Finding My Roots in Mathematics:
A Deaf Scientist’s Journey Into The Oceanic World
Find the derivatives using power rule:

\[ y = 10x^3 \quad y = \frac{1}{2}x^{-2} \]

\[ y = \frac{1}{2\sqrt{x}} \quad y = 3x^{\frac{-1}{15}} \]

\[ y = 8x^6 + 2x^{17} \quad y = \sqrt[5]{x} \]

\[ y = x^{\frac{1}{31}} + x^{-\frac{1}{7}} \quad y = 2x^{12} + 6x^7 + x^7 \]

\[ y = \frac{5}{3}x^3 - \frac{7}{6}x^6 + \frac{5}{4}x^8 \quad y = \frac{1}{2}x^{\frac{3}{2}} - \frac{22}{7}x^{-\frac{3}{7}} + x^{\frac{3}{7}} \]

Ex 1: Starting today a table is being sold at Jaime’s furniture store for $345. This is 69% of its regular price. What was the price yesterday?

Let \( x \) = price yesterday

\[ \$345 \text{ is } 69\% \text{ of } x. \]

\[ \frac{345}{0.69} = \frac{345}{69} = \frac{345}{100} = 345 \]

\[ x = \frac{345}{0.69} = \frac{345}{69} = 345 \]
All other teachers

Math teacher
Sea turtle migration

Marine reserve baseline monitoring
Rocky Intertidal
LEARNING SCIENCE
BY DOING SCIENCE

Scientific diving training

Benthic community survey
ECOLOGY OF FEAR
ECOLOGY OF FEAR

With Crab

With No Crab
White Band Disease

Disease prevalence

Heat stress

Microbial community
Root(Colony Forming Unit/m$^2$) vs Health Status

- Diseased
- Healthy

- Marine Agar
- TCBS Agar

Medium

- Graph showing the comparison of root forming units per square meter between diseased and healthy health statuses for marine agar and TCBS agar media.
Transformed data allow us to see data clearly and detect patterns.
Reciprocal feedbacks between spatial subsidies and reserve networks in coral reef meta-ecosystems

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Abstract. Top-down processes such as predation and herbivory have been shown to control the dynamics of communities across a range of ecosystems by generating trophic cascades. However, theory is only beginning to describe how these local trophic processes interact with spatial subsidies in the form of material (nutrient, detritus) transport and organismal dispersal to (1) shape the structure of interconnected (meta-) ecosystems and (2) determine their optimal management via reserve networks. Here, we develop a meta-ecosystem model to understand how the reciprocal feedbacks between spatial subsidies and reserve networks modulate the importance of top-down control in a simple herbivorous fish–macroalgae–coral system. We show that in large and isolated reserve networks where connectivity between protected and unprotected areas is limited, spatial subsidies remain largely confined to reserves. This retention of spatial subsidies promotes the top-down control of corals and macroalgae by herbivores inside reserves but reduces it outside reserves. Conversely, in small and aggregated reserves where connectivity between protected and unprotected areas is high, the spillover of spatial subsidies causes a reduction in top-down control of corals and macroalgae by herbivores inside reserves and an increase in the strength of top-down control outside reserves. In addition, we demonstrate that there is a trade-off between local and regional conservation objectives when designing reserve networks: small and aggregated reserves based on the extent of dispersal maximize the abundance of corals and herbivores regionally, whereas large and isolated reserves always maximize the abundance of corals within reserves, regardless of the extent of dispersal. The existence of such “conservation traps,” which arise from the fulfillment of population-level objectives within local reserves at the cost of community-level objectives at regional scales, suggests the importance of adopting a more holistic strategy to manage complex and interconnected ecosystems.

Keywords: corals; dispersal; material transport; meta-ecosystem; reserve networks; spatial management; spatial subsidies; top-down control; trophic cascades
Regional subsidies

Local ecosystem $x$

- Herbivores
- Macroalgae
- Corals
- Detritus
- Nutrients

$q$

$h$

Local ecosystem $y$

- Herbivores
- Macroalgae
- Corals
- Detritus
- Nutrients

$q$

$h$

Regional subsidies
Modeling local and regional dynamics using integro-differential equations

\[
\frac{dH(x)}{dt} = \frac{aM(x)H(x)}{1 + avM(x)} - m_H H(x) - h(x)H(x) - d_H H(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_H(y) \kappa_H(x - y) \, dy
\]

\[
\frac{dC(x)}{dt} = \left[ \int_{-\frac{L}{2}}^{\frac{L}{2}} r_c C(y) \kappa_c(x - y) \, dy \right] (1 - M(x) - C(x)) - m_c C(x)
\]

\[
\frac{dM(x)}{dt} = \left[ \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{r_M N(y)}{1 + kN(y)} M(y) \kappa_M(x - y) \, dy \right] (1 - M(x) - C(x)) - m_M M(x) - \frac{aM(x)H(x)}{1 + avM(x)}
\]

\[
\frac{dD(x)}{dt} = m_M M(x) + m_H H(x) + m_c C(x) - \gamma D(x) - d_D D(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_D(y) \kappa_D(x - y) \, dy
\]

\[
\frac{dN(x)}{dt} = q - \epsilon N(x) + f \gamma D(x) - \frac{r_M N(x)}{1 + kN(x)} M(x) - d_N N(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_N(y) \kappa_N(x - y) \, dy
\]
function [equi, abundS, abundM1, abundN1, abundC, abundM2, abundN2, mapVals] = ...

determine_local_stability_metaecosystem_1D (rSval, mSval, rMval, mMval, rCval, mCval, betaval, q1val, q2val, eps1val, eps2val, ...

global S C M1 M2 N1 N2 eps1 eps2 rM rC rS q1 q2 mM mC mS d beta;

syms S C M1 M2 N1 N2 gam eps1 eps2 rM rC rS q1 q2 mM mC mS d beta;

model=[rS*S*(1-S-M1)-mS*S; ...
   rM*N1+M1*(1-S-M1)-mM*M1; ...
   d*(eps2*N2-eps1*N1)+q1-eps1*N1-rM*M1*N1; ...
   rC*C*(1-C-M2)-mC*C; ...
   rM*N2+M2*(1-C-M2)-mM*M2-beta*M2; ...
   d*(eps1*N1-eps2*N2)+q2-eps2*N2-rM*M2*N2];

sol=solve(model, S, M1, N1, C, M2, N2);

% Number of solutions
nsol=length(sol.C);

% Jacobian matrix used to compute local stability
v=[S, M1, N1, C, M2, N2];

jacGenericTemplate=jacobian(model, v);

mapVals=nan(length(betaval),1);
abundS=nan(length(betaval),1);
abundM1=nan(length(betaval),1);
abundN1=nan(length(betaval),1);
abundC=nan(length(betaval),1);
abundM2=nan(length(betaval),1);
abundN2=nan(length(betaval),1);

% Equilibrium states

equi.DensSUnstable=nan(nsol, length(betaval));
equi.DensM1Unstable=nan(nsol, length(betaval));
equi.DensM1Unstable=nan(nsol, length(betaval));
Large, isolated reserve

outside reserve

inside reserve
Small, aggregated reserves
When you are in the water and seaweed touches your leg
Length and growth rate were driven by high photosynthesis in CBN.

Net Primary Productivity (mg O$_2$ gDW$^{-1}$ h$^{-1}$)
NZ_Mean1$Treatment <- factor(NZ_Mean1$Treatment, levels=c("HLU", "U", "HU", "LU"),
RR <- filter(NZ_Mean1, Site == "RR")
TMB <- filter(NZ_Mean1, Site == "TMB")
RR_Plot <- ggplot(data = RR, aes(x = Month, y = Std.Cover.Mean, fill = Functional.
geom_bar(stat="identity") + facet_wrap(~Treatment, ncol = 4) +
scale_fill_brewer(type = "div", palette = "RdBu") +
ylab("Average Percent Cover") +
ggtitle("Raramai") +
guides(fill=guide_legend(title="Functional Group")))
jpeg("RR.jpeg", width = 10, height = 6, units = "in", res = 300)
RR_Plot
dev.off()
TMB_Plot <- ggplot(data = TMB, aes(x = Month, y = Std.Cover.Mean, fill = Functional.
NZ$spp.Name, NZ$Functional_Group), mean, na.rm = TRUE)
> names(NZ_Mean) <- c("Year", "Month", "Site", "Treatment", "spp.Name", "Functional.Group", 
NZ_Mean$Month <- as.factor(NZ_Mean$Month)
NZ_Mean$Treatment <- factor(NZ_Mean$Treatment, levels=c("HLU", "U", "HU", "LU", "HL", 
NZ_Mean1 <- read.csv("NZ_Mean.csv") # Use NZ_Mean data and add standardized percent cover
NZ_Mean1$Month <- factor(NZ_Mean1$Month, levels=c("10", "3"))
NZ_Mean1$Treatment <- factor(NZ_Mean1$Treatment, levels=c("HLU", "U", "HU", "LU", "HL", 
RR <- filter(NZ_Mean1, Site == "RR")
TMB <- filter(NZ_Mean1, Site == "TMB")
RR_Plot <- ggplot(data = RR, aes(x = Month, y = Std.Cover.Mean, fill = Functional.Group))

Size-dependent photosynthesis rate

Rate of Net Primary Productivity vs. Biomass
Bayesian analyses to answer the burning question:

Can we use our past as a predictor for our future?
Using **math** to define our natural world

Mathematical modeling allows us to:

- Remove logistical constraints
- Identify uncertainties
- Detect patterns
POST DOC
Kelp Forests

HABITAT AND BREEDING G roundS

FOOD SOURCE

OCEANIC PRODUCTION
Low pH and High Nutrients Scenarios
Mathematics is not a fixed concept, but a fluid entity that can be replaced, rearranged, and created with artistry akin to language.
Oliver looked around, then ran frantically over the bridge, muttering under his breath.

Having looked around, Oliver ran frantically over the bridge, muttering under his breath.

Oliver looked around. Muttering under his breath, he ran frantically over the bridge.

Frantically, he ran over the bridge, muttering under his breath.
Math Manipulation

\( \frac{d\bar{g}}{dt} = \frac{\sigma_g^2(kt + \epsilon_\theta - \bar{g})}{\sigma_w^2} + \epsilon_{\bar{g}} \)

\[
E \left( \frac{d\bar{g}}{dt} \bigg| \bar{g} \right) = \frac{\sigma_g^2(kt - \bar{g})}{\sigma_w^2}
\]

\[
V \left( \frac{d\bar{g}}{dt} \bigg| \bar{g} \right) = \frac{\sigma_g^2}{N_e} + \frac{\sigma_g^4\sigma_\theta^2}{\sigma_w^4}
\]

\[
E(r) = r_m - \frac{\sigma_z^2}{2\sigma_w^2} - \frac{k^2\sigma_w^2}{2\sigma_g^4} - \frac{1}{4N_e} - \frac{\sigma_\theta^2}{2\sigma_w^2} \left( \frac{\sigma_g^2}{2\sigma_w^2} + 1 \right)
\]
All other teachers

Math mentor
A world driven by DATA

The importance of meaningful representation, number sense/flexibility, and data fluency.
Top 20 Emerging Jobs

- Machine Learning Engineer: 9.8x
- Data Scientist: 6.5x
- Sales Development Representative: 5.7x
- Customer Success Manager: 5.6x
- Big Data Developer: 5.5x
- Full Stack Engineer: 5.5x
- Unity Developer: 5.1x
- Director of Data Science: 4.9x
- Brand Partner: 4.5x
- Full Stack Developer: 4.5x

Rate of Growth (2012 - 2017)
65% of people say they wished they learned more about how to analyze and interpret data.
Traditional Math

Real World
Rationalize the denominator in the equation:

\[ \frac{3}{\sqrt{x - 7}} \]

Find the imaginary zeros of the equation:

\[ f(x) = 4x^4 + 35x^2 - 9 \]
Number Sense/Math Flexibility

$$\begin{array}{c}
11 \\
469 \\
\times 32 \\
938
\end{array}$$

**Window**

- $40 \times 2 = 80$
- $30 \times 2 = 60$
- $20 \times 10 = 200$
- $5 \times 10 = 50$
- $1200 + 60 + 200 + 10 = 1470$

**Traditional**

- $42 \times 35 = 1470$
- $1200 + 60 + 200 + 10 = 1470$
- $1260 + 1200 = 2460$
- $210 + 1260 = 1470$

**Breaking Apart**

- $40 \times 30 = 1200$
- $40 \times 5 = 200$
- $2 \times 30 = 60$
- $2 \times 5 = 10$
- $1470$

**Lattice**

- $4 \times 2 = 8$
- $4 \times 3 = 12$
- $2 \times 2 = 4$
- $2 \times 0 = 0$
- $4 \times 6 = 24$
- $7 \times 0 = 0$
- $1470$
## Data Fluency

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<th>Population</th>
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<th>Pop. Density</th>
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<th>Net_migration</th>
<th>Infant_mortality</th>
<th>GDP $/capit</th>
<th>Literacy %</th>
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</table>

Countries of the world csv
When a plant doesn’t thrive, you fix the environment in which it grows, *not the plant.*
Traditional Math → Real World
Change will not come if we wait for some other person... or some other time.

We are the ones we’ve been waiting for.

We are the change that we seek.

- Barack Obama
QUESTIONS?