In [5]:
```
import sys
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
import seaborn as sns
from scipy.stats import zscore
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.model_selection import train_test_split, cross_val_score
```

In [2]:
```
# code in this cell from:
# https://stackoverflow.com/questions/27934885/how-to-hide-code-from-cells-in
from IPython.display import HTML

HTML('''<script>
code_show=true;
function code_toggle() {
 if (code_show){
 $('div.input').hide();
 } else {
 $('div.input').show();
 }
 code_show = !code_show
}
$( document ).ready(code_toggle);
</script>
<form action="javascript:code_toggle()"><input type="submit" value="Click her
```

Out[2]: Click here to display/hide the code.

In [6]:
```
# switch to seaborn default stylistic parameters
sns.set()
sns.set_context('notebook')
```

In [7]:
```
#read in data
df = pd.read_csv("C:/Users/urban boutique/Desktop/California.csv")
```

In [9]:

```
#remove commas from data and convert into int
df = df.replace(',','', regex=True)

df["Population"] = df["Population"].astype(str).astype(int)
df["Violent_crime"] = df["Violent_crime"].astype(str).astype(int)
df["Murder_manslaughter"] = df["Murder_manslaughter"].astype(str).astype(int)
df["Rape"] = df["Rape"].astype(str).astype(int)
df["Robbery"] = df["Robbery"].astype(str).astype(int)
df["Aggravated_assault"] = df["Aggravated_assault"].astype(str).astype(int)
df["Property_crime"] = df["Property_crime"].astype(str).astype(int)
df["Burglary"] = df["Burglary"].astype(str).astype(int)
df["Larceny_theft"] = df["Larceny_theft"].astype(str).astype(int)
df["Motor_Vehicle_theft"] = df["Motor_Vehicle_theft"].astype(str).astype(int)
df["Arson"] = df["Arson"].astype(str).astype(int)
```

In [10]:

```
#display data
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 457 entries, 0 to 456
Data columns (total 12 columns):
 #   Column               Non-Null Count  Dtype 
---  ------               --------------  ----- 
 0   City                 457 non-null    object
 1   Population           457 non-null    int32 
 2   Violent_crime        457 non-null    int32 
 3   Murder_manslaughter  457 non-null    int32 
 4   Rape                 457 non-null    int32 
 5   Robbery              457 non-null    int32 
 6   Aggravated_assault   457 non-null    int32 
 7   Property_crime       457 non-null    int32 
 8   Burglary             457 non-null    int32 
 9   Larceny_theft        457 non-null    int32 
 10  Motor_Vehicle_theft  457 non-null    int32 
 11  Arson                457 non-null    int32 
dtypes: int32(11), object(1)
memory usage: 23.3+ KB
```

In [11]:

```
#display first 10 rows of data
df.head(10)
```

Out[11]:

	City	Population	Violent_crime	Murder_manslaughter	Rape	Robbery	Aggravated_ass
0	Adelanto	34491	276	1	20	42	
1	Agoura Hills	20490	21	0	6	4	
2	Alameda	78907	162	0	7	94	
3	Albany	20083	40	0	8	21	
4	Alhambra	84837	161	2	11	89	
5	Aliso Viejo	52247	27	1	3	13	
6	Alturas	2471	10	0	2	1	
7	American Canyon	20452	53	0	7	7	
8	Anaheim	353915	1120	8	141	396	
9	Anderson	10545	61	1	5	12	

In [12]:

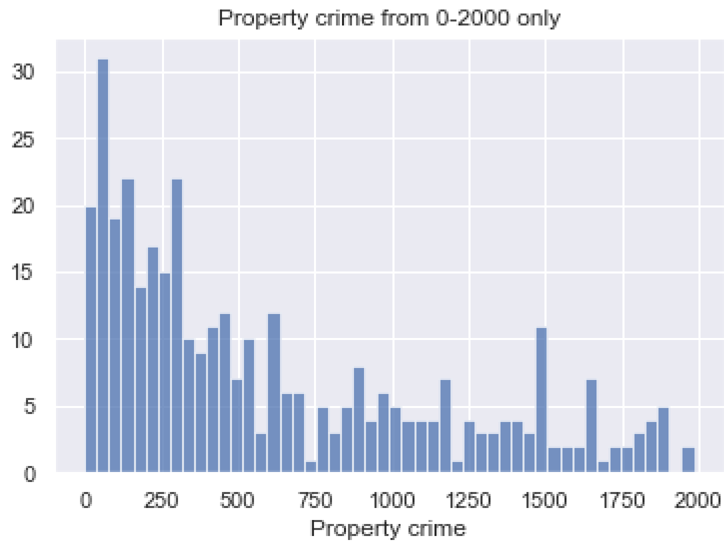
```
# sort data by population from smallest to largest. Display the first 10 citi
df = df.sort_values(by='Population')
df.head(10)
```

Out[12]:

	City	Population	Violent_crime	Murder_manslaughter	Rape	Robbery	Aggravated_as
427	Vernon	112	27	0	1	12	
186	Industry	201	72	0	1	41	
350	Sand City	407	9	0	0	2	
142	Fort Jones	690	2	0	1	0	
130	Etna	716	2	0	1	0	
191	Isleton	849	7	1	0	0	
112	Dorris	897	4	0	0	0	
417	Tulelake	985	3	0	1	0	
43	Bradbury	1089	1	0	0	1	
136	Ferndale	1363	4	0	0	0	

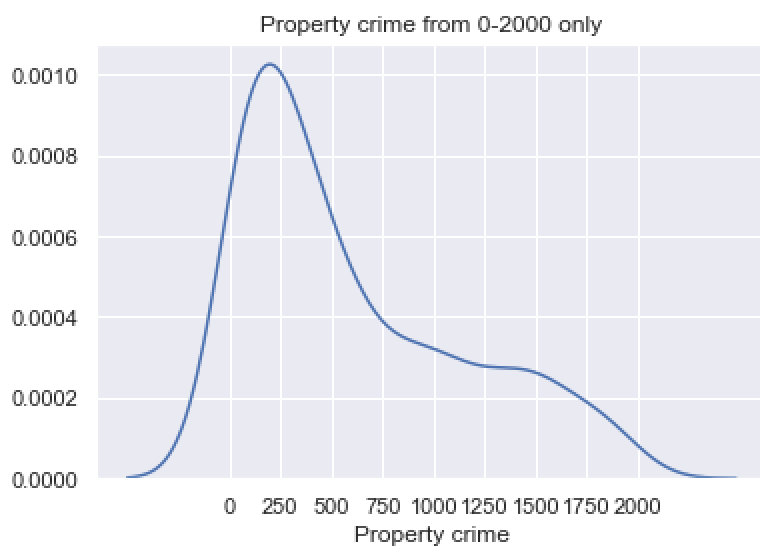
In [28]:

```
# A histogram showing Property_crime from 0 - 2000 only

data = df[df['Property_crime'].between(0,2000)]

h = sns.histplot(data=data,x=data['Property_crime'], bins=50)

h.set(title = 'Property crime from 0-2000 only', xlabel = 'Property crime', y
```



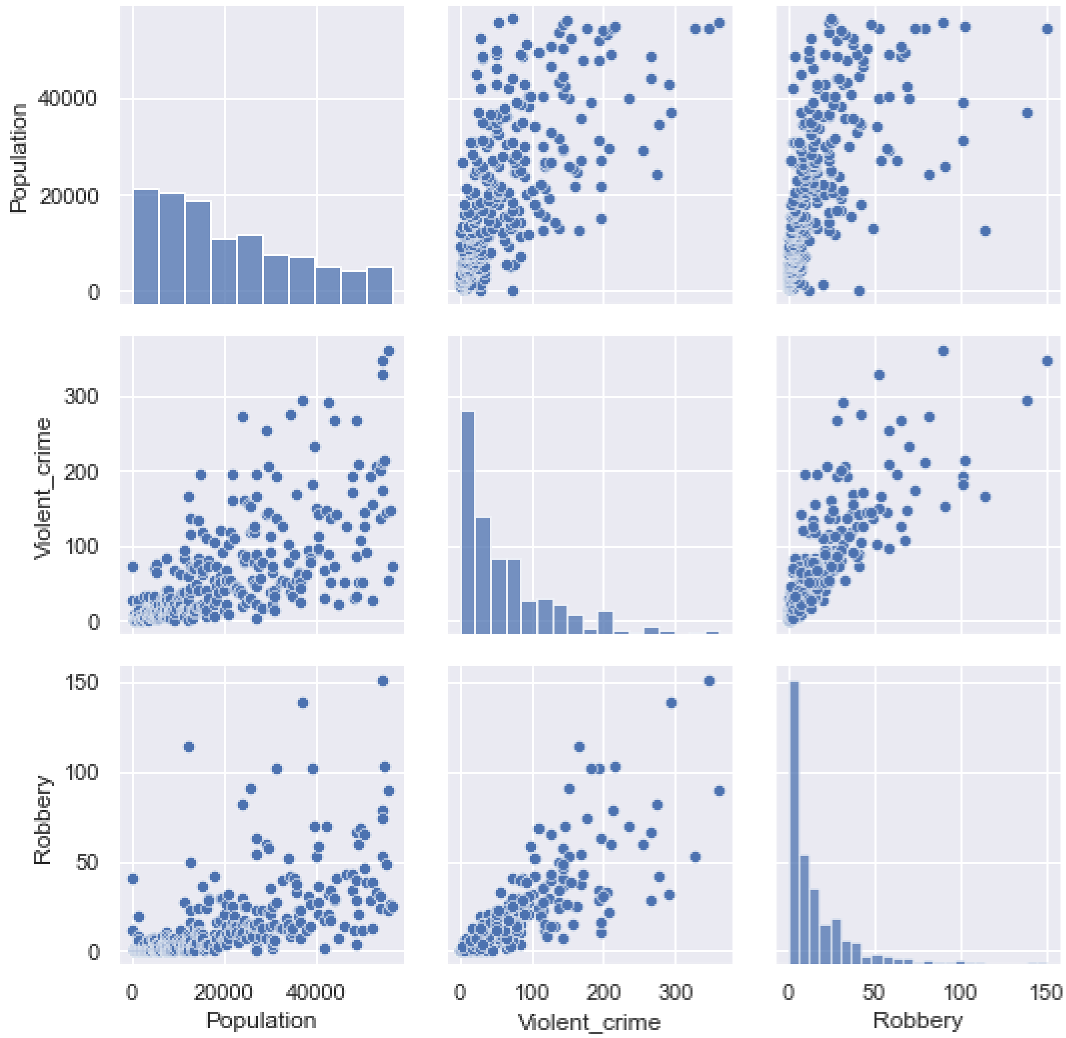
In [34]:

```
# A density plot showing Property_crime amounts from 0 - 2000

data = df[df['Property_crime'].between(0,2000)]
g = sns.kdeplot(data = data, x='Property_crime')
g.set(title = 'Property crime from 0-2000 only', xlabel = 'Property crime', y
```



In [280]:

```
# A grid of scatterplots using only Population, Violent_crime, and Robbery

g = sns.PairGrid(df.loc[:,['Population','Violent_crime','Robbery']].head(300))
g.map_diag(sns.histplot)
g.map_offdiag(sns.scatterplot);
```

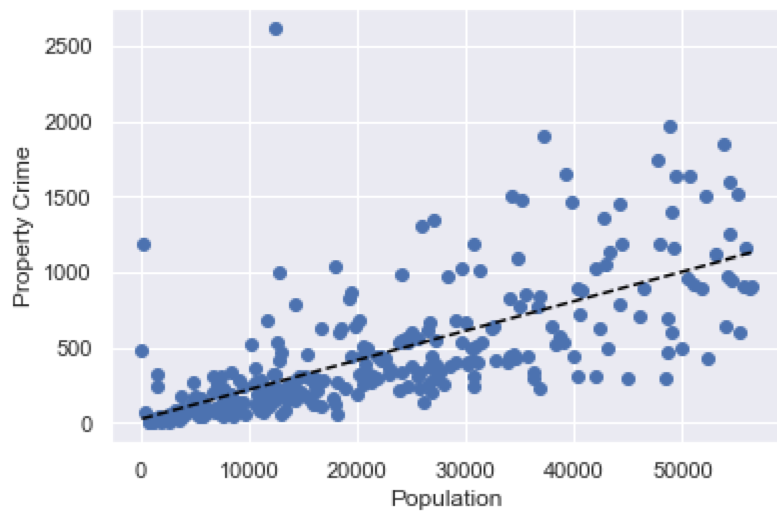


In [277]:

```
#Let's build a model to predict a citys property crime from its population.

# A scatterplot of Property_crime by Population (Property_crime on y axis),
# with linear model on it (as a line).

X = df["Population"].head(300)
y = df["Property_crime"].head(300)

plt.plot(X, y, 'o');

m, b = np.polyfit(X, y, 1)
plt.plot(X, m*X+b,color="black",linestyle="dashed")

plt.xlabel('Population')
plt.ylabel('Property Crime')
```

Out[277]:

```
Text(0, 0.5, 'Property Crime')
```



In [278]:

```
# The coefficients and R-squared value of the model.
X = np.array(X).reshape(-1,1)

reg = LinearRegression().fit(X,y)

print("intercept: " + format(reg.intercept_, ".2f"))
print("coefficient for Population: " + format(reg.coef_[0], ".2f"))
print("r-squared value: " + format(reg.score(X, y), ".2f"))
```

```
intercept: 24.88
coefficient for Population: 0.02
r-squared value: 0.50
```

In [62]:

```
# Three new linear models for Property_crime

# Using predictors Population, Violent_crime, and Robbery.
X1 = df[["Population","Violent_crime","Robbery"]]
y1 = df["Property_crime"]

# Using predictors Population, Burglary, and Larceny_theft.
X2 = df[["Population","Burglary","Larceny_theft"]]
y2 = df["Property_crime"]

# Using predictors Population, Rape, and Murder_manslaughter.
X3 = df[["Population","Rape","Murder_manslaughter"]]
y3 = df["Property_crime"]

reg1 = LinearRegression().fit(X1,y1)
reg2 = LinearRegression().fit(X2,y2)
reg3 = LinearRegression().fit(X3,y3)

print("reg1:", reg1.get_params())
print("reg2:", reg2.get_params())
print("reg3:", reg3.get_params())
```

```
reg1: {'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize':
False, 'positive': False}
reg2: {'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize':
False, 'positive': False}
reg3: {'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize':
False, 'positive': False}
```

In [63]:

```
# Coefficients (including intercept) for the new models.

print("reg1")
print("intercept: " + format(reg1.intercept_, ".2f"))
print("coefficients:")
print(" Population: " + format(reg1.coef_[0], ".2f"))
print(" Violent crime: " + format(reg1.coef_[1], ".2f"))
print(" Robbery: " + format(reg1.coef_[2], ".2f"))
print("")

print("reg2")
print("intercept: " + format(reg2.intercept_, ".2f"))
print("coefficients:")
print(" Population: " + format(reg2.coef_[0], ".2f"))
print(" Burglary: " + format(reg2.coef_[1], ".2f"))
print(" Larceny_theft: " + format(reg2.coef_[2], ".2f"))
print("")

print("reg3")
print("intercept: " + format(reg3.intercept_, ".2f"))
print("coefficients:")
print(" Population: " + format(reg3.coef_[0], ".2f"))
print(" Rape: " + format(reg3.coef_[1], ".2f"))
print(" Murder_manslaughter: " + format(reg3.coef_[2], ".2f"))
```

```
reg1
intercept: 125.28
coefficients:
 Population: 0.02
 Violent crime: -4.59
 Robbery: 16.68

reg2
intercept: -39.36
coefficients:
 Population: 0.00
 Burglary: 1.56
 Larceny_theft: 1.03

reg3
intercept: 41.13
coefficients:
 Population: 0.02
 Rape: -11.48
 Murder_manslaughter: 171.49
```

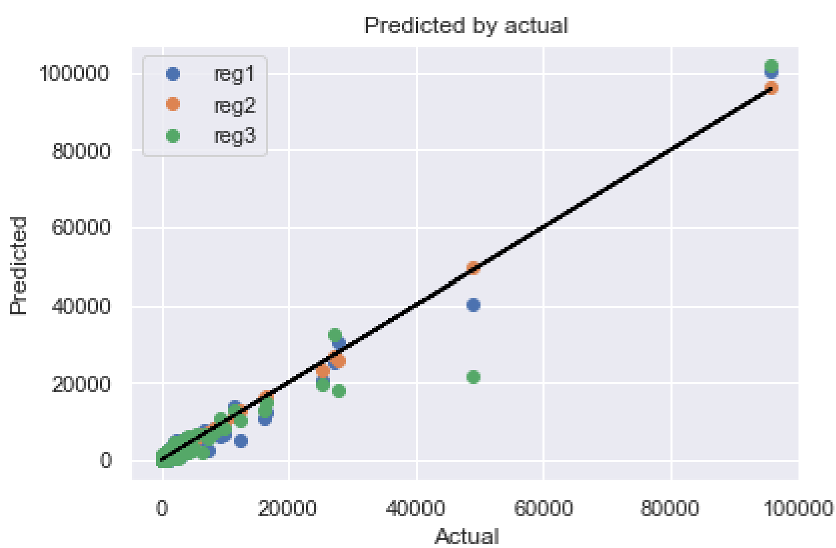
In [65]:

```
# Compute the predicted Property_crime for the new model using different valu

# a city with a population of 30,000, violent crime of 100, and robbery of 20
X1new=[[30000,100,20]]
y1new=reg1.predict(X1new)
print(format(y1new[0], ".2f"))

# a city with a population of 30,000, burglary of 200, and larceny theft of 2
X2new=[[30000,200,20]]
y2new=reg2.predict(X2new)
print(format(y2new[0], ".2f"))

# a city with a population of 30,000, rape of 3, and murder & manslaughter of
X3new=[[30000,3,3]]
y3new=reg3.predict(X3new)
print(format(y3new[0], ".2f"))
```

```
554.80
338.54
1147.88
```

In [74]:

```
# Plot predicted values against actual values. In this case we plotted predic
def plot_actual_predicted(actual, predicted, title, model):
    plt.plot(actual,predicted,'o',label=model)
    plt.title(title)
    m, b = np.polyfit(actual, actual, 1)
    plt.plot(actual, m*actual+b,color='black', linestyle="dashed")
    plt.xlabel('Actual')
    plt.ylabel('Predicted')
    plt.legend()


predictors1 = ["Population","Violent_crime","Robbery"]
target1 = "Property_crime"
X1 = df[predictors1].values
y1 = df[target1].values

predictors2 = ["Population","Burglary","Larceny_theft"]
target2 = "Property_crime"
X2 = df[predictors2].values
y2 = df[target2].values

predictors3 = ["Population","Rape","Murder_manslaughter"]
target3 = "Property_crime"
X3 = df[predictors3].values
y3 = df[target3].values

plot_actual_predicted(y1, reg1.predict(X1), 'Predicted by actual', 'reg1')
plot_actual_predicted(y2, reg2.predict(X2), 'Predicted by actual', 'reg2')
plot_actual_predicted(y3, reg3.predict(X3), 'Predicted by actual', 'reg3')
```



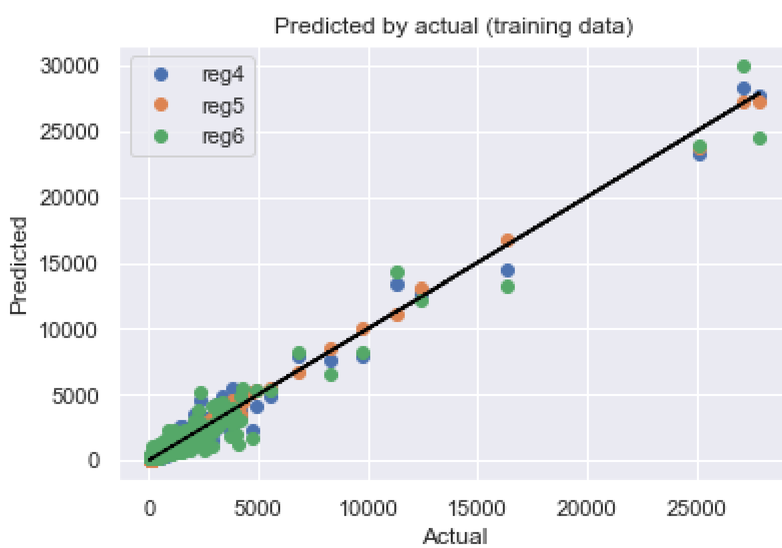
In [ ]:

```
# The plot shows that our predictions are good for the most part. We actually
```

In [76]:
```
# split the data of into separate training and set sets.
X1_train, X1_test, y1_train, y1_test = train_test_split(X1, y1, test_size=0.2
X2_train, X2_test, y2_train, y2_test = train_test_split(X2, y2, test_size=0.2
X3_train, X3_test, y3_train, y3_test = train_test_split(X3, y3, test_size=0.2

# fit the models using the training data
reg4 = LinearRegression()
reg4.fit(X1_train,y1_train)

reg5 = LinearRegression()
reg5.fit(X2_train,y2_train)

reg6 = LinearRegression()
reg6.fit(X3_train,y3_train)

print(reg4.get_params())
print(reg5.get_params())
print(reg6.get_params())
```

```
{'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize': False,
'positive': False}
{'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize': False,
'positive': False}
{'copy_X': True, 'fit_intercept': True, 'n_jobs': None, 'normalize': False,
'positive': False}
```

In [78]:
```
# Plot using the training data.

plot_actual_predicted(y1_train, reg4.predict(X1_train), 'Predicted by actual
plot_actual_predicted(y2_train, reg5.predict(X2_train), 'Predicted by actual
plot_actual_predicted(y3_train, reg6.predict(X3_train), 'Predicted by actual
```



In [79]:
```
# Plot using the test data

plot_actual_predicted(y1_test, reg4.predict(X1_test), 'Predicted by actual (t
plot_actual_predicted(y2_test, reg5.predict(X2_test), 'Predicted by actual (t
plot_actual_predicted(y3_test, reg6.predict(X3_test), 'Predicted by actual (t
```