Estimating yellow eel (*Anguilla anguilla* (L.)) fyke net selectivity using a partially observed continuous Markov model

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Outline

1. Motivation

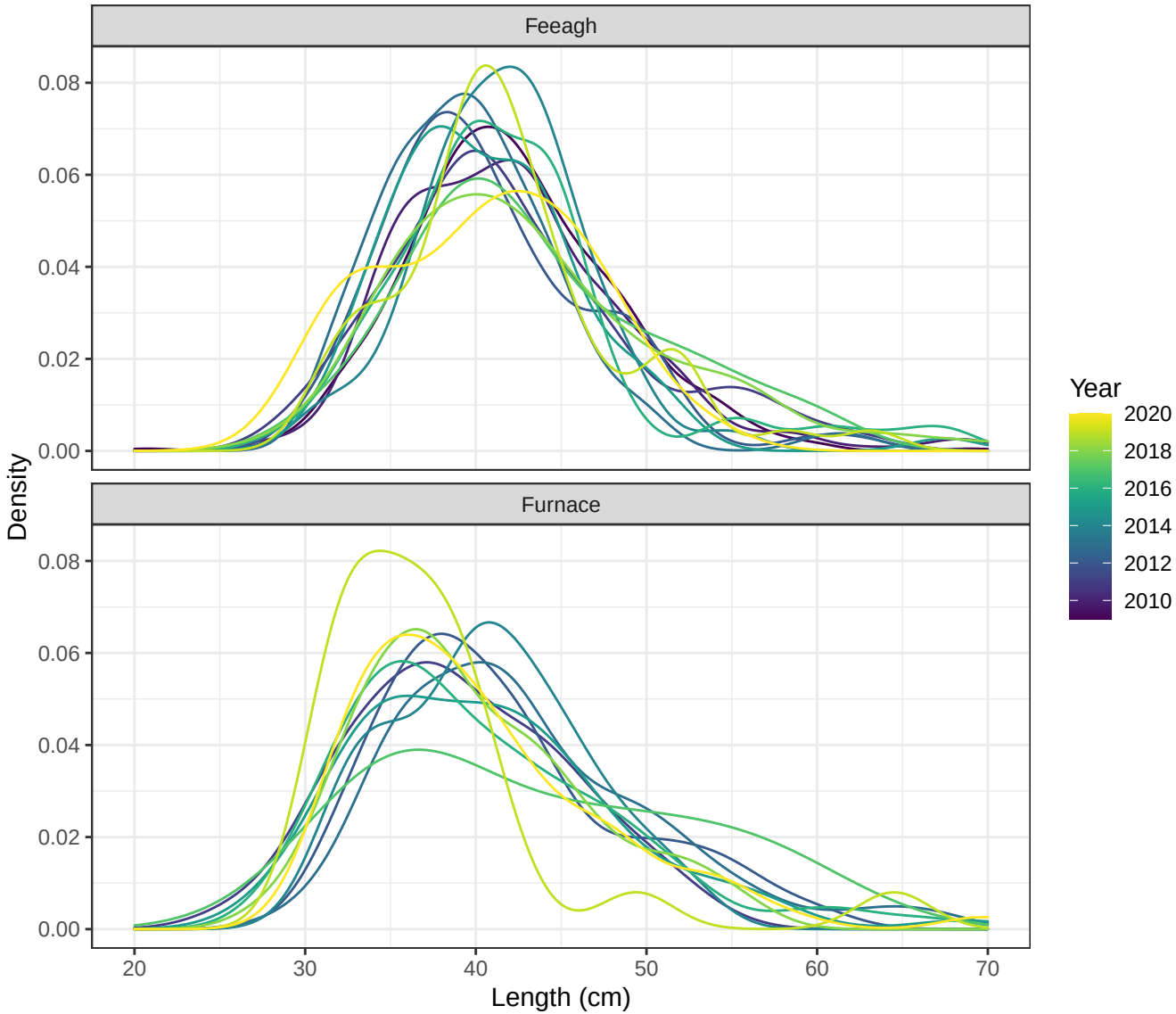
2. System model

3. Estimation

4. Results

5. Summary

Summer fyke net surveys



Aims

- Use enclosure experiments to estimate selectivity of the gears
- Develop and simulation test an enclosure system model
- Apply to real data

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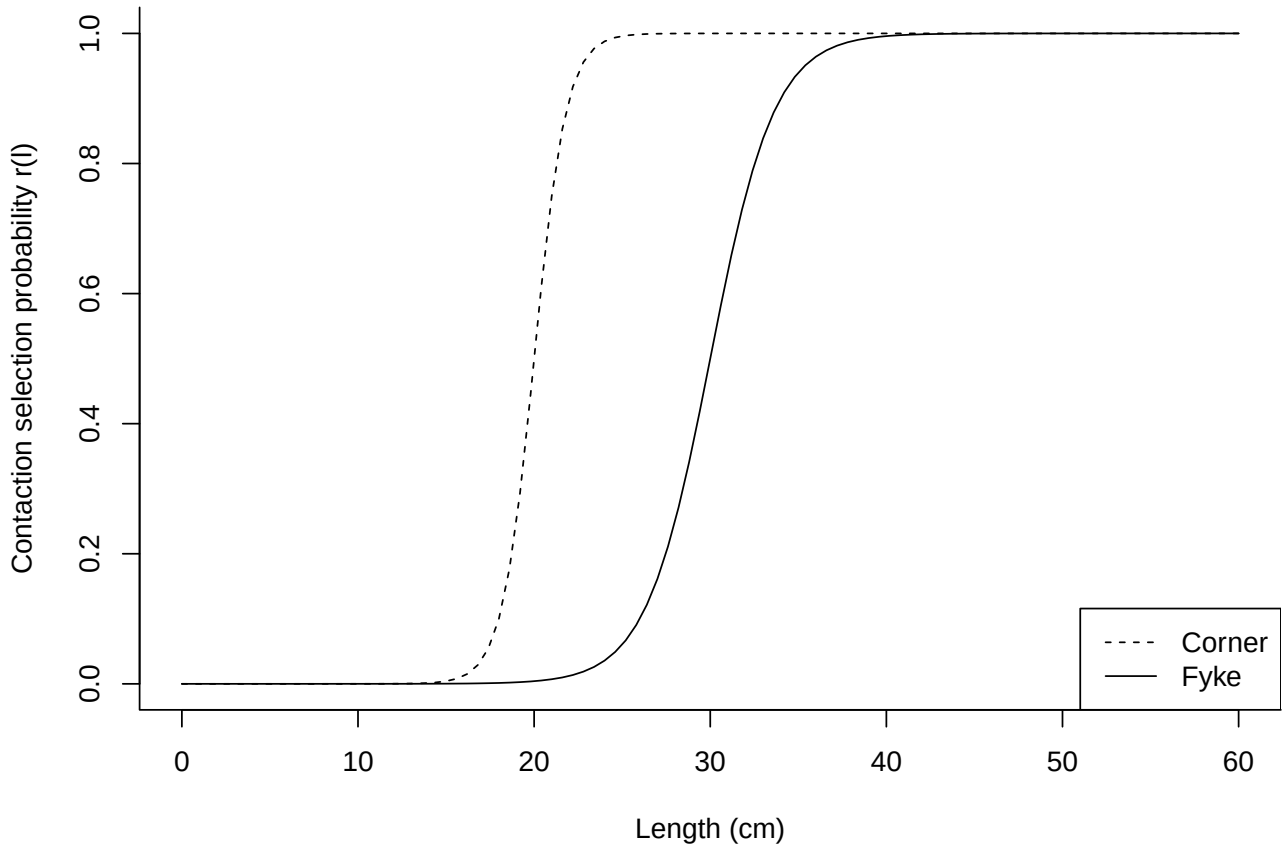
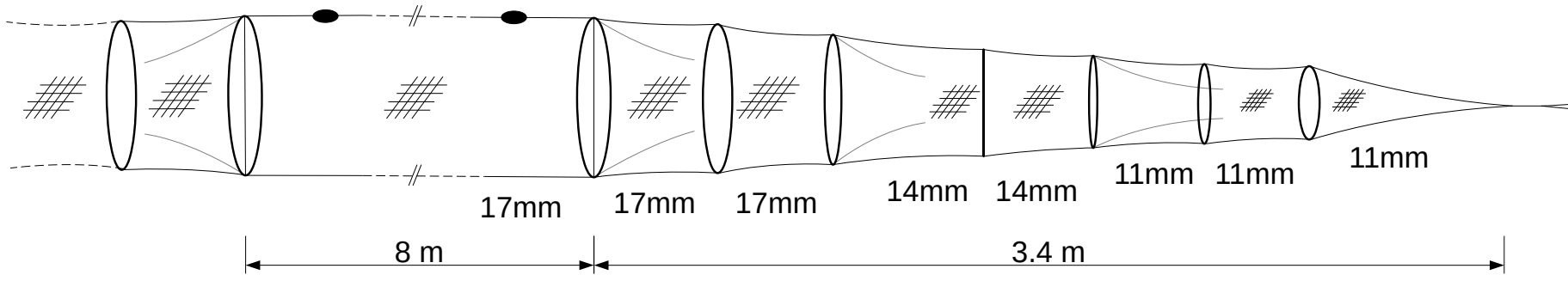
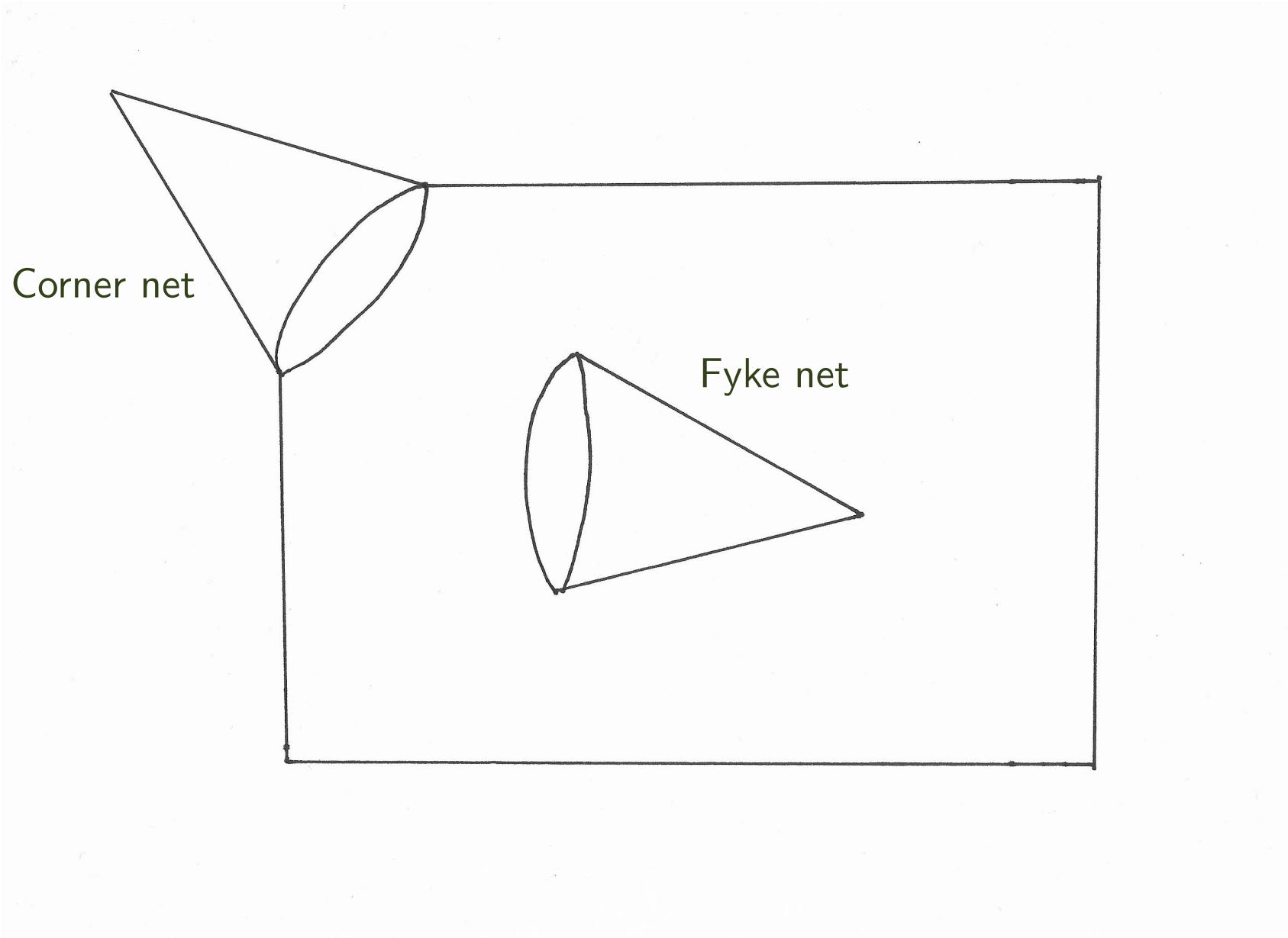
Parametric contact selection curves



Parametric contact selection curves



Stylised enclosure



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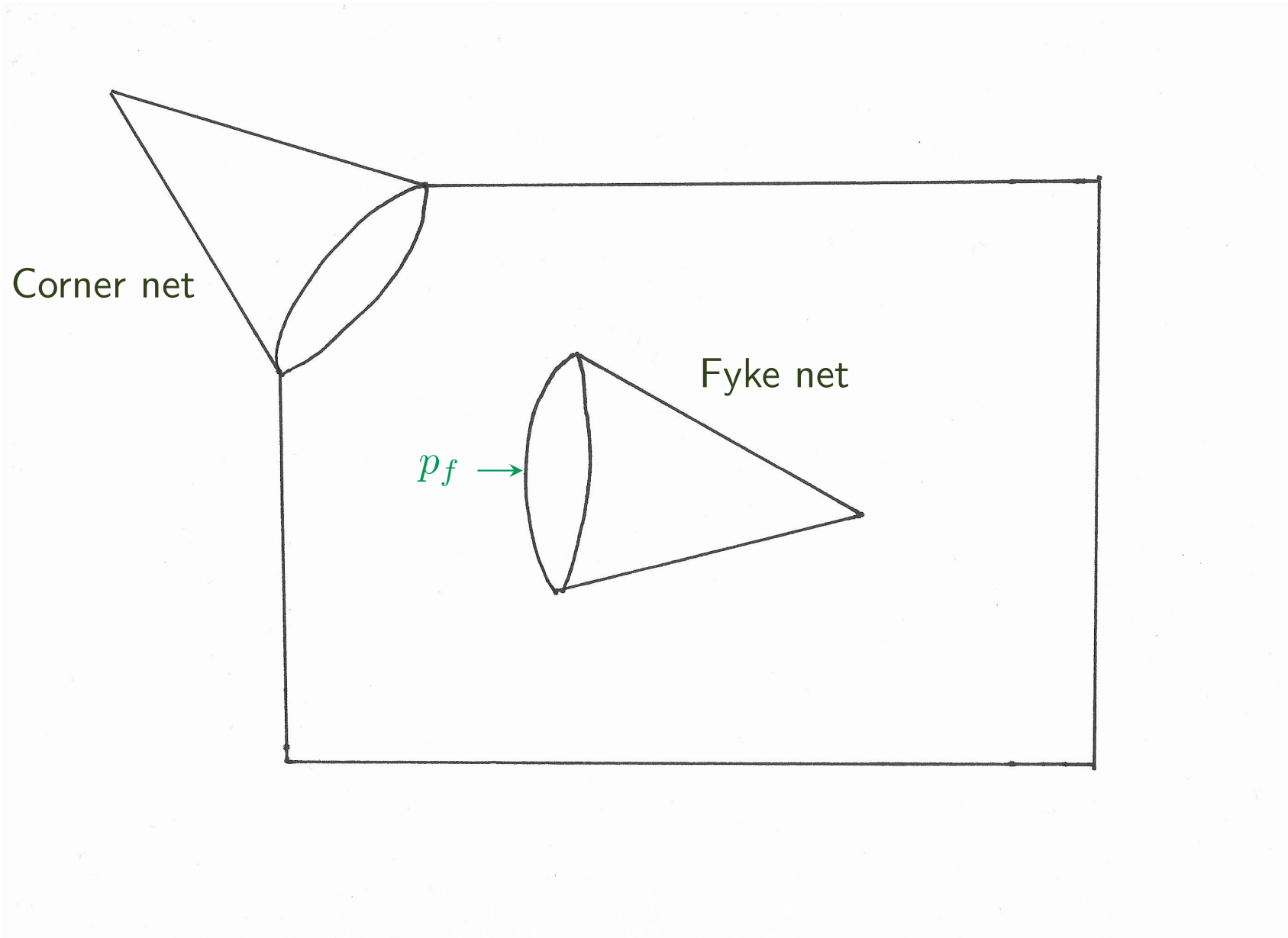

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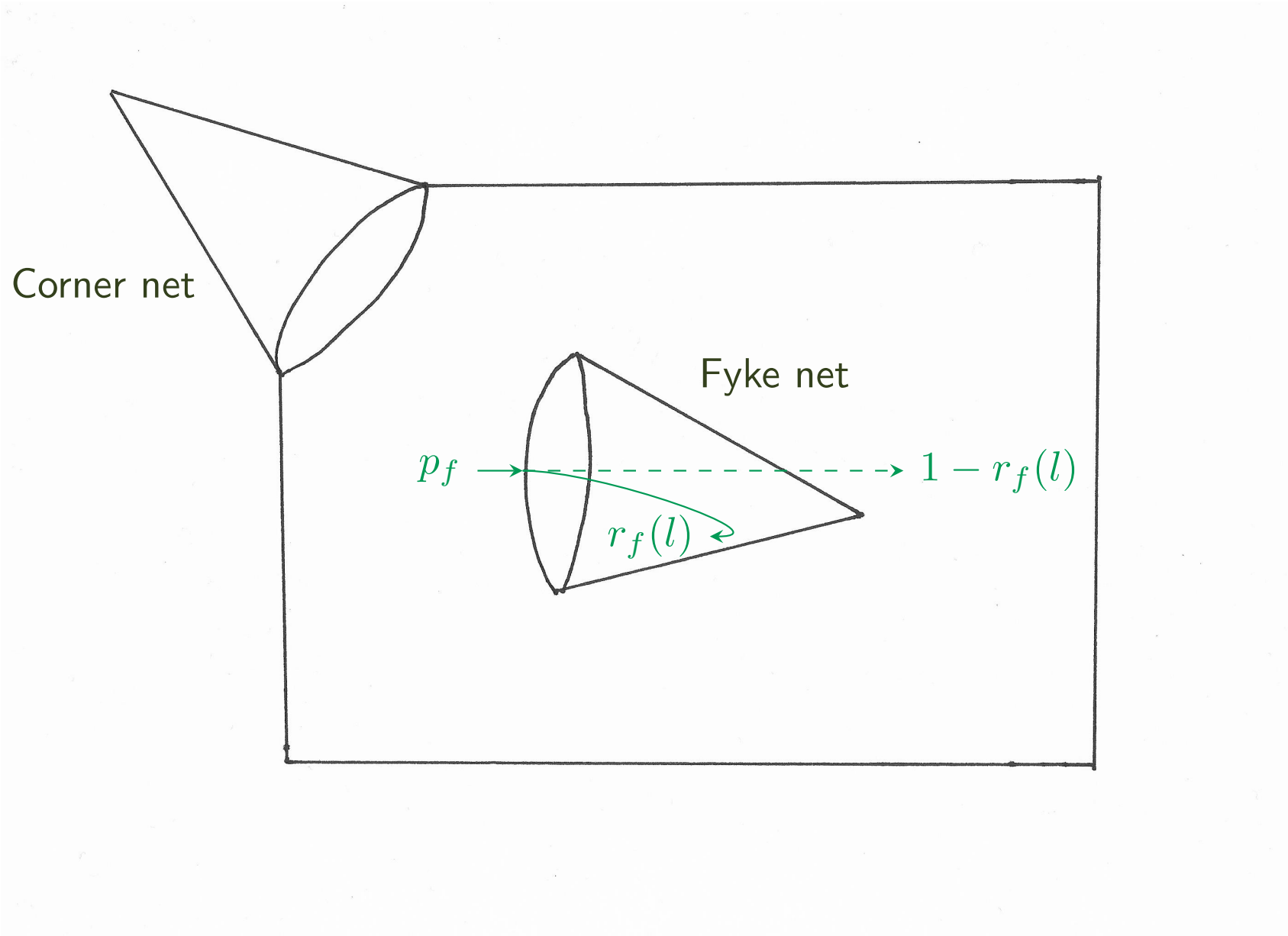

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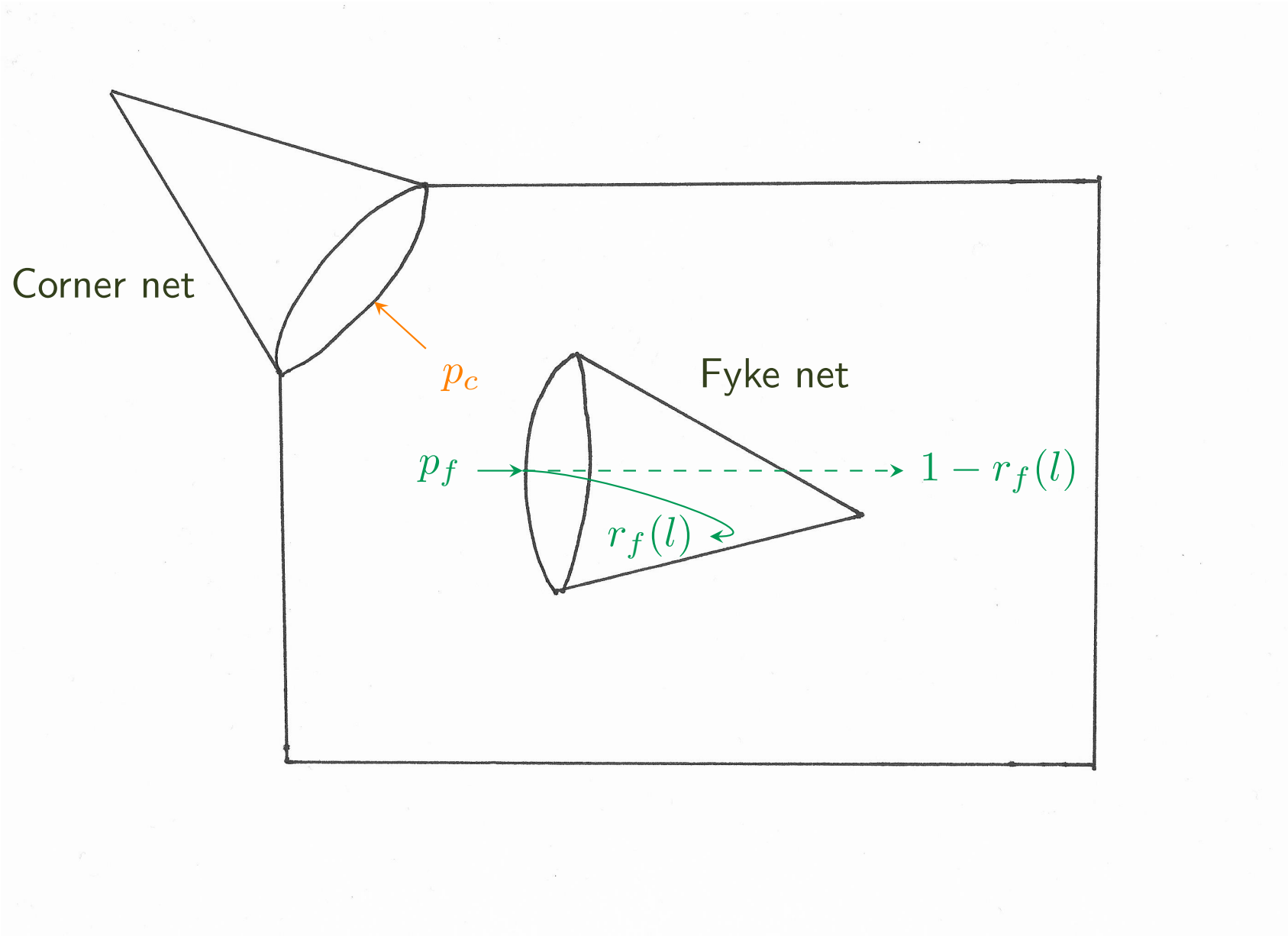

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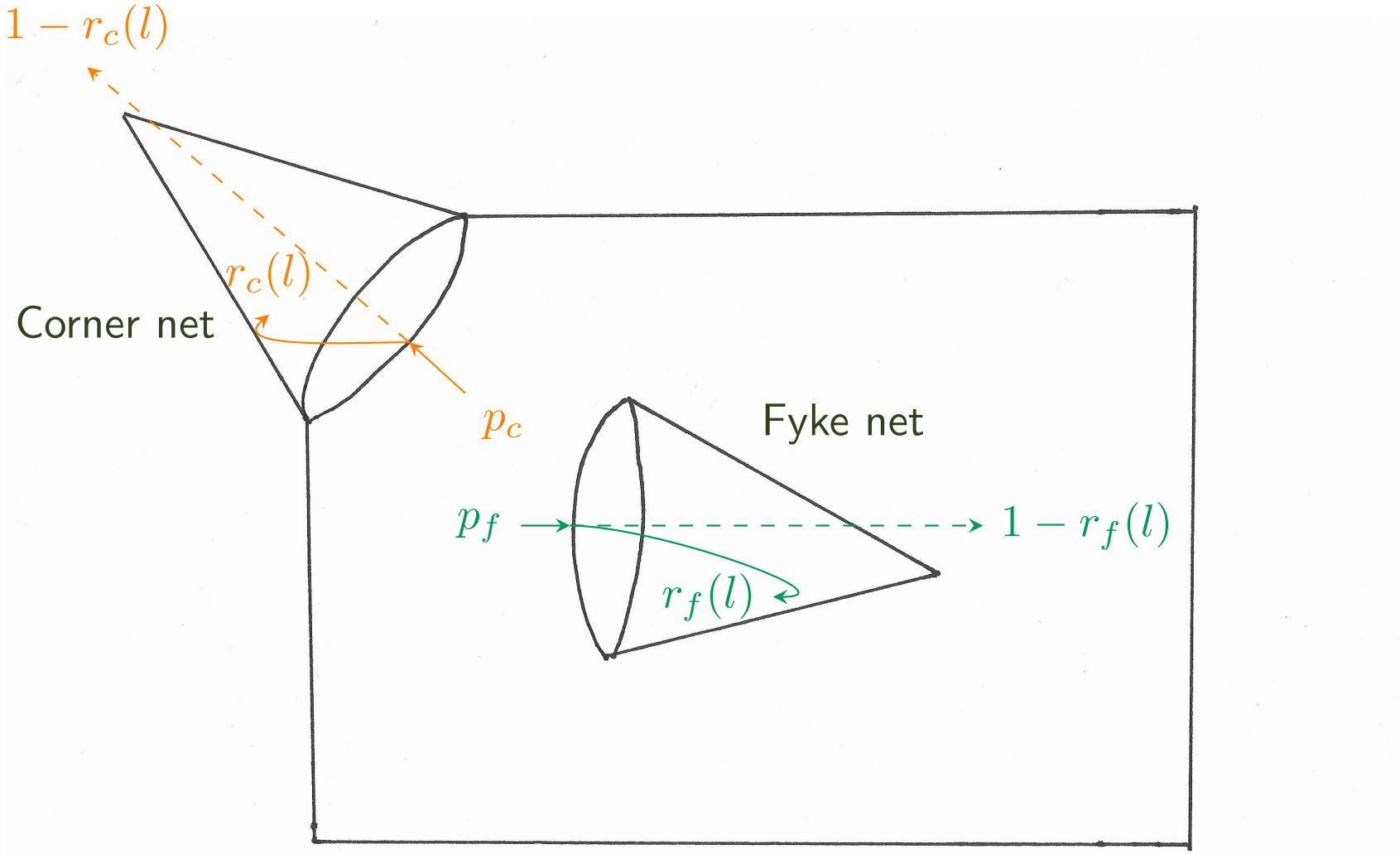

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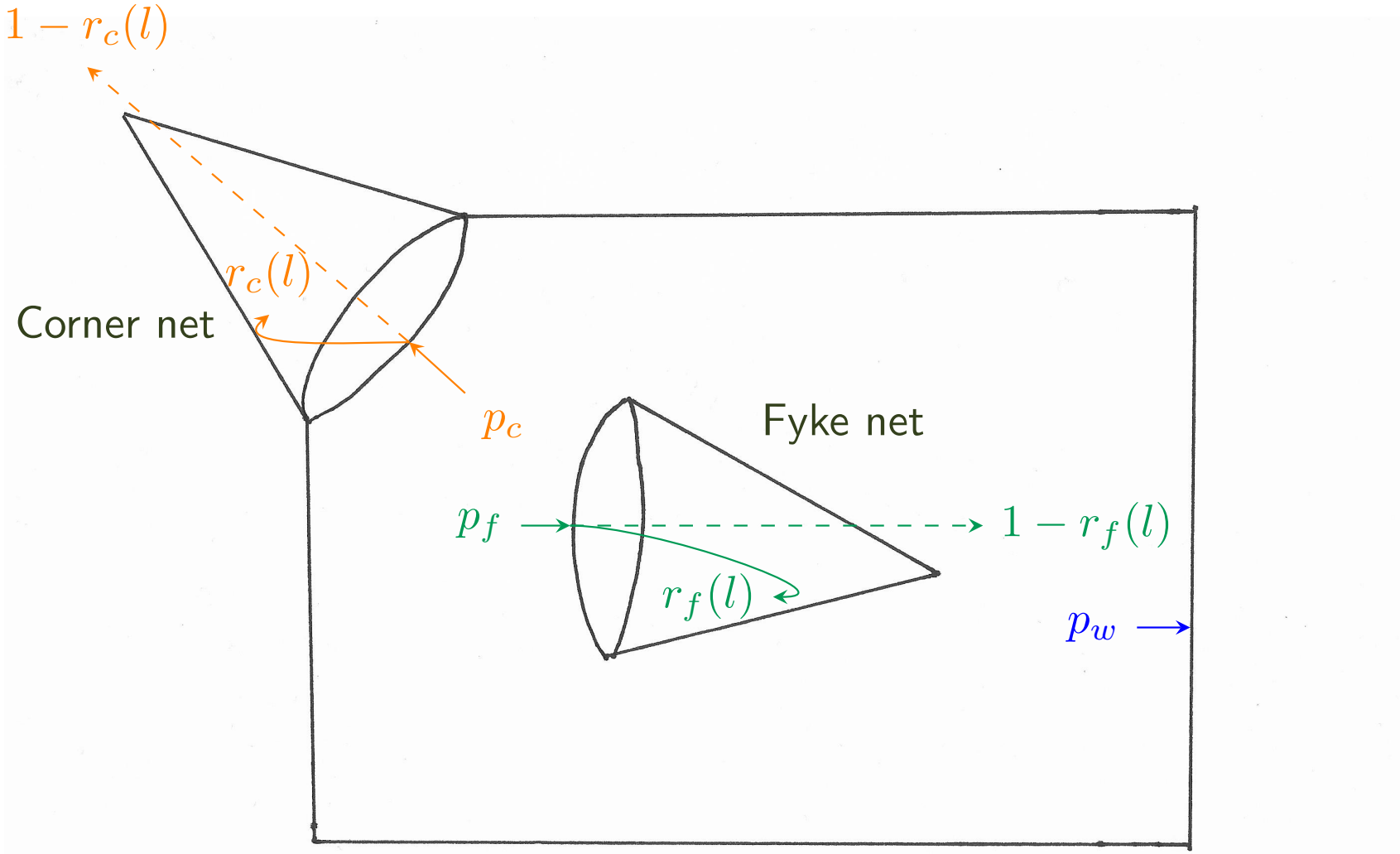

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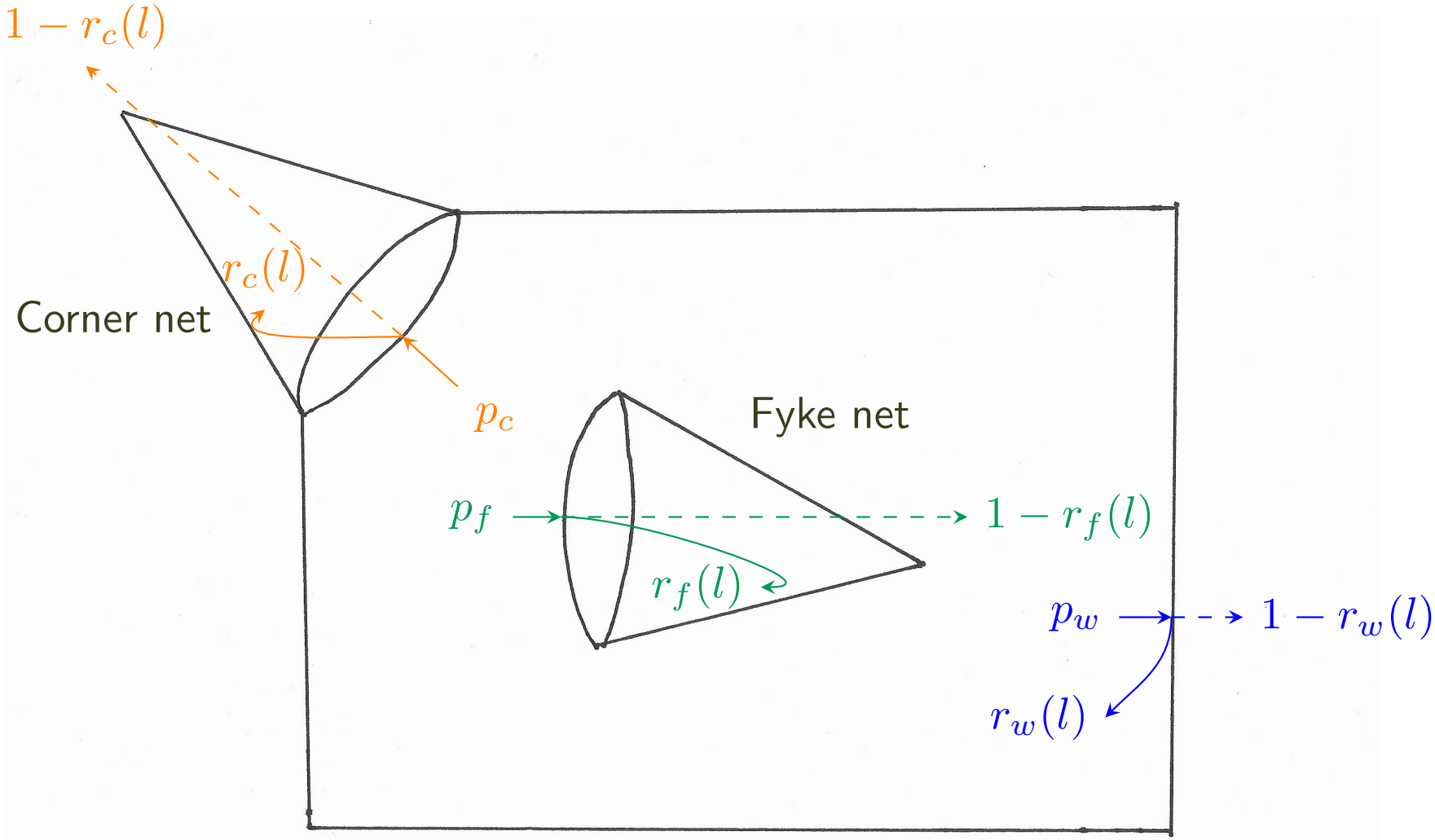
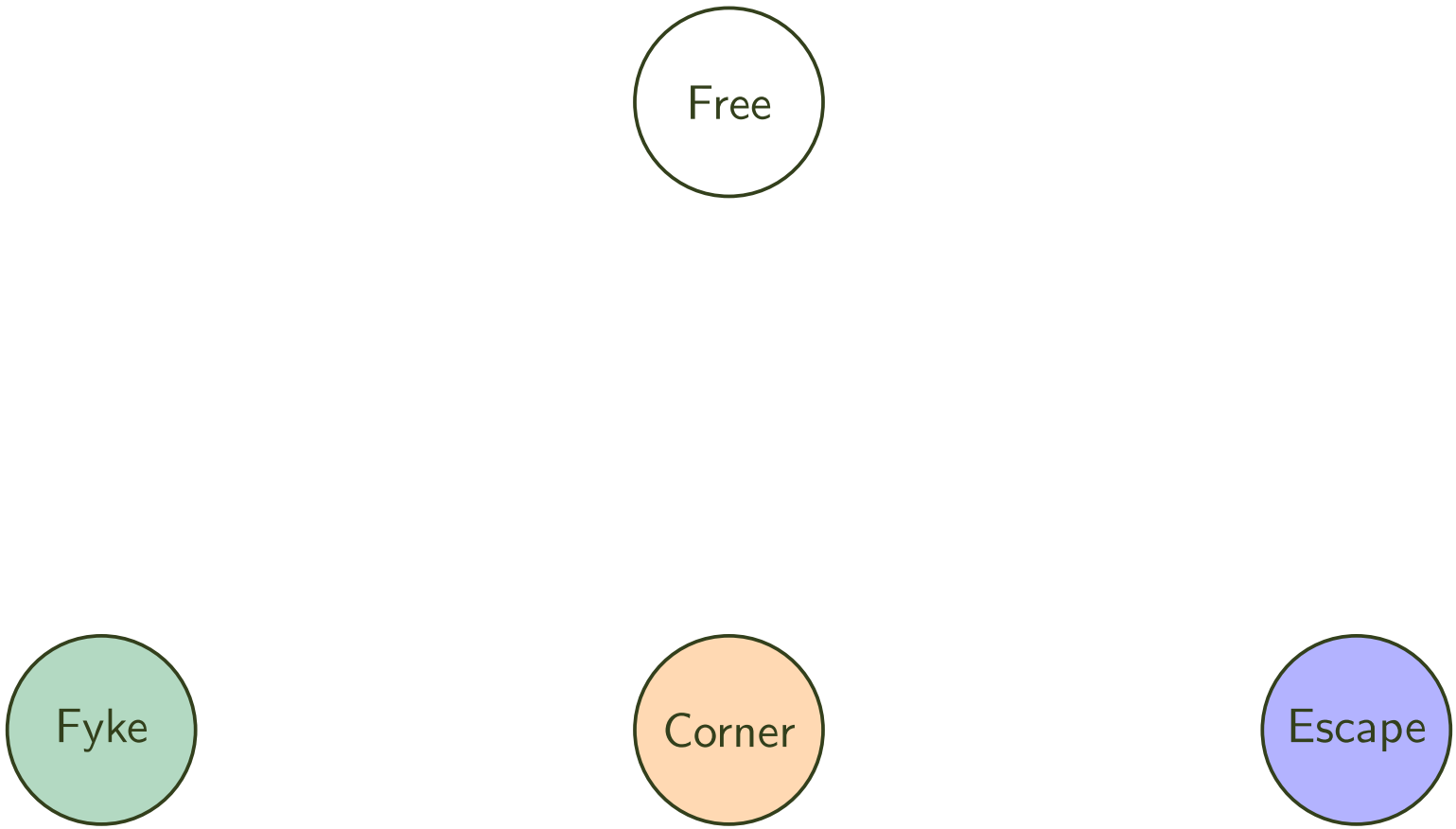


Transition probabilities



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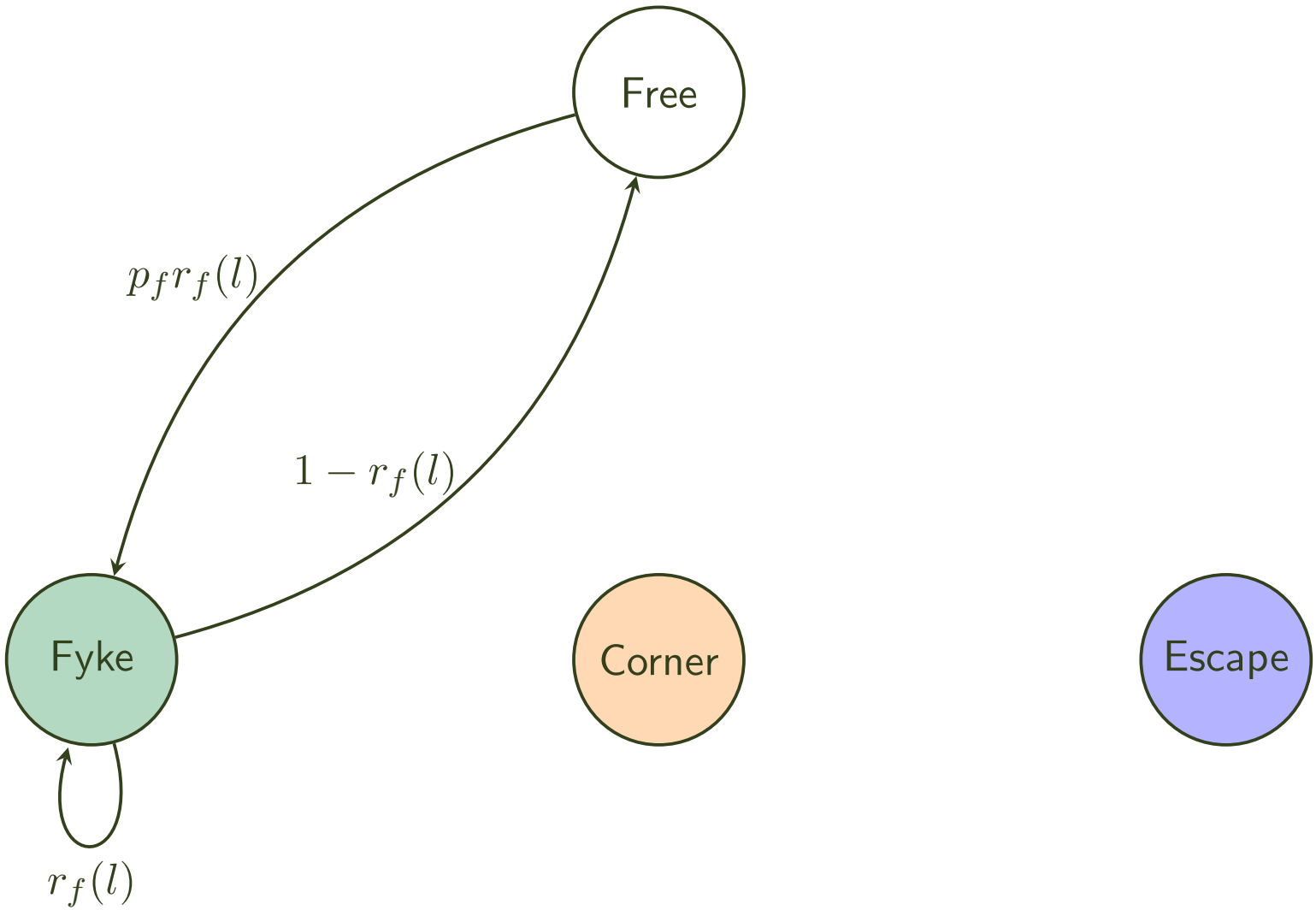

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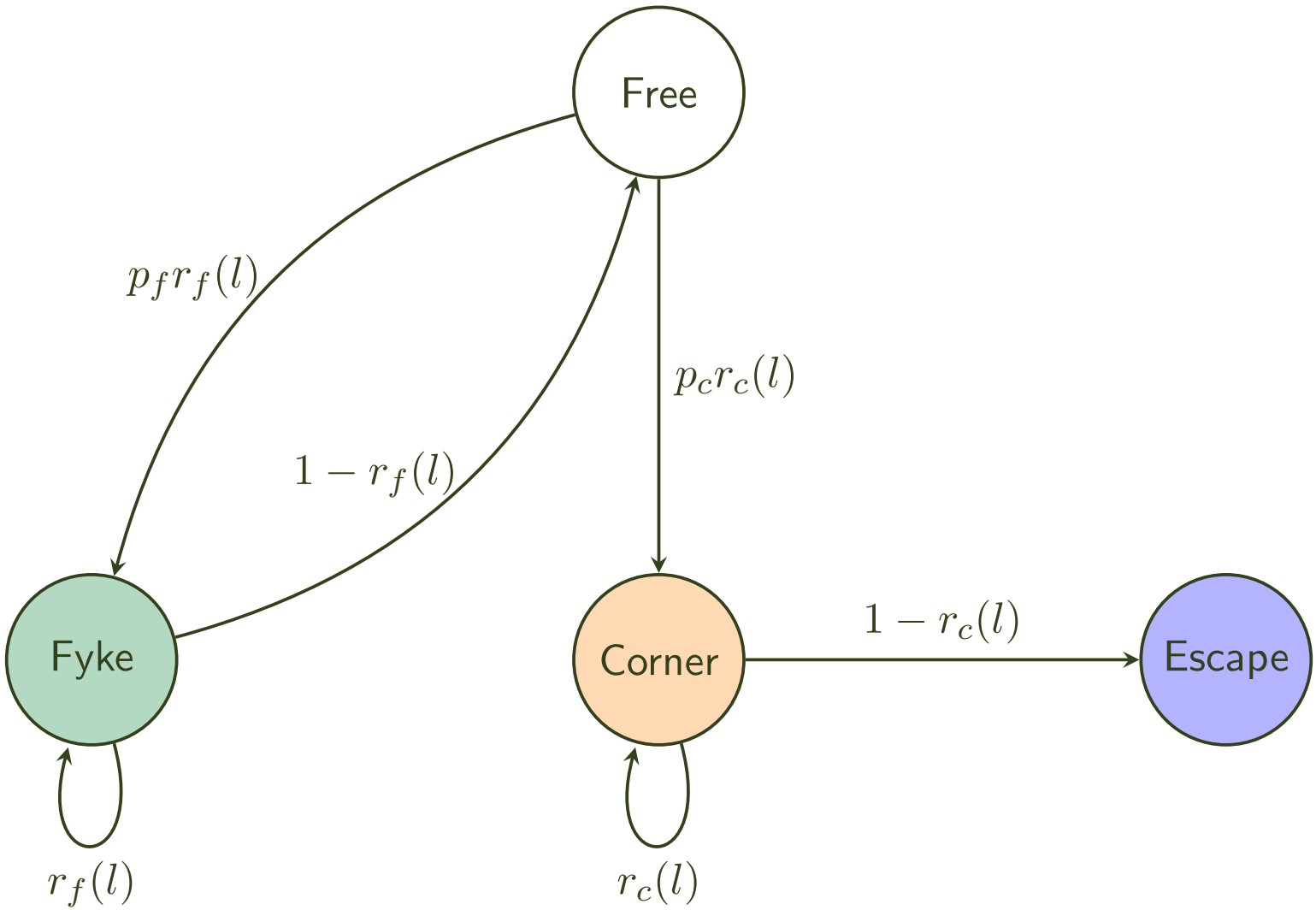

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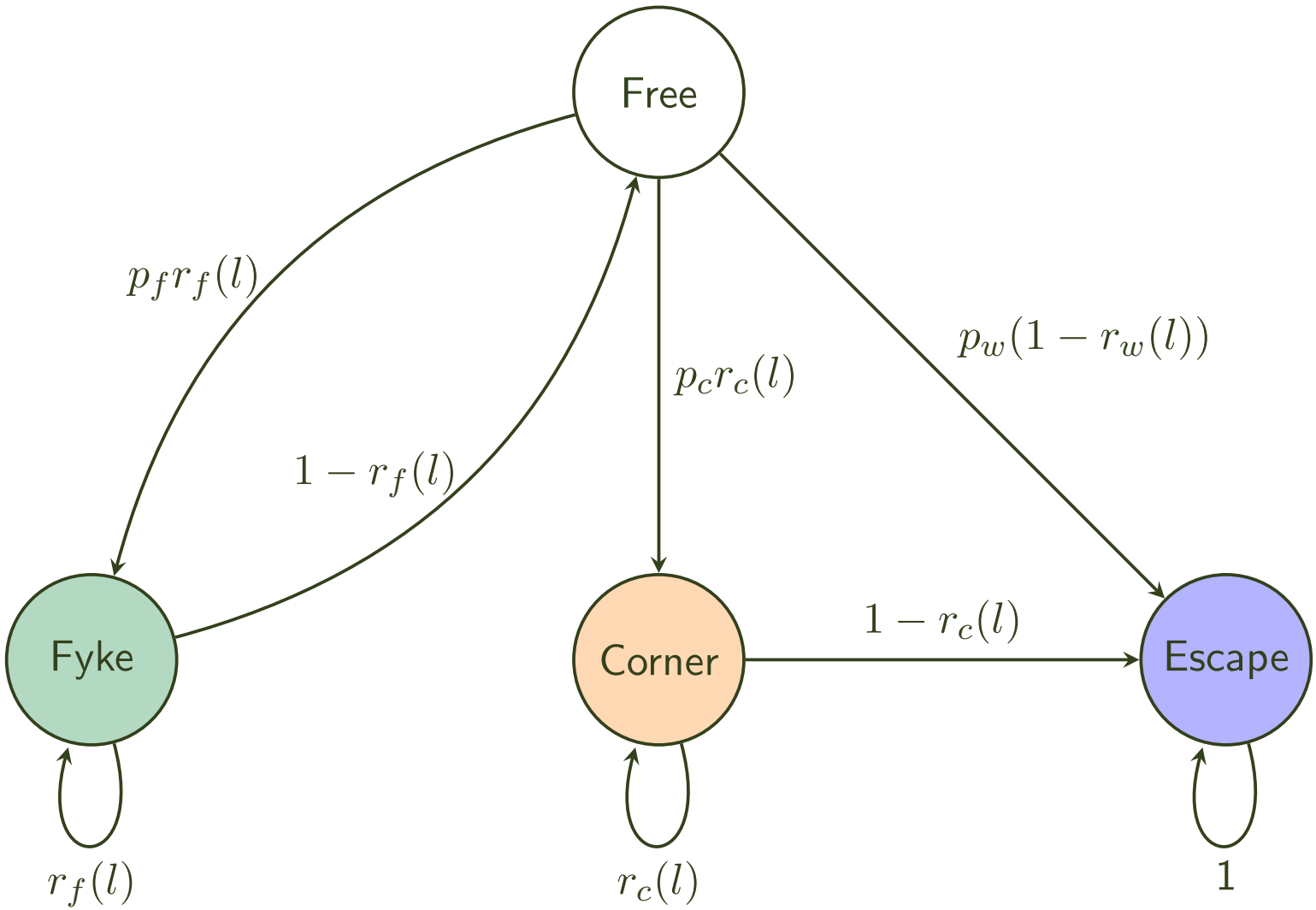

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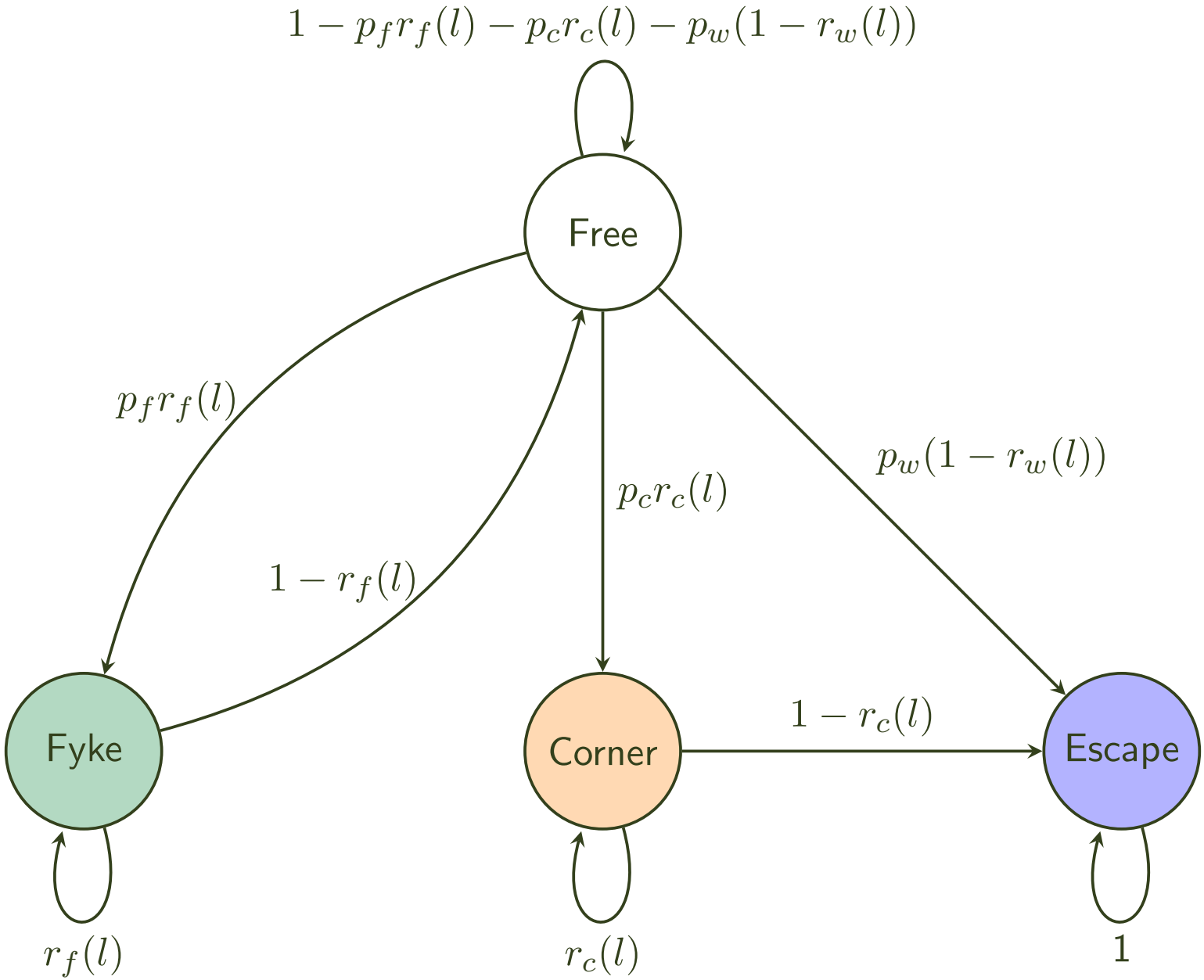


Continuous time Markov process

Transition intensity (instantaneous risk of moving from state r to state $s \neq r$)

$$q_{rs}(t, l) = \lim_{\delta t \to 0} \mathrm{P}(S(t + \delta t) = s \mid S(t) = r, l)/\delta t$$

Assume homogenous in time. Multistate transition intensity matrix[1]

$$\mathbf{Q}_l = \begin{array}{r} \\ \text{Free} \\ \text{Fyke} \\ \text{Corner} \\ \text{Escape} \end{array} \begin{array}{c} \begin{array}{cccc} \text{Free} & \text{Fyke} & \text{Corner} & \text{Escape} \end{array} \\ \begin{pmatrix} -p_f r_{f,l} - p_c r_{c,l} - p_w(1 - r_{w,l}) & p_f r_{f,l} & p_c r_{c,l} & p_w(1 - r_{w,l}) \\ 1 - r_{f,l} & r_{f,l} - 1 & 0 & 0 \\ 0 & 0 & r_{c,l} - 1 & 1 - r_{c,l} \\ 0 & 0 & 0 & 0 \end{pmatrix} \end{array}$$

Transition probabilities to time t given by

$$\mathbf{P}_l(t) = e^{t\mathbf{Q}_l}$$

[1] Jackson, C. H. (2011). Multi-state models for panel data: the msm package for R. Journal of Statistical Software, 38(8), 1-29.

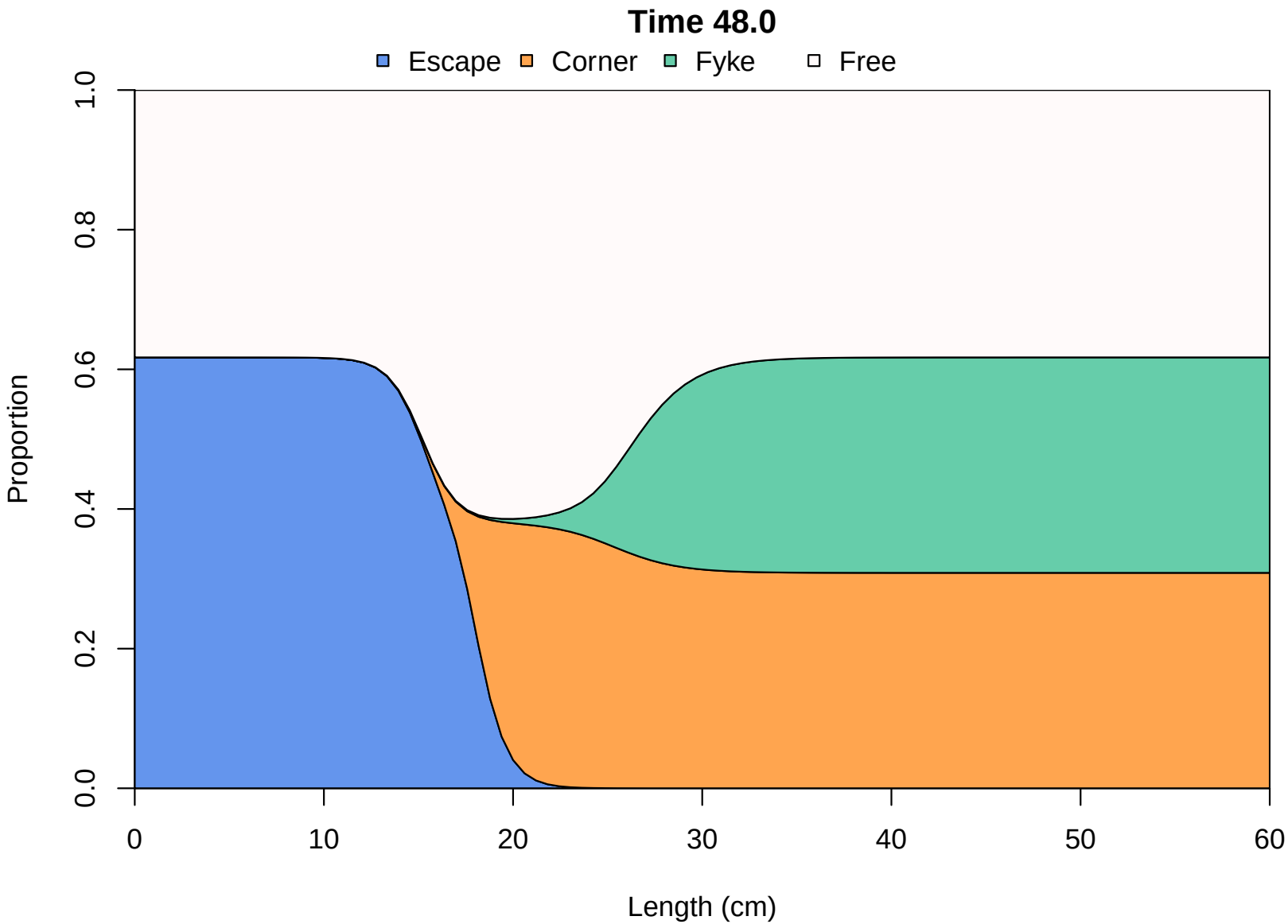
Probability of being in a state at time t

$$\boldsymbol{\pi}_l(t) = \boldsymbol{\pi}_l(0)\mathbf{P}_l(t)$$

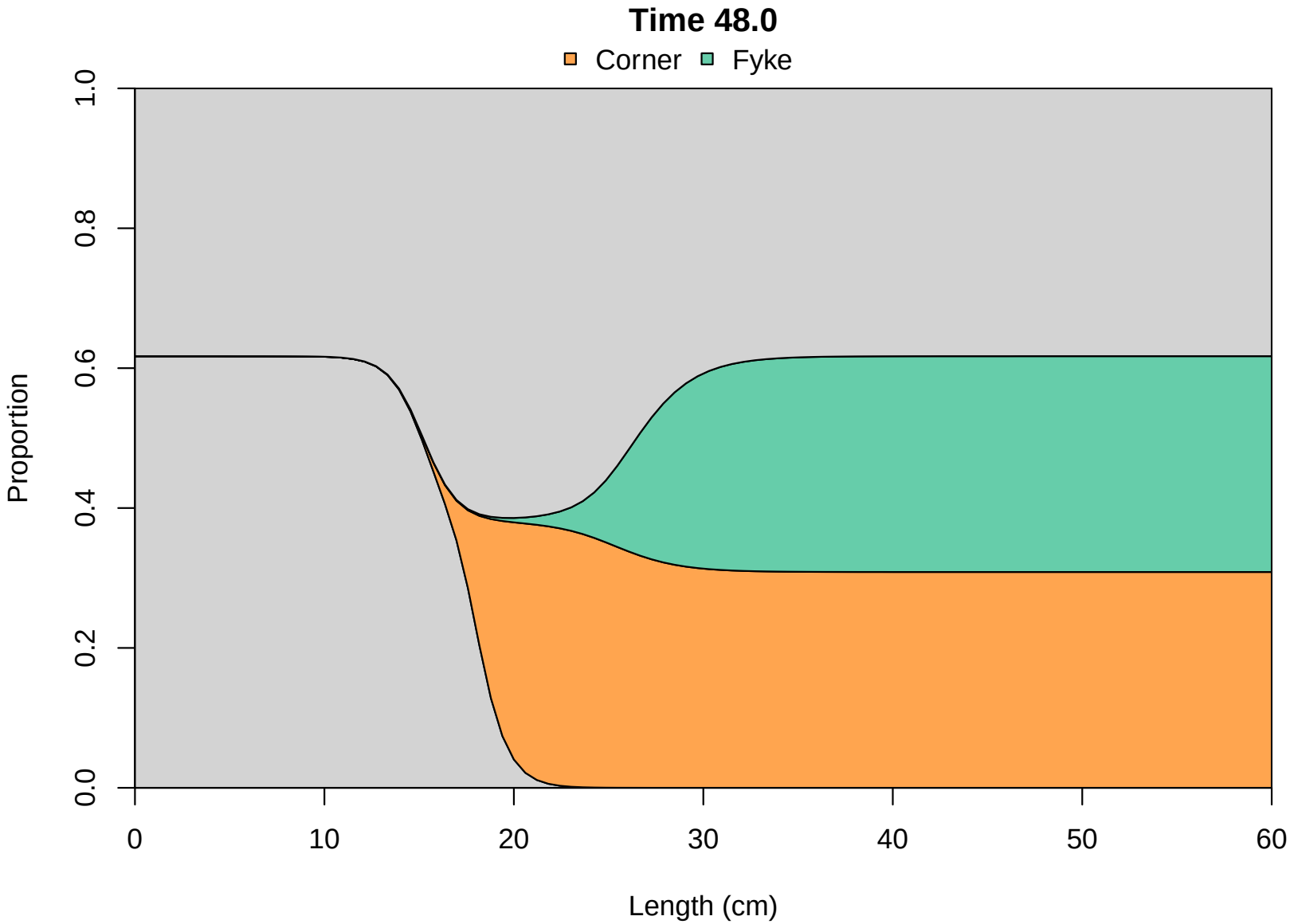
$$\begin{aligned}\boldsymbol{\pi}_l(0) &= [\pi_{0,l}(0), \pi_{f,l}(0), \pi_{c,l}(0), \pi_{e,l}(0)] \\ &= [1, 0, 0, 0]\end{aligned}$$

Switch to visual

Observations



Observations



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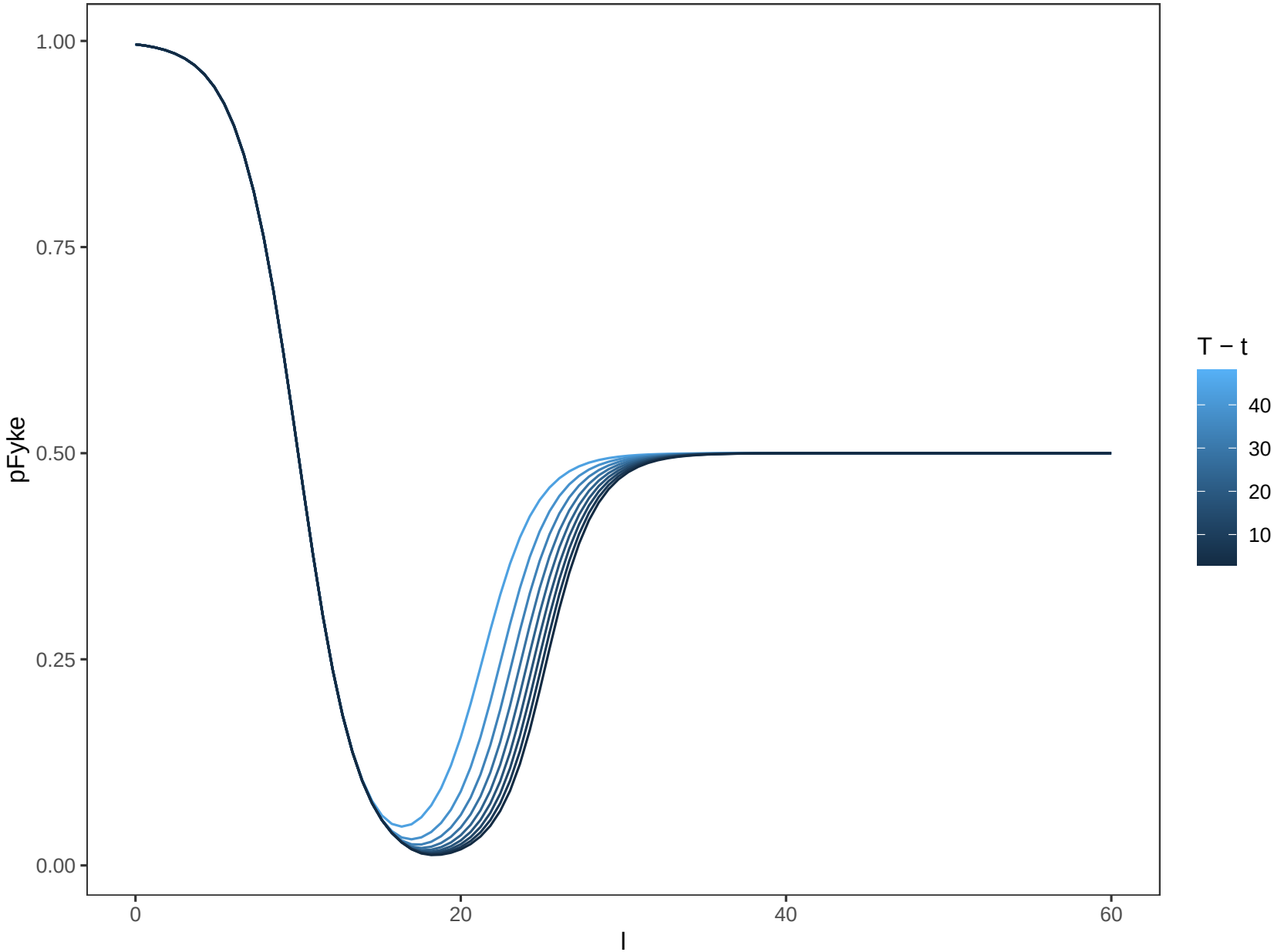

Observations

Expected number of fish in each state at time t

$$\mathbf{n}_l(t) = \mathbf{n}_l(0)\mathbf{P}_l(t)$$

As they all start out free

$$\mathbf{n}_l(0) = [n_{0,l}(0), 0, 0, 0]$$

Proportion of observed fish in the fyke net

$$\phi_l(t) = \frac{n_{f,l}(t)}{n_{f,l}(t) + n_{c,l}(t)} = \frac{\pi_{f,l}(t)}{\pi_{f,l}(t) + \pi_{c,l}(t)}$$

is independent of the total number at length

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Likelihood

Data consist of counts at length in the

- fyke net $(n_{f,l}(T))$
- corner net $(n_{c,l}(T))$

at the end of the experiment $t = T$
Propose a binomial likelihood where for length l

$$L(\boldsymbol{\theta}|n_{f,l}, n_{c,l}, T) = \prod_l \binom{n_{f,l} + n_{c,l}}{n_{f,l}} \phi_l(T)^{n_{f,l}} (1 - \phi_l(T))^{n_{c,l}}$$

At the moment

$$\boldsymbol{\theta} = \{L_{50,c}, L_{50,f}, SR_c, SR_f, p_f, p_c\}$$

with wall parameters fixed
Optimisation using grid of starting values and `nlminb` from highest likelihood currently

Simulation testing

Extensive simulation testing - differences in the gears confers estimability

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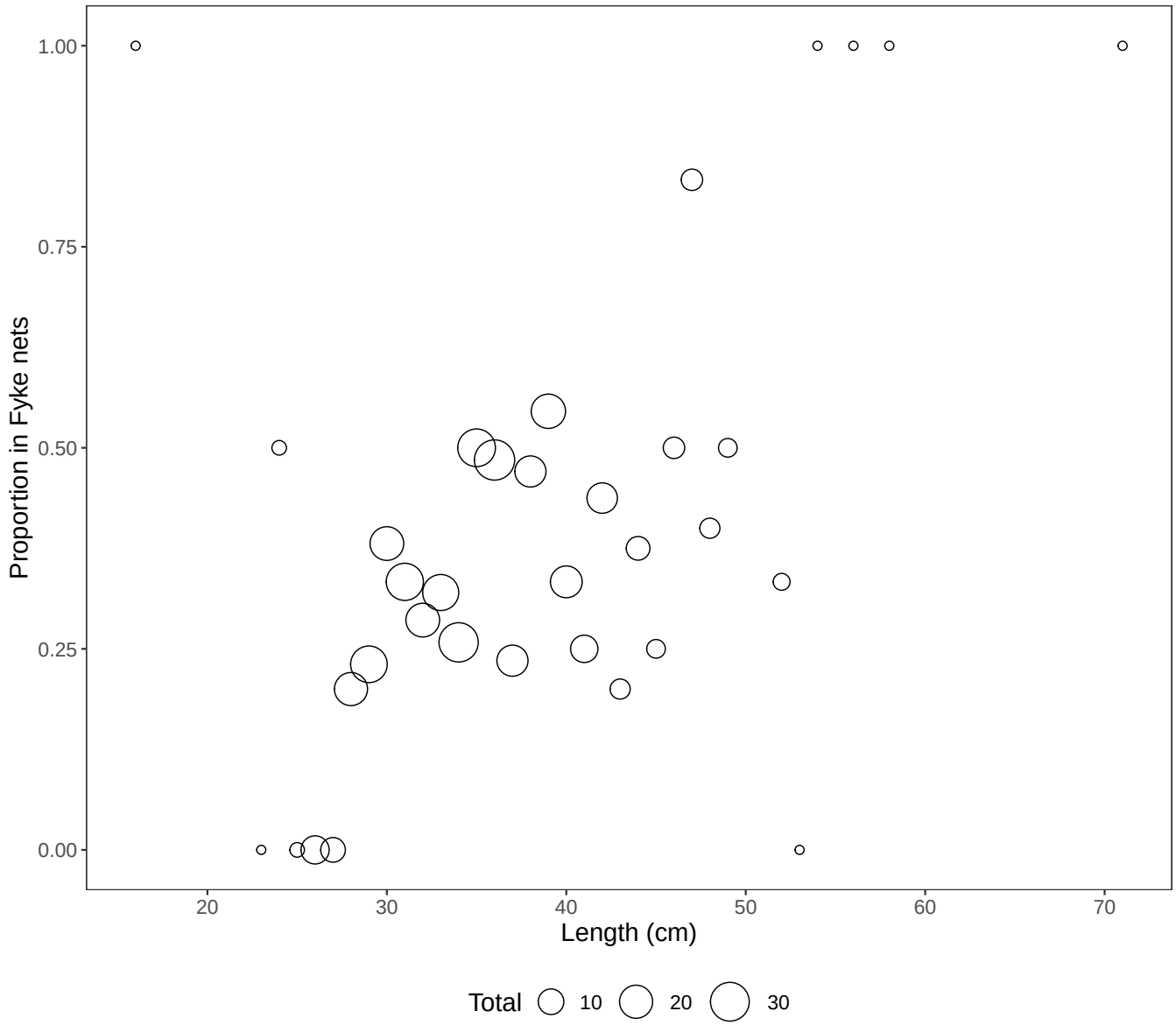
Real data fit



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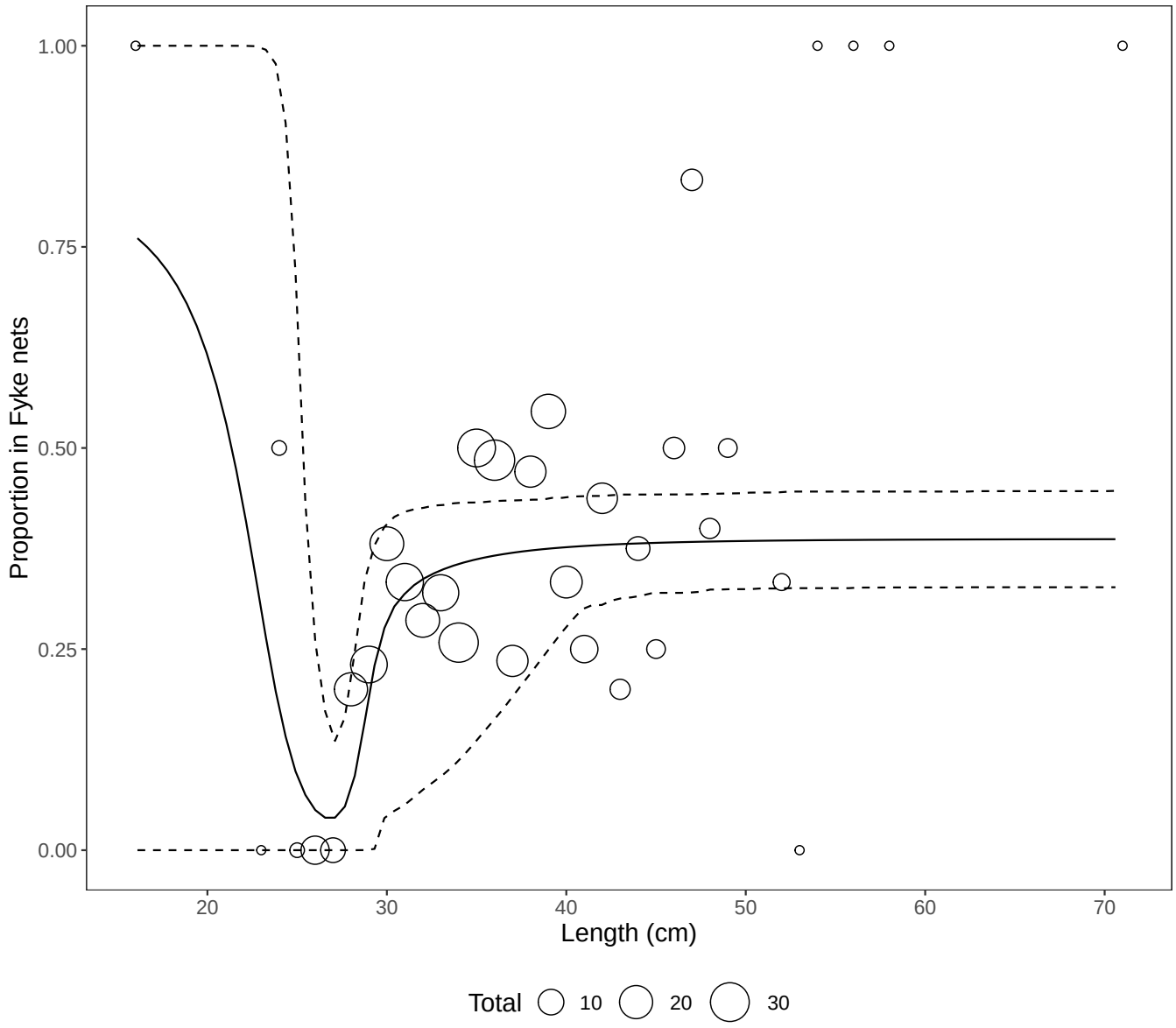
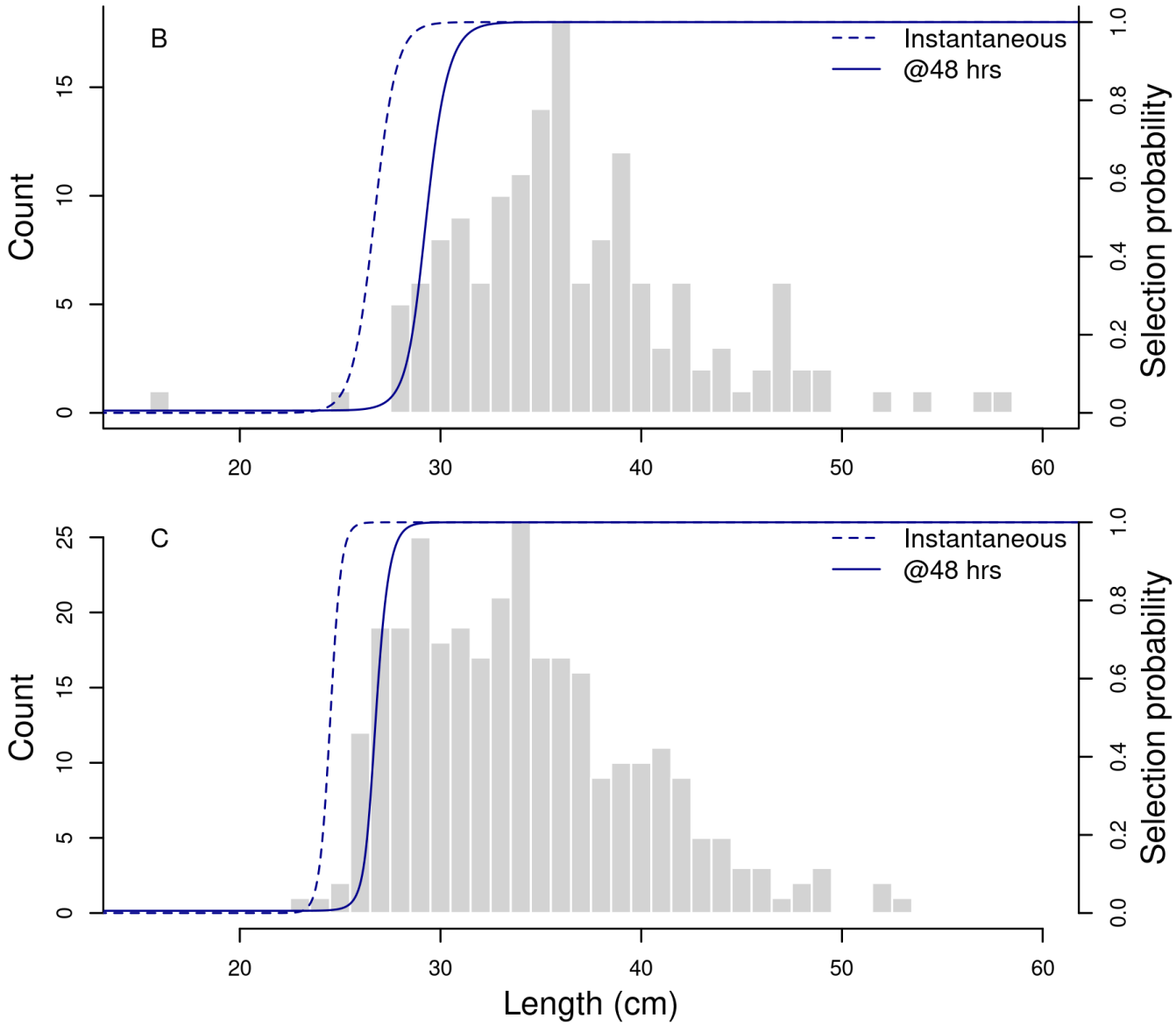


Real data estimated contact selection



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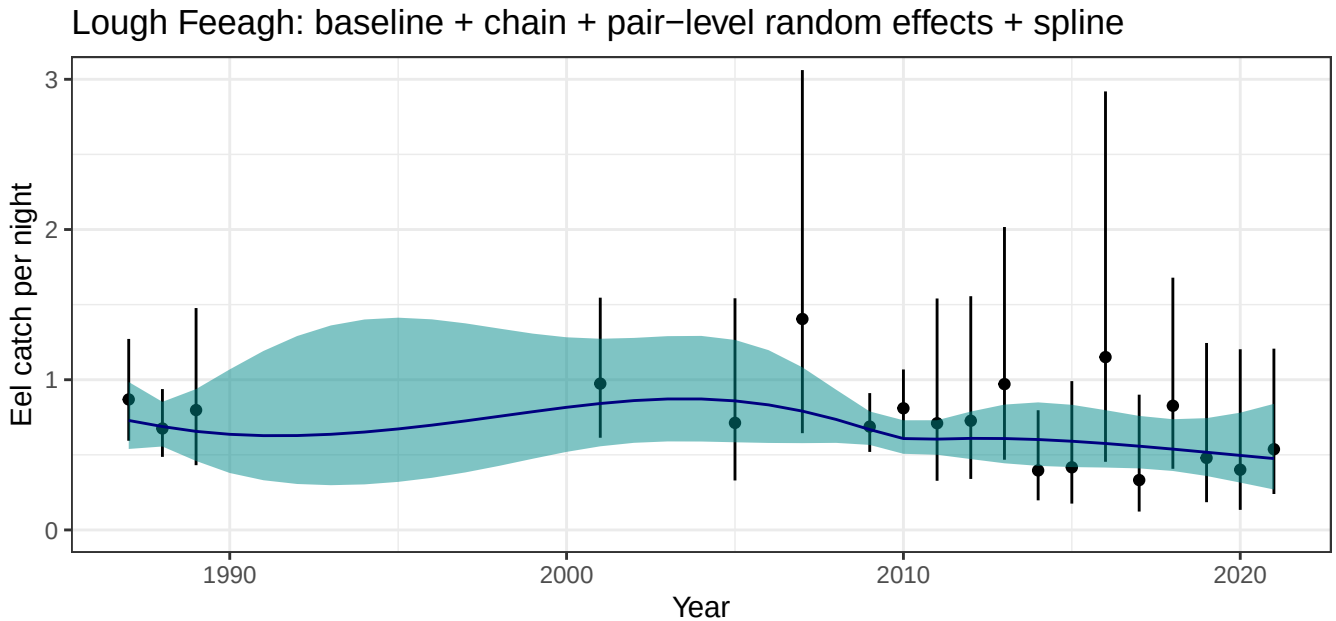
Summary

- Proposed model of system in development (compartments, continuous, transitions, main features)
- Contact probabilities inestimable
- Corner net parameters difficult to estimate
- Estimability of fyke net selection demonstrated
- Real data fits full selection at smaller lengths than previously reported

Further work: toward a production model

Yellow eel survey modelling



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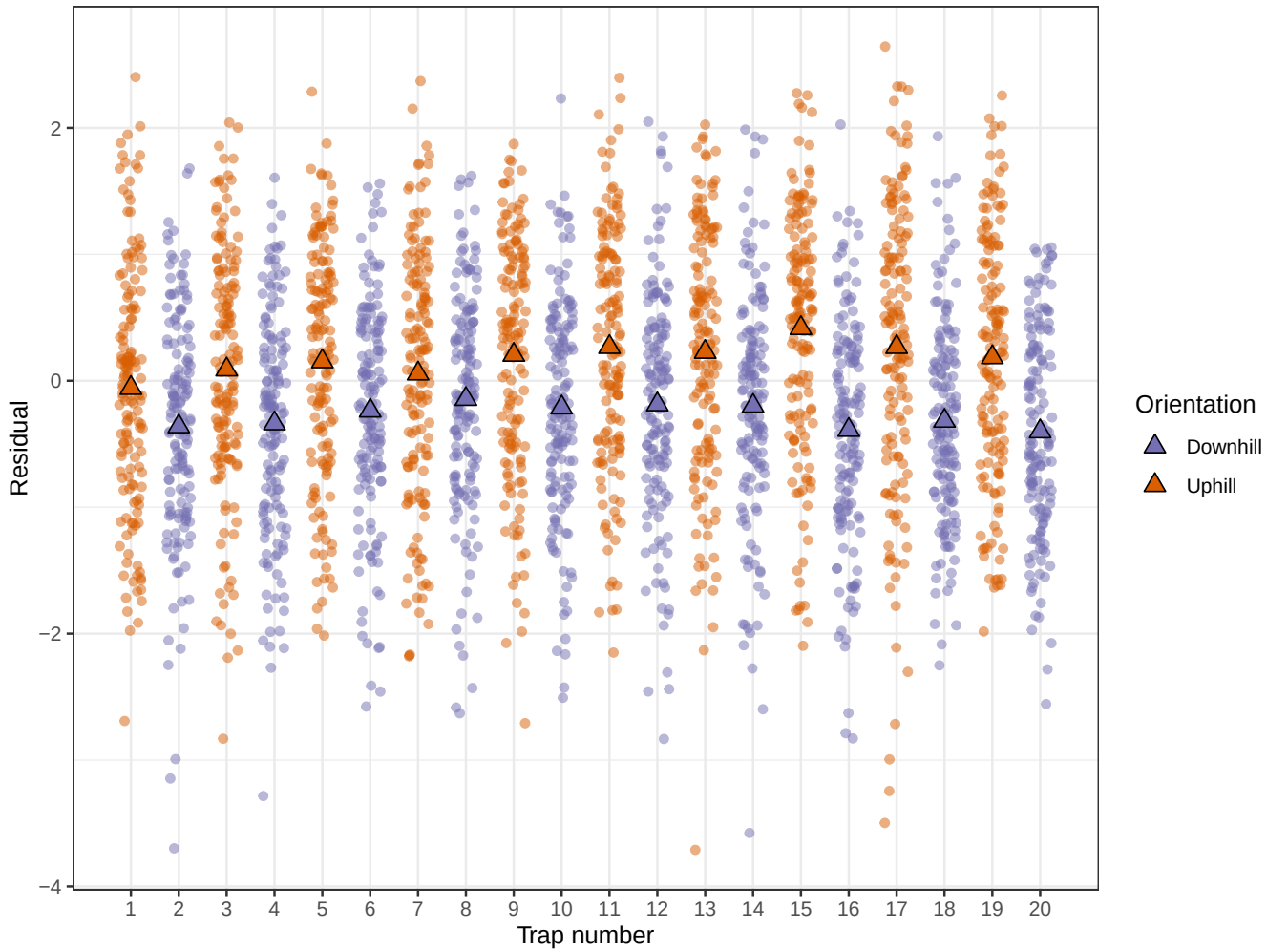

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