

# Applied conservation biology: Analyzing and partitioning intraspecific diversity

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**Q: What is a population (ESU, MU, distinct population segment) and how do you identify one?**

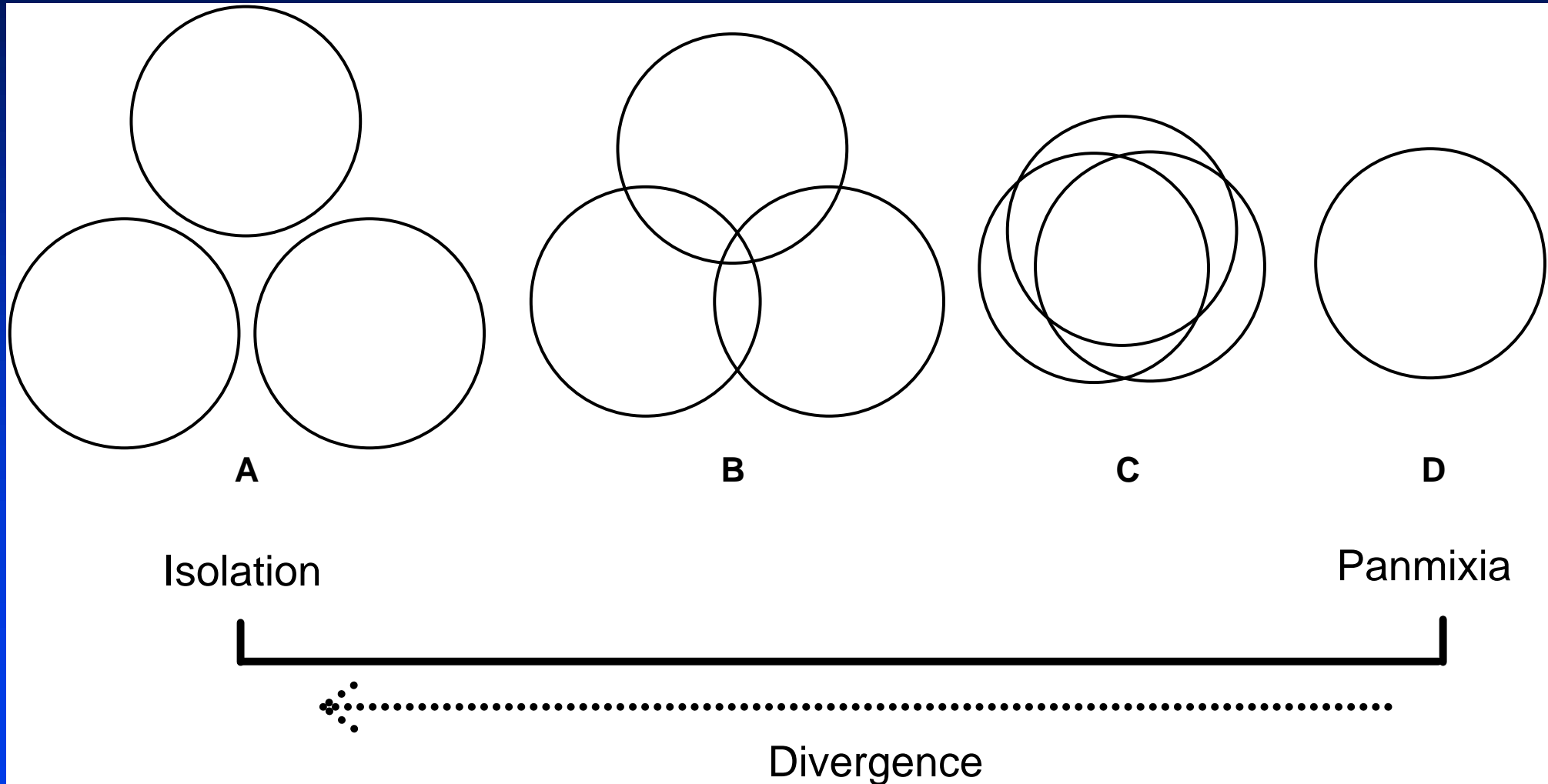
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**A: It depends**

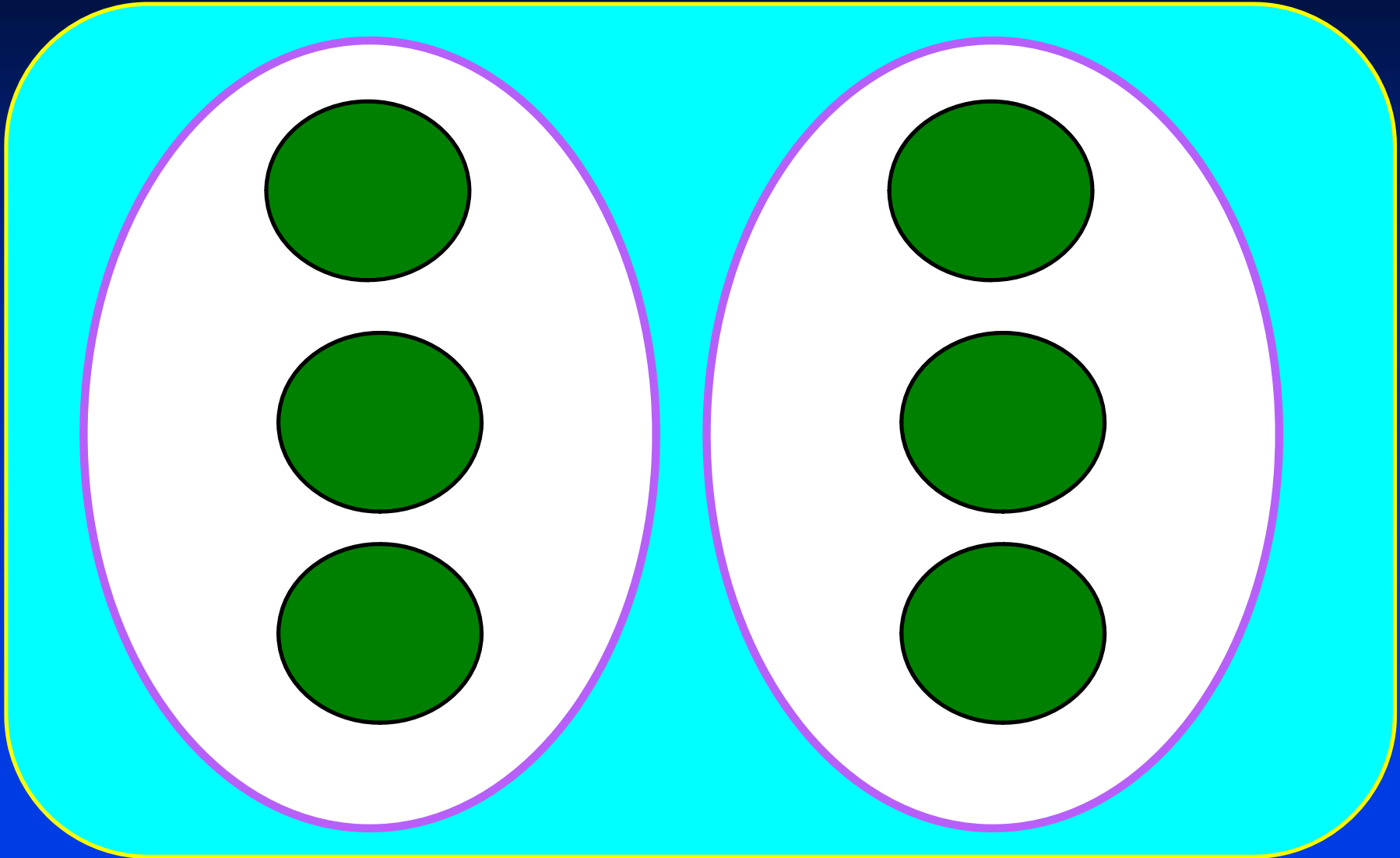
**What will you do with the information?**

**What are the objectives?**

# Reality: Divergence occurs along a continuum



How many units?



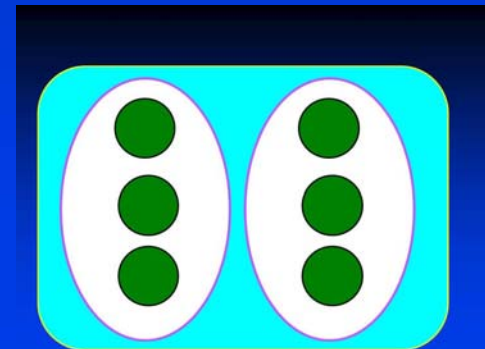
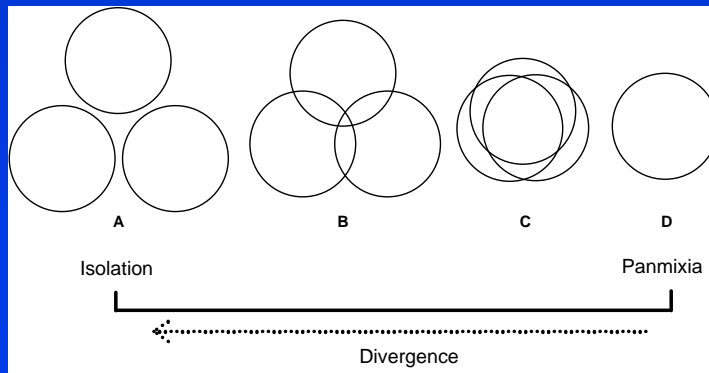
# Take home message #1:

There is no single 'correct' answer to the question, What is a stock (ESU, MU ...)?

Two steps are involved:

Describe biological relationships

Decide on a threshold of divergence



# NMFS ESU concept for salmon (1991)

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## 1. Substantial reproductive isolation

- Tagging data
- Neutral genetic markers

## 2. Importance to evolutionary legacy

- Ecological differences in habitat
- Life history/morphological differences  
(proxies for local adaptations)

# Joint FWS/NMFS DPS policy (1996)

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## 1. Discreteness

- Markedly separated (genetics, morphology ...)
- International boundaries

## 2. Significance

- Unusual ecological setting
- Loss would create significant gap in range
- Differs markedly in genetic characters

# **COSEWIC and Designatable Units under SARA**

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**Revised DU guidelines closely parallel  
DPS policy in US**

**Pacific species currently under review:**

**Darkblotched, quillback, yelloweye rockfish**

**White hake**

**Deepwater redfish**

**Basking shark**



# Some ESU references

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Fraser and Bernatchez 2001 *Mol. Ecol*  
Review paper

Waples 2006 Book chapter

What would salmon ESUs look like  
if they were defined according to other  
published ESU criteria?

# Key references for populations:

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Waples, R. S., and O. Gaggiotti. 2006. **What is a population?** *Molecular Ecology* 15:1419-1439

Manel, S., O. Gaggiotti, and R. S. Waples. 2005. **Assignment methods: matching biological questions with appropriate techniques.** *Trends in Ecology and Evolution* 20:136-142.

# Two population concepts:

(Andrewartha and Birch 1984)

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## Ecological paradigm

A group of individuals that co-occur in space and time and **have an opportunity to interact**  
(cohesive forces are demographic)

## Evolutionary paradigm

A group of **interbreeding individuals** that exist together in time and space  
(cohesive forces are genetic)

# Take home message #2:

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Most published definitions of  
'population' are

- Not quantitative
- Not testable
- Not repeatable

# Identifying populations: Examples of possible objectives

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1. We want to ask evolutionary questions that depend on identifying 'populations' or 'ESUs'
2. We need to manage "MUs" or "populations" separately because of a legal mandate
3. We want to maximize sustainable harvest; we want to minimize impacts on "weak" stocks

# Matching the population concept with conservation objectives

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We want to minimize impacts on “weak” stocks, because

- Locally depleted stocks take a long time to rebuild (**Ecological paradigm**)
- Local extirpation might represent an irreversible loss of biodiversity (**Evolutionary paradigm**)

# Take home message #3:

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**It is important to choose a population (ESU, etc.) concept that is appropriate for your Objective(s).**

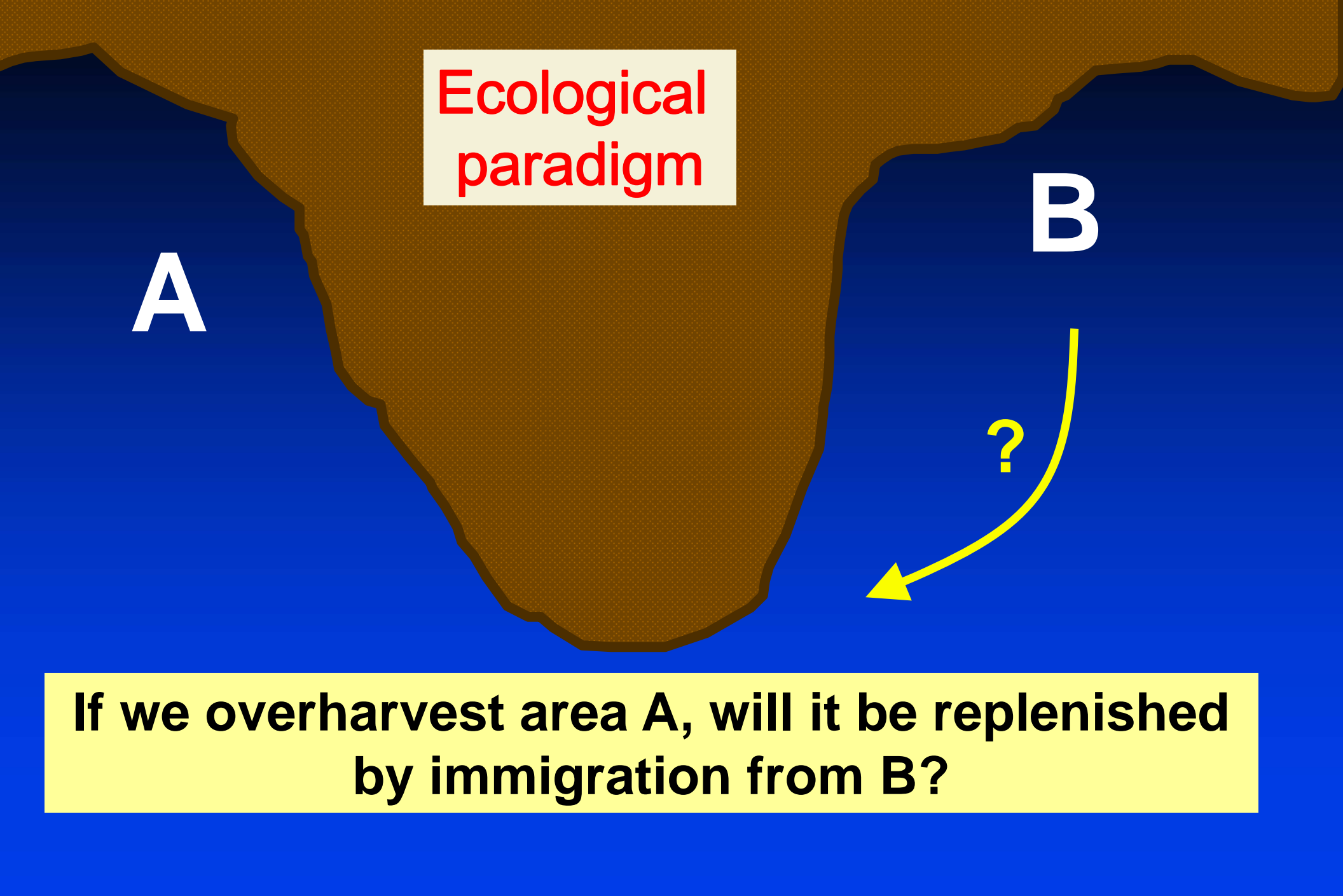
**Ecological  
paradigm**

**A**

**B**

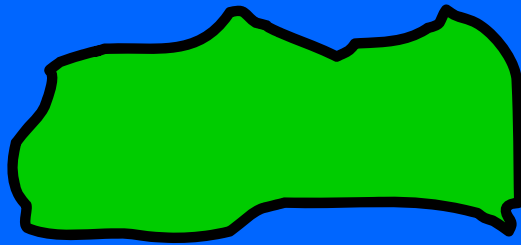
?

**If we overharvest area A, will it be replenished  
by immigration from B?**

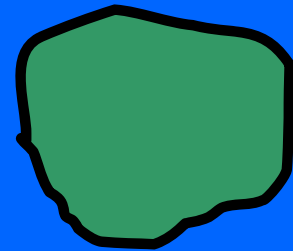




# Marine reserve design



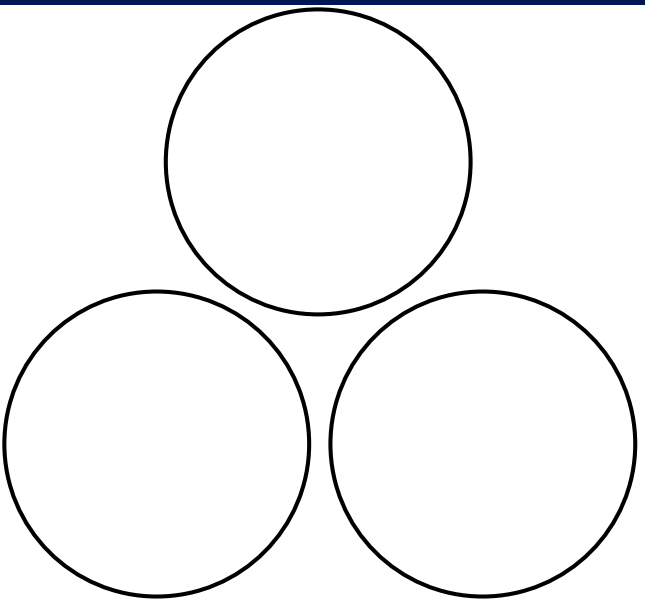
Larval  
dispersal?



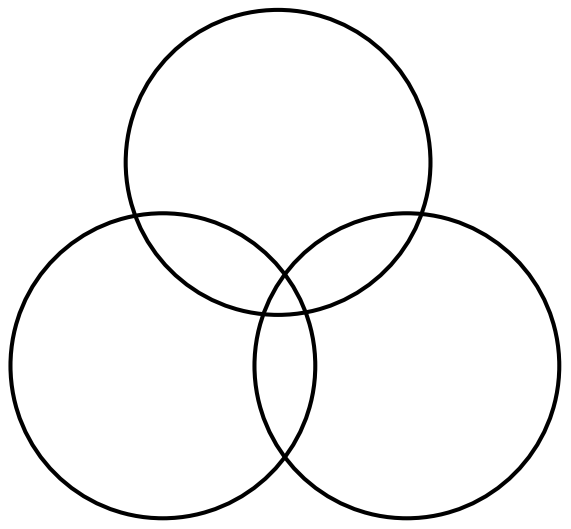


Effect size

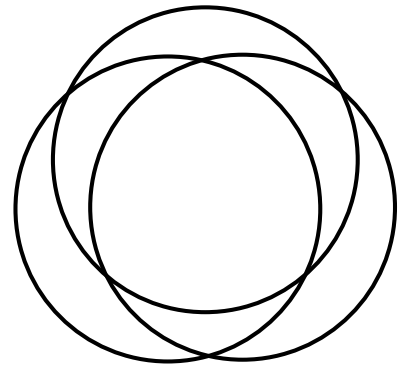
$H_0$



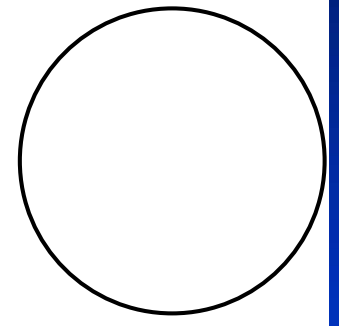
A



B



C



D

Isolation

**What is a population/stock?**

Panmixia



Divergence

# Take home message #4:

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A standard statistical test does not answer the question,

“Is it different enough?”

With large samples of individuals and loci, even small genetic differences can be highly significant

# A possible population criterion

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## Ecological paradigm (units = $m$ )

Migration rate less than a specified level,  
leading to demographic independence

$(H_0: m < 0.1)^*$

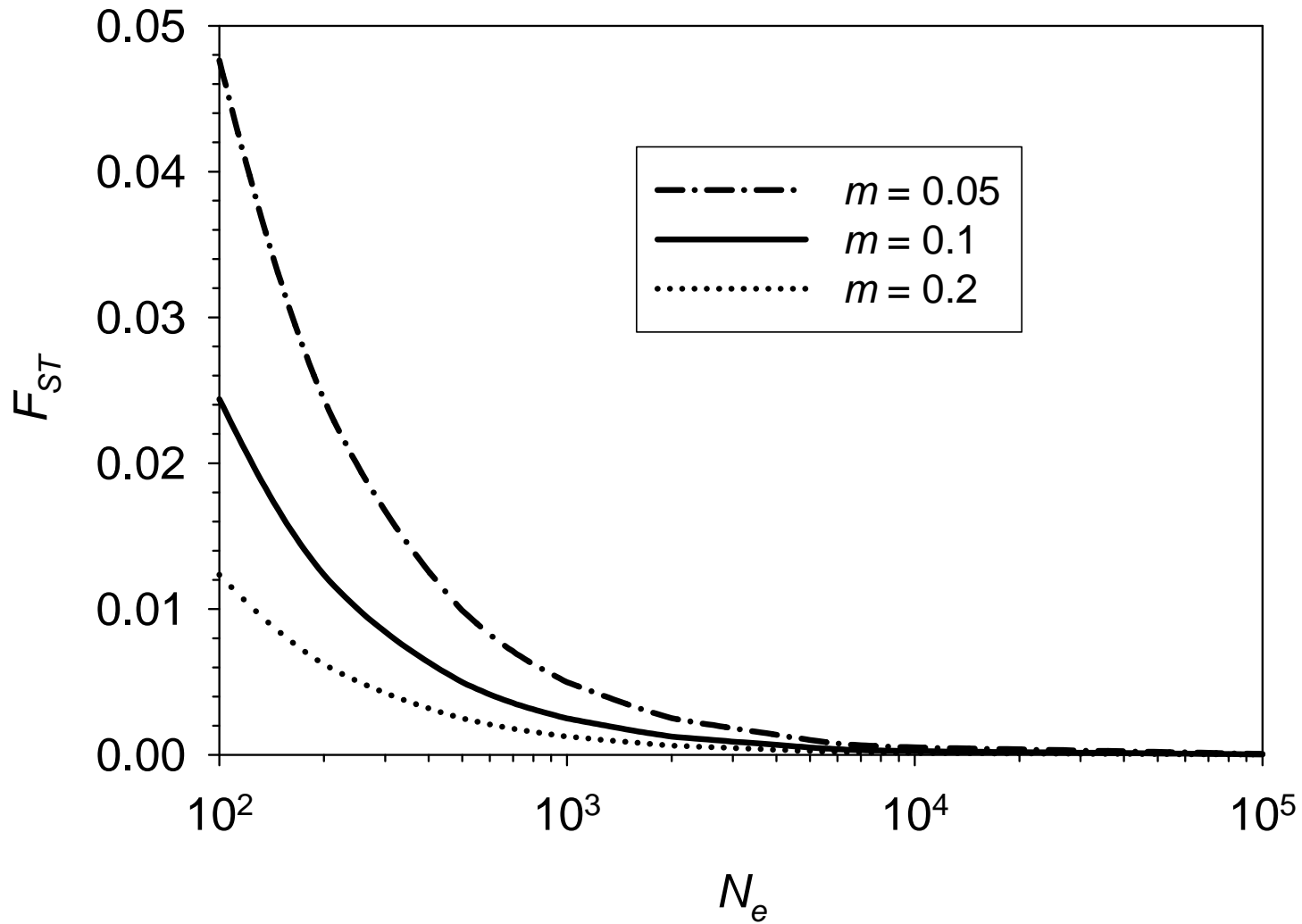
\*Local demes tend to have independent  
demographic trajectories if  $m$  is less than  
about 10% (Hastings 1993)

# Genetic data and the ecological paradigm

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## Fundamental problems:

1. Genetic indices yield information about  $mN_e$  but need information about  $m$
2. Transition to demographic independence occurs in region of high gene flow ( $m \sim 10\%$ ) where genetic methods have little power



Waples, Punt, Cope (2008)

# Flavors of demographic independence

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**ESA (avoid extinctions): migration low enough to allow separate PVAs**

**MMPA (stocks = functioning units in ecosystems): avoid local depletions**

**MSA (avoid overfishing): migration too low to provide rescue effect, generally within 10 yr**

# Some strategies for dealing with high gene flow species

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Get more data (individuals, samples, loci)

Careful attention to sampling protocols

Departures from randomness

Understand life history

**Temporal replication**

Combine information from different methods



# Summary

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**Clarify objectives**

**Clarify population paradigm**

**Clarify how different units have to be**

**Clarify science vs mgt/policy/legal roles**

**Recognize limitations of statistical tests**

**Holistic approach**