Appendix 1: Hypotheses of factors influencing the distribution and abundance of wintering and migrating Western Sandpipers (*Calidris mauri*; WESA) and Dunlin (*Calidris alpina pacifica*; DUNL) and implication for large-scale study design. H = hypothesis; P = prediction; SD = study design; D = data; A = analysis

Climate Change	**Survey Design / Data / Analysis**	**Management / Conservation**
H1: Increasing temperatures will provide more available winter food resources in northern coastal estuaries and non-coastal agricultural habitats. **P1**: Long-term Response: As climate warms shorebirds will over-winter further north and use more interior agricultural habitats. **P2**: Short-term Response: Use by DUNL and WESA in years following warm winter will increase at northern estuaries.	**SD**: Need latitudinal gradient of wintering estuary surveys including sites both north and south of current wintering range (e.g. Alaska, Chile, Brazil) **SD**: Need both coastal and interior monitoring site **D**: Quantify "warm" winter in prior year - Average daily high (Nov – Feb) - Average daily low (Nov – Feb) **D:** Winter survey in AK and BC **A**: Fit model with interaction between latitudinal strata and year **A:** Perhaps lag-effect from previous winter.	Predict hotspots of wintering shorebirds in a future landscape to inform how to optimize conservation action and management.
H2: Sea-level rise and changing water regimes will reduce available habitat and lead to a re-distribution **P1**: Estuaries with low tidal gradient combined with steep surrounding terrestrial topography will be impacted	**SD**: Need sample of sites along the tidal gradient and surrounding topography. **A:** Employ bird use and habitat data from surveys and sea-level rise projections to predict the impact of SLR on shorebird populations.	Provide vulnerability assessment of coastal estuaries along the Pacific Coast to the impact of sea-level rise in the context of tidal flat dependent species.

greater than higher tidal gradient and lower surrounding terrestrial topography.	**D:** Need SLR projections for set of sites as well as specific habitats that are needed by shorebirds.	
Predators	**Design and Data**	**Management / Conservation**
H1: Increases in the abundance of birds of prey has resulted in changes in migratory behaviour or shorebirds and possibly changes in use of wintering grounds. **P1:** We predict higher use of large, open sites (i.e. safer) versus small and dangerous sites (Taylor et al. 2007). **P2:** We predict higher use of sites with lower probability of predator occurrence. **P3:** We predict sites with increasing predator abundance will have lower shorebird growth rates than sites with stable or decreasing predator abundance.	**SD:** Need sample of "safe" and "dangerous" sites - Average distance to shore for estuary as index of site safety. **D**: Count predators: evaluate and control for predator pressure variation among sites **D:** Record start and end times of surveys and the number of avian predators seen. **A:** Control for different amounts of foraging habitat within each estuary site **D:** Calculate safety index for all estuary sites in Western sandpiper and Dunlin wintering range	Identify the distribution of safe to unsafe estuary sites for wintering sandpipers. "Dangerous" sites within closer proximity to safe sites may be better able to sustain shorebirds amid annual variation and long-term trends in predator abundance. Management could be used to maximize safety within a site.
H2: Shorebirds have become more numerous in non-coastal areas which have fewer predators.	**SD:** Need sample of sites that represent coastal and non-coastal gradient	Identify important sites for wintering shorebirds that are non-coastal.

P1: Shorebird depart relatively dangerous coastal sites for safer non-costal sites. Trend of increasing abundance of shorebirds in non-coastal regions compared to coastal areas. **P2:** Higher probability of raptors in coastal areas compared to non-coastal.	**D:** Count predators: evaluate and control for predator pressure variation among sites **A:** Density control for different amounts of foraging habitat within each estuary site	Provide recommendations to land managers about the spatial and temporal variation in shorebird use of their regions.
Contamination	**Survey Design and Data**	**Management / Conservation**
H1: Shorebirds accumulate industrial and urban pollution at wintering sites that are subsequently released in sudden high doses as fat is burned during migratory flights that then disrupt their ability survive and reproduce. P1: High contamination sites have less use than low contamination sites.	**SD:** Need sample of sites representing gradient of contamination. **SD:** Need method to assess contamination level at site. **A:** Are tidal flats closer to distance to river inputs associated with higher contamination and subsequently less use by shorebirds?	Demonstrate the distribution of contaminants and its effect on the distribution of shorebirds both within and among estuary sites. Identify hotspots of contamination in the flyway and provide recommendations for limiting contamination sources.
Human Disturbance	**Survey Design and Data**	**Management / Conservation**
H1: Human disturbance at wintering sites reduces the time available for shorebirds to accumulate fat for migration and subsequently could impact survival and productivity.	**SD**: Need sample of sites with varying levels of human disturbance during winter.	Human management recommendations if disturbance shown to lead to decreases in site use.

P1: Density of wintering shorebirds will be greater at sites with lower disturbance. **P2**: Population growth rates of wintering shorebirds will be lower at sites with high human disturbance than at sites with low disturbance	**D**: Quantify "human disturbance" or surrogate for all wintering sites. - **GIS**: housing density - **GIS**: population within distance buffer of estuary site - **Observation**: number people in sampling unit during annual survey - **Observation**: number of disturbance flights and duration **D:** Count predators to evaluate and control for predator pressure variation among sites **A:** Relative measure of use: Density control for different amounts of foraging habitat within each estuary site -	
Habitat Loss	**Survey Design and Data**	**Management / Conservation**
H1: Declining availability of shorebird habitat results in changes in the distribution of shorebirds. **P1:** Sites with reductions in the amount or quality of shorebird habitat will have relatively greater declines in shorebirds than those with stable or increasing amounts of habitat. **P2:** Sites with reductions in the amount or quality of shorebird habitat will have decreasing	**SD:** Need to define what we consider to be habitat across the entire range. - Tidal flat - Salt Pond - Flooded agriculture **SD:** Need method to characterize habitat and at the appropriate scale **SD:** need sample of sites with varying extent of degradation now and possible in the future.	Identify hotspots of habitat degradation and subsequently shorebird declines across the wintering range and provide recommendations to local land conservation and management agencies.

turnover times during migration.	**D:** Quantify “habitat” - **GIS:** Tidal flat, Salt Pond, Agriculture - **Observation**: soil sample – biomass, grain size **D:** Quantify “degradation” - **GIS**: change in acres of tidal flat - **Observation**: change in food availability (requires multiple surveys of food over course of project) - **A**: Compare time series of bird counts to index of habitat quantity and quality over time	