

We found a major disparity between the times series analyses of the two populations and modeled growth rates for the species in Central Chile. Although both long-term data sets show a stable / growing population, the demographic model indicates an important decline rate (λ < 1). The "extinction debt" (Tilman et al. 1994) hypothesis suggests that, because the American Oystercatcher is a long-lived species with a high survival rate, a decline due to a reduced recruitment rate would be difficult to detect over a short period of time (Jiménez-Franco et al. 2022). However, we used 15 years of data, and during that time, a population decline of $1-\lambda^{15} = 1-0.93^{15} = 66\%$ should have been evident.

We can think of two potential general explanations for this discrepancy: random errors derived from the quality of the data we used, and/or a geographical bias in the sampling schemes. In the first case, we believe that the quality of the data was adequate for our intended purposes. The fact that two large datasets with very different origins revealed similar long-term trends strongly suggests that the observed patterns are genuine. Although eBird data present challenges due to potential biases—such as species overrepresentation, spatial biases, and variation in participant skill levels, among others (Adde et al. 2021, Scher and Clark 2023)—we are confident in the quality of our own monitoring program, in terms of inter-year data comparability (same observer, MAV, and censusing scheme over 16 years), and data "density" (+ 90 censuses per year, see Estades and Vukasovic 2013 for details). On the other hand, we are aware of the small samples we used to estimate vital rates for the species in Central Chile. However, the fact that the estimated parameters in our study are very similar to those reported for breeding populations in North Carolina, USA (Simons and Schulte 2010, Felton et al. 2017), strongly suggests that our calculations are robust and consistent with previous research. Both studies share similar methodologies, providing a basis for comparison. For instance, breeding populations at multiple sites were monitored in both cases. Nests were checked regularly until hatching or failure. And while the scale of the studies differed, key aspects of data collection were

Fig. 3. (A) Number of American Oystercatcher (*Haematopus palliatus pitanay*) individuals observed in the Topocalma, Mataquito, Reloca, and Itata estuaries through long-term monitoring. (B) Aggregated maximum monthly values reported for American Oystercatcher in eBird for the Valparaíso, O'Higgins, Maule, Ñuble, and Bio-Bio regions. (C) and (D) Trend curves of the time series for the data presented in "A" and "B" respectively, includes a rectilinear trend line for each case.



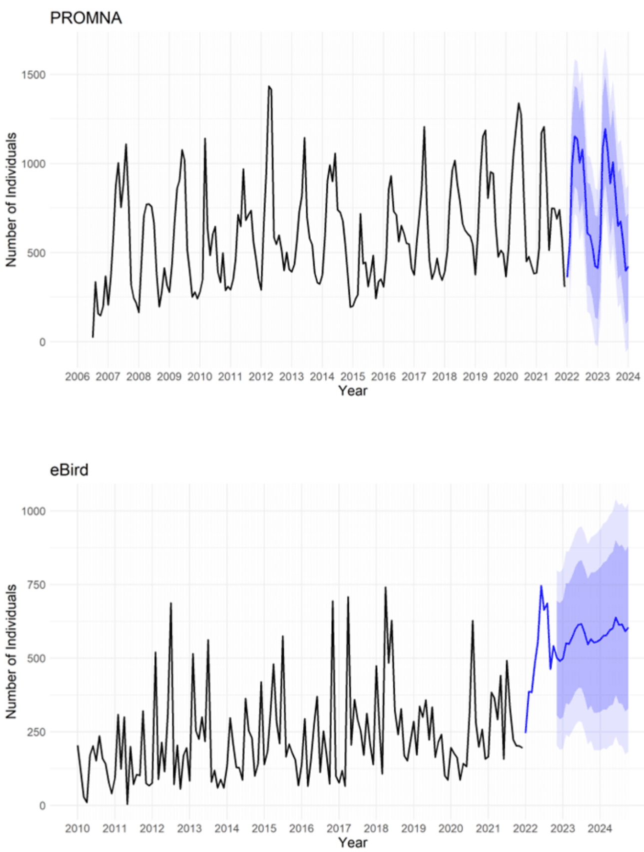
comparable. Importantly, both studies faced gaps in published estimates for certain vital rates. For example, Felton et al. (2017) incorporated survival probabilities from Eurasian Oystercatchers (Ens and Underhill 2014) to supplement their model, a strategy we also adopted to complete our analyses. This alignment in methodologies, data collection protocols, and even the necessity of incorporating external estimates for some vital rates underscores the validity of our approach and situates our findings within the broader context of American Oystercatcher research.

A more likely explanation for the observed pattern may have to do with the location of the sampling sites from which people are gathering data on the species. In our case, the two populations (Itata and Carampangue) are in areas with a relatively high level of human recreational activity. A similar situation happens in most other sites in Chile where oystercatcher recruitment has been studied (Figueroa et al. 2018, Aguilera et al. 2019). Two factors might contribute to the latter. First, monitoring nest success requires frequent visits to a site (Mayfield 1975), a task that benefits from good accessibility, which, in turn, attracts more people to the area. Second, apparently, for many individuals and local organizations the motivation to start monitoring the nest success of a population occurs after the realization that there might be a problem that needs to be assessed. Therefore, we hypothesize that most information on the breeding performance of American Oystercatchers in Chile comes from sites that are already disturbed by human activities, thus providing a biased estimate of most vital rates.

If this latter assumption is correct, that would mean that the average growth rate for American Oystercatchers in Central Chile may be enough to support a stable metapopulation, but it is being underestimated because most observations on the species are likely conducted in population sinks. In population source-sink dynamics (Pulliam 1988), in source areas recruitment and immigration exceeds mortality rate, while in sink areas deaths outnumber births, with the population necessarily sustained by immigration (Paquet et al. 2020). Thus, for the populations in this study, a constant immigration from source populations would be required (Watkinson and Sutherland 1995).

Our long-term data set shows an important and consistent population increase at the end of the breeding season (Fig. 3A). However, this increase cannot be interpreted as the sole result of recruitment, as this would require the population to increase by more than 200% each breeding season, nor can the steep decline observed during each winter (Fig. 3A) be attributed only to mortality. More likely these changes are due the movement of a significant number of individuals from and to neighboring coastal areas. Observations of some of our banded birds show movements of more than 100 km.

Fig. 4. Estimated population size forecasts (±95% CI and ±99% CI) for American Oystercatcher (*Haematopus palliates pitanay*) for 24 months from the time series for each data set, both the long-term monitoring data (PROMNA) and the regional monthly maximum values for eBird data (Valparaíso, O'Higgins, Maule, Ñuble, and Bío-Bío), using the "forecast" package (Hyndman et al. 2023).



Although most of the causes of the low vital rates observed among American Oystercatchers in Chile are related to anthropogenic disturbances, such as the transit of off-road vehicles and the impact of domestic dogs, there is an increasingly important threat factor that is not directly associated to local human disturbance. Storms that produce unusually high waves affect the species throughout its entire distribution (Griffin et al. 2023), and are becoming more frequent in Central Chile as a result of global warming (Martínez et al. 2018). If that trend continues, the regional abundance of the American Oystercatcher population may start to decline. In addition to seasonal fluctuations in population size, Figure 3C shows a significant drop in population trend in 2015, coinciding with the 2015–2016 ENSO events, considered the most powerful of the last decade (Huang et al. 2016). Sea temperature oscillation cycles have a strong impact on marine food chains and negatively affect seabirds (Schoen et al. 2024). The aforementioned drop in the population trend of the American Oystercatcher could be explained by the deterioration of habitat conditions, such as the recruitment of benthic species (Navarrete et al. 2002), on a regional scale as a consequence of

Table 2. Best models to estimate the apparent survival (ϕ) of the American Oystercatcher (*Haematopus palliatus pitanay*) according to ΔQAICc. In the model, "g" corresponds to a group of individuals (banded as adults or chicks), "." constant between groups and time, and "t" varies between each occasion. Where k is the number of parameters in the model, QAICc is the value of the Quasi-likelihood Akaike Information Criterion. The survival analysis was based on 56 captured individuals (21 adults and 35 chicks) marked and followed between 2015 and 2021.

Model	k	QAICc	ΔQAICc	QAIC Weight
ϕ(g) p(g)	4	798.299	0.000	0.990
ϕ(.) p(g)	3	807.700	9.400	0.009
ϕ(g) p(g*t)	102	863.151	64.852	0.000

ENSO events, forcing individuals to disperse along the coast. Given that the American Oystercatcher, and other resident shorebirds, are less vulnerable to variations in oceanographic conditions than seabirds whose prey depend on them (Seher et al. 2022), temporary relocation would be the way to mitigate the decline in quality of local habitat and, in turn, explains the prompt recovery of population size.

The conservation of the American Oystercatcher on the coasts of Chile requires an integrated management of the coastal and estuary habitats. Citizens' limited knowledge of ecological processes and current regulations that protect biodiversity in Chile are critical factors facing conservation challenges for this species (Núñez 2019). Given the high impact that vehicles on beaches have on nesting oystercatchers, it is imperative that greater control measures be implemented by authorities to control the access of vehicles and improve the information delivery to the community to achieve cooperation in the preservation of these highly important but vulnerable areas.

Our survival estimates represent apparent survival, which inherently includes the effects of permanent emigration, as individuals that leave the study area and do not return are indistinguishable from mortality in capture-recapture models (Ponchon et al. 2018). This limitation is particularly relevant for pre-reproductive individuals, as movement dynamics of juveniles, immatures, and subadults often involve temporary dispersal to other areas, with delayed returns to breeding sites observed in many long-lived species. Such dynamics likely contribute to the lower apparent survival ($\phi_c = 0.53$) and re-sighting probabilities ($p_c = 0.12$) for individuals banded as chicks compared to adults. To address potential biases, we implemented a multi-site design, conducting searches for marked individuals across eight sites, which improves the accuracy and precision of survival estimates (Ponchon et al. 2018). However, even with this approach, the inherent mobility of pre-reproductive individuals remains a challenge, potentially affecting their apparent survival estimates. Importantly, the survival estimate for immatures was not directly used in our population model, as we relied on published estimates for this parameter from Felton et al. (2017). We expect to significantly improve our estimates of the adult annual survival rate in the near future because of an increased banding effort and a recently implemented web-based band reporting system. Additionally, we are currently expanding our study sites to include areas with little human presence, which will provide a more comprehensive understanding of survival and movement dynamics across different environmental conditions. These efforts underscore our commitment to refining demographic estimates and addressing the limitations inherent in this study.

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Data Availability:

Our data is openly available: https://uchile-my.sharepoint.com/:f:/g/personal/rthomson_uchile_cl/EmLVz-WDYkJDiFHU0E9MET-MBysGRwvqpGFzwFlJU9R9Anw?e=gMdK5I.

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