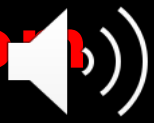
Receiver Operating Characteristic (ROC) Curves

Statistics for proteomics

William E Fondrie

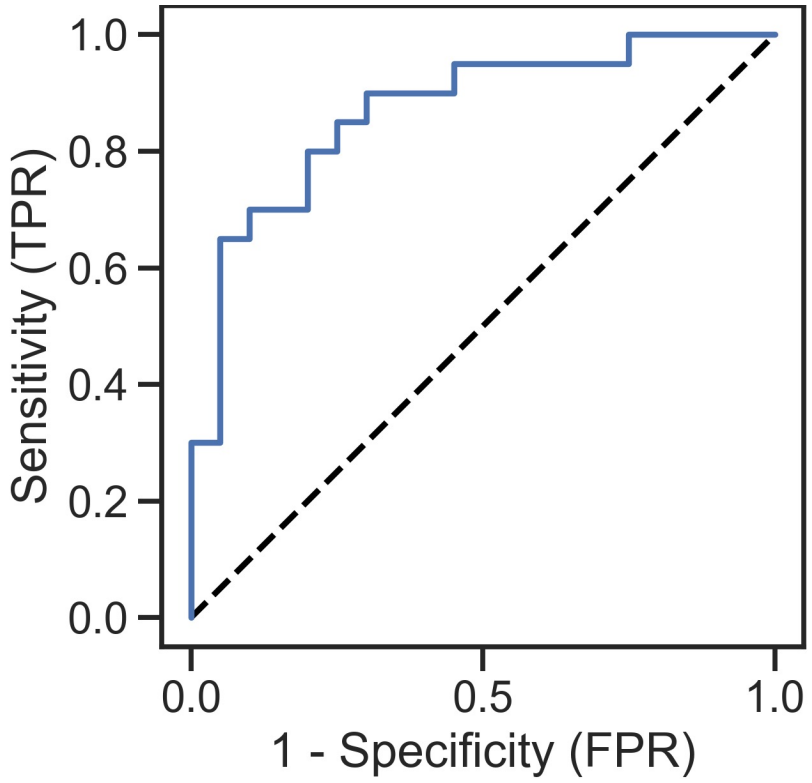
University of Washington

https://willfondrie.com



What are receiver operating characteristic (ROC) curves?

- First used in WWII for the analysis of radio signals
- Assess performance at a binary classification task:
  - Does this patient have this disease?
  - Is this tissue cancerous?
  - Do these two proteins interact?

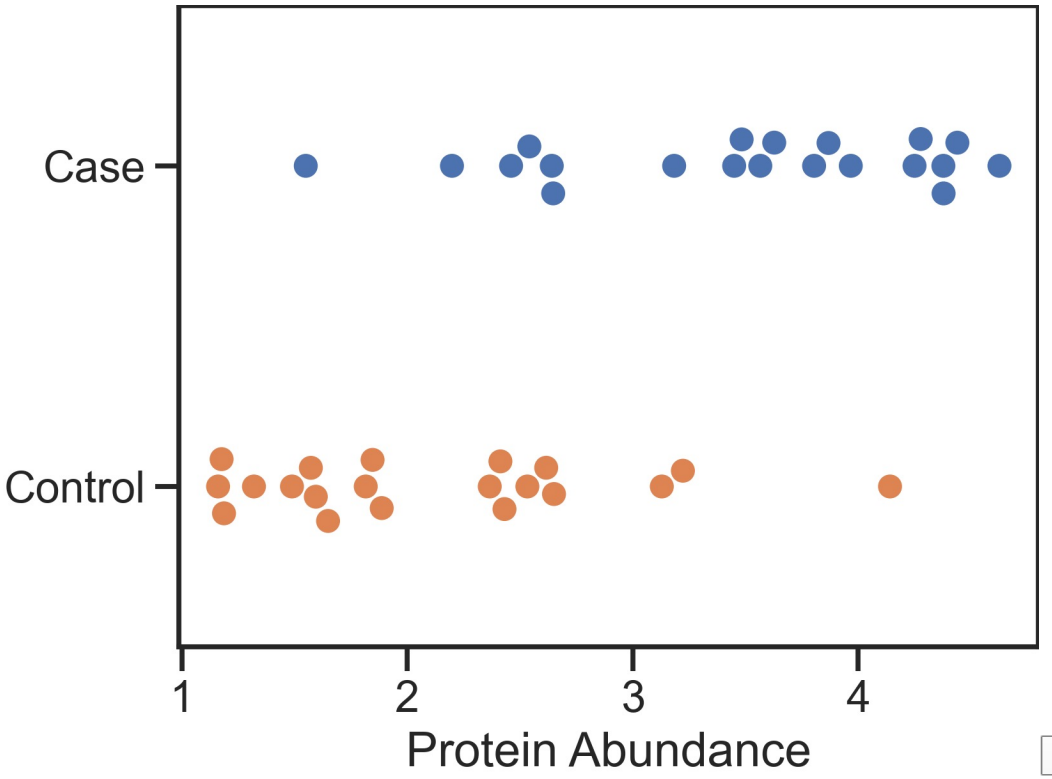


Our example binary classification task

Predict whether a patient has a disease from the abundance of a single protein biomarker.

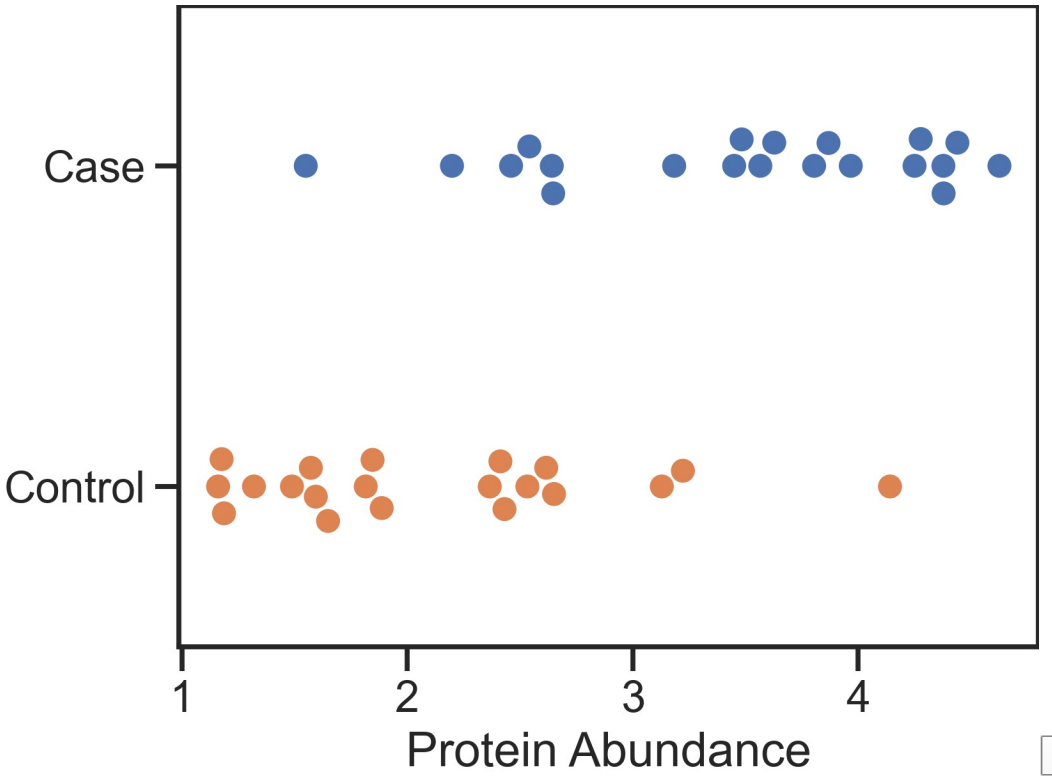
- Measurements from 20 cases and 20 controls

How well does our biomarker perform?



Sensitivity and specificity are useful metrics

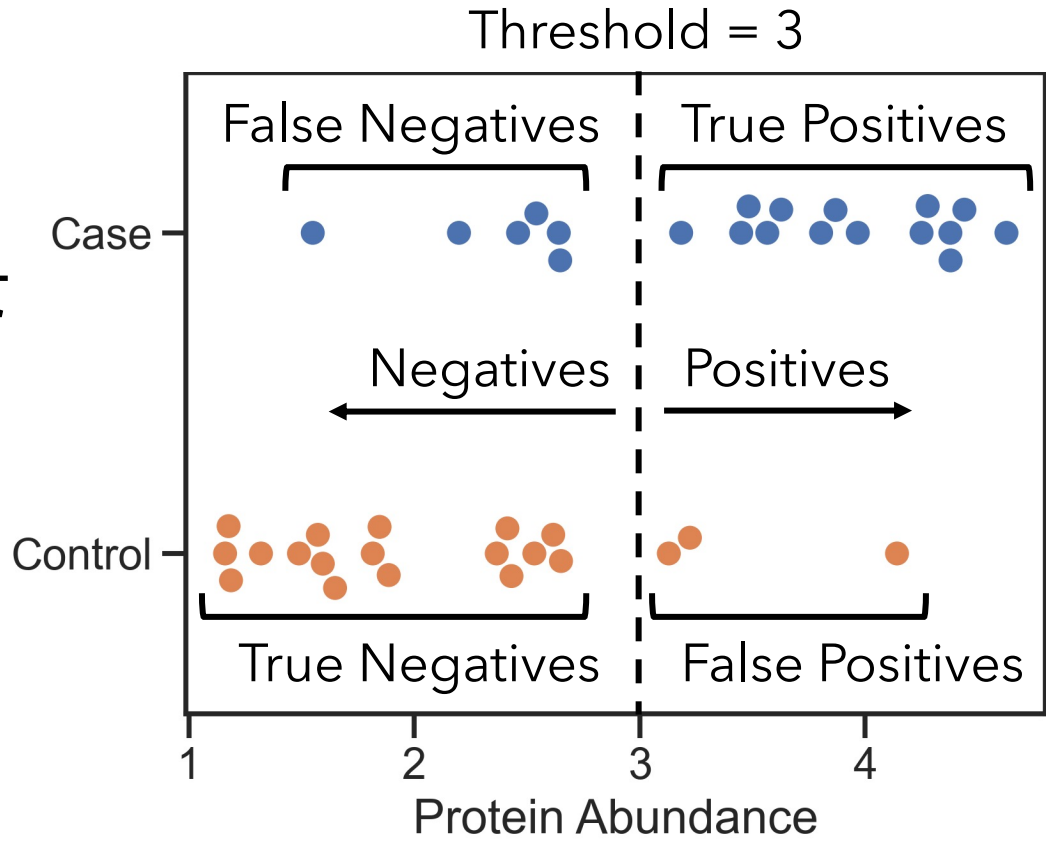
- Sensitivity is the proportion of positives (cases) that are correctly identified.
- Specificity is the proportion of negatives (controls) that are correctly identified.



How do we calculate sensitivity and specificity?

- Sensitivity

$$= \frac{True\ Positives}{True\ Positives + False\ Negatives}$$



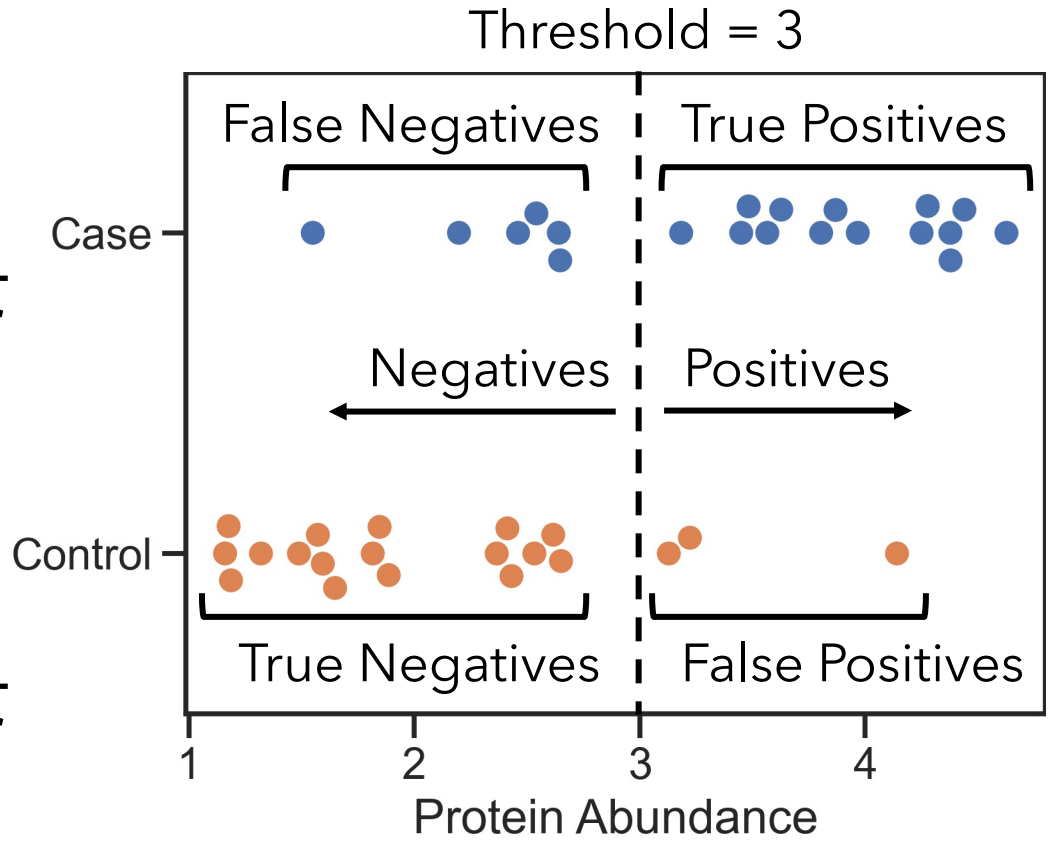
How do we calculate sensitivity and specificity?

- Sensitivity $= 14/(14+6) = 0.70$

$$= \frac{True\ Positives}{True\ Positives + False\ Negatives}$$

- Specificity

$$= \frac{True\ Negatives}{True\ Negatives + False\ Positives}$$



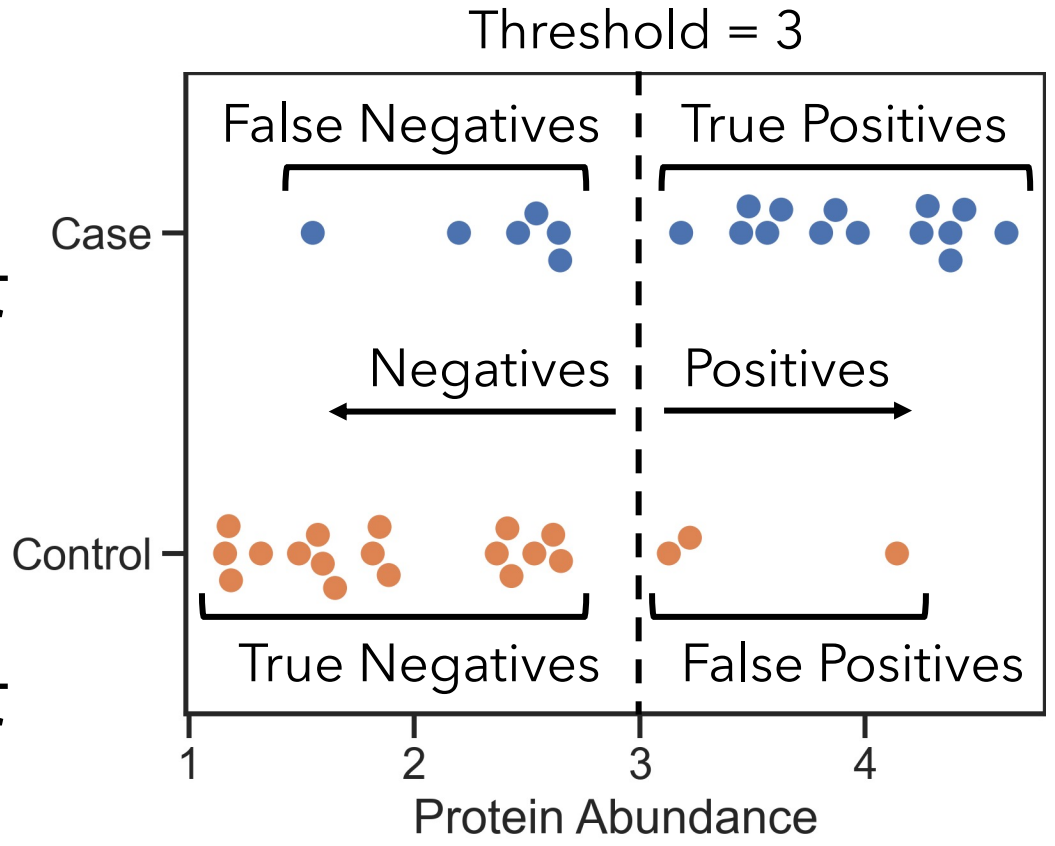
How do we calculate sensitivity and specificity?

- Sensitivity $= 14/(14+6) = 0.70$

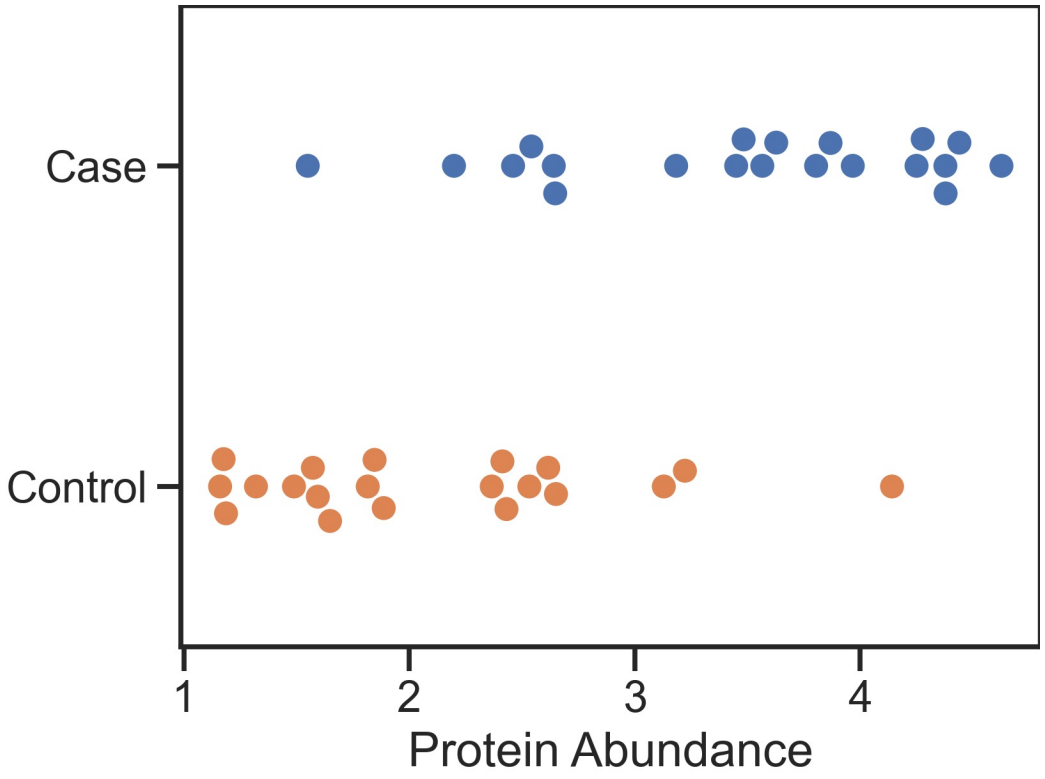
$$= \frac{True\ Positives}{True\ Positives + False\ Negatives}$$

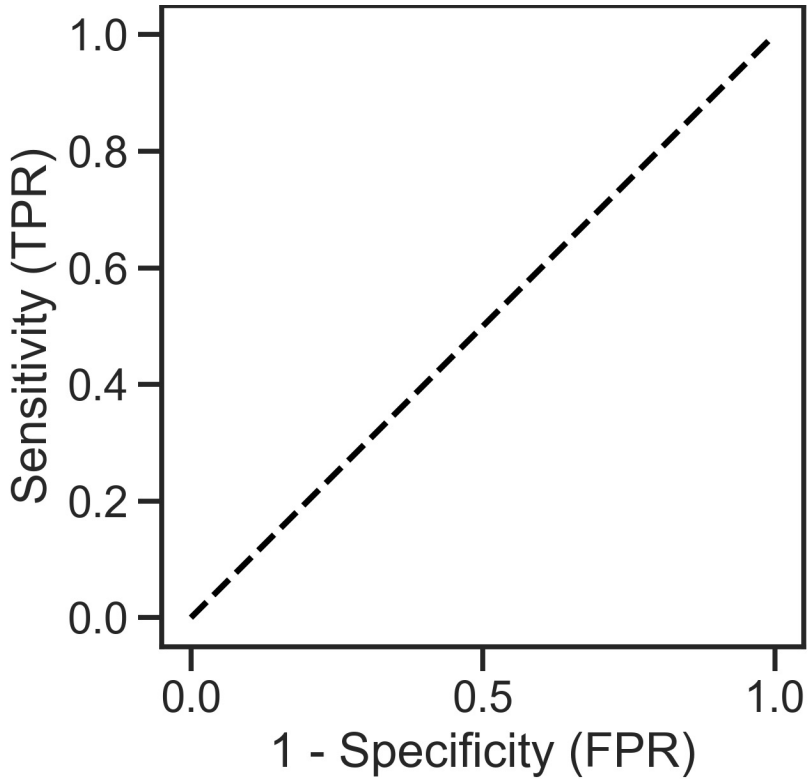
- Specificity $= 17/(17+3) = 0.85$

$$= \frac{True\ Negatives}{True\ Negatives + False\ Positives}$$



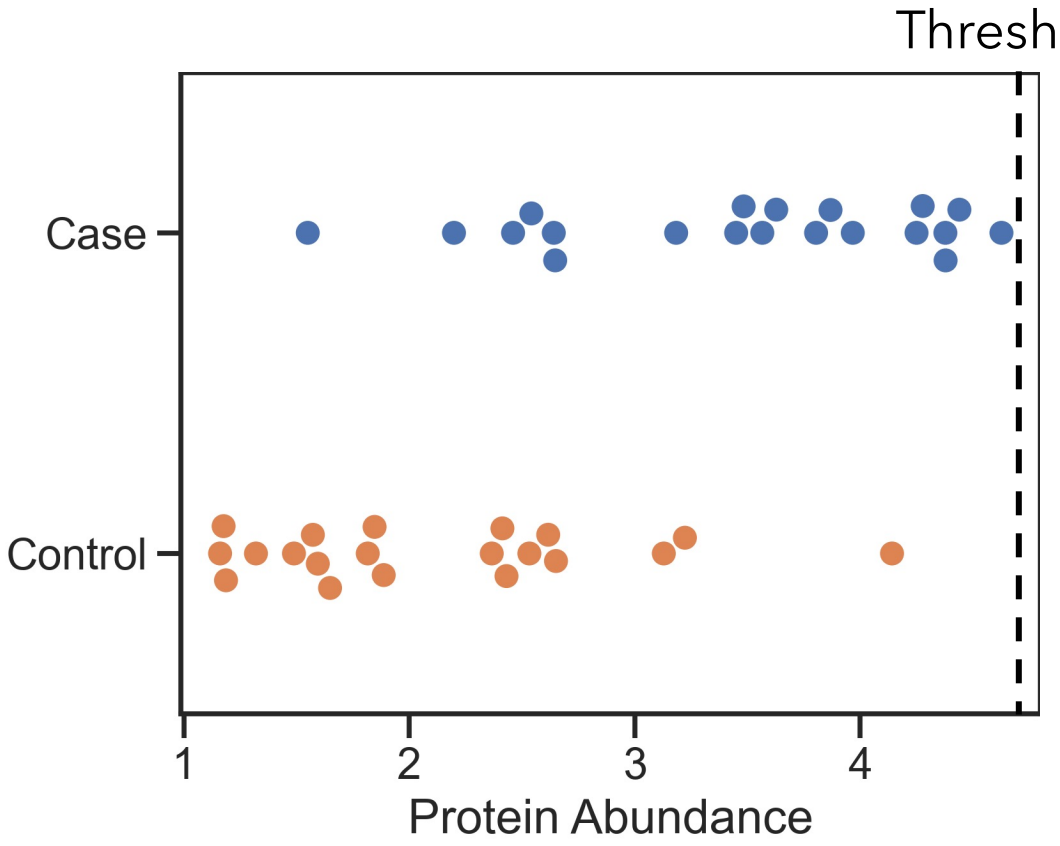
ROC curves show the sensitivity and specificity across all thresholds

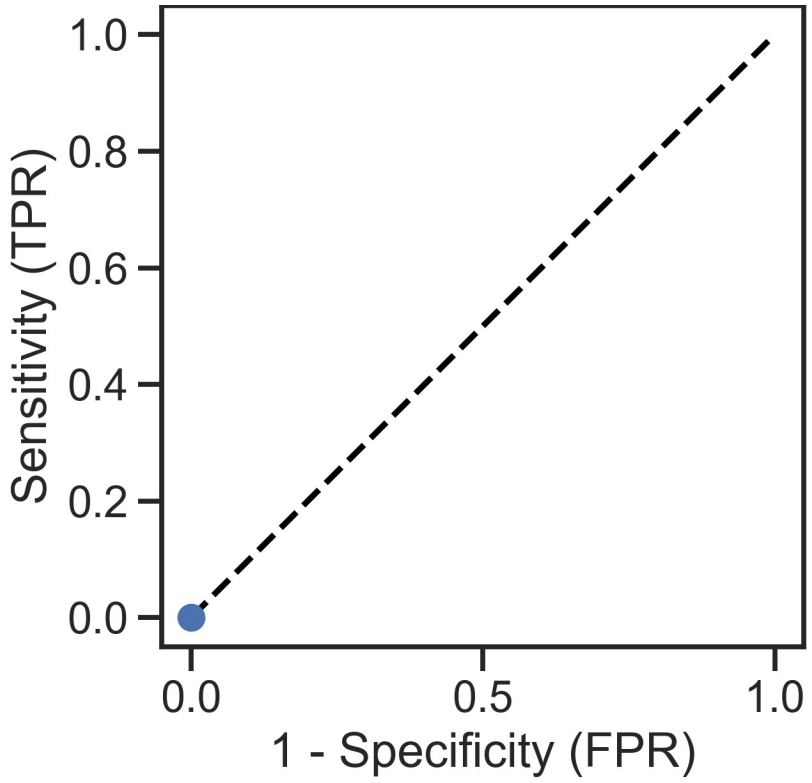




TPR = True Positive Rate, FPR = False Positive Rate

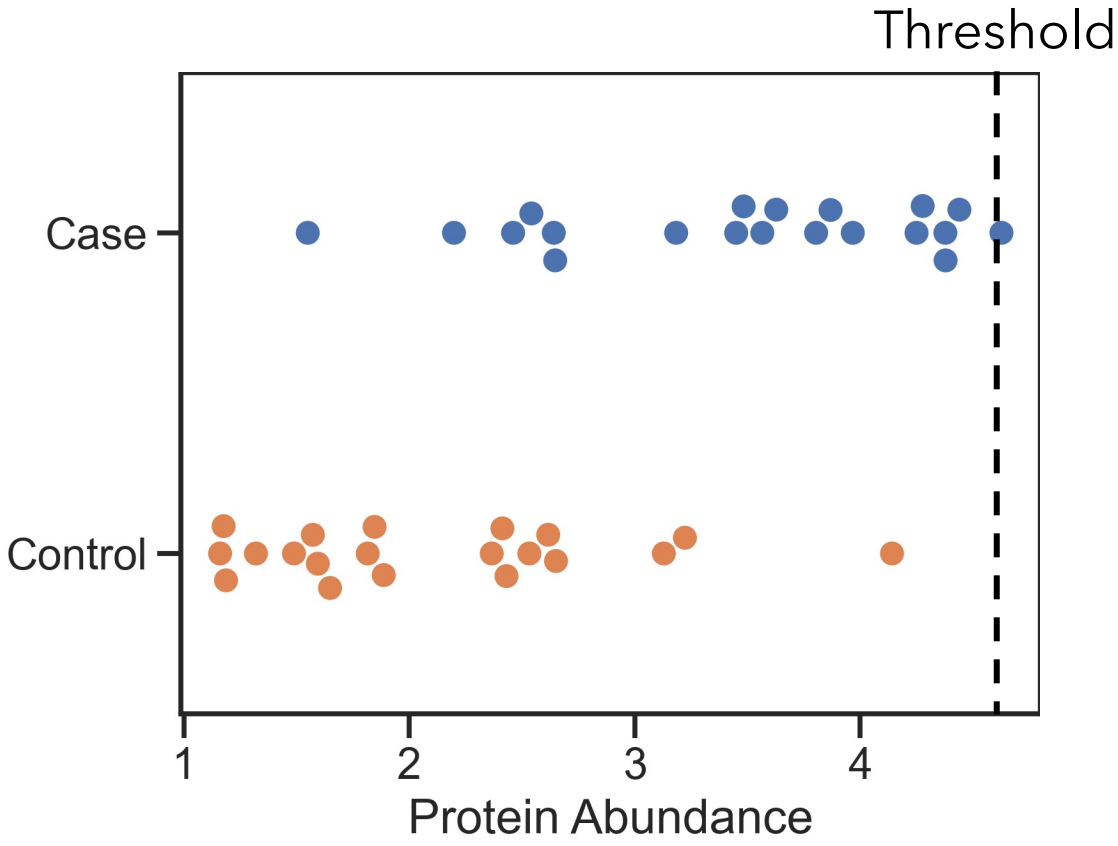
ROC curves show the sensitivity and specificity across all thresholds

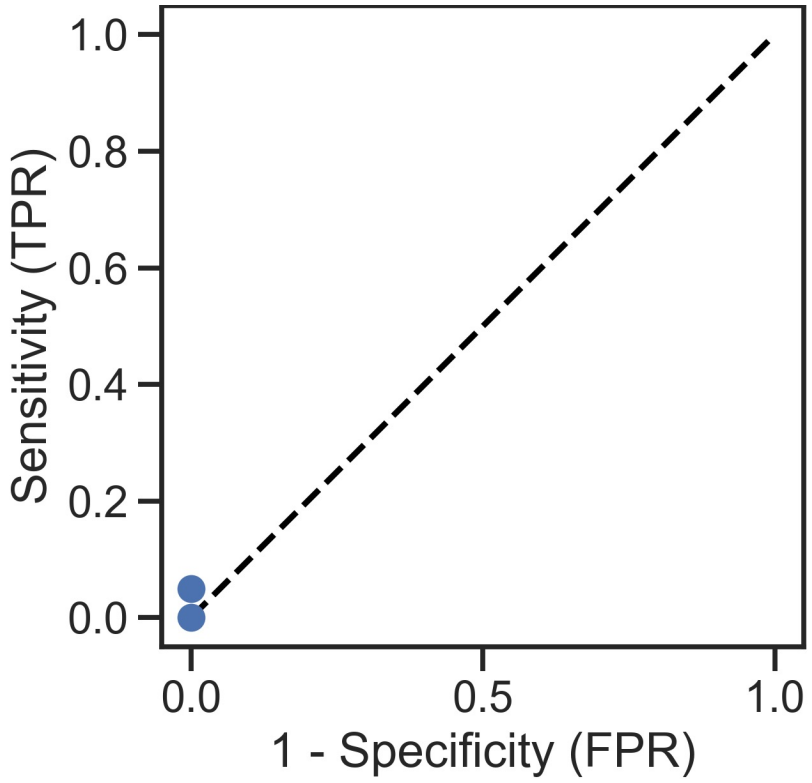




TPR = True Positive Rate, FPR = False Positive Rate

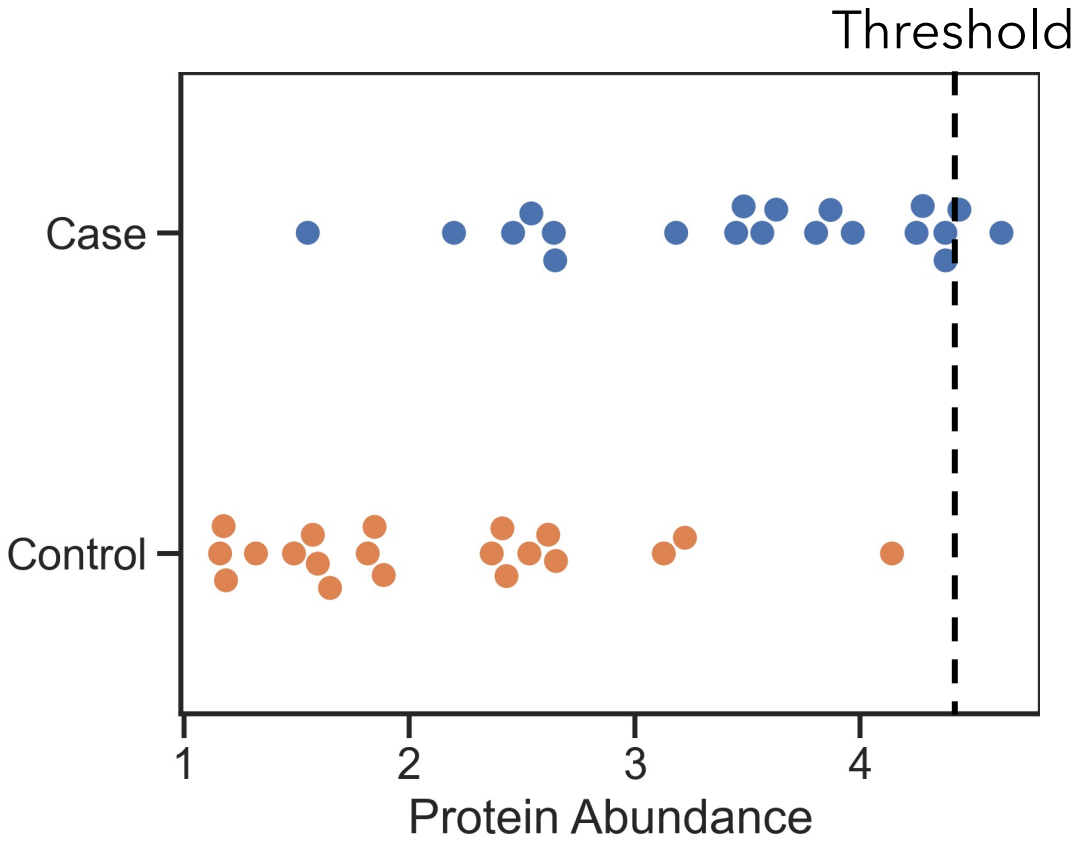
ROC curves show the sensitivity and specificity across all thresholds

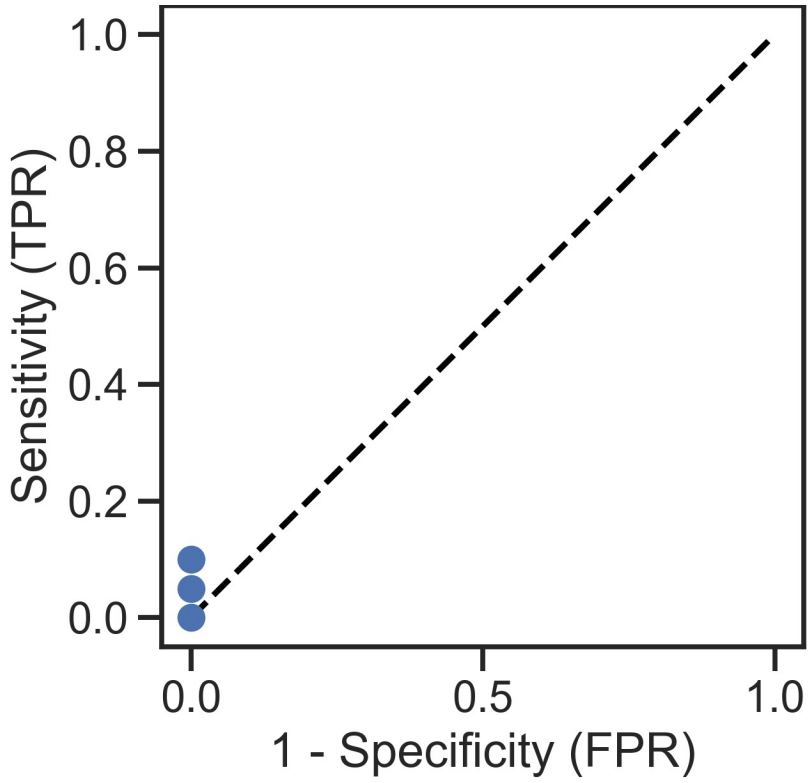




TPR = True Positive Rate, FPR = False Positive Rate

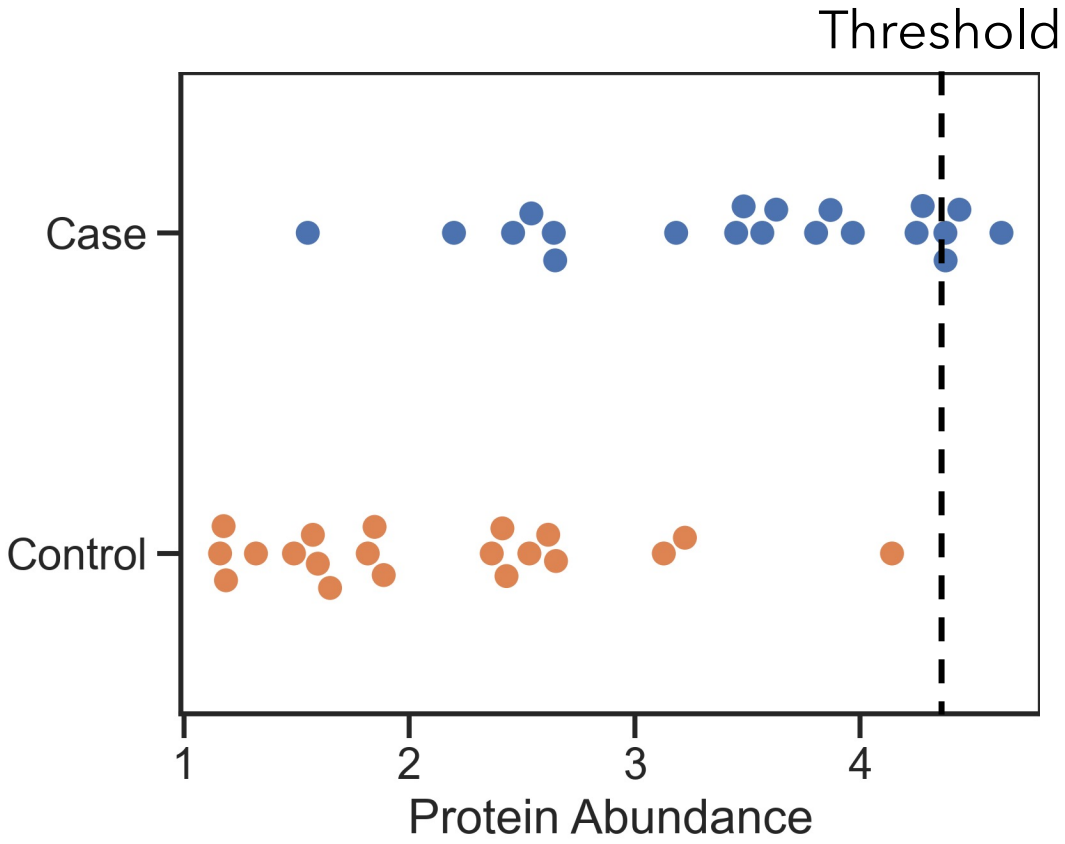
ROC curves show the sensitivity and specificity across all thresholds

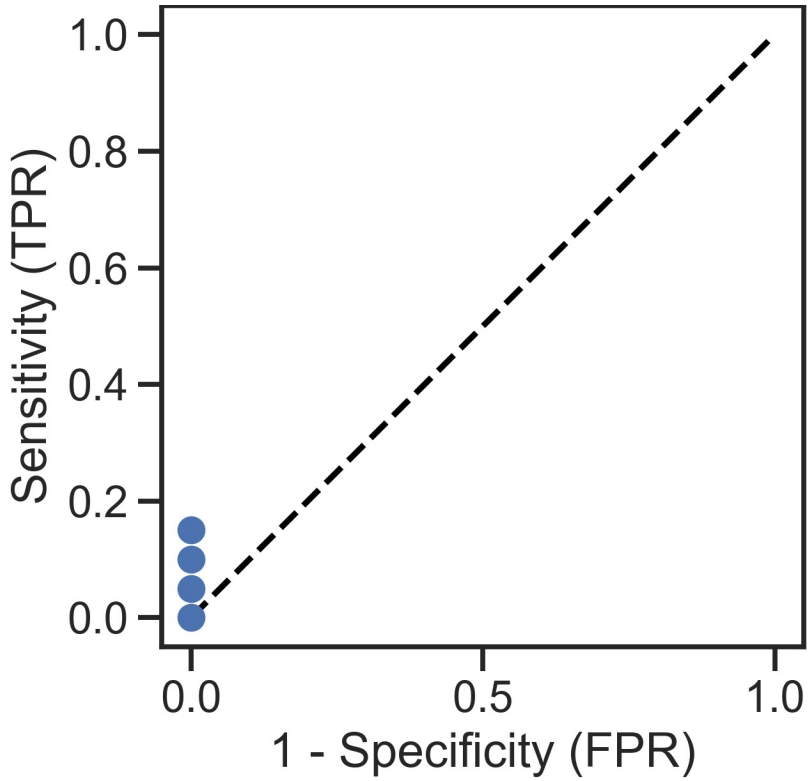




TPR = True Positive Rate, FPR = False Positive Rate

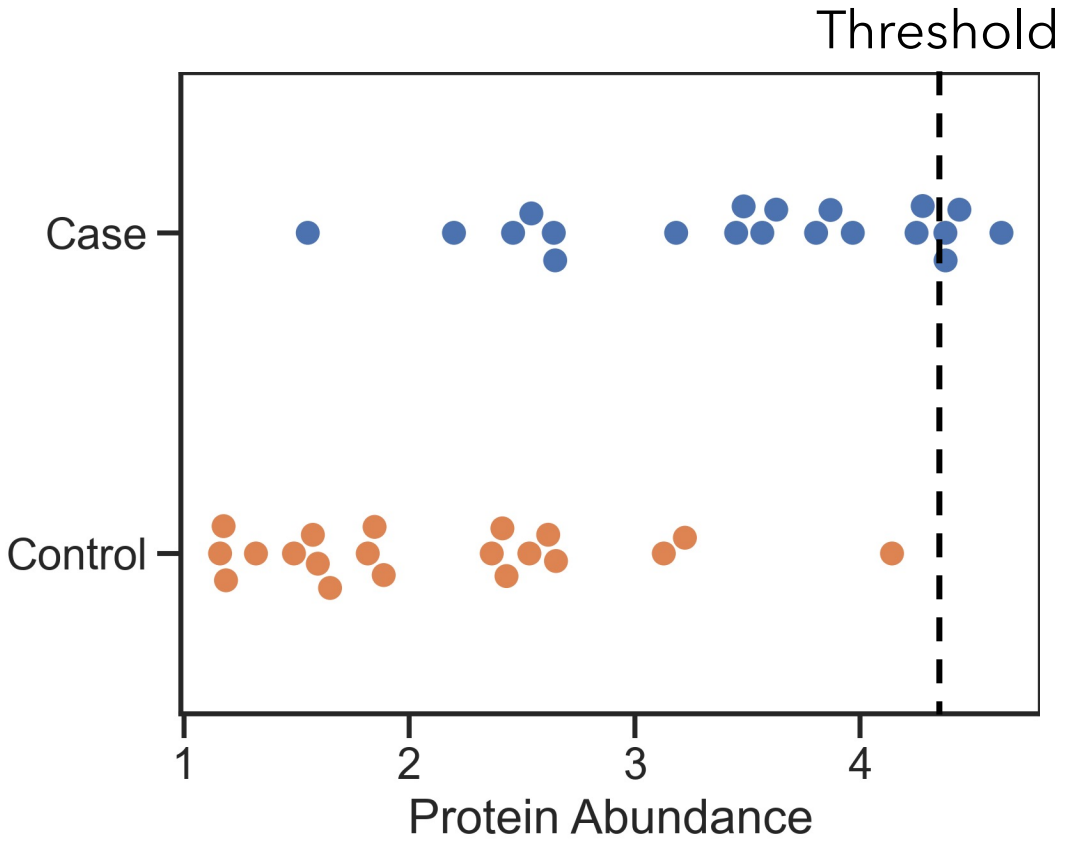
ROC curves show the sensitivity and specificity across all thresholds

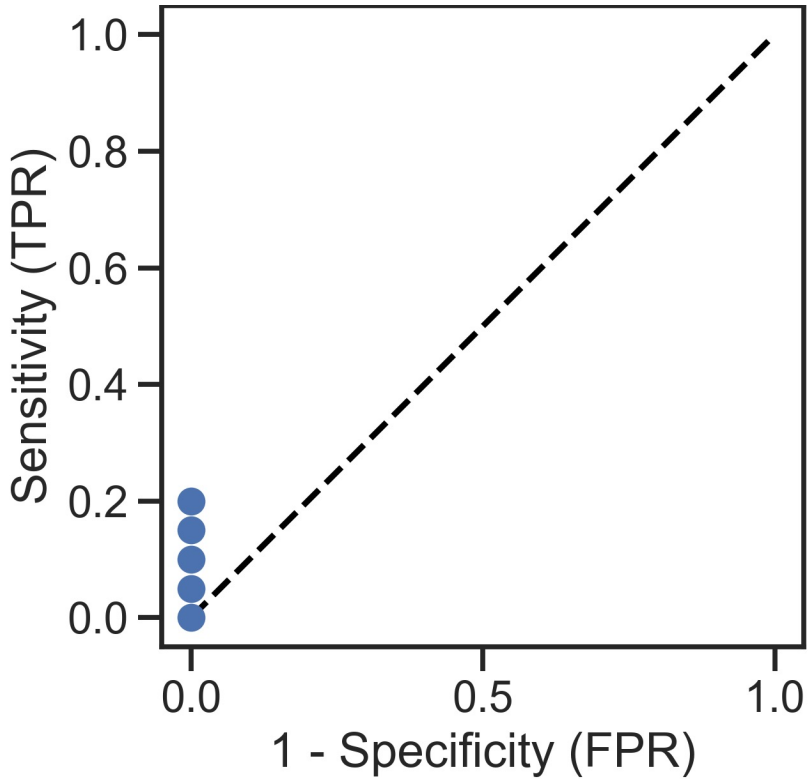




TPR = True Positive Rate, FPR = False Positive Rate

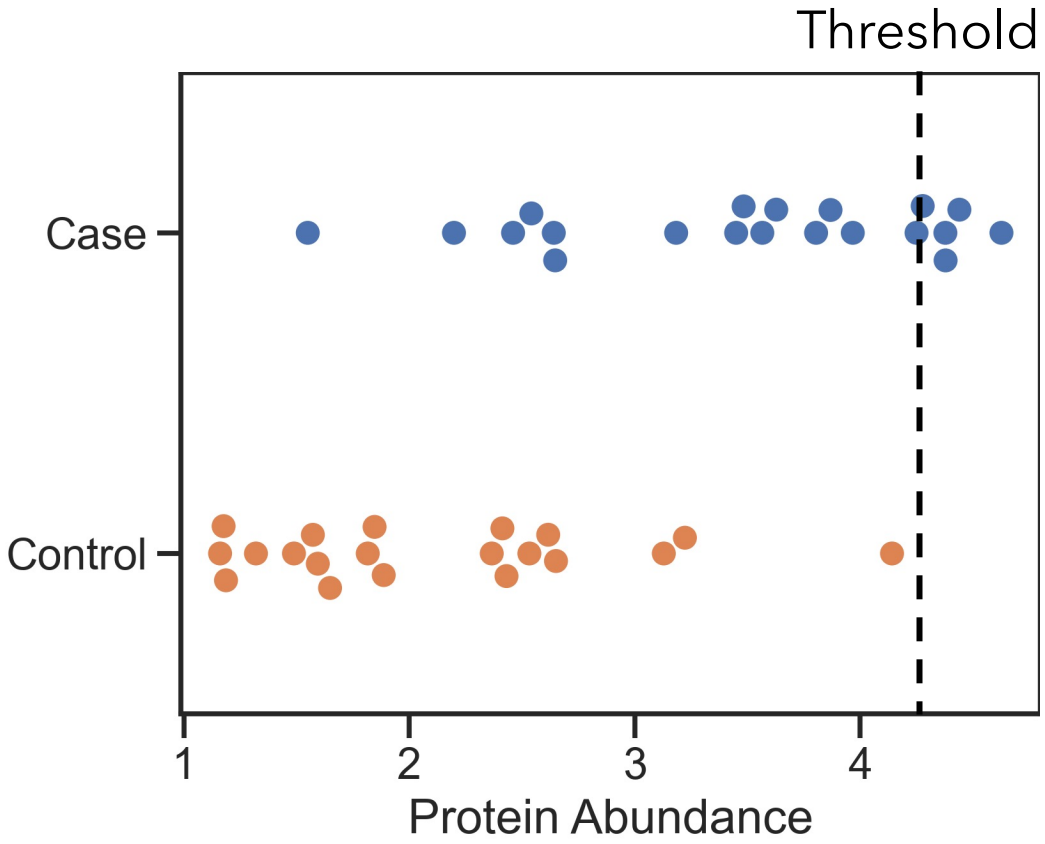
ROC curves show the sensitivity and specificity across all thresholds

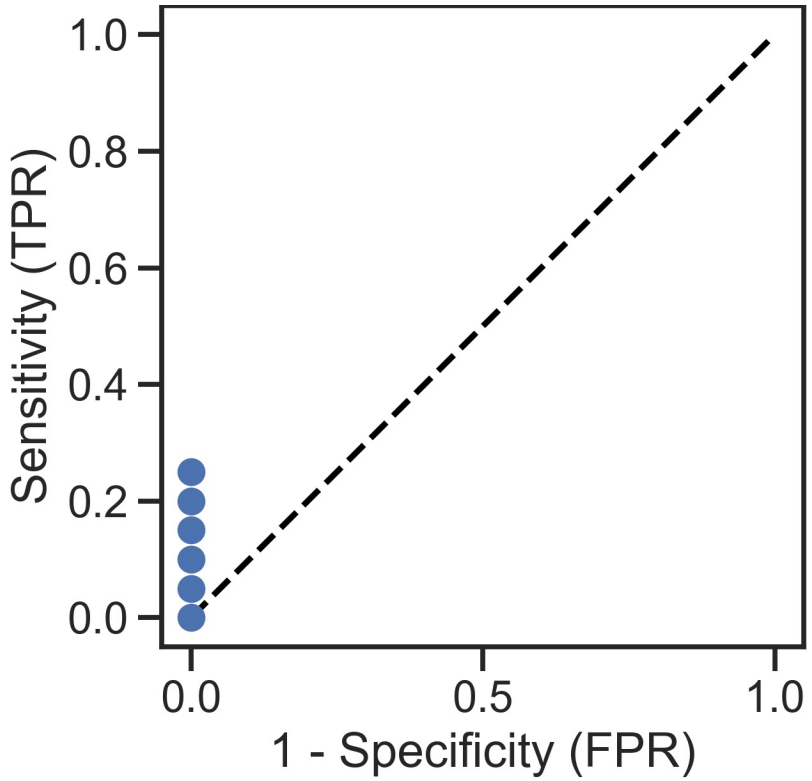




TPR = True Positive Rate, FPR = False Positive Rate

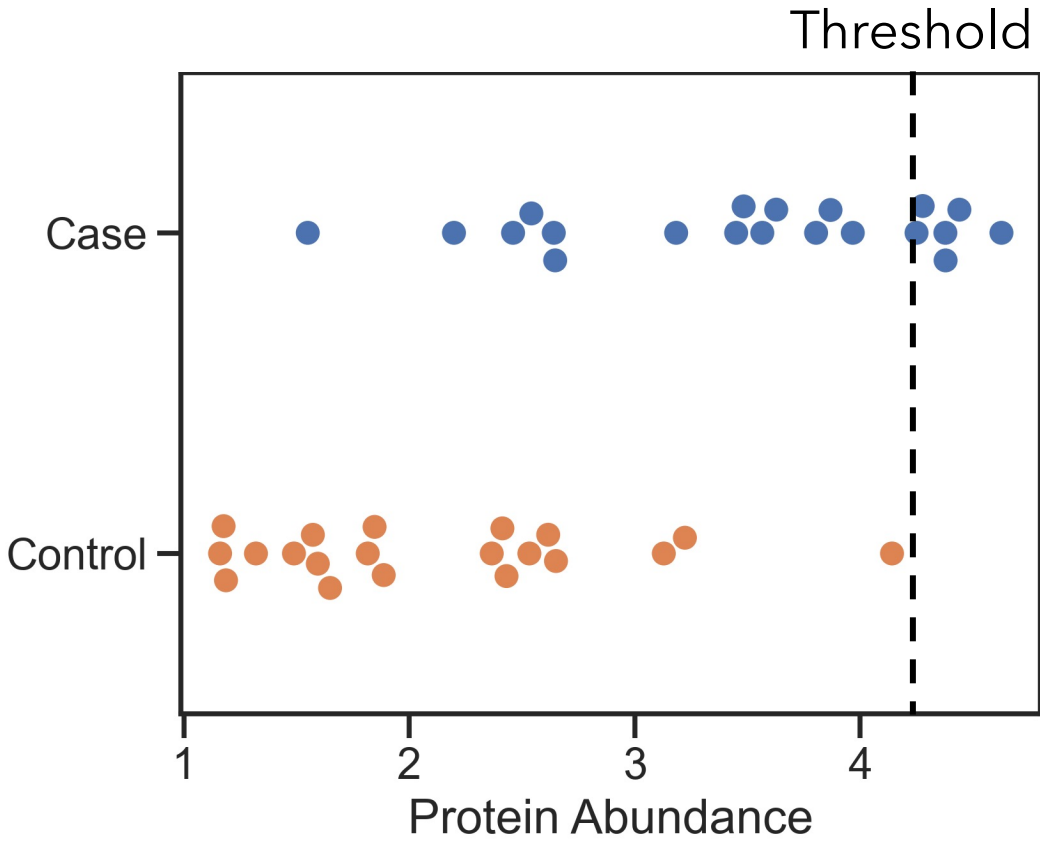
ROC curves show the sensitivity and specificity across all thresholds

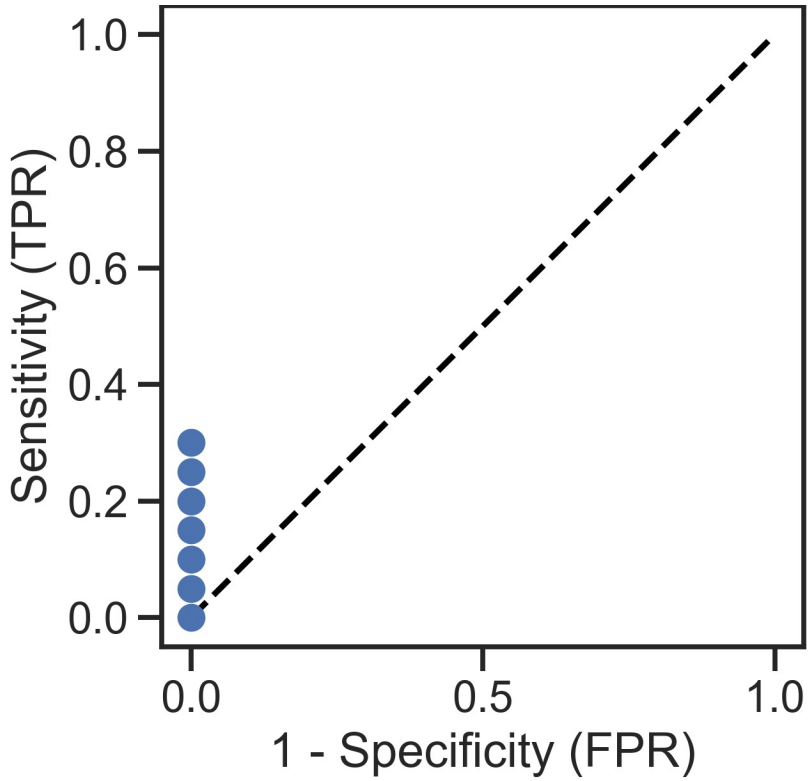




TPR = True Positive Rate, FPR = False Positive Rate

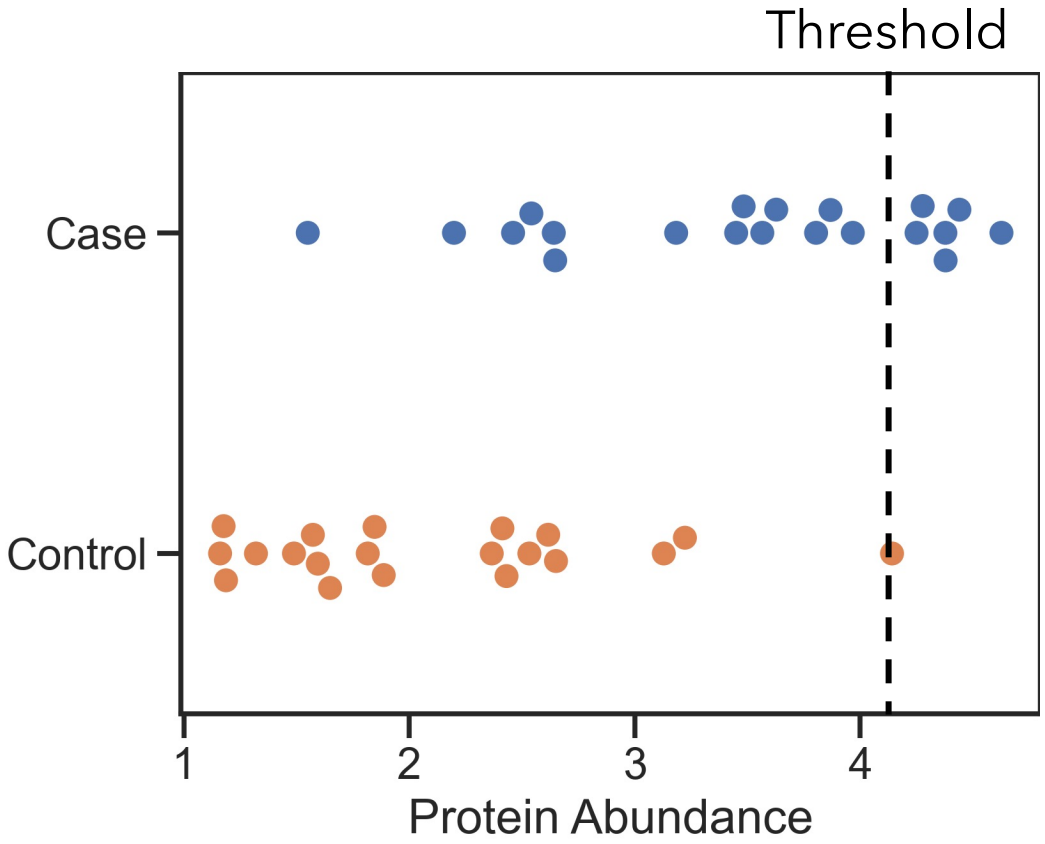
ROC curves show the sensitivity and specificity across all thresholds

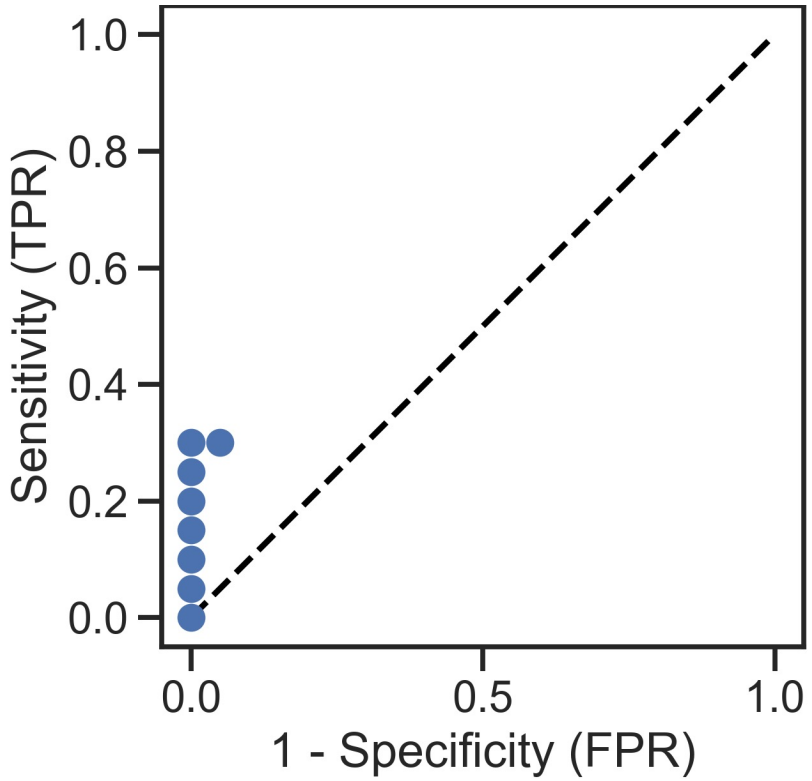




TPR = True Positive Rate, FPR = False Positive Rate

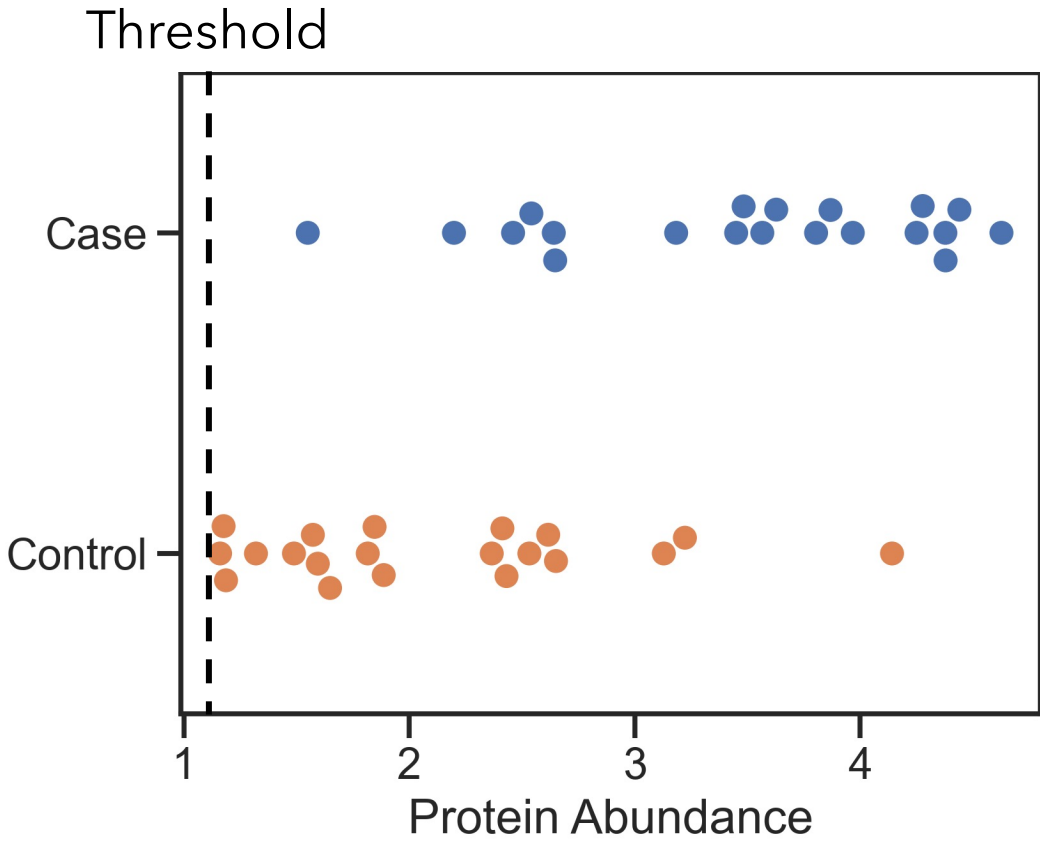
ROC curves show the sensitivity and specificity across all thresholds

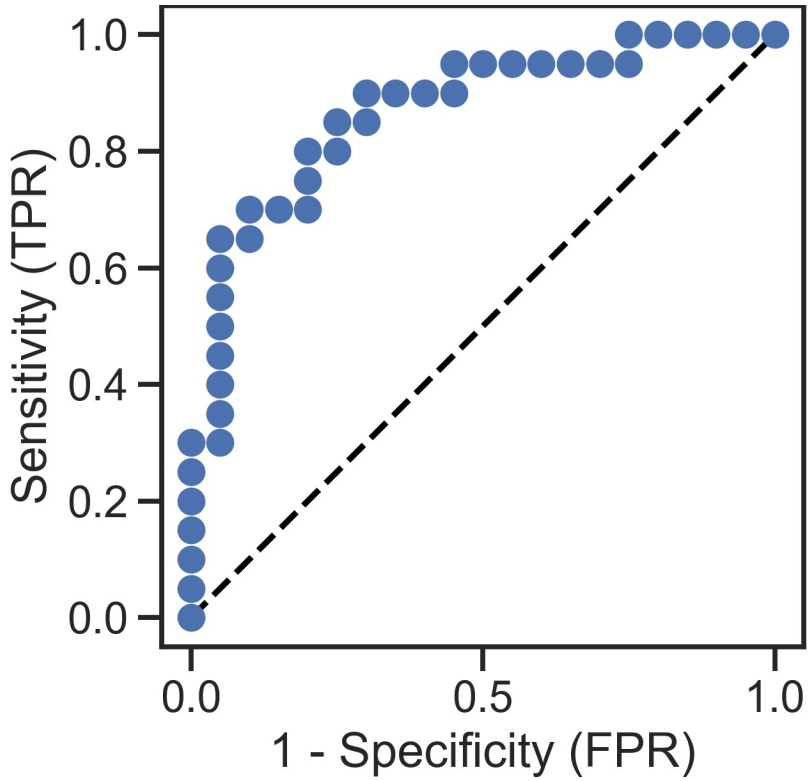




TPR = True Positive Rate, FPR = False Positive Rate

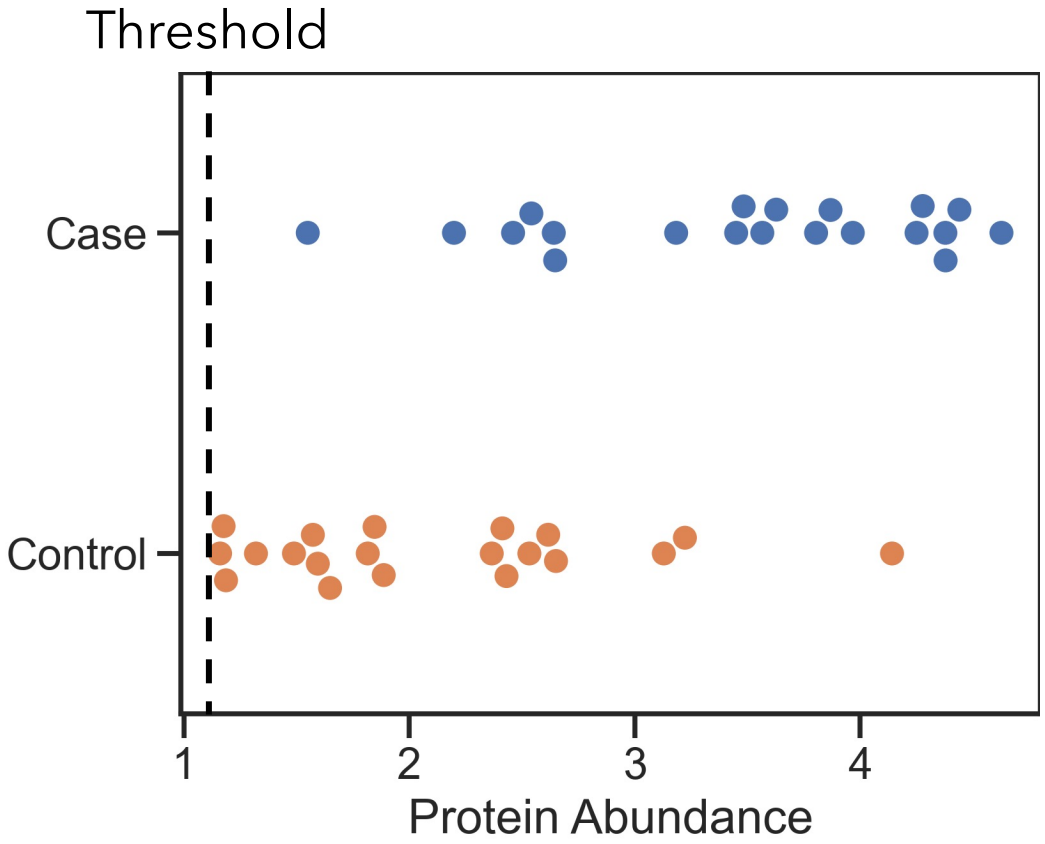
ROC curves show the sensitivity and specificity across all thresholds

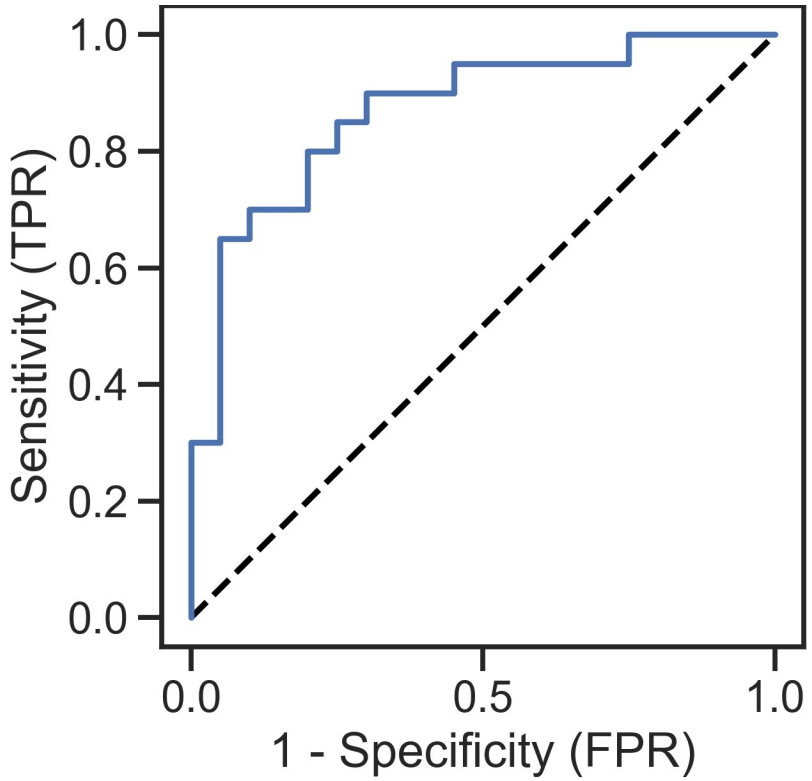




TPR = True Positive Rate, FPR = False Positive Rate

ROC curves show the sensitivity and specificity across all thresholds

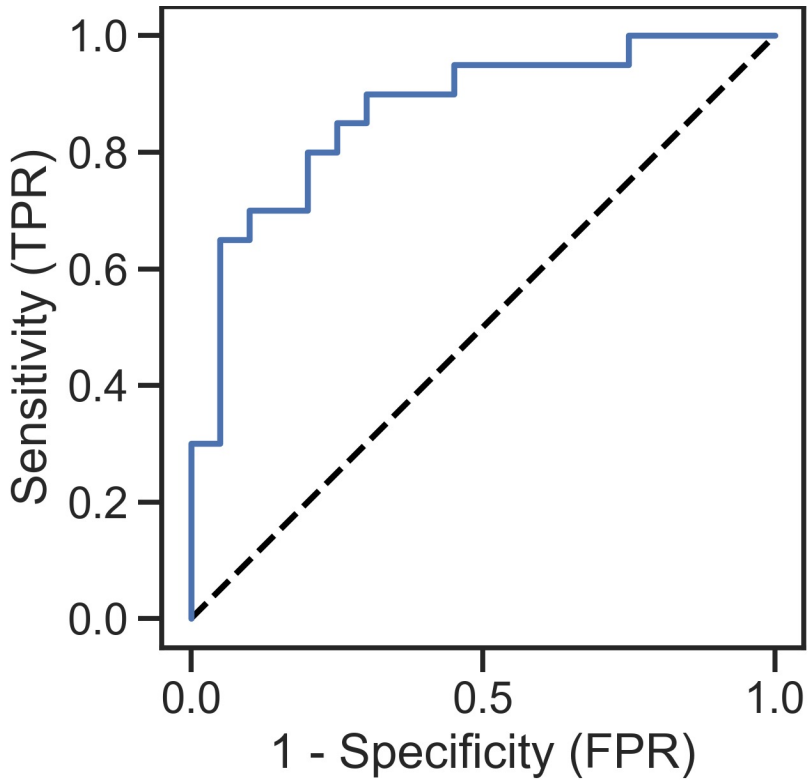




TPR = True Positive Rate, FPR = False Positive Rate

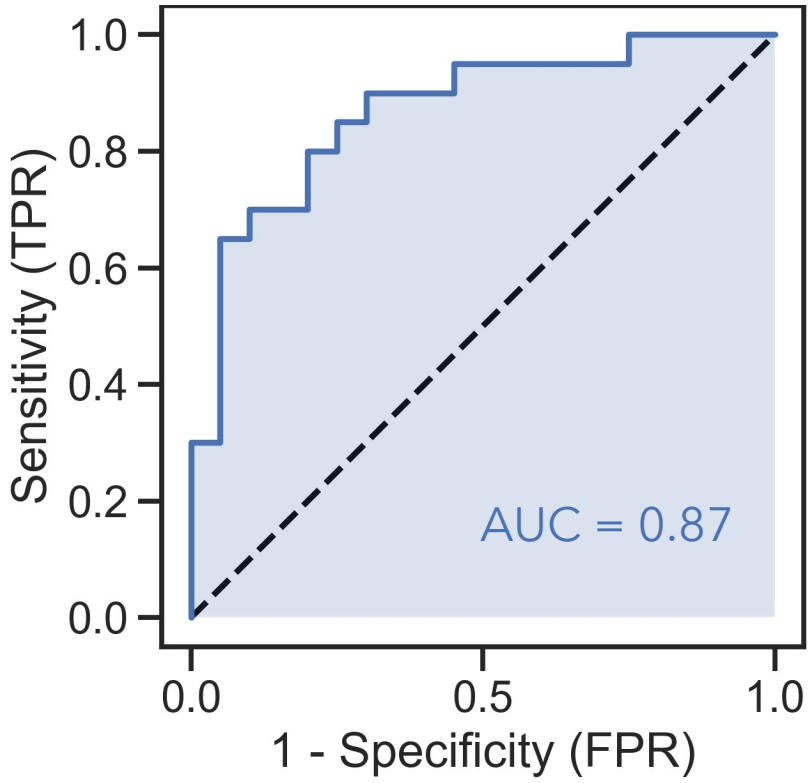
How do we evaluate ROC curves?

- The dashed line indicates the performance of randomly guessing.



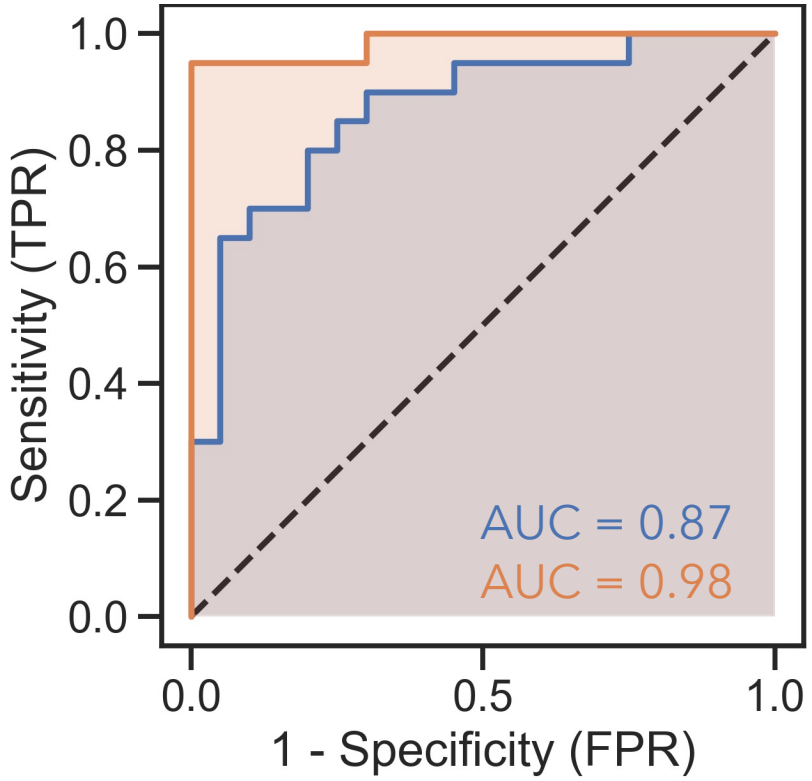
How do we evaluate ROC curves?

- The dashed line indicates the performance of randomly guessing.
- The area under the curve (AUC) provides an overall measure of performance.



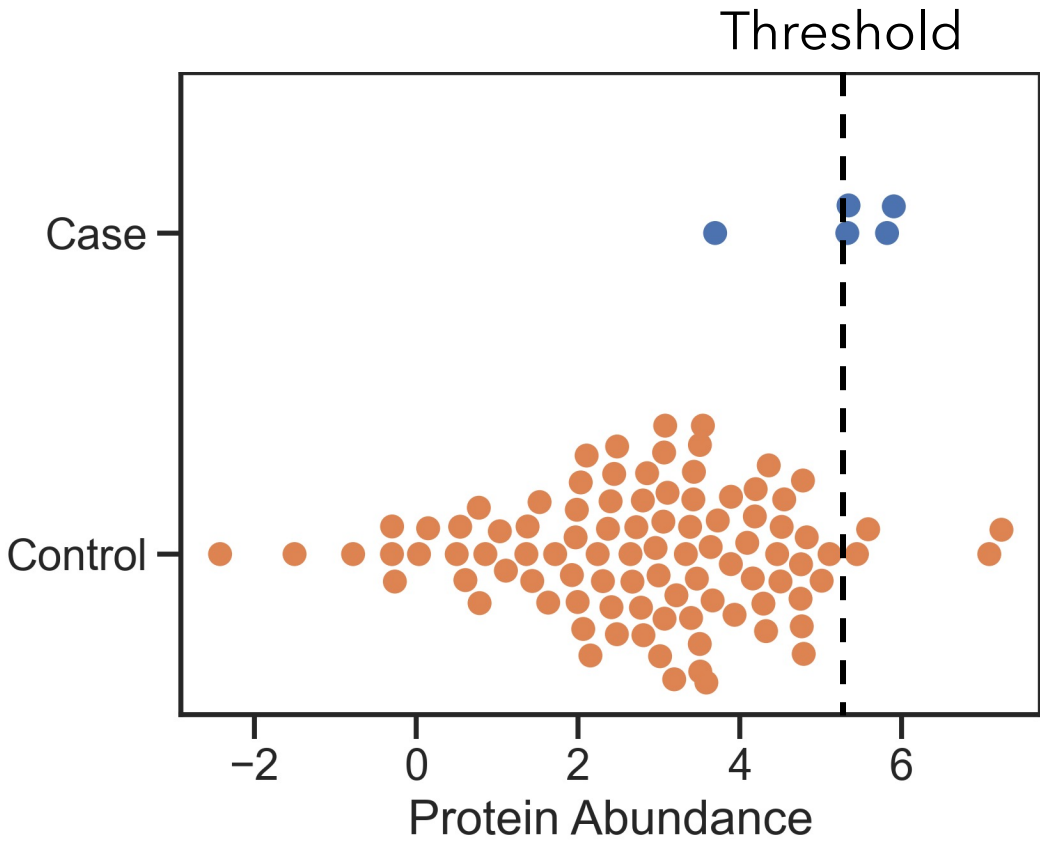
How do we evaluate ROC curves?

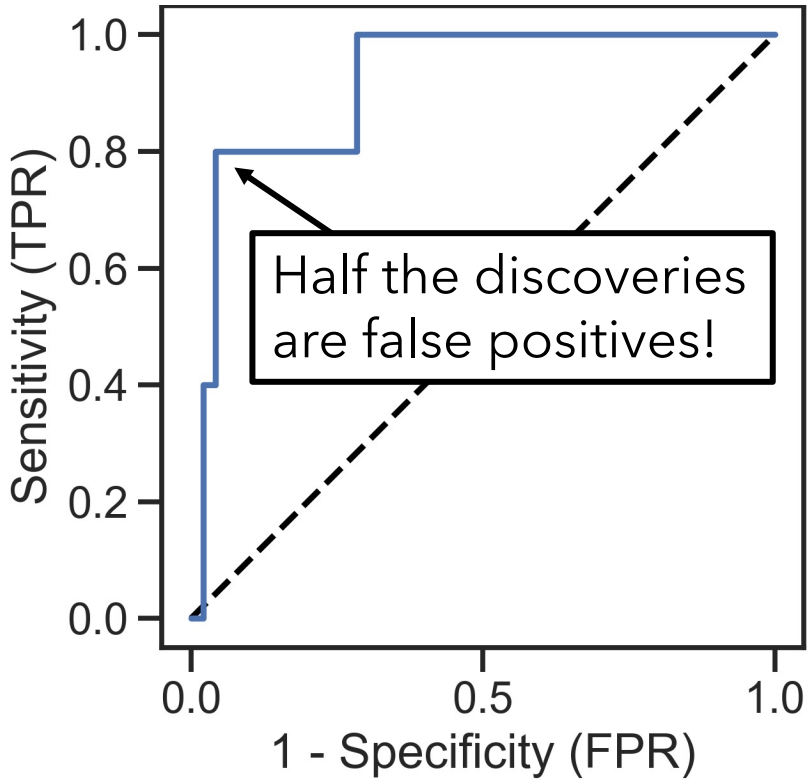
- The dashed line indicates the performance of randomly guessing.
- The area under the curve (AUC) provides an overall measure of performance.



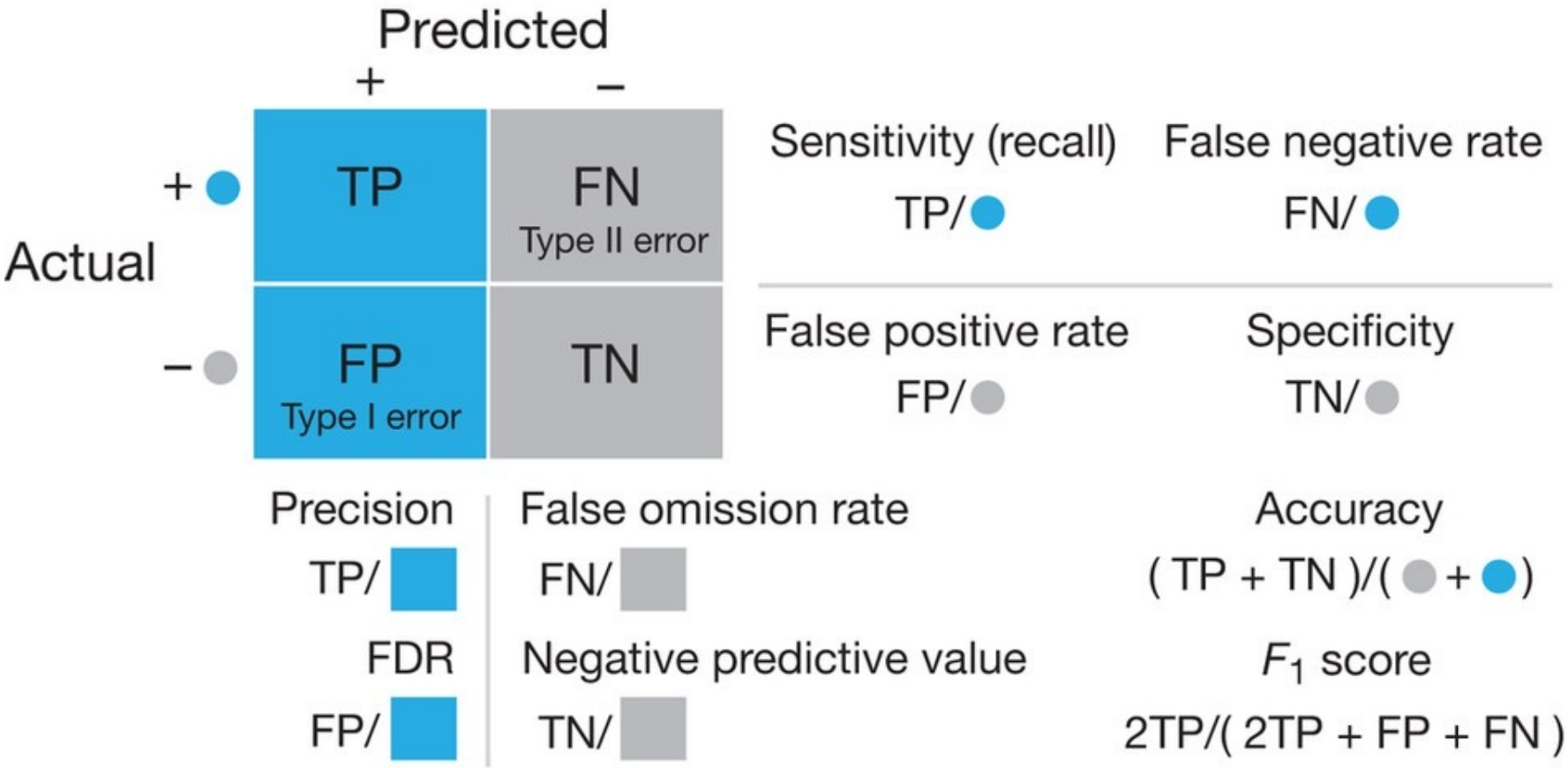
ROC curves can misleading when the classes are imbalanced

What if we had only 5 cases and 95 controls in our data?





There are many other metrics we can use



Lever, J., Krzywinski, M. & Altman, N. Classification evaluation. *Nat Methods* **13,** 603–604 (2016). https://doi.org/10.1038/nmeth.3945