

Shelford's Law of Tolerance in the Great Barrier Reef

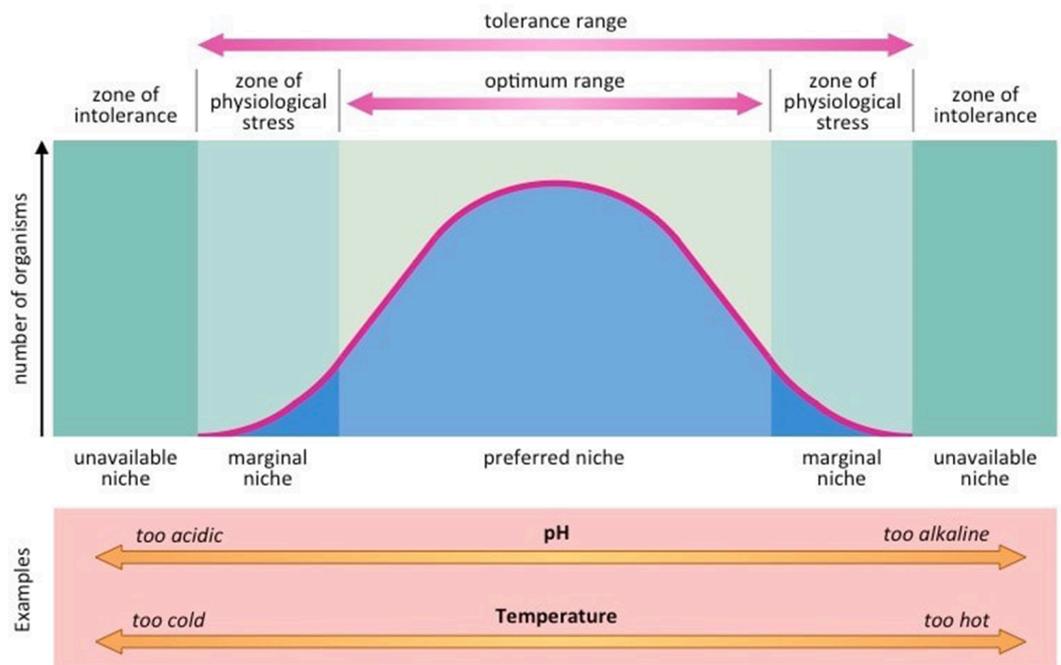
What Is Shelford's Law of Tolerance?

Shelford's Law of Tolerance states that the survival, growth, and reproduction of an organism depend on how well it can tolerate changes in environmental conditions. Every species has a minimum, maximum, and optimal range for each environmental factor. If conditions fall outside these limits, the species may become stressed, decline in number, or even disappear from the habitat.

Key environmental factors include:

- Temperature
- Salinity
- Light availability
- Nutrient levels
- pH (acidity)
- Oxygen levels

Marine ecosystems, such as the Great Barrier Reef (GBR), provide strong and relatable examples of how tolerance limits shape biodiversity.



Temperature Tolerance in Corals

Corals on the GBR rely on a close relationship with tiny algae called zooxanthellae, which live inside their tissues. These algae perform photosynthesis and supply the coral with energy. However, this relationship works only within a narrow temperature range.

Optimal range: around 23–29°C

Above the upper limit: algae are expelled, causing coral bleaching

Below the lower limit: coral metabolism slows and stress increases

Example

During unusually warm summers, parts of the GBR have experienced extended periods above 30°C. Corals that cannot tolerate these temperatures bleach and may die if the heat stress continues. This demonstrates the coral's limited upper tolerance.

pH Tolerance and Ocean Acidification

Ocean water normally has a pH slightly above 8. Many marine organisms depend on these stable conditions because they build shells or skeletons from calcium carbonate.

Example

As pH drops due to increasing carbon dioxide absorption, corals struggle to produce strong skeletons. While small decreases in pH are tolerable, major declines move conditions outside their tolerance range, making reef construction slower and more fragile.



How Aquariums Use Shelford's Law of Tolerance

Modern aquariums like Hobart Zoo and Aquarium apply Shelford's Law of Tolerance to keep marine organisms healthy by maintaining environmental conditions within each species' preferred range. Aquarists use a range of tools to control the water environment. Coral tanks require precise lighting systems that mimic natural sunlight patterns, while fish displays often depend on filtration units that maintain stable salinity and oxygen levels. By managing these factors, aquariums keep conditions within tolerance limits, reduce stress, and support long-term survival, growth, and reproduction of the species in their care.

Common Aquarium Tools and What They Measure

Digital Thermometer / Temperature Probe – measures water temperature to ensure it stays within the species' tolerance range.

Heaters – regulate and stabilise water temperature when it moves outside the preferred limits.

Refractometer – measures salinity by detecting how much light bends (refracts) as it passes through a water sample; used to keep salinity stable, especially in marine tanks.

pH Meter/Strips – measures the acidity or alkalinity of the water to maintain suitable chemical conditions.

Dissolved Oxygen (DO) Meter – measures the level of oxygen available for respiration in fish, corals, and other animals.

Ammonia, Nitrite, and Nitrate Test Kits – measure nitrogen waste products to ensure filtration systems are working and to prevent toxic build-ups.

Protein Skimmer – removes dissolved organic compounds before they break down; supports water quality and oxygenation.

Light Meters and Programmable LED Lighting – measure and control light intensity and wavelength for photosynthetic organisms like corals.

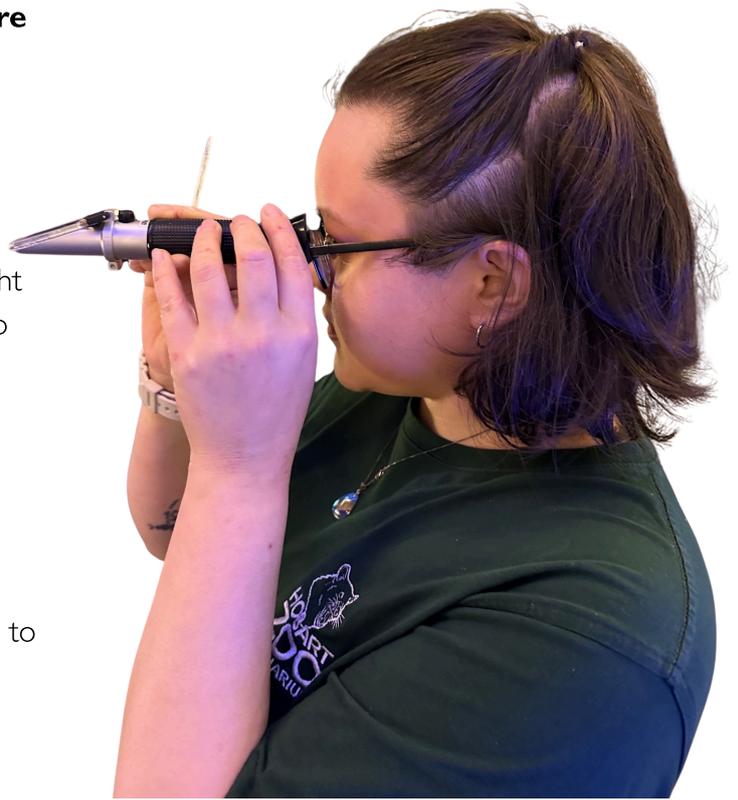


Figure 1 - A Hobart Zoo and Aquarium Marine Biologist measuring salinity levels with a refractometer.

It is essential for Marine Biologists and aquarists to regularly apply the principles of Shelford's Law of Tolerance to ensure that aquatic species thrive. Understanding tolerance limits helps scientists:

- Predict which species are most at risk from environmental change
- Understand the optimal conditions for species to thrive
- Explain why certain organisms live only in specific parts of the reef
- Manage conservation programs and protect vulnerable species
- Recognise early signs of stress within ecosystems

The Great Barrier Reef is a complex environment where even small changes in temperature, light, or chemistry can push species beyond their tolerance limits. Studying these limits helps us understand how the reef functions and how to better protect it.



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