I.1: Plenary

I.1.1: Plenary Robert Clark

Using Population Models to Test Ecological Hypotheses and Guide Conservation Decisions

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The North American waterfowl community has a rich history of accomplishment in areas as diverse as behavior, evolution, harvest management and population ecology. This is due in part to the remarkable diversity of waterfowl and an enduring commitment to managing populations for long-term sustainability and for access by people - both hunters and viewers. Understanding why some duck populations have declined or remain below conservation goals while others have increased dramatically is also an area of considerable recent concern to waterfowl ecologists and managers alike. Furthermore, determining how future climate and land use changes will affect duck populations is challenging but would inform long-term perspectives for habitat conservation initiatives at several spatial scales. The impressive breadth and scope of waterfowl monitoring programs – spanning long time series of species-specific abundance data and demographic and movement information – combined with models such as integrated population models creates unprecedented opportunities to test hypotheses about population responses to ecological drivers and management alternatives (harvest, habitat). Here, I review several recent controversies and long-standing uncertainties about the impacts of varying environmental conditions and management alternatives on duck populations, setting the stage for subsequent detailed case-studies focused on scaup, black duck and pintail, as well as white-fronted and brant geese.

I.1.2: Plenary Michael Schaub

Inference About Population Processes by Combining Counts and Demographic Data Using Integrated Population Models

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Integrated population models are powerful models that can be used to jointly analyse population counts and data that are specific on one or more demographic rates. Joint analysis of all available data sets has the advantage that demographic parameters for which no explicit data are available can often be estimated and that the precision of parameter estimates is improved. Both advantages are a direct consequence of the more complete extraction of the information in the data. A key part of an integrated population model is a state-transition model which links age- or stage-specific population sizes with demographic rates. I demonstrate how integrated population models work, show recent applications and highlight perspectives and challenges of their application for the waterfowl community.

J.1: Integrated Population Models to Inform Waterfowl Ecology and Conservation (Organizers: Todd Arnold, David Koons)

J.1.1: Weegman

Integrated Population Modelling Reveals a Perceived Source to be a Cryptic Sink

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Demographic links among fragmented populations are commonly studied as source-sink dynamics, whereby source populations exhibit net recruitment and net emigration, while sinks suffer net mortality but enjoy net immigration. It is commonly assumed that large, persistent aggregations of individuals must be sources, but this ignores the possibility that they are sinks instead, buoyed demographically by immigration. We tested this assumption using Bayesian integrated population modelling of Greenland white-fronted geese (*Anser albifrons flavirostris*) at their largest wintering site (Wexford, Ireland), combining capture-mark-recapture, census and recruitment data collected from 1982 to 2010. Management for this species occurs largely on wintering areas; thus, study of source-sink dynamics of discrete regular wintering units provides unprecedented insights into population regulation and enables identification of likely processes influencing population dynamics at Wexford and among 70 other Greenland white-fronted goose wintering subpopulations. Using results from integrated population modelling, we parameterized an age-structured population projection matrix to determine the contribution of movement rates (emigration and immigration), recruitment and mortality to the dynamics of the Wexford subpopulation. Survival estimates for juvenile and adult birds at Wexford, and adult birds elsewhere fluctuated over the 29-year study period, but were not identifiably different. However, per capita recruitment rates at Wexford in later years (post-1995) were identifiably lower than in earlier years (pre-1995). The observed persistence of the Wexford subpopulation was only possible with high rates of immigration, which exceeded emigration in each year. Thus, despite its apparent stability, Wexford has functioned as a sink over the entire study period. These results demonstrate that even large populations can potentially be sinks, and that movement dynamics (e.g., immigration) among winters can dramatically obscure key processes driving population size. Further, novel population models which integrate capture-mark-recapture, census and recruitment data are essential to correctly ascribing source-sink status and accurately informing development of site-safeguard networks.

J.1.2: Koons

Drivers of Lesser Scaup Population Dynamics at a Continental Scale

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Although once one of the most abundant ducks in North America, the lesser scaup (*Aythya affinis*) population declined precipitously during the 1980's. The population breeding in the traditional survey area has stabilized in recent years, but abundance is still ~13% below the long-term average. However, the timing of breeding population (BPOP) surveys (designed to match spring migration phenology of mallards) may not capture peak scaup abundance on breeding areas. Further, there are no direct sources of data to inform reproductive success over long periods of time. As a result, there exists persistent debate about the demographic parameters responsible for suppressed lesser scaup abundance. The integrated population modeling (IPM) framework, which allows one to jointly utilize the information contained in multiple datasets, could nevertheless be ideal for finally gaining insight into the drivers of population dynamics for waterfowl species of management concern like lesser scaup. Using such a framework to integrate BPOP survey data, banding data, and information from the parts collection survey, we estimated temporal variation in survival, reproductive success, population structure, total abundance, and population growth rates between 1957 and 2012 while reconciling bias that might be contained in any one dataset. We then used results from the IPM within recently developed 'transient' life table response experiments to identify the demographic parameters that contributed most to long-term changes in lesser scaup population dynamics. To parameterize biologically-meaningful IPMs, we developed a list of factors that could be affecting the lesser scaup population, and for which indices can readily be measured at large spatial scales and over long periods of time. We included these indices in the IPM framework to determine the relative contributions of these to lesser scaup population dynamics. This robust approach will help guide future research and management actions aimed at restoring the continental lesser scaup population. Furthermore, the IPM framework will serve as a template for researchers to work with managers and develop holistic management plans (incorporating a variety of data sources) for the conservation of migratory birds at large spatial scales.

J.1.3: Osnas

An Integrated Population Model for Northern Pintail to Guide Harvest and Habitat Management

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We developed an integrated population model of northern pintail to help guide harvest and habitat management. The model is an age- and sex-structured state-space projection of breeding population size from 1960 to 2014 that jointly estimates survival and productivity while accounting for the observation processes of decreased detectability during drought years (pintail “overflight”) and increased juvenile vulnerability to hunting. We used bandings from pre- and post-hunting season to partition survival into seasonal components and wrote demographic parameters as functions of habitat and population size. We found strong evidence for density- and habitat-dependence on productivity, including a winter habitat effect on productivity (“cross-seasonal effect”) but very little evidence for density or habitat effects on post-hunting survival, although habitat covariates were limited to historical rainfall data. In fact, process variance in productivity accounted for ~30% of process variation in annual population growth rate while survival accounted for relatively little process variation and was relatively constant across this time period even though estimated harvest rates changed nearly 2-fold. Only for juvenile cohorts was there a trend in survival. In this cohort, survival decreased when harvest rate was > ~10% during the 1960s through 1970s. In adult cohorts, harvest rates were never >10% and survival was relatively invariant. These results could be explained by: some form of compensation between harvest and non-harvest mortality when harvest rates are low; an improvement over time in an unmeasured habitat covariate that increased juvenile survival; and/or insufficient variation in harvest rates or habitat conditions to reliably detect an effect on adult survival. Because there was limited evidence for density-dependence in survival and harvest rates were low, individual heterogeneity may be a possible mechanism of compensation. In terms of harvest and habitat management, these results suggest that the waterfowl community should not expect large changes in continent-wide survival with changes in habitats or harvest rates of historical magnitude, except perhaps in juvenile cohorts, but wide-scale changes in breeding habitats could be expected to fundamentally alter population trajectories.

J.1.4: Arnold

An Integrated Population Model for American Black Ducks

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American black ducks (*Anas rubripes*) breed in forested regions of eastern Canada and the northeastern United States, where breeding population surveys are difficult to conduct due to dense forest cover and remote terrain. In this presentation, I develop an integrated population model (IPM) for black ducks during 1969-1998 that uses only harvest surveys and banding data. Use of harvest survey data allowed me to obtain Lincoln estimates of population size for adults and juveniles during late summer (i.e. fall flight) and for all ages combined during late winter (i.e. BPOP). Using banding data from before and after the hunting season (i.e. pre- and postseason) allowed me to partition annual survival into hunting season (~Sep-Feb) and breeding season (~Apr-Aug) components. Hunting season survival was strongly affected by harvest rate, especially for juveniles, but there was evidence of compensation between seasons (i.e., if hunting season survival was low, subsequent breeding season survival was high; r = -0.72). However, there was no evidence that population regulation resulted from density dependence, because vital rates were uncorrelated with estimates of population size. The ratio of juvenile to adult population size each fall provided a reliable estimate of annual fecundity, which was strongly correlated with vulnerability-adjusted age ratios based on the Parts Collection Survey (R^2 = 0.88), and fecundity explained the greatest amount of variation in annual population growth. I suggest that compensation of harvest in black ducks is best explained by individual heterogeneity in both natural and hunting mortality, and that black duck populations were more stable during this period than Mid-winter Survey data led us to believe.

J.1.5: Riecke^

Integrated Population Models: Derived Parameters and Sampling Variance

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Integrated population models have become increasingly popular management tools, where investigators seek to combine demographic and census data to better understand processes driving population dynamics. These models are particularly useful for identifying and exploring knowledge gaps within datasets, where biologically meaningful parameters, such as immigration, emigration, reproduction, and the relative contribution of unmonitored populations to lambda, can be derived from other sources of data. However, when uncontrolled sampling variance exists in the data, biologically meaningful, derived process parameters serve as additional error terms, where parameter estimates may be severely biased. We use Pacific black brant (*Branta bernicla nigricans*) and simulated waterfowl datasets to demonstrate covariance among derived process parameters such as immigration, reproduction, and the relative contribution of unmonitored populations, and sampling variance. Preliminary results indicate biological inference can be dramatically altered by model parameterization, where derived parameters can lead to potentially spurious conclusions in the face of uncontrolled sampling variance.

*Speaker; ^Student

J.1.6: Arnold

Integrated Population Models to Inform Waterfowl Ecology and Conservation: Pitfalls and Promises

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Integrated population models (IPM) allow researchers to combine separate and independent datasets, such as breeding pair surveys, productivity estimates, band-recovery data, and harvest estimates, thereby facilitating development of long-term, cross-seasonal, and/or spatial comparisons of demographic performance and population dynamics. By sharing information among datasets, IPMs can improve the precision of vital rate estimates and diminish biases due to measurement error, and they can be used to estimate otherwise unmeasurable or unmeasured parameters, such as immigration and among-population movement rates. By leveraging information across datasets that inform the common process of population dynamics, IPMs are capable of providing improved insights for habitat and harvest management. However, IPMs can also highlight irreconcilable differences among existing data sets. Given the rich and long-term data sets available to waterfowl researchers, we believe that IPMs have a bright future for waterfowl ecology and management.