The use of technical measures in fisheries management

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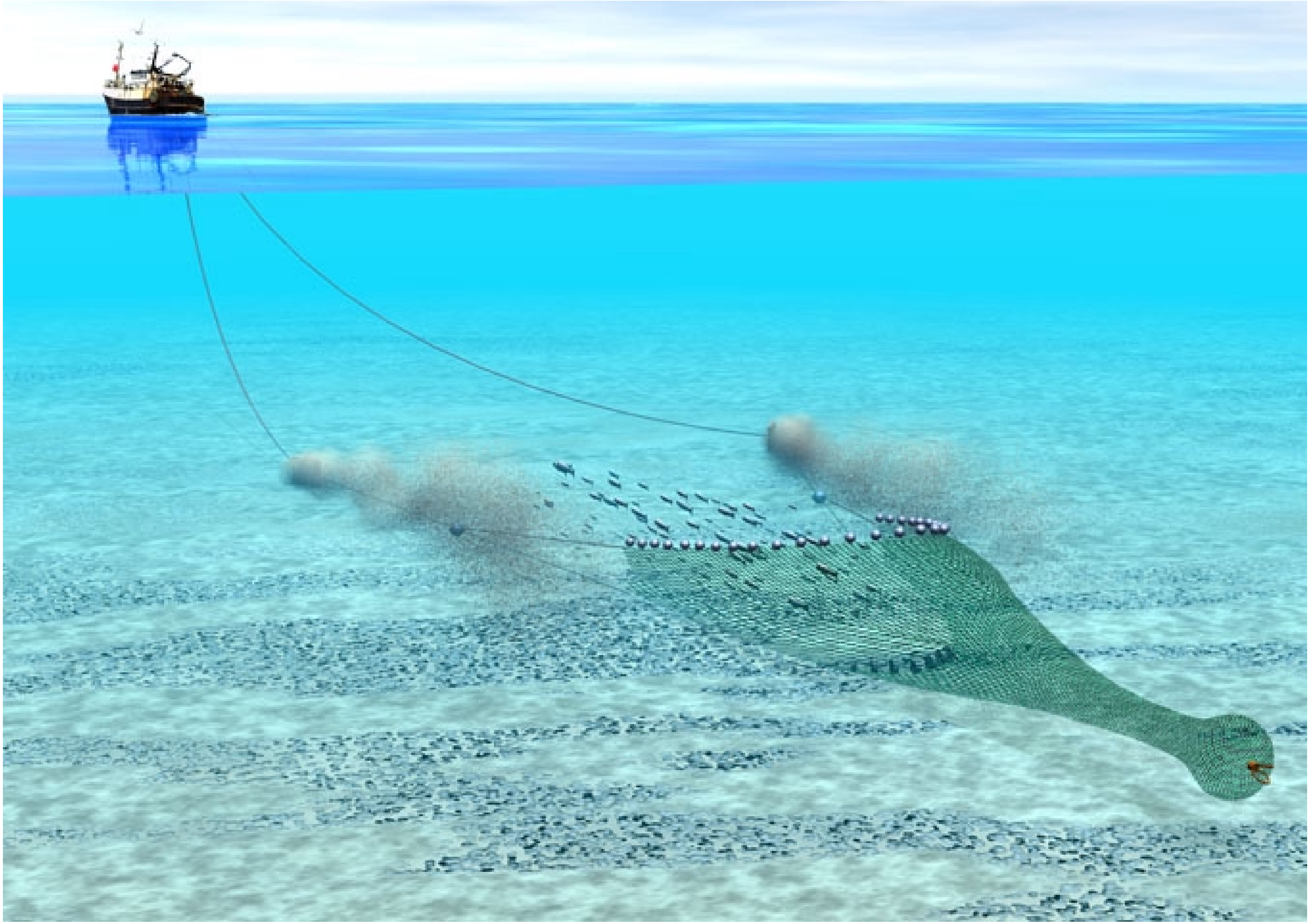
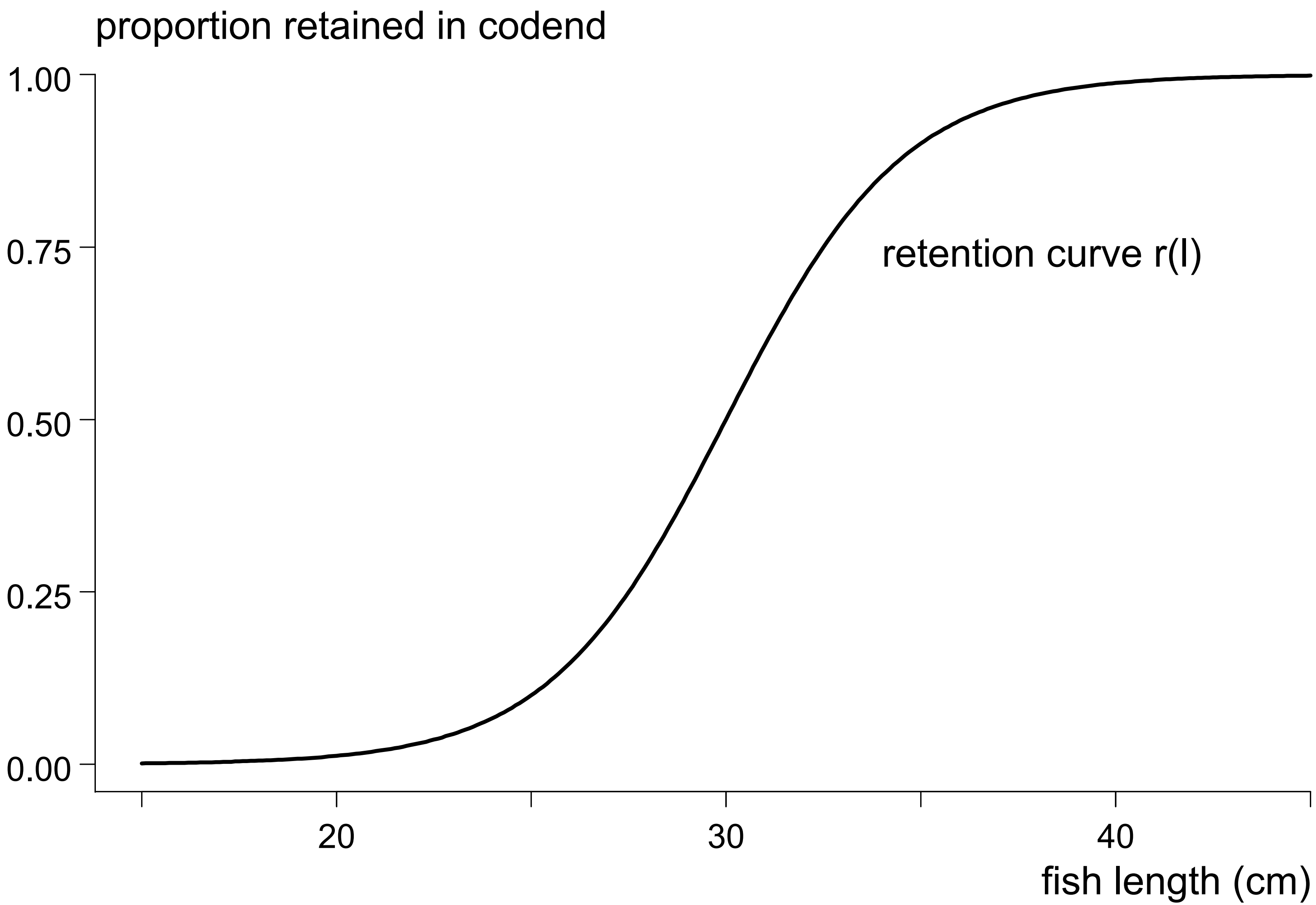
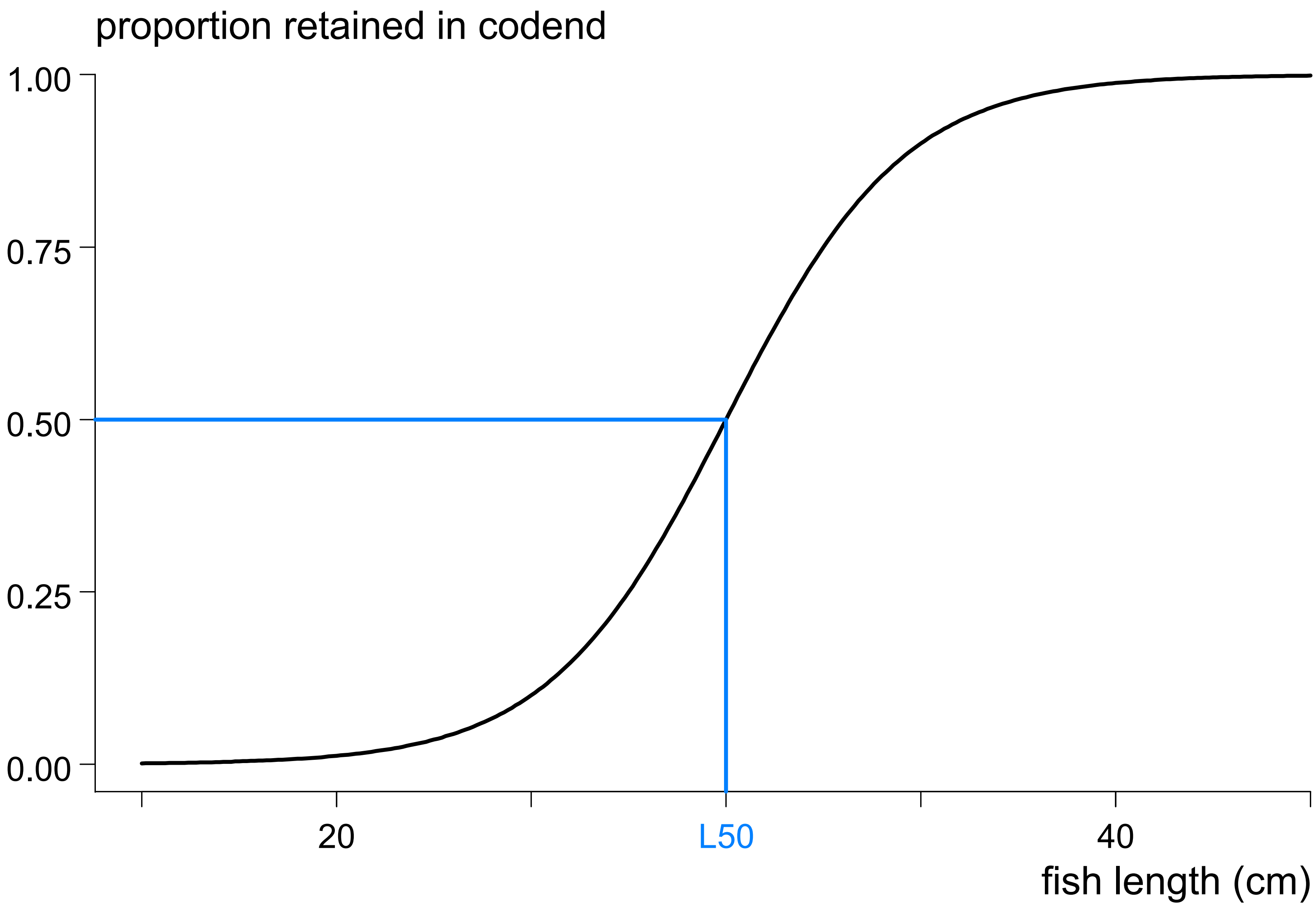
… fishermen … have subtily contrived an instrument … to which is attached a net so close meshed that no fish be it ever so small which enters therein can escape …

… the fishermen take such quantity of small fish that they do not know what to do with them…

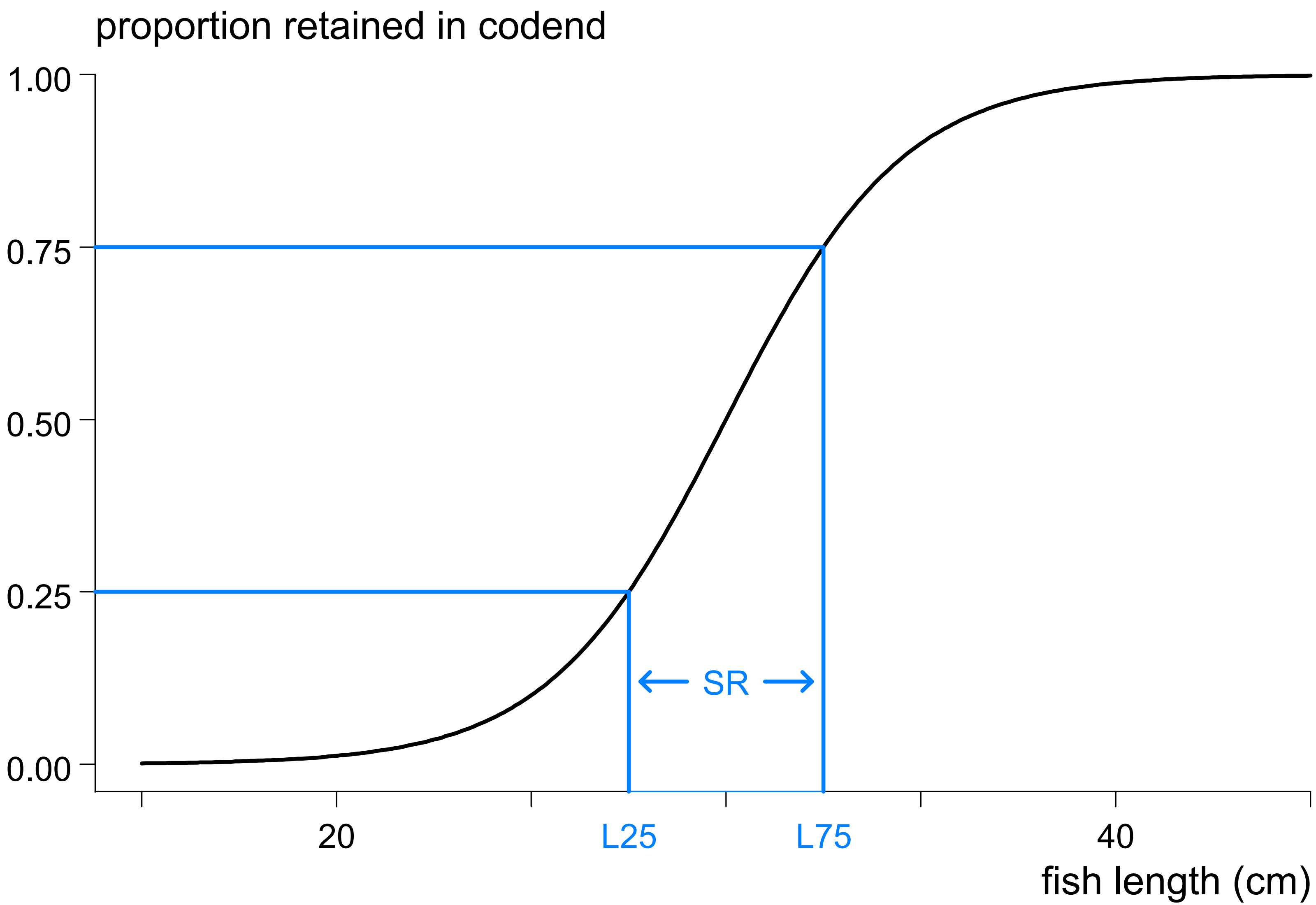
Petition of parliament to Edward III 1376



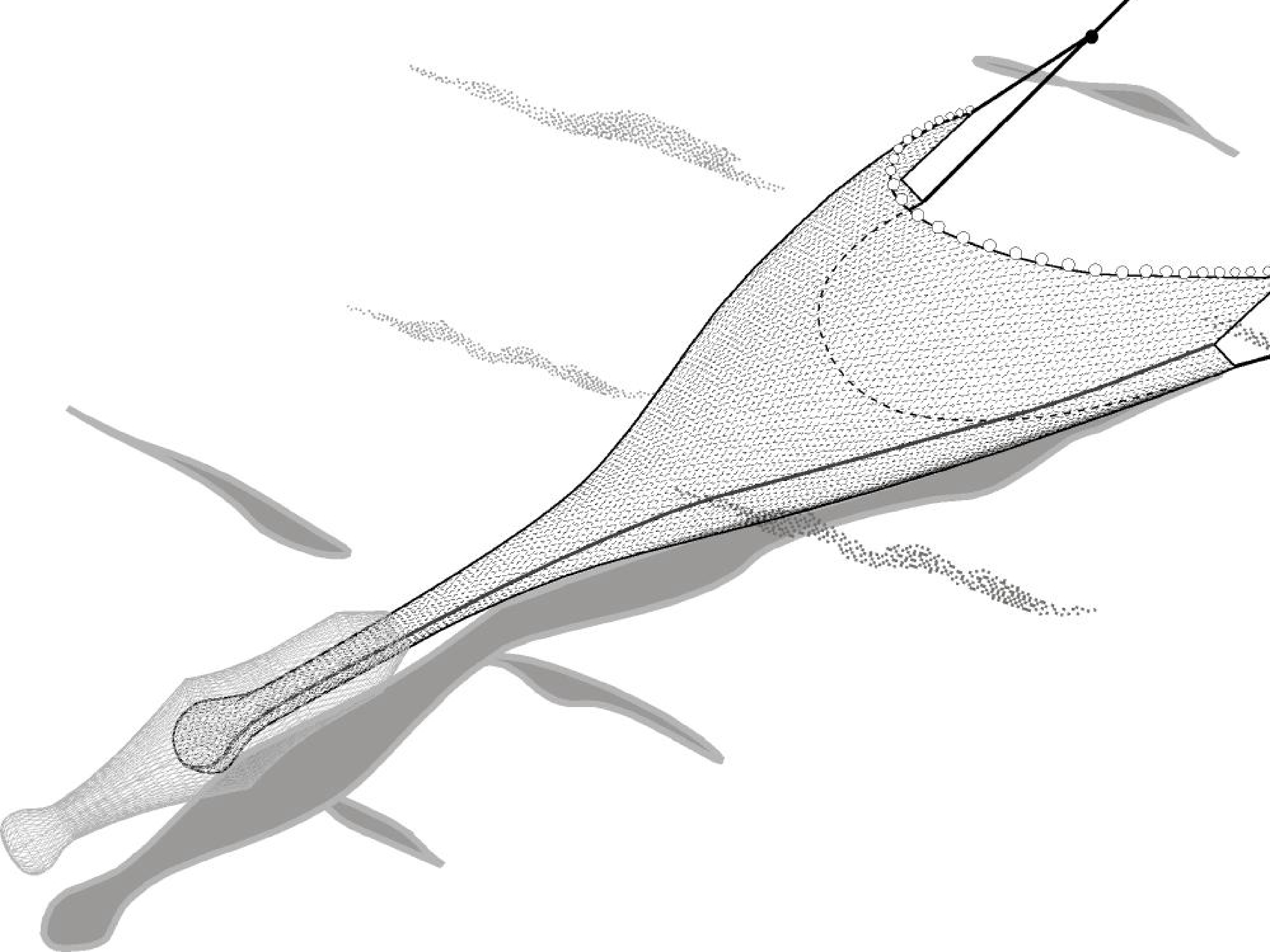

proportion retained in codend
1.00
0.75
0.50
0.25
0.00
retention curve r(l)
20
30
40
fish length (cm)



proportion retained in codend
1.00
0.75
0.50
0.25
0.00
20
L50
40
fish length (cm)



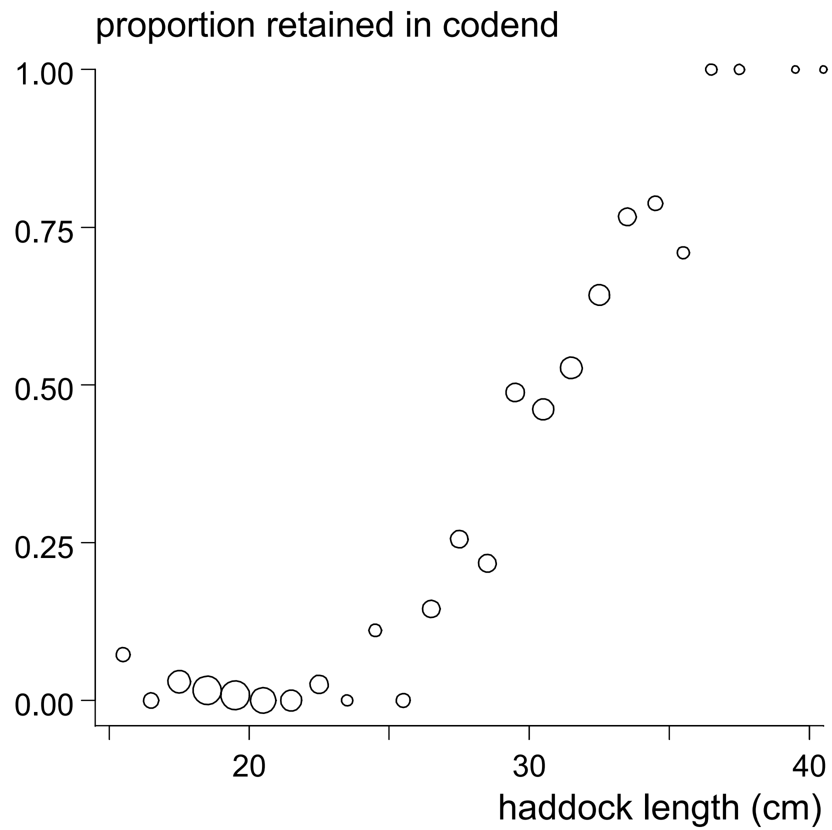
proportion retained in codend
1.00
0.75
0.50
0.25
0.00
SR
20
L25
L75
40
fish length (cm)



y_{1l} = # length l fish in codend

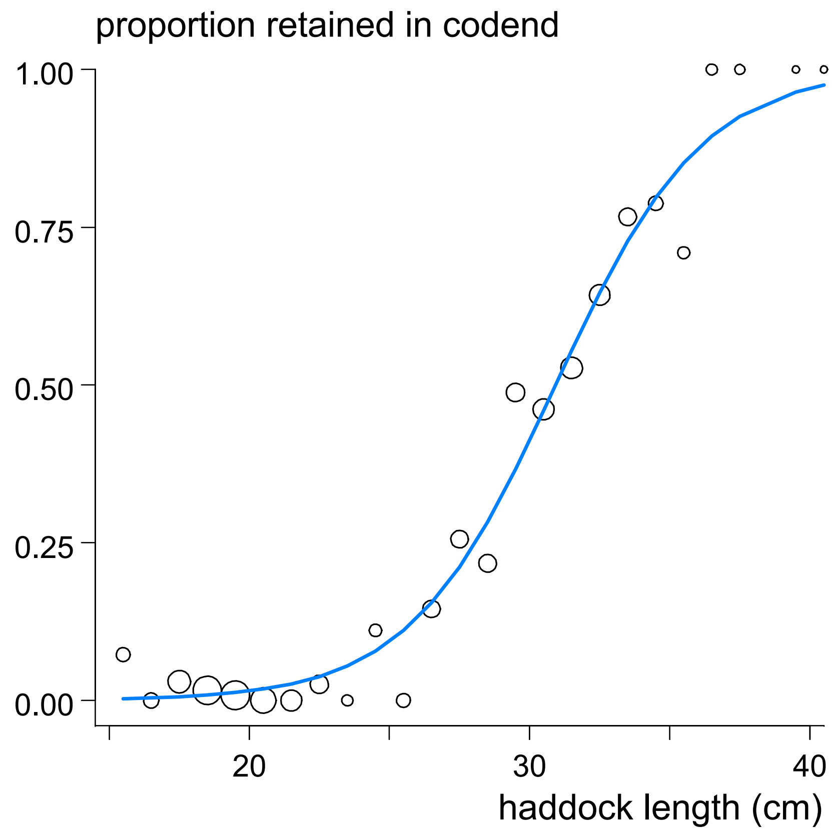
y_{2l} = # length l fish in cover

$$y_{1l} \sim \mathrm{Bi}(\, y_{1l} + y_{2l} \,, r(l)\,)$$



logistic selection

$$r(l) = \frac{\exp(\alpha + \beta l)}{1 + \exp(\alpha + \beta l)}$$

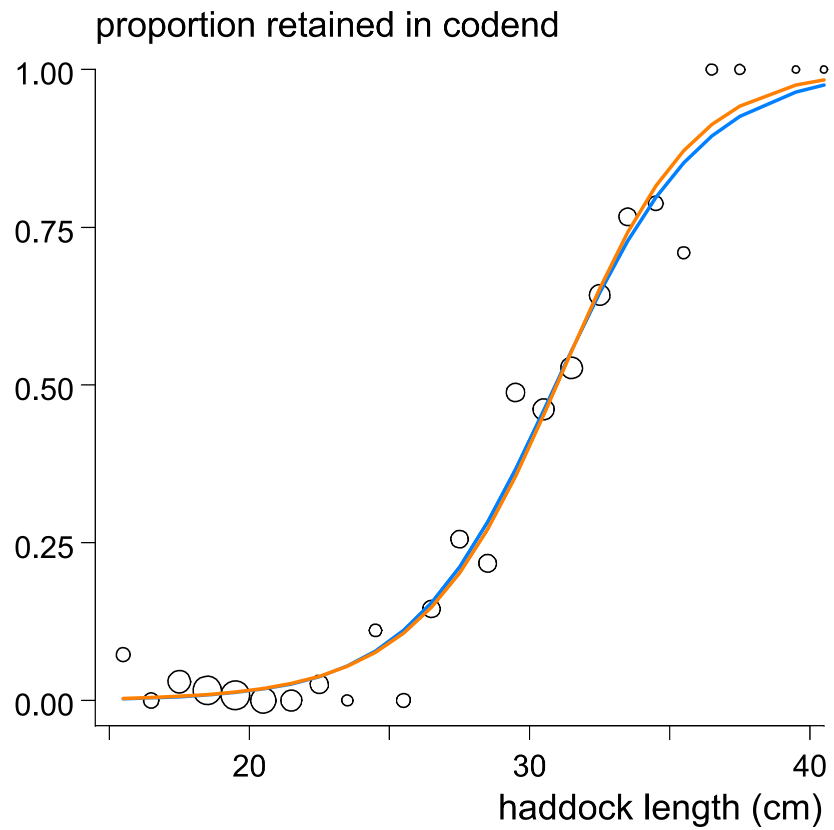


logistic selection

$$r(l) = \frac{\exp(\alpha + \beta l)}{1 + \exp(\alpha + \beta l)}$$

Richards selection

$$r(l) = \left(\frac{\exp(\alpha + \beta l)}{1 + \exp(\alpha + \beta l)} \right)^{1/\delta}$$



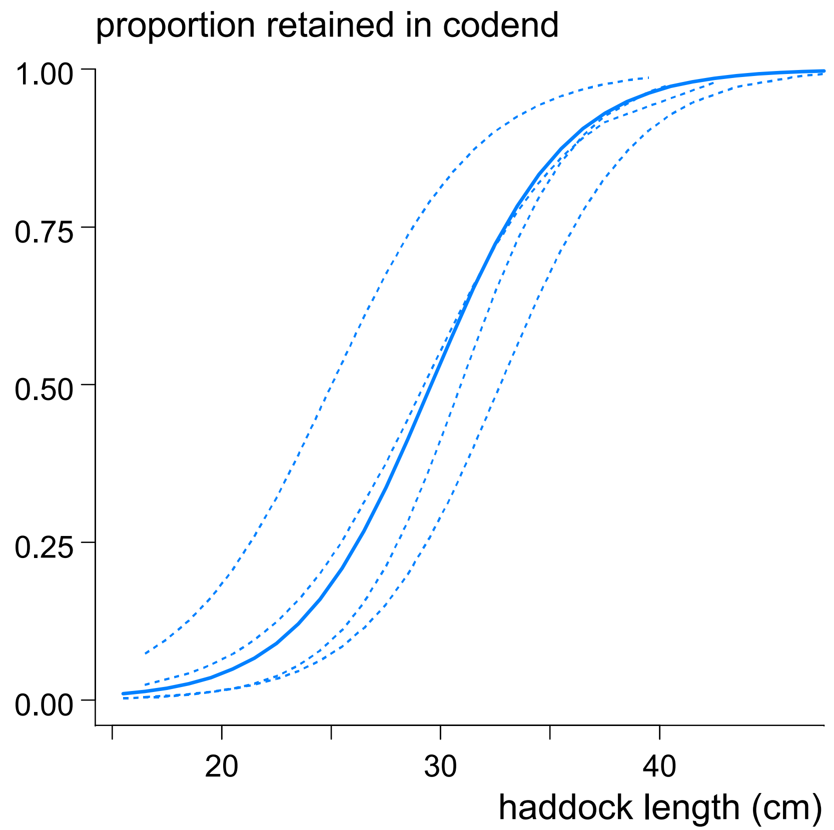
$$y_{h1l} \sim \mathrm{Bi}(y_{h1l} + y_{h2l}, r_h(l))$$

$$r_h(l) = \frac{\exp(\alpha_h + \beta_h l)}{1 + \exp(\alpha_h + \beta_h l)}$$

$$\nu_h = (\alpha_h, \beta_h)'$$

Assume $\nu_h \sim \mathrm{N}(\theta, D)$

Estimate θ and D using generalised linear mixed modelling routines



Haul h: selection parameters ν_h

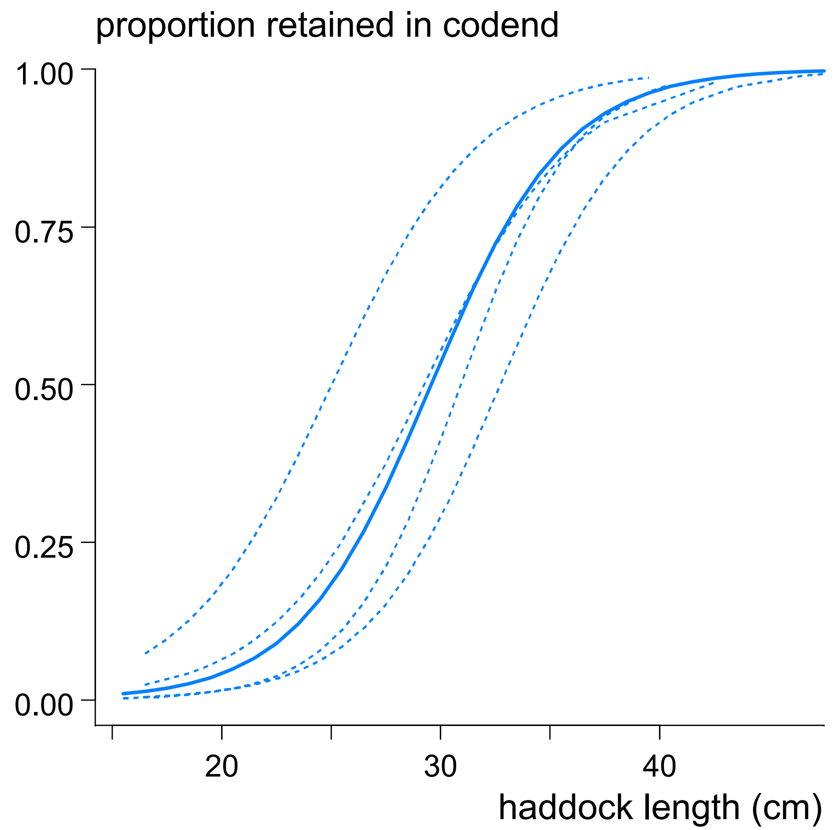
Obtain $\hat{\nu}_h$ and $R_h = \mathrm{Var}[\hat{\nu}_h]$

$$\hat{\nu}_h \sim \mathrm{N}(\nu_h, R_h)$$

Assume $\nu_h \sim \mathrm{N}(\theta, D)$

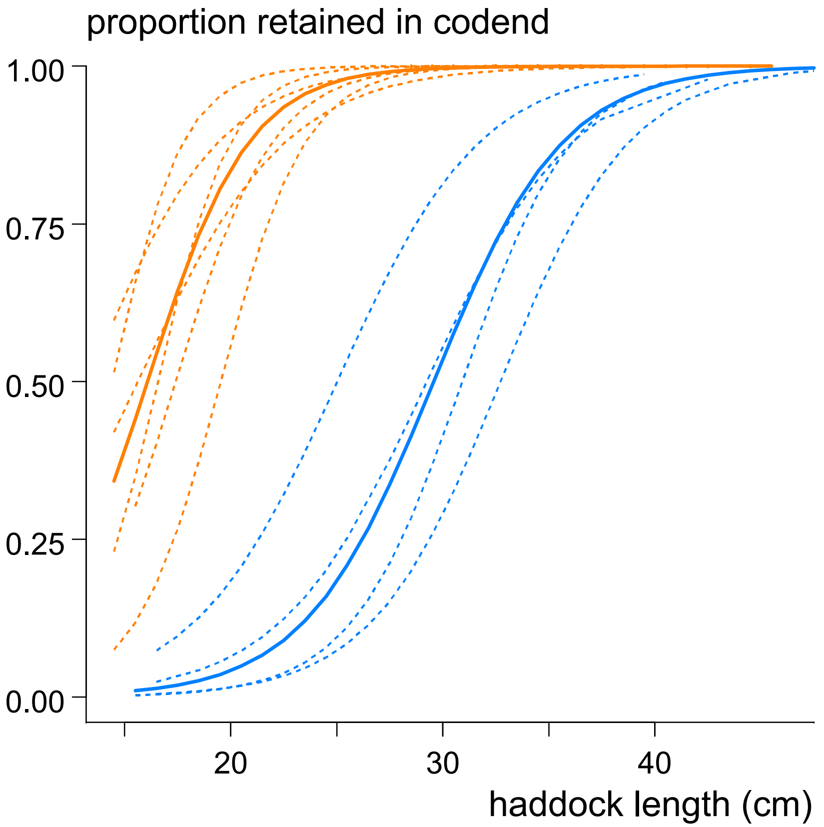
$$\hat{\nu}_h \sim \mathrm{N}(\theta, D + R_h)$$

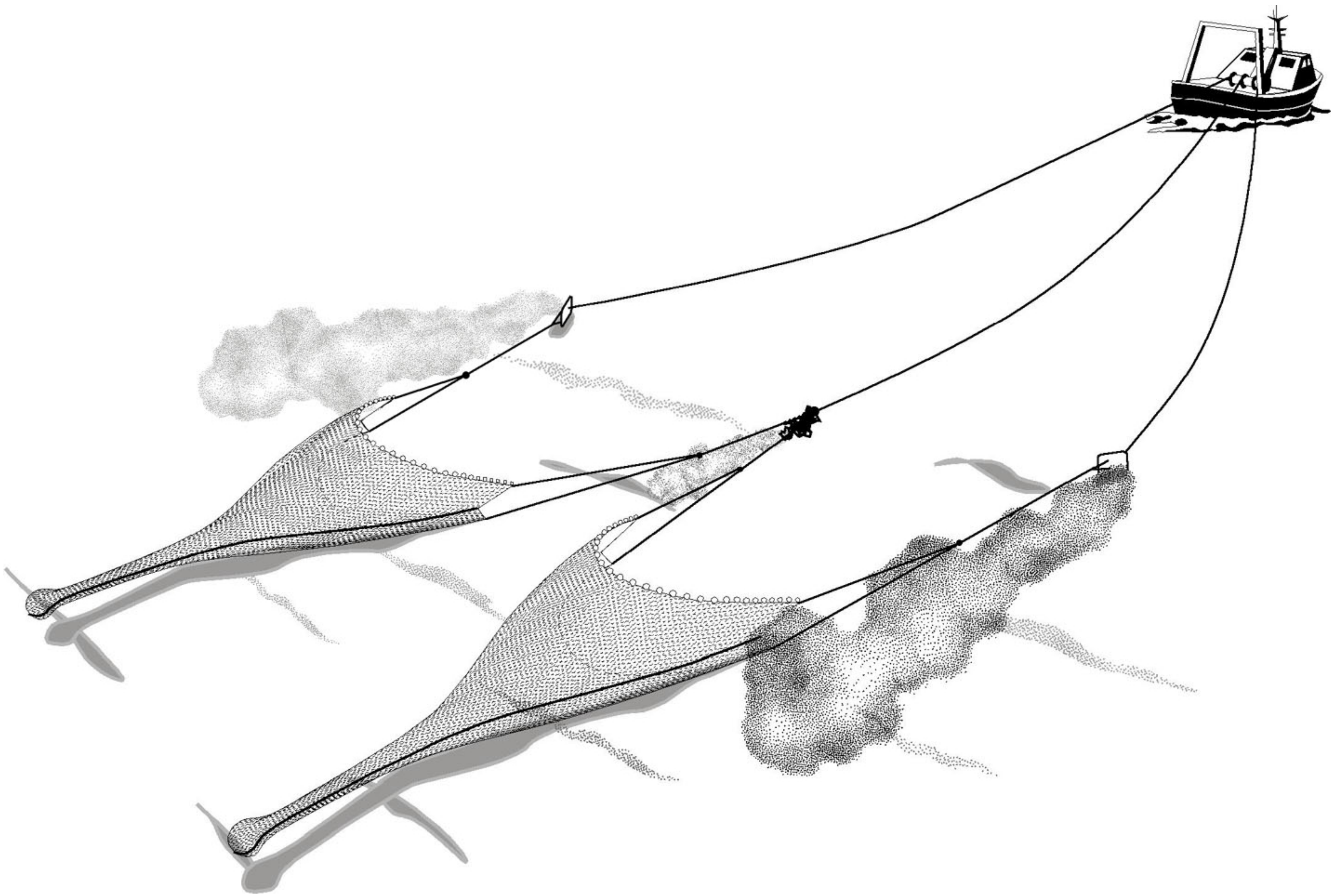
Estimate θ and D by REML



Fixed effects

$$\hat{\nu}_h \sim \mathrm{N}(X_h\theta, D + R_h)$$





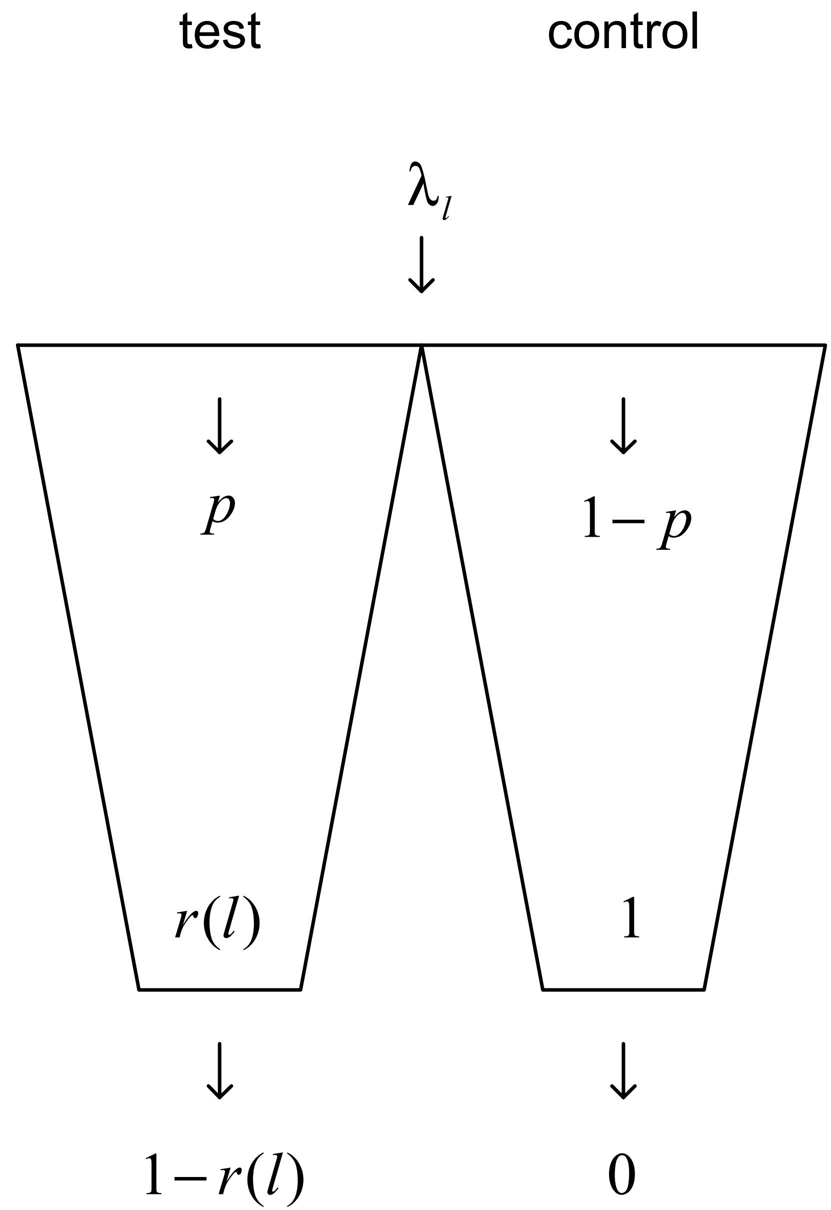
$$y_{1l} = \#\text{length } l \text{ fish in test net}$$
$$\sim \text{Po}(p\lambda_l r(l))$$

$$y_{2l} = \#\text{length } l \text{ fish in control net}$$
$$\sim \text{Po}((1-p)\lambda_l)$$

$$y_{1l} \sim \text{Bi}(y_{1l} + y_{2l}, \phi(l))$$

$$\phi(l) = \frac{p\lambda_l r(l)}{p\lambda_l r(l) + (1-p)\lambda_l}$$
$$= \frac{pr(l)}{pr(l) + 1 - p}$$

$$\text{logit}(\phi(l)) = \text{logit}(p) + \log(r(l))$$



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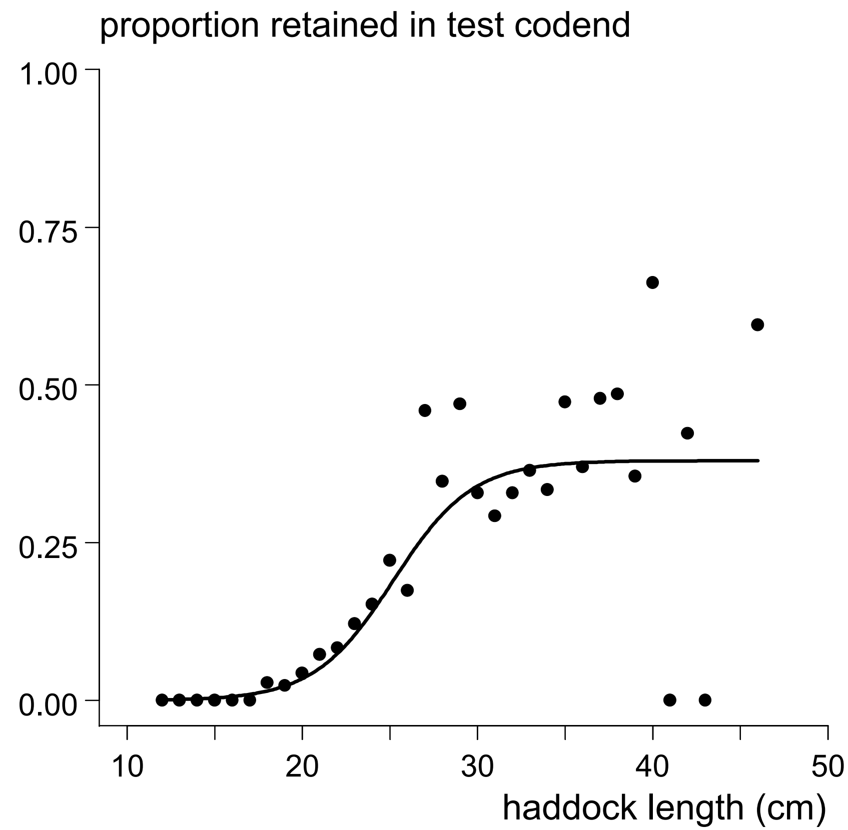


$$\nu_h = \left(\alpha_h, \beta_h, z_h = \text{logit}(p_h)\right)'$$

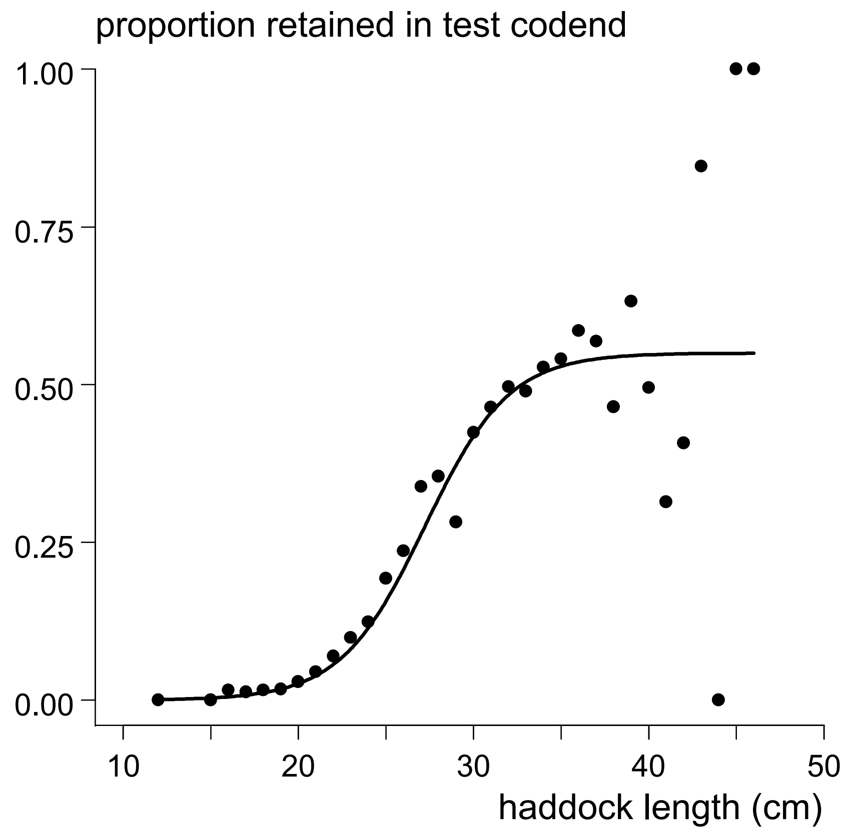
Obtain $\hat{\nu}_h$ and $R_h = \text{Var}[\hat{\nu}_h]$

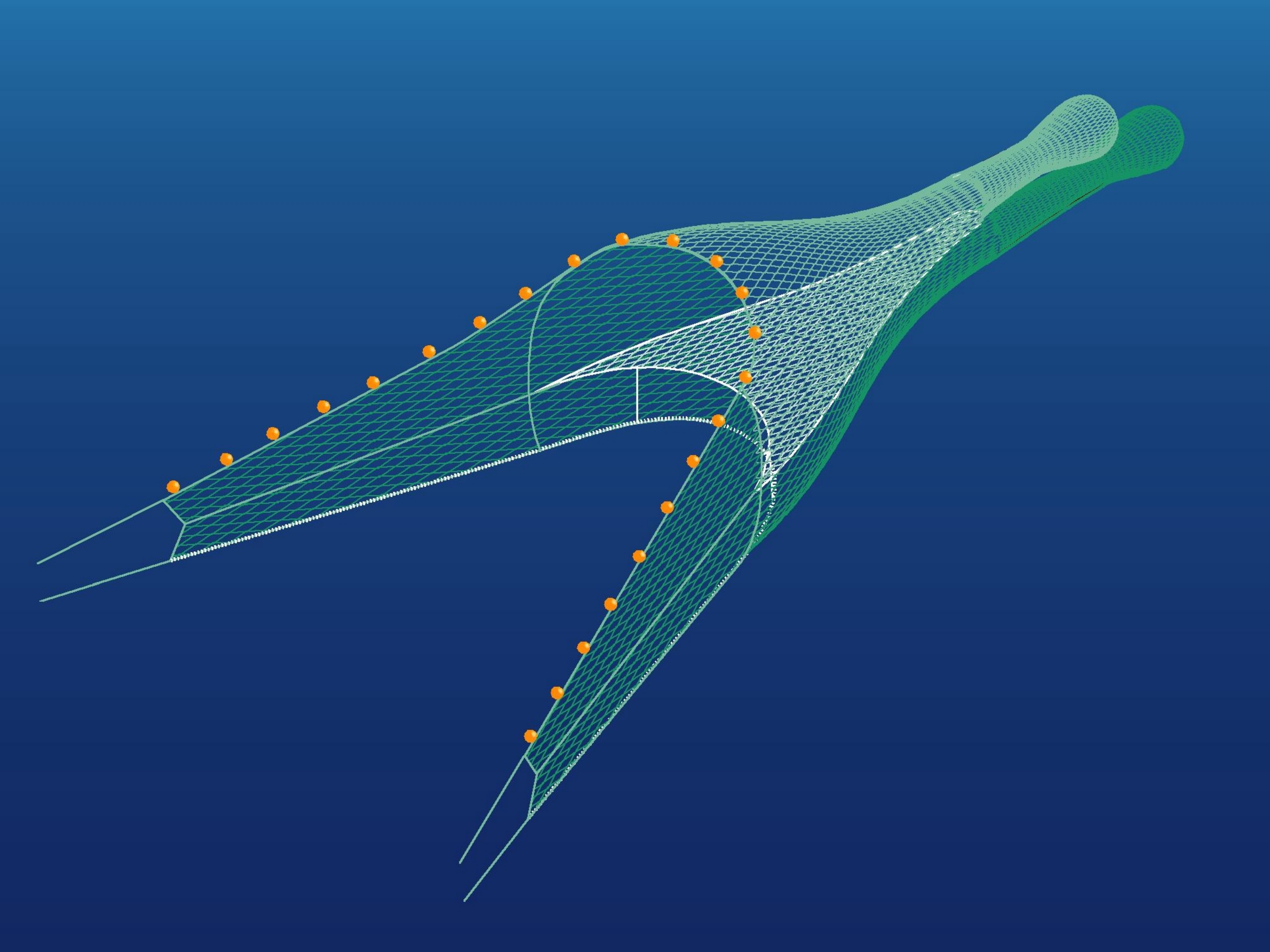
$$\hat{\nu}_h \sim \text{N}(\nu_h, R_h)$$

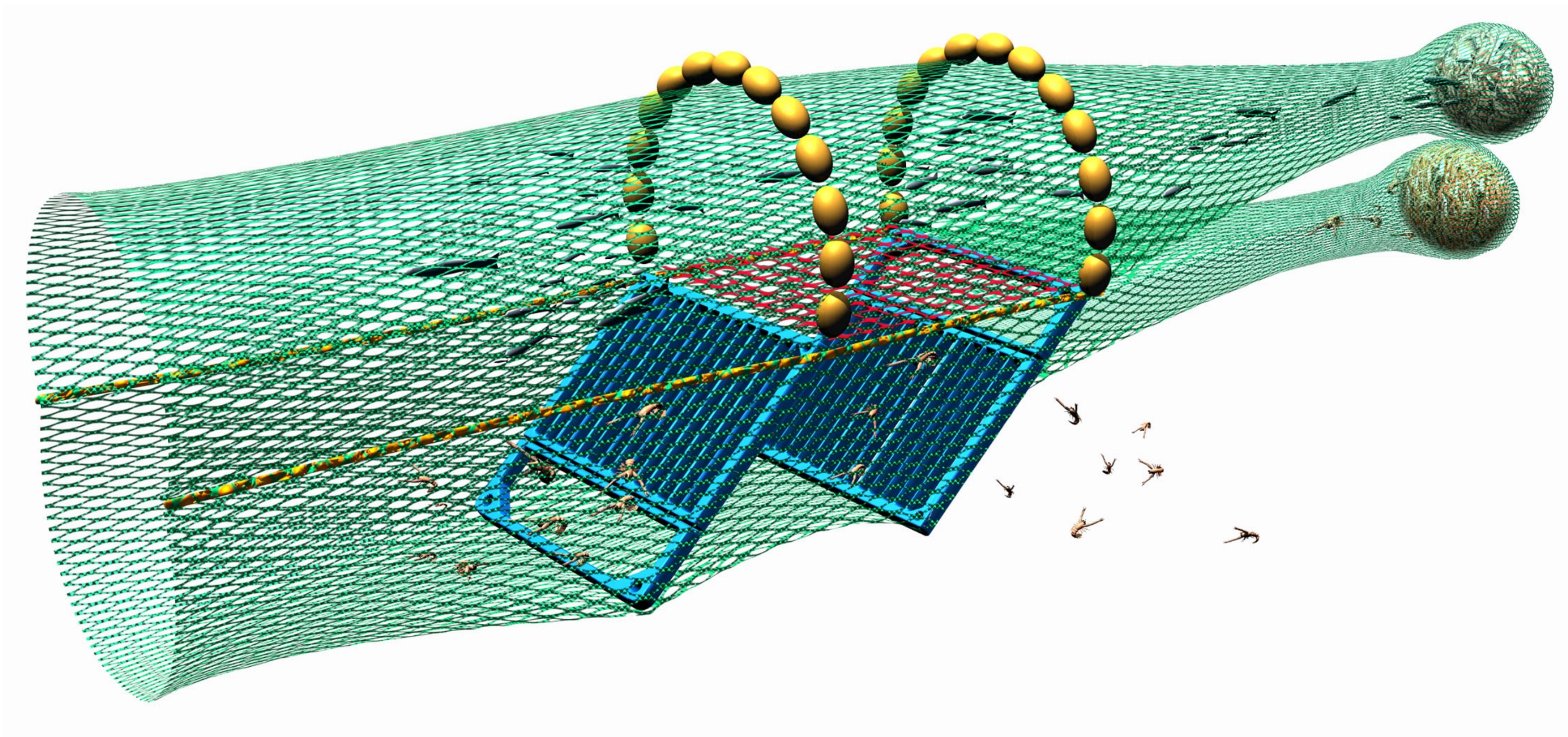
Assume $\nu_h \sim \text{N}(\theta, D)$

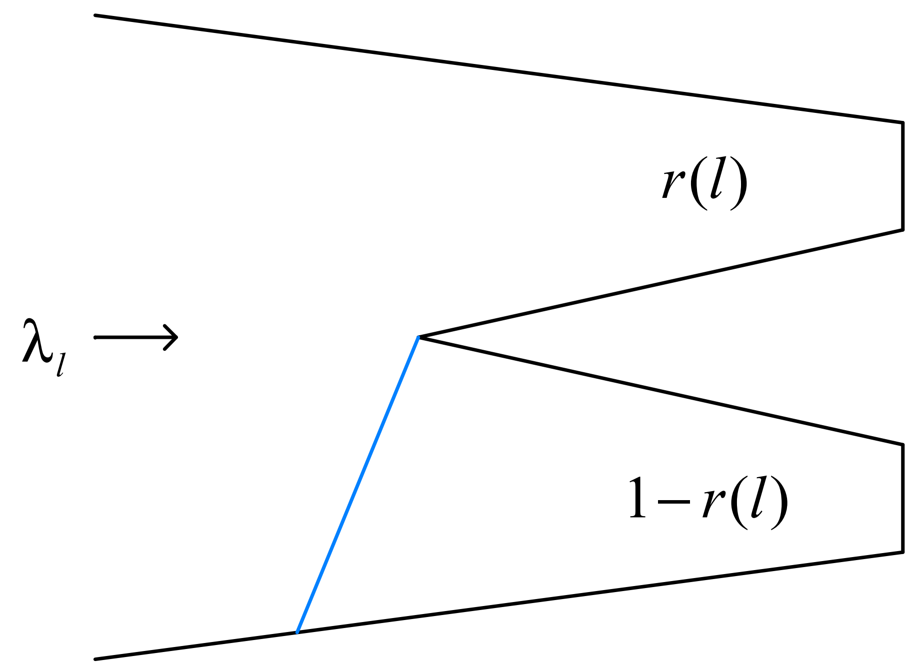
$$\hat{\nu}_h \sim \text{N}(\theta, D + R_h)$$

Estimate θ and D by REML







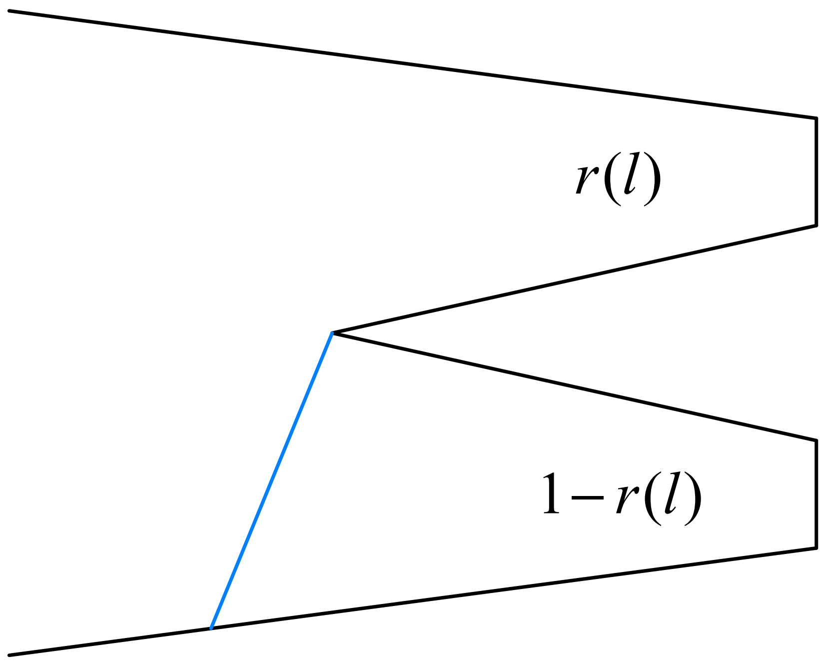


λ_l
$r(l)$
$1-r(l)$

$y_{1l} = \#\,\text{length } l \text{ fish in upper net}$

$y_{2l} = \#\,\text{length } l \text{ fish in lower net}$

$y_{1l} \sim \text{Bi}(y_{1l} + y_{2l}, r(l))$

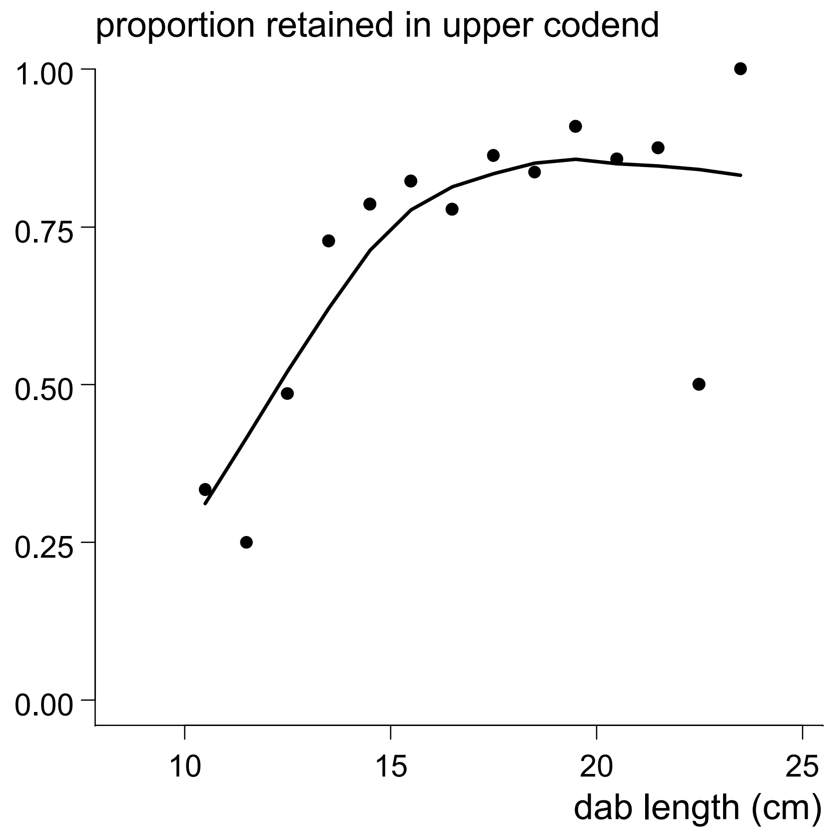


$y_{1l} = \#\,\text{length } l \text{ fish in upper net}$

$y_{2l} = \#\,\text{length } l \text{ fish in lower net}$

$$y_{1l} \sim \text{Bi}(y_{1l} + y_{2l}, r(l))$$

$$\text{logit}(r(l)) = s(l)$$



$$\nu_h = \left(s_h(1), s_h(2) \ldots\ s_h(L)\right)'$$

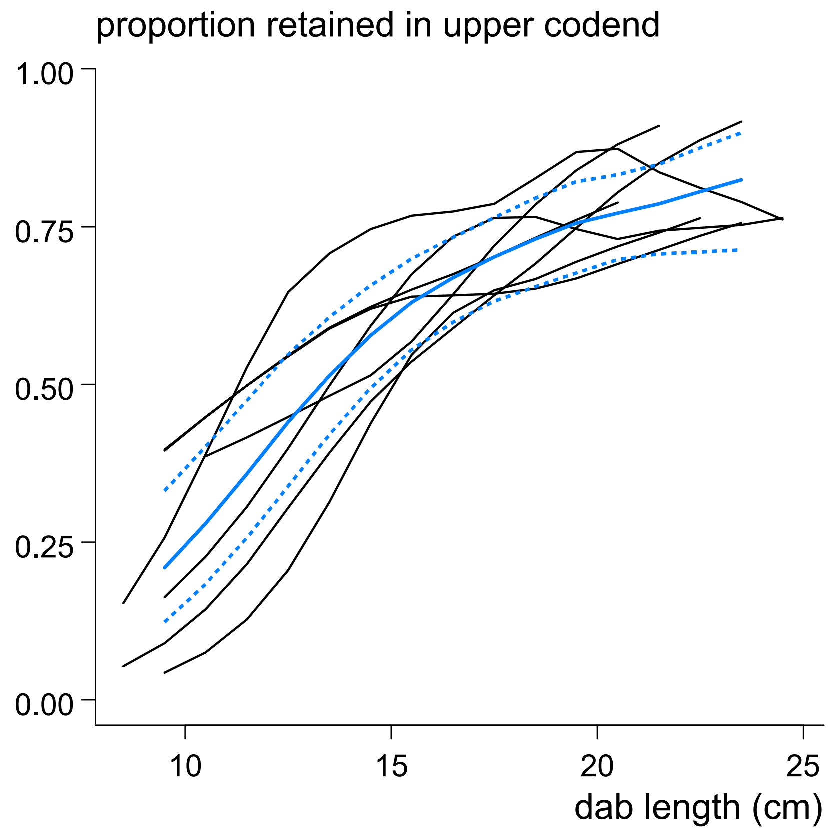
Obtain $\hat{\nu}_h$ and $R_h = \text{Var}[\hat{\nu}_h]$

$$\hat{\nu}_h \sim \text{N}(\nu_h, R_h)$$

Assume $\nu_h \sim \text{N}(\theta, D)$

$$\hat{\nu}_h \sim \text{N}(\theta, D + R_h)$$

Estimate θ_l and D_{ll} by REML, one length class at a time



What effect will a technical measure have on a fish population and and the fishery?

Take current estimates of fishing mortality at age and adjust
to account for changes in selection.

Project fish population and fishery forward in time.

Short term loss in yield.

Medium term gain in yield and stock biomass.