Prediction Model of Red Tides in Fujian Sea Area Based on BP Neural Network

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Abstract. This paper presented a new model of the red tide in Fujian Province by BP neural network (BPNN) based on five sets of marine condition data between 2015 to 2019. Data cleansing and normalization were applied before the training. The 12-fold cross-validation reduced the short of data. As a result, this model could get a related correct prediction of red tide in this particular area.

1. Introduction
Red tide is an unusual phenomenon offshore, in which one or several types of algae are sharply concentrated and reproduced so as to color the seawater. With the development of industries, domestic garbage and industrial pollutants gathered by rivers or directly poured into oceans have negative influences on the ocean. The waste from the marine industry and the offshore farms also deteriorate the ocean environment. According to the study of Zohdi E. et. al (2019), these emissions mainly include nitrogen, heavy metals and some other organic compounds, which may support the harmful algal blooming (red tide) and have adverse effects in many ways. Firstly, there are direct restrictions on the local fishery industry, because some algae and the red tide water are noxious in most cases and the algal will use up the oxygen in water, which both may make fishes to die. Secondly, the potential influence on human beings and the whole ecosystem is adverse. The poisons gathered by aquatic animals and released into the air may be absorbed by other creators and even humans. These red tide toxins, especially those in shellfish, may cause nerve paralysis or diarrhea. The tourism industry might be suppressed on account of the awful odor and views.

Fujian province is located in the southeast of China, which has access to various resources from the sea. In 2018, the fishery industry brought about a profit of approximately 3,000 billion Yuan, and the increasing trend has been remained for several years. However, seawater pollution, especially red tide, poses a threat to the farmed species in coastal water. A serious red tide occurred in Fujian in May 2019, and Xiamen Provincial Center for Disease Control and Prevention posted a warning to citizens to be careful about buying seafood from nearby sea areas.

Nowadays, thanks to the development of detectors, people can observe red tides by collecting samples through field trips or robots with sensors or by getting data from satellites. At first, the model was set up with a single factor. For example, in 1949, Riley et al. set up the relationship between the type and number of phytoplankton and water quality in typical cases.

Then, the later researchers gradually created multi-factor models, but most of them were mainly divided into two types, numerical models (basing on statistics) and conceptual models (basing on biology and chemistry). In 2012, Farman Ara's team established a three-dimensional model to simulate...
the relationship between red-tide development and the traits of sea surface. There was another model (Machin Abdolahzadeh et al.) based on the root-mean-square deviation, an advanced method considering the effects of harmful algal cells. It is worth noting that the numerical prediction model for red tides based on BP neural network was established by Xinhong Su's team in 2019. They input the meteorological indicators to the second-order network before the model was learned and trained. In conclusion, the method had a correction rate of more than 84%. But they did not take the condition of oceans into consideration.

2. Method
This section will introduce the method for building the model in this paper and how to put it into practice. Because the prediction depends on various factors such as temperature, salinity, air pressure, sunlight intensity, and currents, the results may be affected seriously by small errors. It is also complex to find a general internal relation in theory. Therefore, the neural network suitable to analyze a complex system and limit errors with enough data, can be an effective method of building a prediction model.

2.1 BP neural network
This section will introduce how the PB neural network works and how to train this model.

![Diagram of MLP model](image)

Figure 1. The arrows indicate how the data flow through the MLP model, and the layers from left to right are input layer, hidden layer and output layer.

The perceptron (Frank Rosenblatt, 1957), as a foundation cell of neural network, can represent the smallest logical units, including AND, OR, NO gates, and their weight functions. It can receive multiple input signals and output only one signal through the Eq.1, where $W_{ij}$ represents the weight of links between two nerve cells (i, j) and $O_j$ represents the output of nerve cell j. This function, Sigmod, is called an activation function.

$$I_j = \sum_{i} W_{ij} O_i$$

$$O_j = \text{sigmod}(I_j) = \frac{1}{1 + e^{-I_j}}$$

If a single layer cannot fit the truth very well, the multi-layer perceptron with several layers, which is the foundational construct of neural network, could adopt the complex one. Nevertheless, links
between cells in the same layers or cells in nonadjacent layers are not allowed, and there will not be any cycles under the strict disciplines above. The Fig. 1 is a schematic diagram showing the mechanism of data flow in MLP, where I is the input layer, H is the hidden layer with five nodes (H1, H2, H3, H4, H5), and Out is the single output. This construct is a typical model of neural networks, and the number of layers is flexible to fit different conditions.

This paper used the Back Propagation neural network method to train the model, which is a widely used method and worked well in previous ocean prediction projects. During the training process, the program compared the prediction value with the reference value, and then the weights of links were iterated according to the comparison results.

The error of the output layer can be calculated through Eq.2. Then, the new $W_{ij}$ will be corrected by Eq.3 where $\lambda$ is the learning speed.

$$E_j = \text{sig mod}'(O_j) \cdot \sum_k E_k W_{jk} = O_j(1-O_j) \sum_k E_k W_{jk}$$ (2)

$$W_{ij} = W_{ij} + \lambda E_j O_i$$ (3)

Every sample went through this network and changed the indexes of the nodes they passed to, to get the most suitable model in the end. Sometimes, the maximum iteration time might drive a suitable result away, so the loss functions were essential.

2.2 Data processing

The Fujian Provincial Department of Ocean and Fisheries updates offshore data every season, and there have also been reports of red tides in history. According to them, 96 pieces of red tide data out of 799 offshore data from 2015 to 2018 were gathered and selected. In the next step, because the water temperature, salinity, mass of suspended solids, content of dissolved oxygen, active phosphate and inorganic nitrogen are important indexes, they were set as input after data cleansing. However, three pieces of dissolved oxygen are negative numbers, which is impossible theoretically. It might result from the improper operations in lab tests and the deletions by mistake. Finally, the data were normalized to 0-1, which is helpful to speed up the training process and to improve the accuracy. The table 1 shows six samples, and the entire data set is shown in the appendix.

| Water temperature (℃) | Salinity (%) | Suspended solid(mg/L) | Dissolved oxygen(mg/L) | Active phosphate(mg/L) | Inorganic nitrogen(mg/L) | If it is a red tide? |
|-----------------------|--------------|----------------------|------------------------|------------------------|--------------------------|---------------------|
| 19.6                  | 31.55        | 15                   | 7.94                   | 0.008                  | 0.1685                   | 0                   |
| 24                    | 30.2         | 17                   | 6.33                   | 0.029                  | 0.283                    | 0                   |
| 24                    | 28.7         | 12                   | 6.09                   | 0.02                   | 0.186                    | 0                   |
| 18.7                  | 30.48        | 7                    | 8.52                   | 0.00075                | 0.2855                   | 0                   |
| 18.28                 | 31.52        | 10.5                 | 8.13                   | 0.004                  | 0.2695                   | 0                   |
| 18.47                 | 29.48        | 5                    | 8                      | 0.0055                 | 0.501                    | 1                   |

2.3 Model building

Following the method introduced above, the section will show the results of the prediction model.

Firstly, because of the imbalance of the data set (the red tide conditions are less than normal conditions), 12-fold cross-validation was used. This method divided the data set into 12 parts and continued to choose one of them as the testing set and the rest as training sets. After repeating this process 12 times, the limited group of data could be utilized well, and the accuracy of 12 predictions could be used to judge the results of this prediction model. In this program, packages from the Scikit-learn, a machine learning library, were used in Python to train and check the outcomes. According to general experience, five input nodes and five hidden layers (five nodes in each layer) serve as the only output. Though the strong learning ability of neural network usually leads to overfitting, and the fallback mechanism is available, this data set is small enough to avoid meaningless
iteration of the error.

2.4 Results
This research considered the relation between the red tide and water temperature, salinity, mass of suspended solids, content of dissolved oxygen, active phosphate, and inorganic nitrogen in the Fujian sea area from 2015 to 2019. After that, a BPNN model was built, and some samples were simulated and predicted. According to the functions transferred, the accuracy of twelve prediction results was output, as shown in Fig. 2. After calculating the mean of these results, the average accuracy of this model was 79%, so it is reasonable to believe that this model is applicable to Fujian sea area to some extent.

![Figure 2. The distribution of prediction accuracy](image)

3. Conclusions and limitation
This section will show and explain the conclusions of this research and some problems which might weaken the conclusions. Then, some further measures will be proposed to resolve the uncertain.

One of the shortages is that red tides usually occur in a small area and are always judged by the density of specific tonic (depends on different sea areas). So, the inputs in this model might be incorrect because of the ambiguous location records, which might exclude the detection points. Moreover, the method is a statistical method, so the conclusion is limited in this particular area and cannot be extended. Because it is hard to find some other places that have similar geographical conditions and types of red tide.

The current conclusion is acceptable in predicting natural events, but the accuracy will be higher by trying more indexes of the model. In addition, a province is too large to set up a model, so if enough data could be accessed, dividing the area into small parts and analyzing them continuously will lead to more meaningful and practical results. Hence, we are looking forward to collecting more data, and the detection procedures can be more normative.

Appendix

| Water temperature (°C) | Salinity (%) | Suspended solid (mg/L) | Dissolved oxygen (mg/L) | Active phosphate (mg/L) | Inorganic nitrogen (mg/L) | If it is a red tide? |
|-----------------------|--------------|------------------------|------------------------|------------------------|-------------------------|---------------------|
| 19.6                  | 31.55        | 15                     | 7.94                   | 0.008                  | 0.1685                  | 0                   |
|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| 24 | 30.2 | 17 | 6.33 | 0.029 | 0.283 | 0 |
| 24 | 28.7 | 12 | 6.09 | 0.02 | 0.186 | 0 |
| 20.2 | 32.4 | 9 | -1 | 0.008 | 0.122 | 0 |
| 18.7 | 30.48 | 7 | 8.52 | 0.00075 | 0.2855 | 0 |
| 18.28 | 31.52 | 10.5 | 8.13 | 0.004 | 0.2695 | 0 |
| 18.47 | 29.48 | 5 | 8 | 0.0055 | 0.501 | 1 |
| 18.47 | 29.53 | 6 | 7.94 | 0.008 | 0.694 | 1 |
| 18.94 | 34.76 | 9.3 | 7.79 | 0.002 | 0.061 | 0 |
| 18.58 | 29.83 | 12 | 7.8 | 0.012 | 0.427 | 1 |
| 17.93 | 32.96 | 9.3 | 7.78 | 0.00967 | 0.3247 | 1 |
| 19.83 | 35.31 | 3 | 7.22 | 0.00633 | 0.147 | 0 |
| 19.41 | 34.69 | 5.3 | 7.59 | 0.00467 | 0.1343 | 0 |
| 23.5 | 34 | 14 | 6.41 | 0.0015 | 0.0255 | 0 |
| 24.8 | 29.1 | 13 | 6.42 | 0.014 | 0.189 | 0 |
| 23.75 | 33.5 | 12 | 6.6 | 0.004 | 0.0315 | 0 |
| 24.2 | 33.1 | 16 | 6.35 | 0.009 | 0.027 | 0 |
| 25.45 | 22.7 | 17.5 | 6.02 | 0.0255 | 0.0895 | 0 |
| 23.77 | 33.7 | 11.3 | 6.26 | 0.012 | 0.0356 | 0 |
| 24.3 | 33.1 | 16 | 6.04 | 0.008 | 0.066 | 0 |
| 23.87 | 33.37 | 13 | 6.04 | 0.012 | 0.107 | 0 |
| 24 | 34.07 | 13.7 | 6.03 | 0.01267 | 0.0647 | 0 |
| 27.4 | 33.3 | 17.5 | 6.4 | 0.0255 | 0.1425 | 0 |
| 23 | 30.3 | 14 | 6.5 | 0.034 | 0.351 | 0 |
| 25 | 29.2 | 34 | 6.35 | 0.029 | 0.24 | 0 |
| 23.2 | 29.7 | -1 | -1 | 0.012 | 0.086 | 0 |
| 21 | 27.7 | 36 | 7.12 | 0.0275 | 0.6025 | 1 |
| 17.6 | 25.6 | 37 | 6.05 | 0.042 | 0.702 | 0 |
| 21 | 26.9 | 16 | 6.9 | 0.108 | 0.616 | 0 |
| 15.25 | 28.1 | 31 | 6.6 | 0.0175 | 0.252 | 0 |
| 17.4 | 29.7 | 21 | 7.9 | 0.00275 | 0.164 | 0 |
| 17.35 | 30.05 | 20 | 8.2 | 0.0015 | 0.1285 | 0 |
| 17.97 | 28.93 | 19 | 8.57 | 0.00967 | 0.1803 | 0 |
| 18.1 | 27.3 | 17.5 | 8.56 | 0.0015 | 0.156 | 0 |
| 19 | 25.9 | 15 | 8.68 | 0.0015 | 0.153 | 0 |
| 16.83 | 27.4 | 20 | 6.79 | 0.007 | 0.1276 | 0 |
| 18.5 | 24.05 | 10 | 6.61 | 0.00225 | 0.1405 | 0 |
| 18.23 | 29.3 | 13.7 | 6.84 | 0.0015 | 0.089 | 0 |
| 19.4 | 21.3 | 16 | 8.01 | 0.005 | 0.298 | 1 |
| 17.43 | 28.13 | 19.3 | 6.67 | 0.00433 | 0.1044 | 0 |
| 18.5 | 25.9 | 21 | 7.17 | 0.0015 | 0.163 | 0 |
| 18.07 | 28.87 | 24.3 | 6.97 | 0.0015 | 0.1053 | 0 |
| 18.6 | 29.3 | 26.5 | 6.6 | 0.0015 | 0.1255 | 0 |
| 18.83 | 29.33 | 23 | 6.67 | 0.0015 | 0.096 | 0 |
|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 18.7 | 21.55 | 14.5 | 6.74 | 0.00275 | 0.228 |
| 17.65 | 26.35 | 19 | 7.52 | 0.0015 | 0.1575 |
| 18.5 | 21.6 | 11 | 6.63 | 0.005 | 0.205 |
| 18.25 | 17.05 | 32.5 | 6.3 | 0.007 | 0.3325 |
| 26.7 | 32.3 | 15 | 5 | 0.02 | 0.216 |
| 27.8 | 31.2 | 26 | 6.2 | 0.006 | 0.385 |
| 27.9 | 31 | 23 | 6.15 | 0.015 | 0.2925 |
| 27.25 | 30.95 | 21.5 | 6 | 0.0095 | 0.0985 |
| 27.8 | 29.3 | 19 | 5.5 | 0.044 | 0.196 |
| 25.3 | 32.67 | 24.7 | 5.13 | 0.00367 | 0.081 |
| 26.05 | 32.65 | 19 | 6.95 | 0.0015 | 0.0785 |
| 27.03 | 33.6 | 18.3 | 6.33 | 0.0015 | 0.0573 |
| 26.2 | 32.05 | 21 | 6.6 | 0.0015 | 0.187 |
| 25.73 | 33.23 | 20.3 | 7.6 | 0.005 | 0.0453 |
| 26.5 | 32.2 | 20.5 | 6.4 | 0.005 | 0.095 |
| 26.4 | 27.75 | 34.5 | 5.2 | 0.0155 | 0.4165 |
| 26.17 | 34.2 | 16.7 | 6.7 | 0.0015 | 0.0109 |
| 26.15 | 32.55 | 23 | 5.75 | 0.013 | 0.223 |
| 25.23 | 33.37 | 17.7 | 5.97 | 0.0015 | 0.056 |
| 23.4 | 34.35 | 24 | 5.6 | 0.003 | 0.0665 |
| 25.15 | 33.85 | 22.5 | 5.85 | 0.0045 | 0.0795 |
| 27 | 29.3 | 35 | 5.7 | 0.008 | 0.462 |
| 27.75 | 33.1 | 25 | 7.14 | 0.00275 | 0.0612 |
| 27.5 | 27.2 | 25.5 | 7.95 | 0.031 | 0.265 |
| 27.55 | 26.55 | 21 | 7.24 | 0.0635 | 0.4915 |
| 27.25 | 22.6 | 25 | 7.18 | 0.0205 | 0.413 |
| 27.3 | 21.5 | 9 | 6.59 | 0.034 | 0.507 |
| 25.25 | 24.4 | 17 | 7.03 | 0.049 | 0.591 |
| 24.73 | 27.6 | 24.7 | 6.37 | 0.014 | 0.356 |
| 24.7 | 26.5 | 10 | 6.66 | 0.024 | 0.392 |
| 24.4 | 26.85 | 12.5 | 7.04 | 0.0265 | 0.38 |
| 24.45 | 25.65 | 8.5 | 7.06 | 0.0285 | 0.359 |
| 24.9 | 15.4 | 15 | 6.51 | 0.027 | 0.757 |
| 24.6 | 26 | 17 | 6.9 | 0.019 | 0.371 |
| 24.8 | 27.17 | 14 | 6.78 | 0.01333 | 0.329 |
| 25.7 | 22 | 15.5 | 6.52 | 0.0265 | 0.556 |
| 25.53 | 31.93 | 15 | 6.47 | 0.00317 | 0.105 |
| 25 | 28.17 | 11 | 6.51 | 0.02133 | 0.3127 |
| 25.07 | 28.97 | 15.7 | 6.54 | 0.01 | 0.267 |
| 25.4 | 22.85 | 14 | 6.95 | 0.02 | 0.551 |
| 24.77 | 28.87 | 17.3 | 6.61 | 0.01333 | 0.306 |
| 24.05 | 27.8 | 20 | 6.45 | 0.0125 | 0.47 |
| 13.3 | 26.85 | 31.4 | 8.88 | 0.016 | 0.2655 |
|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 13.13 | 28.5  | 55.4  | 8.37  | 0.02267 | 0.2447 | 0     |
| 12.8  | 29.75 | 31.4  | 8.89  | 0.023   | 0.213  | 0     |
| 13.25 | 25.2  | 23.6  | 8.96  | 0.0215  | 0.4975 | 0     |
| 13.15 | 27.65 | 29    | 8.78  | 0.024   | 0.369  | 0     |
| 14.2  | 29.4  | 26.8  | 8.67  | 0.023   | 0.62   | 0     |
| 13.85 | 19.6  | 33.8  | 8.58  | 0.0275  | 0.764  | 0     |
| 13.3  | 27.2  | 28.9  | 8.04  | 0.018   | 0.271  | 0     |
| 12.83 | 29.3  | 21.9  | 8.43  | 0.02067 | 0.262  | 0     |
| 15.9  | 33.03 | 19.2  | 7.7   | 0.00867 | 0.1273 | 0     |
| 13.75 | 29.65 | 29.8  | 8.1   | 0.014   | 0.1745 | 0     |
| 13.57 | 30.87 | 27.4  | 7.99  | 0.01367 | 0.204  | 0     |
| 13.73 | 31.3  | 22.1  | 7.9   | 0.01133 | 0.1864 | 0     |
| 17    | 27.4  | 27.9  | 7.09  | 0.018   | 0.148  | 0     |
| 17.7  | 30.25 | 55.6  | 7.43  | 0.0195  | 0.192  | 0     |
| 18.15 | 29.6  | 62.9  | 7.5   | 0.014   | 0.1825 | 0     |
| 17.5  | 29.05 | 41.7  | 7.4   | 0.0245  | 0.2565 | 0     |
| 17.5  | 28.7  | 53.9  | 7.6   | 0.033   | 0.294  | 0     |
| 20.35 | 30.4  | 33    | 8.02  | 0.0215  | 0.2565 | 0     |
| 25.6  | 29.63 | 22.7  | 7.57  | 0.014   | 0.1697 | 0     |
| 26.43 | 29.47 | 22.2  | 7.31  | 0.00233 | 0.05   | 0     |
| 26.7  | 24.35 | 20.4  | 7.7   | 0.0015  | 0.0995 | 0     |
| 27.4  | 19    | 19.7  | 7.7   | 0.0015  | 0.17   | 0     |
| 26.3  | 20.85 | 20.4  | 7.52  | 0.0045  | 0.292  | 0     |
| 28.6  | 22.9  | 20.1  | 7.8   | 0.0015  | 0.111  | 0     |
| 25.47 | 32    | 24.3  | 7.5   | 0.004   | 0.056  | 0     |
| 26.35 | 31.9  | 24.5  | 7.71  | 0.00225 | 0.0305 | 0     |
| 27    | 33.9  | 26    | 7.24  | 0.00267 | 0.0237 | 0     |
| 26.6  | 33.1  | 25.6  | 7.31  | 0.002   | 0.021  | 0     |
| 27.6  | 31.7  | 22.9  | 7.9   | 0.0015  | 0.009  | 0     |
| 26.67 | 31.3  | 21.8  | 7.75  | 0.0015  | 0.0253 | 0     |
| 24.25 | 34.15 | 25.5  | 7.46  | 0.00275 | 0.047  | 0     |
| 29    | 32.7  | 21.6  | 7.1   | 0.003   | 0.0225 | 0     |
| 28.2  | 33.5  | 43.5  | 7.06  | 0.008   | 0.045  | 0     |
| 28.1  | 32.75 | 22.2  | 7.36  | 0.0125  | 0.0475 | 0     |
| 29.05 | 31.45 | 24.6  | 7.42  | 0.0245  | 0.0865 | 0     |
| 29.6  | 30.5  | 26.9  | 6.96  | 0.004   | 0.034  | 0     |
| 29.3  | 33.5  | 22.6  | 7.36  | 0.012   | 0.054  | 0     |
| 27.8  | 32.23 | 15.6  | 7.26  | 0.01533 | 0.137  | 0     |
| 28.25 | 32.05 | 26.1  | 7.02  | 0.004   | 0.029  | 0     |
| 28.3  | 26.3  | 18.1  | 6.95  | 0.006   | 0.153  | 0     |
| 28.6  | 29.6  | 21.7  | 7.08  | 0.004   | 0.057  | 0     |
| 27.73 | 33.17 | 20.1  | 7.22  | 0.005   | 0.0486 | 0     |
| 27.5  | 33.2  | 32.9  | 7.31  | 0.028   | 0.156  | 0     |
|     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|
| 27.9 | 31.3 | 19.2 | 7.36 | 0.019 | 0.1405 | 0  |
| 27.25 | 30.35 | 34.5 | 7.36 | 0.0255 | 0.202 | 0  |
| 28  | 31.2 | 23.9 | 7.34 | 0.052 | 0.3665 | 1  |
| 20.05 | 32.2 | 7.4 | 7.38 | 0.0105 | 0.0845 | 0  |
| 19.1 | 30.2 | 12  | 7.49 | 0.014 | 0.135 | 0  |
| 23.07 | 34  | 18.8 | 6.6  | 0.003L | 0.029 | 0  |
| 20.6 | 32.4 | 18.6 | 7.2  | 0.00325 | 0.058 | 0  |
| 21.5 | 30.1 | 12.1 | 7.98 | 0.003L | 0.083 | 0  |
| 21.95 | 31.25 | 10.9 | 7.6  | 0.003L | 0.0795 | 0  |
| 21.9 | 26.25 | 22  | 7.32 | 0.009 | 0.3505 | 1  |
| 22.2 | 33.27 | 19.5 | 7.28 | 0.003L | 0.0189 | 0  |
| 22.7 | 33.55 | 25.2 | 6.64 | 0.003L | 0.031 | 0  |
| 22.57 | 33.17 | 18.7 | 7.46 | 0.003L | 0.0157 | 0  |
| 28.3 | 33  | 20.5 | 6.8  | 0.005 | 0.156 | 0  |
| 25.73 | 33.47 | 27  | 6.68 | 0.01367 | 0.0994 | 0  |
| 28.55 | 33.65 | 16.6 | 6.98 | 0.003 | 0.065 | 0  |
| 26.65 | 28.75 | 34.2 | 7.29 | 0.0145 | 0.23 | 0  |
| 27.3 | 28.3 | 11  | 7.24 | 0.012 | 0.22 | 0  |
| 25.7 | 33.7 | 23  | 6.67 | 0.014 | 0.079 | 0  |
| 26.25 | 33.55 | 9.6  | 6.9  | 0.0115 | 0.1055 | 0  |
| 26.7 | 34.1 | 2.9  | 6.57 | 0.00467 | 0.0573 | 0  |
| 26.3 | 33.7 | 5   | 6.23 | 0.00333 | 0.0616 | 0  |
| 26.57 | 33.5 | 10  | 6.48 | 0.005 | 0.059 | 0  |
| 28.4 | 31.3 | 20.8 | 6.9  | 0.038 | 0.2555 | 0  |
| 24.17 | 30.17 | 56.5 | 5.97 | 0.051 | 0.4213 | 0  |
| 23.07 | 29.53 | 13.4 | 7.24 | 0.037 | 0.3533 | 0  |
| 22.4 | 29.7 | 14.6 | 6.77 | 0.055 | 0.341 | 0  |
| 21.8 | 28.8 | 10  | 7.04 | 0.031 | 0.384 | 0  |
| 21.3 | 29.4 | 27  | 7.1  | 0.024 | 0.305 | 0  |
| 23.3 | 31.6 | 20.8 | 6.66 | 0.007 | 0.2345 | 0  |
| 23.6 | 30.5 | 32  | 6.73 | 0.026 | 0.284 | 0  |
| 22.45 | 29.4 | 20.8 | 6.76 | 0.03 | 0.3485 | 0  |
| 19.9 | 32.9 | 10  | 8.16 | 0.01 | 0.178 | 0  |
| 20.1 | 31  | 27  | 8.16 | 0.02 | 0.655 | 1  |
| 20.3 | 27.3 | 11.5 | 8.12 | 0.096 | 1.418 | 1  |
| 19.88 | 34.83 | 6   | 7.26 | 0.002 | 0.0325 | 0  |
| 19.89 | 34.31 | 10  | 7.64 | 0.001 | 0.0565 | 0  |
| 19.09 | 33.76 | 10  | 7.54 | 0.004 | 0.1085 | 0  |
| 19.92 | 35.34 | 3   | 7.37 | 0.004 | 0.077 | 0  |
| 25.3 | 33.95 | 14.5 | 6.22 | 0.0065 | 0.02 | 0  |
| 25.75 | 33.95 | 15  | 6.4  | 0.0055 | 0.0055 | 0  |
| 26.2 | 33.95 | 18.5 | 6.3  | 0.007 | 0.004 | 0  |
| 24.75 | 34 | 33.5 | 6.31 | 0.007 | 0.0485 | 0  |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 28.5 | 33.75 | 15.5 | 6.34 | 0.0175 | 0.07 | 0 |
| 27.6 | 33.2 | 14 | 6.33 | 0.026 | 0.144 | 0 |
| 28.4 | 31.6 | 14 | 6.31 | 0.064 | 0.319 | 1 |
| 22.25 | 29.2 | 19.5 | 7.14 | 0.0135 | 0.198 | 0 |
| 20.7 | 26.9 | 44 | 7.3 | 0.023 | 0.434 | 0 |
| 19.8 | 16.4 | 93 | 6.92 | 0.07 | 1.613 | 0 |
| 18.25 | 30.85 | 20 | 7.44 | 0.01 | 0.21 | 0 |
| 17.85 | 31.6 | 26 | 6.94 | 0.006 | 0.165 | 0 |
| 17.6 | 27.65 | 20 | 7.15 | 0.0215 | 0.3205 | 1 |
| 18.3 | 24.8 | 24 | 7.87 | 0.042 | 0.829 | 1 |
| 18.5 | 31.17 | 24.7 | 6.75 | 0.0015 | 0.072 | 0 |
| 18.43 | 29.47 | 16 | 6.56 | 0.0015 | 0.1507 | 0 |
| 18.83 | 30.67 | 26.3 | 6.92 | 0.0015 | 0.1043 | 0 |
| 18.95 | 30.8 | 17.5 | 6.38 | 0.0015 | 0.098 | 0 |
| 19 | 30 | 15 | 6.72 | 0.00225 | 0.1255 | 0 |
| 18.33 | 29.33 | 20 | 6.44 | 0.00233 | 0.1363 | 0 |
| 28.45 | 30.2 | 18 | 6.2 | 0.0185 | 0.3585 | 1 |
| 28.1 | 22.4 | 15 | 6.37 | 0.053 | 0.667 | 1 |
| 25.67 | 33.73 | 19.7 | 6.37 | 0.0015 | 0.0493 | 0 |
| 27.45 | 33.6 | 27 | 6.5 | 0.003 | 0.0475 | 0 |
| 25.67 | 33.67 | 20.3 | 5.9 | 0.0015 | 0.0445 | 0 |
| 26.1 | 33.4 | 19.5 | 5.65 | 0.0015 | 0.0365 | 0 |
| 27.1 | 33.5 | 26 | 6.3 | 0.003 | 0.031 | 0 |
| 26.03 | 33.6 | 19.3 | 5.63 | 0.00767 | 0.072 | 0 |
| 29.4 | 31.8 | 24 | 7.3 | 0.0015 | 0.025 | 0 |
| 27.35 | 32.9 | 23 | 5.75 | 0.003 | 0.0325 | 0 |
| 27.6 | 25.65 | 18.5 | 7.01 | 0.021 | 0.611 | 0 |
| 27.5 | 21.9 | 24 | 7.8 | 0.03 | 0.902 | 0 |
| 26.9 | 27.6 | 17 | 7.63 | 0.035 | 0.512 | 0 |
| 25.37 | 30.03 | 19.3 | 5.85 | 0.00533 | 0.204 | 0 |
| 25.45 | 27.9 | 21 | 6.76 | 0.0145 | 0.344 | 0 |
| 25.37 | 28.73 | 16 | 5.73 | 0.017 | 0.258 | 0 |
| 25.65 | 28.35 | 15.5 | 6.7 | 0.0065 | 0.297 | 0 |
| 26.1 | 27.75 | 12.5 | 6.3 | 0.0085 | 0.4285 | 0 |
| 26.8 | 27.8 | 13 | 8.15 | 0.036 | 0.279 | 0 |
| 24.9 | 28 | 19.5 | 5.75 | 0.0095 | 0.343 | 0 |
| 15.1 | 31.47 | 25.5 | 7.88 | 0.009 | 0.2363 | 0 |
| 14.23 | 30.2 | 26.2 | 8.08 | 0.017 | 0.354 | 0 |
| 14.5 | 30.97 | 23 | 8.03 | 0.01367 | 0.2097 | 0 |
| 15.25 | 30.85 | 23.4 | 8.13 | 0.015 | 0.324 | 0 |
| 15.35 | 30.35 | 33.3 | 8.03 | 0.01 | 0.3045 | 0 |
| 15.3 | 30.5 | 24.7 | 8.4 | 0.008 | 0.307 | 0 |
| 14.2 | 30.13 | 42.1 | 8.18 | 0.01767 | 0.3633 | 0 |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 18.9 | 30.6 | 42.3 | 7.42 | 0.012 | 0.173 | 0 |
| 18.5 | 27.5 | 45.3 | 7.32 | 0.06 | 0.46 | 1 |
| 20.6 | 30.35 | 35.6 | 8.1 | 0.027 | 0.255 | 0 |
| 25.73 | 30.43 | 25.2 | 7.04 | 0.0025 | 0.0387 | 0 |
| 27.53 | 33.57 | 22.8 | 6.58 | 0.00317 | 0.027 | 0 |
| 26.83 | 33.73 | 26.5 | 6.81 | 0.003 | 0.0187 | 0 |
| 26.65 | 33.6 | 27.6 | 6.66 | 0.00225 | 0.0115 | 0 |
| 28.1 | 33.8 | 24.9 | 6.6 | 0.003 | 0.012 | 0 |
| 26.63 | 33.63 | 24.3 | 7.22 | 0.003 | 0.0473 | 0 |
| 27.9 | 33.1 | 24.2 | 6.56 | 0.0055 | 0.014 | 0 |
| 29.45 | 33.55 | 25.7 | 7.1 | 0.005 | 0.0505 | 0 |
| 30.7 | 32.5 | 27.5 | 7.2 | 0.013 | 0.072 | 0 |
| 32.1 | 30 | 48.2 | 7.47 | 0.028 | 0.227 | 0 |
| 22.35 | 32.2 | 25.8 | 7.32 | 0.0395 | 0.2695 | 1 |
| 21.8 | 33.9 | 110.8 | 7.12 | 0.054 | 0.39 | 1 |
| 22.9 | 33.5 | 16.4 | 7.18 | 0.028 | 0.202 | 0 |
| 23.5 | 34.1 | 18.4 | 6.77 | 0.003L | 0.008 | 0 |
| 23.37 | 33.43 | 25.6 | 6.89 | 0.003L | 0.0397 | 0 |
| 23.27 | 33.9 | 23.7 | 6.73 | 0.003L | 0.0186 | 0 |
| 23.05 | 33.8 | 12.5 | 6.76 | 0.003L | 0.04 | 0 |
| 23.8 | 33.5 | 8.8 | 6.73 | 0.005 | 0.045 | 0 |
| 23.3 | 33.65 | 27.4 | 6.62 | 0.003L | 0.0265 | 0 |
| 22.57 | 33.27 | 24.5 | 6.81 | 0.003L | 0.0414 | 0 |
| 27.47 | 33.83 | 18.7 | 6.84 | 0.007 | 0.0647 | 0 |
| 26.35 | 33.9 | 22.9 | 6.38 | 0.0055 | 0.084 | 0 |
| 27.8 | 33.6 | 14.7 | 7.01 | 0.008 | 0.073 | 0 |
| 27.7 | 34 | 11.8 | 6.85 | 0.001L | 0.032 | 0 |
| 26.43 | 34 | 34.9 | 6.91 | 0.006 | 0.0684 | 0 |
| 27.4 | 34 | 6.5 | 6.78 | 0.006 | 0.0566 | 0 |
| 27.87 | 33.77 | 8.7 | 6.68 | 0.00433 | 0.048 | 0 |
| 25.7 | 33 | 15.7 | 6.76 | 0.02 | 0.184 | 0 |
| 25.05 | 31.65 | 19.6 | 6.68 | 0.028 | 0.2555 | 0 |
| 24.9 | 27.7 | 66.7 | 6.62 | 0.073 | 0.731 | 0 |
| 19.45 | 27.75 | 21.5 | 7.5 | 0.032 | 0.3555 | 1 |
| 19.8 | 24.3 | 21 | 7.6 | 0.032 | 0.273 | 1 |
| 18.9 | 27.35 | 19 | 7.7 | 0.042 | 0.255 | 1 |
| 19.25 | 22.75 | 17.5 | 7.4 | 0.038 | 0.357 | 1 |
| 19.3 | 29.2 | 21 | 7.4 | 0.026 | 0.317 | 0 |
| 19.1 | 27.8 | 19 | 7.7 | 0.034 | 0.26 | 0 |
| 19.35 | 27.1 | 20.5 | 7.65 | 0.0135 | 0.1905 | 0 |
| 19.5 | 29 | 24 | 7.2 | 0.025 | 0.338 | 0 |
| 18.83 | 31.77 | 4 | 9.55 | 0.0005 | 0.216 | 0 |
| 18.38 | 33.33 | 10 | 8.44 | 0.00367 | 0.17 | 0 |
|   |       |   |   |   |   |   |   |
|---|-------|---|---|---|---|---|---|
| 19.25 | 31.46 | 13 | 10.49 | 0.0005 | 0.181 | 0 |
| 17.85 | 32.73 | 18.7 | 7.58 | 0.016 | 0.369 | 1 |
| 25.9 | 30.05 | 23.5 | 5.35 | 0.0285 | 0.3075 | 0 |
| 28.2 | 27.4 | 21 | 5.6 | 0.042 | 0.291 | 0 |
| 26.05 | 29.15 | 21.5 | 5.15 | 0.0295 | 0.258 | 0 |
| 26.8 | 26.85 | 21 | 5.35 | 0.0335 | 0.315 | 0 |
| 26.4 | 33.4 | 20 | 5.97 | 0.0015 | 0.066 | 0 |
| 23.93 | 34.03 | 19.7 | 6.01 | 0.01233 | 0.038 | 0 |
| 25.2 | 33.5 | 21 | 5.96 | 0.008 | 0.144 | 0 |
| 28.1 | 30.7 | 22 | 5.5 | 0.021 | 0.218 | 0 |
| 24.03 | 32.93 | 31 | 6.01 | 0.01667 | 0.169 | 0 |
| 27.3 | 31.4 | 20 | 5.5 | 0.029 | 0.229 | 0 |
| 25.85 | 30.55 | 22 | 5.35 | 0.034 | 0.23 | 0 |
| 27.5 | 31 | 23 | 5.7 | 0.023 | 0.327 | 0 |
| 21.3 | 30.15 | 23.5 | 5.45 | 0.029 | 0.268 | 0 |
| 20.9 | 27.6 | 21 | 5.5 | 0.028 | 0.245 | 0 |
| 21.1 | 28.75 | 25 | 5.5 | 0.0275 | 0.2245 | 0 |
| 20.95 | 27.65 | 23.5 | 5.55 | 0.0425 | 0.2325 | 0 |
| 20.5 | 27.7 | 23 | 5.2 | 0.029 | 0.267 | 0 |
| 20.5 | 28.3 | 22 | 5.5 | 0.024 | 0.204 | 0 |
| 20.8 | 27.15 | 26.5 | 5.65 | 0.025 | 0.2125 | 0 |
| 20.8 | 29 | 25 | 5.4 | 0.026 | 0.274 | 0 |
| 18 | 26.7 | 20 | 9.17 | 0.006 | 0.21 | 0 |
| 14.25 | 30.4 | 47 | 9.3 | 0.007 | 0.2655 | 0 |
| 15.2 | 26.8 | 45 | 9.28 | 0.0085 | 0.316 | 1 |
| 13.3 | 31.4 | 38.5 | 9.34 | 0.0085 | 0.532 | 1 |
| 16.3 | 25.4 | 39 | 8.7 | 0.039 | 0.428 | 1 |
| 16.2 | 21.6 | 40.5 | 8.75 | 0.0365 | 0.6215 | 1 |
| 15.4 | 25.75 | 40 | 9.05 | 0.0325 | 0.511 | 1 |
| 15.65 | 24.85 | 41 | 8.75 | 0.0295 | 0.5485 | 1 |
| 14.8 | 27.7 | 36 | 9.25 | 0.0185 | 0.2875 | 0 |
| 16.65 | 28.8 | 27 | 7.14 | 0.0055 | 0.066 | 0 |
| 17.15 | 26.9 | 25 | 8.2 | 0.007 | 0.1355 | 0 |
| 17.05 | 28.7 | 21.5 | 7.38 | 0.004 | 0.0683 | 0 |
| 19.7 | 24.9 | 20 | 7.9 | 0.003 | 0.006 | 0 |
| 17.07 | 29.33 | 14.7 | 7.93 | 0.00283 | 0.08 | 0 |
| 17.2 | 26.6 | 20 | 8.6 | 0.007 | 0.134 | 0 |
| 18.83 | 30.87 | 11.3 | 6.88 | 0.0015 | 0.0433 | 0 |
| 17.03 | 28.23 | 21.3 | 8.14 | 0.00433 | 0.1157 | 0 |
| 27.8 | 28 | 19 | 5.6 | 0.044 | 0.954 | 1 |
| 27.8 | 22.25 | 14 | 5.32 | 0.0385 | 0.817 | 1 |
| 27.7 | 27.55 | 13 | 5.14 | 0.0445 | 0.575 | 1 |
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